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IoT Based Smart Applications

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Preface

The Internet of Things (IoT) is emerging as one of the most prominent technological concepts in the twenty-first century. We live in a world where new objects are connected to the Internet with the aim of improving and facilitating people's lives. In addition, objects that we did not even imagine a few years ago as part of the network are now beginning to be connected, offering a new immense range of possibilities. The main motive of this book is to provide insights into IoT, its applications, and implementation techniques. Today, IoT has become a promising technology that connects the different objects embedded with sensors and software to exchange information without human intervention. Here, various IoT-enabled technologies and applications will be discussed along with their pros, cons, and future directions.

This book will also cover the future of IoT in various sectors and will discuss how IoT will be proven to game-changing technology. In this book, the IoT design methodology to define the domain model will be discussed. The designing process using Arduino that offers smart, connected, and secure elements will also be emphasized in this book. The integration of IoT with blockchain, cloud, machine learning, big data, embedded software, and sensors will be covered here. At last, we also intend to cover the various technologies that can be integrated with IoT to get the optimized use of this technology. That is why this book, *IoT Based Smart Applications*, has been written with the collaboration of international scientists who provide different visions and solutions to some of the most important current problems from the point of view of the Internet of Things community and from an even more interesting mixed point of view.

Chapter 1 is entitled "A Study on COVID-19, Its Origin, Phenomenon, Its Variants and IoT-Based Framework to Detect the Presence of Coronavirus." In this chapter, the authors focus on finding out solutions for the detection of this contagious viral infection at the earliest. Computer-based artificial intelligence can be used to monitor and detect the symptoms of coronavirus. For detection of coronavirus infection, computers or smartphones can be embedded with biosensors that will perceive the information and will convert the information into digital data. In this chapter, a study on the coronavirus is done and an IoT-based framework is proposed to detect the coronavirus using IoT-based sensors. The proposed approach will be able to detect the pandemic in its early stages, and so better options will be there to prevent and cure.

Chapter 2 is entitled “Blockchain for Internet of Things (IoT): Research Issues, Challenges and Future Directions.” The authors explain the importance of the blockchain for the Internet of Things. Traditional electronics has become smarter as a result of seeing things on the Internet. Whereas this era known as Blockchain appears as a first-rate deliver of presenting safety to this new age of technological programs, the speedy evolvement of smart devices demands trusted security for the maintenance of the IoT containing application’s knowledge safety, security, and authentication. This research inspects the IoT protection answers by using integrating IoT programs with blockchain. The evaluation consists of blockchain basics, kinds, and layout for the Internet of Things. It will also look at the hurdles and problems of IoT in blockchain adoption, particularly in terms of security, privacy, throughput, block size, multichain management, and social control.

Chapter 3 is entitled “Smart Healthcare by Harnessing the Internet of Things (IoT): Applications, Challenges and Future Aspects.” In this chapter, the authors discussed IoT-enabled devices that have helped in solving many problems in the healthcare sector. The improved potential to keep patients safe and healthy has empowered physicians to provide superlative care. These devices range from sensors that monitor patient’s gluten and glucose levels in the blood, blood pressure, and heart rate to even monitoring food and water intake. This chapter intends to provide a detailed overview of how IoT has spread its branches far and wide into the field of healthcare. The real-time applications of IoT, such as the diagnosis of diseases, surgery, and clinical trials, have been explained in detail. Moreover, various important aspects like biosafety, security, and legal challenges with respect to its commercialization have also been discussed.

Chapter 4 is entitled “Applications of IoT in Smart Homes and Cities.” This is a summarized chapter in which the authors focus on some of the most interesting concepts behind IoT, like the different possible applications of IoT in smart homes and smart cities, the components related to IoT architectures, the importance and type of sensors, the main network technologies, implementation of IoT, the most relevant current challenges, and some possible lines of future work.

Chapter 5 is entitled “Gesture-Based Smart Assistive Device for Elderly and Disabled People Using IoT.” In this chapter, the authors introduce the design in a manner that many elderly people and people with disabilities receive daily benefits. This is done using sensors and microcontrollers to achieve automation with the widely used Android mobile operating system. Home appliances and electrical devices can be controlled via Bluetooth wireless communication protocol and Android mobile from anywhere outside of the house when the appliances are not switched off. Numerous home appliances and electrical devices such as fans, refrigerators, and lights can be controlled via the Android OS. Home automation can include the control of HVAC (heating, ventilation, and air conditioning), lighting, security locks of gates and doors, home appliances, and devices to provide and improve convenience, comfort, energy efficiency, and security. Home automation can provide a better quality of life for those who may need care or nursing facilities, people with disabilities, and the elderly. To address the problem, solutions and related technologies are reviewed and presented.

Chapter 6 is entitled "IoT-Enabled Intelligent Traffic Management System." In this chapter, the authors address the problem of rapidly rising vehicle count and propose intelligent transportation problem using various sensors. The chapter focuses on providing a review of some challenges and emerging trends, and compares various sensor frameworks in terms of cost, reliability, accuracy, performance, and maintenance. The number of automobiles on the road has risen dramatically in recent years. Traffic congestion is a rising issue that everybody deals with daily. Manual traffic control by traffic cops has not proven to be successful. The signal's fixed set time in all conditions (low and high traffic density) hasn't solved the issue. The use of the Internet of Things (IoT) is proposed as a model for effectively solving the problems described above. For Internet-based computing, we use the cloud, which provides various resources such as servers, storage, and application for traffic management. To track the number of vehicles and traffic congestion on a road, a network of sensors is used, and rerouting is done according to the traffic density on the lanes.

Chapter 7 is entitled "A Survey and Challenges: Embedded System on IoT." An embedded system is made up of electronic hardware and software. It contains a sensor to sense the environment and actuators to respond. There are millions of such embedded devices available in the environment, but interoperability between them is a significant issue. IoT is a technology that provides communication between such embedded devices over the Internet. Therefore, the existence of IoT is an outcome of the fourth industrial revolution of disruptive communication technologies. It is integrated with sensors, embedded systems, computing, and communication technologies. Embedded system is the heart of IoT. IoT computes and communicates data and stores it in the cloud for future data analysis. IoT is mainly used to provide seamless data storing and analyze the environment. This chapter addresses the design aspects of a system required for IoT to use in any general application. This chapter presents system architectural comparison, interrupts, task execution, scheduling, switching tasks and latency, prioritization of tasks, real-time tasks, real-time operating system, multitasking, sensors, actuators, memory footprints, and communication standards. This chapter summarizes the architecture and its processors recommended for IoT.

Chapter 8 is entitled "Integration of Big Data and IoT in Modern Era." This is a summary chapter in which the authors focus on some of the most interesting concepts about big data, existing attacks, and an integration technique of big data and IoT that will help reduce the data generated in an IoT environment.

Chapter 9 is entitled "Internet of Things (IoT) for Sensor-Based Smart Farming: Challenges and Opportunities." In this chapter, the authors talk about the implementation of IoT in the smart farming and agriculture industry and its various applications in the field of technological advancements. In the past couple of years, the agriculture sector has grown a lot because of the advancements in technology. For instance, with the assistance of the Internet of Things (IoT), farmers can now monitor soil humidity, crop health, and many other parameters using various sensors without even going to the field. Thus, by reducing human intervention through automation, Internet of Things (IoT) technology can make the agriculture industry more efficient and effective, and can lower the production cost. Internet of Things is a gateway to the solution of smart farming which will certainly mitigate problems like famines.

Chapter 10 is entitled "Implementation of IoT in Various Domains." In this chapter, the authors discuss IoT for industrial applications and how these systems are being implemented in various fields. Moreover, the authors focus on the implementation, advantages, disadvantages, and applications for Industry 4.0. The authors also analyze the usage of artificial intelligence (AI) that has moved H-IoT to almost the next level in various domains in which a range of different sensors is commonly used.

Chapter 11 is entitled "Application of IoT in Wearable Technology." According to the authors, Internet of Wearable Things is among the expert improvements that have adapted to the digital age. Wearables are finding a wider range of applications in our everyday lives. A wide range of digital gadgets referred to as "wearables" includes sensors that offer the thrilling possibility for features used in tracking and sending alert signs. Wearables are grouped into four dominating bunches: (i) wellness, (ii) sports exercises and ordinary distraction, (iii) observing and confinement, and (iv) security. They depict how different sensors may provide a wide range of readings that could be useful for a range of methods. Wearables come in a variety of shapes and sizes; they all have a certain purpose to perform in different sectors. One of the important attacks on the wearable era is the authentication among other troubles viz-a-viz erroneous sensors, battery/energy problems, limiting the users in monitoring location/space, and lack of interoperability. This chapter furthermore addresses the chances and applications and also discusses the circumstances identified with executing.

Chapter 12 is entitled "Role of IoT in Smart Homes and Smart Cities: Challenges, Benefits and Applications." In this chapter, the authors describe IoT and its application to smart homes and smart cities, how to create and use these applications using IoT, the various hardware and software features required for IoT use, the challenges and weaknesses of IoT usage for smart homes and smart cities, and benefits of using IoT in smart homes and smart cities. This chapter examines the current and future examples of IoT, and it will show readers how IoT will interact with our lives in the future

Chapter 13 is entitled "Investigating Role of IoT in Development of Smart Application for Security Enhancement." This chapter presents IoT solutions to enable the customers to automate, analyze, and integrate their systems to a greater extent. The Internet of Things includes sensors, networks, and robotics, and it employs both old and new technologies. The Internet of Things makes use of software breakthroughs, lower hardware costs, and a contemporary approach to technology. This research has focused on IoT-based smart applications that could be used for security enhancement in industries as well as homes. In other words, this research has introduced smart applications to maintain security from threats such as theft, fire, and other unexpected events that may result in financial loss.

Chapter 14 is entitled “Role of Augmented Reality and Internet of Things in Education Sector.” In this chapter, the authors outline the role of augmented reality and IoT in education systems. The research on the role of augmented reality in education systems is relatively at an early stage, and IoT is expected to improve the quality of education through the development of innovative applications. Using this technology, one can gain insights into why it is a part of everyday learning and teaching methods. The right approach is to integrate IoT and AR to make AR scalable, allowing for more perceptual coverage of a wider range of educational systems and interactions via IoT around the world. This chapter explains the use of augmented reality in the IoT. The authors also deal with some common applications of the related technologies together with the benefits and the expected growth of IoT.

Chapter 15 is entitled “Raspbian Magic Mirror: A Smart Mirror System to Assist on IoT Platform.” In this chapter, the authors introduce the design and build a smart mirror that can be used for home automation and has a user-friendly interface for data monitoring. The smart mirror displays information such as the current date, time, and temperature in addition to the image. A future trend is towards implementing a smart mirror that can gather and obtain data via IoT devices and serve as a platform for home automation. The experiment results reveal that utilizing a Raspberry Pi is significantly more cost-effective and offers excellent results to construct a smart mirror.

Chapter 16 is entitled “Use of Machine Learning and IoT in Agriculture.” This chapter provides the latest insights into current research initiatives that significantly impact smart agriculture and farming. It provides a detailed impact of IoT, machine learning, and data analytics that can be used for disease control, monitoring the climate, measuring soil temperature, nutrient value, moisture levels, controlling and analyzing water consumption, and much more. These shall help follow the scientific procedures for plant growth and increase of crop yield. It refers to the latest work of researchers to provide the solutions to various agricultural challenges, using several ways to automate and maximize agricultural produce.

Chapter 17 is entitled “Intelligent Technology, Systems Support, and Smart Cities.” This chapter explores all the facilities supported by the latest technologies and their role in supporting the functioning of smart cities. The authors present a review of IoT issues and challenges in the emerging stages of the design of smart cities in India. Some of the issues addressed by the authors include legal, regulatory, economic, infrastructure, security, and privacy aspects. The chapter also deals with network communication models used in establishing connection between devices and the Internet.

Chapter 18, entitled “Deep Learning Approach for IOT-Based Multi-Class Weed Classification Using YOLOv5,” discusses the deep learning approach for IOT-based multi-class weed classification using YOLOv5, and the quality information about soil, local climate, and the crop in an IOT environment is captured by the sensors. Furthermore, it is possible to obtain statistics that go beyond human observation. They enhance and speed up data collection, perform commands automatically or remotely, and perform remote tasks and actions in real time.

Chapter 19 entitled "Intelligence and Cognitive Computing at the edge for IoT: Architecture, Challenges, and Applications" discusses the intelligence and cognitive computing at the edge for IoT with its Architecture, Challenges and Applications where the cognitive computing is the development of computerized models to mimic human behavior. The best examples are virtual assistants such as Siri, Alexa, and Cortana. Cognitive computing and AI play a big role in solving problems and building applications to support several domains in Internet of Things (IoT). The downside to AI and cognitive computing is the complexity of the architecture involved in building models that support IoT.

Chapter 20 is entitled "IOT Sensors-Based Smart Agriculture Using AGRO-ROBOT" that discusses the current investigation and research innovation of Agro-robot to define the technical work in the form of project and prototype which illustrates how Robots are capable and useable in field of farming and other works to solve the challenges of agriculture by using robotics.

Chapter 21 is entitled "Role of the Internet of Things (IoT) in Digital Financial Inclusion." This chapter aims to identify the underlying factors affecting the role of IoT in digital financial inclusion. The chapter is based on a sample size of 120 respondents from the National Capital Region of India. The principal components analysis method is used to find the factors. Many of the significant factors are identified, viz. IoT awareness, financial service awareness, usability, benefits, trust, security, and privacy, as well as accessibility.

Chapter 22 is entitled "Diagnosis of COVID-19 Using Low Energy IoT-Enabled System." This chapter focuses on Web of Things / Internet of Things (IoT) which is an innovation used to give data and check the framework during COVID-19 scourge. This innovative stage can be utilized to handle difficulties during lockdown-like circumstances. IoT would assist in giving a mechanized and straightforward treatment procedure to handle COVID-19 epidemic (pandemic situations) circumstance. With Internet of Things (IoT), machine learning and artificial intelligence, the distributed computing phase is highly accurate as it enables to provide active feedback from management and evaluators. For additional useful applications, we can also point out the most checked slots and ranking reasons.

The editors are indebted to Almighty God for giving blessings to complete this book. Completing a book is not an easy task; it starts with consuming many hours, months, and more. We can attest that during that time, we were working closely with publishers, editors, and authors. We are very much thankful to our beloved Eliska Vickova, Managing Editor, European Alliance for Innovation (EAI), for having faith and giving us a chance to edit this book. From proposal submission till completion, your support was very helpful to us. We are sincerely thankful to the EAI Springer Group. We want to convey our thanks to all the authors who participated in this book project; due to scope and quality, we could not accept many good chapters, but we are sure that the work included in this book will prove helpful to young researchers and industry entrants in the field of IoT and big data. Our book will help them build their planning strategy and will prove to solve their real-time problems. We will be very happy to hear your feedback about this book. Though utmost care was taken in selecting the chapters and authors' work, which was

closely monitored and revised with rigorous peer review, authors' or readers' reviews and feedback will be very useful for us, to ensure their points are addressed in our forthcoming books. We request you to purchase this book for your institution library and research lab, and to take advantage of the cutting-edge technology exploration information throughout this book.

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Contents

Chapter 1
A Study on COVID–19, Its Origin, Phenomenon, Variants, and IoT-Based Framework to Detect the Presence of Coronavirus

Vikas Menon, Digvijay Pandey, Dishant Khosla, Mandheer Kaur, Harshit Kumar Vashishtha, A. Shaji George, and Binay Kumar Pandey

1.1 Introduction

In 1965 a common cold named B814 came into existence when Tyrrell and Bynoe were studying samples of human embryonic trachea taken from the respiratory tract of an adult. At the same time, Hamre and Prock now obtained samples from medical students with cold and cultured a virus in tissue culture showing unusual properties they named it Hamre's virus, later on known as 229E. The relationship between B814 and 229E viruses with myxoviruses or paramyxoviruses known at that time was not found to be close enough. In the late 1960s, morphological constraints were found to be having similarities between certain animal viruses such as mouse

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hepatitis virus, swine flu, gastroenteritis virus, and infectious bronchitis virus with some human strains as studied by Tyrrell along with a group of virologists working together. This new group of viruses having the crown-like appearance of the surface projections was later officially accepted as coronavirus. Research studies conducted on the coronaviruses revealed that in humans living in temperate regions, the occurrence of respiratory coronavirus infections was more often observed in the winter and spring as compared to the summer season [1, 2].

Coronaviruses are enveloped viruses with a positive-sense single-stranded RNA genome and a nucleocapsid of helical symmetry constituting the family Coronaviridae, subfamily Orthocoronavirinae, and order Nidovirales. Coronaviruses are the largest among known RNA viruses with genome sizes ranging from approximately 27–34 kilobases. Coronaviruses can cause severe illnesses ranging widely in any age group. China has been said to be the forefront country where the emergence of viral infections occur, and this may be due to the consumption of poultry, bats, snakes, and other wildlife animals. In 1997, China witnessed avian influenza in 2003, the severe acute respiratory syndrome (SARS caused by a coronavirus), and in 2010 a severe fever with thrombocytopenia syndrome (SFTS). In 2012 a severe illness outbreak began in Saudi Arabia with the Middle East Respiratory Syndrome (MERS). On 12 December 2019, 27 cases of viral pneumonia with an unknown causal agent as an outbreak were reported in the city of Wuhan, China, by the Wuhan Municipal Health Commission (WMHC). On December 31, 2019, Chinese authorities declared the outbreak of a novel strain of coronavirus causing severe illness and named it SARS-CoV-2. WHO declared 2019-nCoV an epidemic for world public health on 30 January 2020 [3]. The basis of their studies summarized that the genetic makeup of bat coronavirus has most similarities with 2019-nCoV and has maximum similar codons as with snakes. They also, depicted that viral receptor-binding spike glycoproteins are responsible for homologous recombination that determines cross-species transmission. The information derived from their evolutionary analysis can be highly significant in the future for effectively controlling the pandemic 2019-nCoV [4, 5].

The COVID-19 has proven a big challenge since 2019 for the whole world. Human civilization needs to battle the COVID-19 with effective measures and precautions. Researchers and doctors from all over the world are consistently working on generating solutions for the problem. One of the biotechnological reports revealed that real-time PCR used for COVID-19 can de reframed with the Internet of Things (IoT). This trial will collect real-time data from users which can further be used to identify the suspected cases. This methodology will monitor the post-virus recovery response. This system is composed of five main components: data collection system and sensors for uploading, isolation spots, algorithms for data analysis, health workers, and cloud infrastructure. Various algorithms used are vector machine, neural network, Naive-Bayes, K-nearest neighbor, decision table, decision stump, One R, and Zero R. This experiment has given effective and reliable results with 90% accuracy. Based on this study, we believe that this real-time data and IoT-based framework have the potential for identification and management of COVID-19.

Another IoT-based COVID-19 detection model is based on the body components framework. In this context, the parameters considered for IoT-based diagnosis are body temperature and respiratory quotient. Along with these physical parameters, some biochemical factors can also be included like total leukocyte count. This data can be accessed over Wi-Fi and with the Internet also. Assisting accessories like breathalyzer will be sanitized automatically and automatic loading of injection needles can be done and is convenient. This product would be commercially economical and reliable.

1.2 Origin of 2019-nCoV

The first outburst of pneumonia transmitted person to person having an unknown causal agent was reported in Wuhan City, Chinese Hubei Province, on 31th December 2019 [3], and pathogen identification was done later on. For identification of the causal agent, a large number of plausible pathogenic constraints were screened and then ruled out, including the *Middle-East respiratory syndrome coronavirus* (MERS-CoV), the *severe acute respiratory syndrome coronavirus* (SARS-CoV), avian influenza virus, and other common pathogens causing respiratory problems. According to the scientific literature and medical history, there was no evidence of contagious transmission as thought to be [6]. The first-ever "super-spreading" evidence came into knowledge when two local 2019-nCoV infected patients visited to Guangdong Province of Wuhan on the 20th of January 2020, and 14 medical staff who attended these patients got infected by 2019-nCoV which concluded the human-to-human contagion [5]. Further laboratory investigations were done in four different Chinese research institutions: the Academy of Military Medical Sciences, the Chinese CDC, the Chinese Academy of Medical Science, and the Chinese Academy of Sciences and Wuhan Institute of Virology. Laboratory testing specimens were taken from the upper respiratory tract of the patients admitted with the symptoms of 2019-nCoV and maintained in COPAN Universal Transport Medium. RT-PCR Diagnostic Panel was used to confirm the 2019-nCoV infection onset by qualitative detection of nucleic acid taken from respiratory specimens. Laboratory tests done on all the throat swab specimens revealed their deduction of lymphocytes in most patients [7, 8]. This result suggests that 2019nCoV was affecting T lymphocytes, as SARSCoV does, thus weakening the immunity of the person been infected. A further conclusion was drawn that this virus generates a cytokine disturbance in the body, inducing a cascade of immune responses, leading to changes in white blood cell count and cells responsible for immunity such as lymphocytes spreading through the respiratory mucosa [9, 10].

Studies done on infected persons suggested person-to-person transmission occurs commonly during the close exposure of a normal person to a person infected with COVID-19. Studies revealed that respiratory droplets are produced when the infected person coughs or sneezes. These respiratory droplets produced due to coughing or sneezing can land on the surface or body nearby and when the normal person comes in direct contact can get transmitted either through eyes, nose, and mouth or possibly be inhaled into the lungs of those within close proximity [11]. However, the probability of airborne transmission from person to person over long distances is not verified (CDC 2020). 2019-nCoV is an RNA virus, having a high mutation rate, due to genome-encoded exonuclease mutation rate in the coronaviruses might be somewhat lower than that of other RNA viruses. This mutation rate increases the possibility for this newly introduced epidemic viral pathogen to become more virulent and more efficient to be transmitted from person to person [12, 13].

1.3 Current Situation of the Epidemic and Preventive Measures

Until April 2020, 2019-nCoV positive cases were increasing throughout the world. As of 9th April, there were a total of 14, 90,790 cases confirmed in the whole world, including 88,982 deaths and 3, 32,486 cured cases. For combating epidemic 2019-nCoV, the central and state governments of all countries throughout the world have taken a series of desperate measures. All government agencies have started to conduct laboratory exploration for characterization and treatment of the disease, including quarantining of suspected patients, monitoring clinical status of patients individually, and developing diagnostic and treatment protocols [14–16]. Africa Task Force for the Novel Coronavirus on Feb 3 was established by the Africa Centres for Disease Control and Prevention [17]. A lot of countries including India have gone for 1–3 weeks lockdown so that patients infected with the coronavirus remain in quarantine to minimize the spreading of the virus.

For the status in India, as per statistical survey analysis till 2019, 88.5% of caseload was observed in states such as Maharashtra, Delhi, Tamil Nadu, Madhya Pradesh, Gujarat, Rajasthan, and Uttar Pradesh. In comparison to these stats, very few state and union territories of India affected by this disease are Northeastern states like Meghalaya, Mizoram, and Nagaland and union territories like Andaman Nicobar, Dadra and Nagar Haveli, and Daman and Diu. Maximum expression of this disease was reported in Maharashtra (107958) followed by Tamil Nadu (44661) and Delhi (41182). The fatality rate concluded was 2.9%.

The key factors which contribute to the progression of the disease are migration and population density. Delhi, Uttar Pradesh, Madhya Pradesh, and Maharashtra have shown maximum migration of labor.

The maximum cases reported of cases are between the age group 25–59. Telangana has reported maximum COVID-19 cases due to migration in the earlier part of May 2020. Another promising factor responsible for disease transmission is population density as shown in Fig. 1.1. Highly dense states and localities were declared 123 hot spots by the government of India based on census.

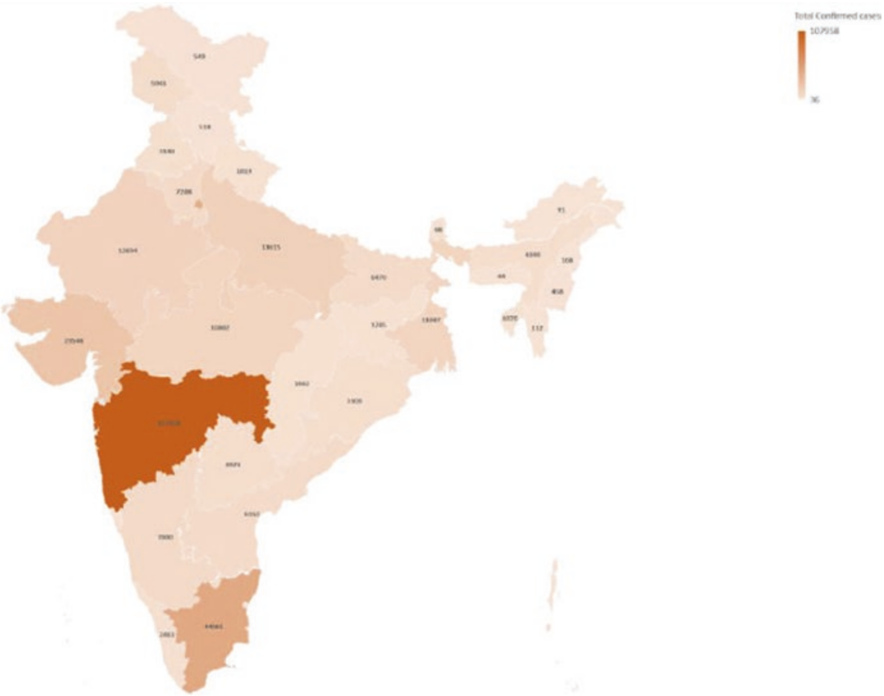

Fig. 1.1 Map showing caseload of COVID-19 statewise

Preventive Measures: COVID-19 got transmitted from person to person in many ways such as through droplets and aerosol via cough and sneeze. Close contact between people also increases the transmission rate. Poor ventilation and crowded indoor maximize the disease progression. In India, different states government has taken many actions to slow the disease spread rate. One study reported that Kerala has got early slowdown in spread rate by applying the following measures:

- Insistent testing and checking of all travelers from China and other countries
- Powerful contact and tracing 28 days follow-up
- Proving sampling collection centers in the district and local levels
- 28 days quarantine period
- Establishment of isolation centers near the communities
- Superior hospital readiness to prevent disease progression

1.4 IoT-Based Framework to Detect Coronavirus

For smart network and proper health management systems, IoT-enabled interconnected devices are very crucial for fighting with pandemics. With the decisions-making process, the system can track and alert the patient to improve security. IoT can be used as countermeasure technique for COVID-19 pandemic. Table 1.1 shows IoT application.

The framework based on the Internet of Things (IoT) [18–20] is explained which are cheaper, user friendly, and readily available [21–24]. In the first step, for a suspected patient, the symptoms of SARS-CoV-2 are to be detected properly and accurately. The common symptoms of SARS-CoV-2 are breath soreness, fever, dry cough, pain, drop in SPO_2 level, and weakness. In the proposed framework, IoT-based sensors can take input from the user, measure the level of each symptom explained, and provide data processing for analytics. In the framework, IoT-based sensors include a heart rate sensor, temperature control, microphone, and proximity sensor which enable the system to detect the symptoms of coronavirus easily.

> Each sensor reading has the application of a different algorithm owing to the different symptoms of the disease. For example, fever can be detected with the help of an IoT-based temperature sensor. The human fatigue can be detected using the IoT-based camera where a human is asked to do 30 sit-ups and the situ-ups can be analyzed. Also, samples of lung CT scans and x-rays of the chest can be uploaded via the same IoT-based camera [25]. The IoT-based microphone sensor can be used to identify the cough type whether it is a dry cough or not.

In the proposed framework, the abovementioned sensors have been used. Using the sensors to collect the data and analyze and gather the results, the prediction of symptoms is done. The data is stored for analysis purposes.

> After collecting the records and data from various patients, they are used as inputs to the various techniques of machine learning. The techniques of machine learning in the medical field include neural networks and k-nearest neighbor. There are various deep learning [26]

Table 1.1 IoT application in health care

S. No	Application	Description
1	Internet-connected hospitals	IoT-based systems can be used to connect hospitals to the Internet, where corrective measures can be taken if some emergency is raised
2.	Automated treatment process	It helps in the appropriate handling of cases and treatments
3.	Smart tracing of infected patients	With the use of RFID devices, the movement of patients can be tracked
4.	Real-time information	During the spread of this infection, on-time information sharing can be done
5.	Geospatial AI-based application	The data can be taken of affected areas using a GIS system and areas can be put in a contamination zone

> methods in the machine learning techniques which are quite accurate and come under the family of neural networks. CNN and RNN are the two main algorithms for deep learning which are used for recognition and classification.

Recurrent neural network (RNN) and convolution neural network (CNN) imply recursive neural network [26, 27]. In RNN, the next layer input will be the output of the previous layer saved. The measurement of signals and tests is mostly done by RNN. CNN is used for spatial data whereas RNN is used for saving temporal data. Figure 1.2 shows the proposed framework.

In the first step, the collection of the data IoT sensors is done. For example, the computed tomography (CT) scan of the lungs, x-ray scan of the chest and lungs, and videos are captured through an IoT-enabled high-quality camera sensor, and stand-sit measurements of the suspected patient is collected by it; through the IoT-based microphone, the cough sound is taken and identification can then be done. Using the IoT-enabled heart rate sensor, heart rate can be recorded, the oxygen level of a person can be detected using SPO2 sensor, and the IoT-based temperature sensor is used to measure the degree of temperature. In the next step, for further processing of the data, the received data in the analog form is converted into digital form. After digitizing the data, the next step includes the preprocessing and standardization of the data which is moved to the cloud network. Then, the analysis and management

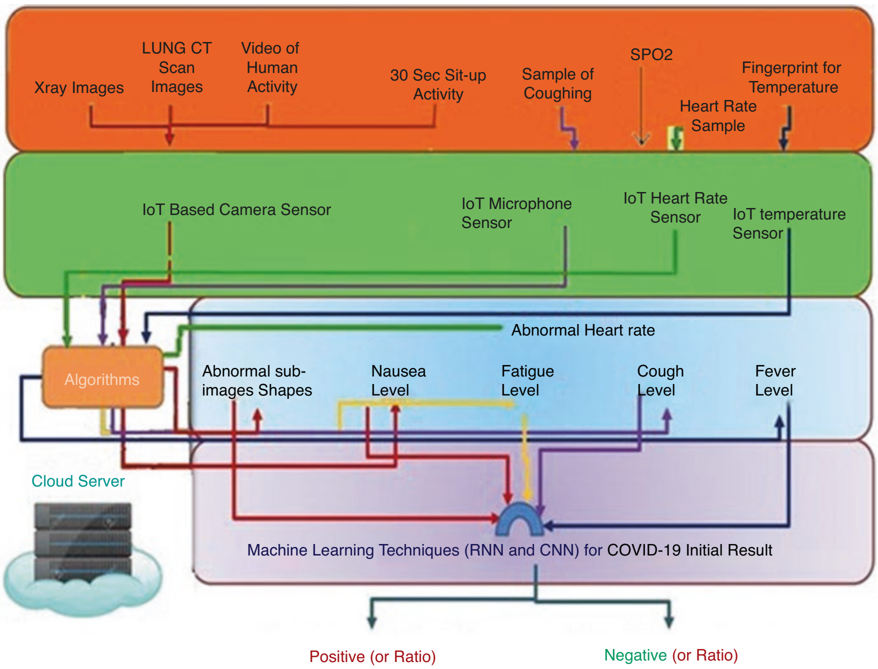

Fig. 1.2 Proposed framework to predict COVID-19 using IoT

of data are done. This is done when the health-care [28] personnel receive the symptoms of the patient through a cloud network in the form of data. The doctor who is authorized to access the cloud network detects the symptoms and diagnoses the disease COVID-19 to be either positive or negative [29]. The progressive CT scan images of the lungs are shown in Fig. 1.3.

Using x-Ray images, the presence of coronavirus with the use of deep learning is possible and being used with the accuracy of training model of 99% and 98% of the confusion matrix [30]. With the presence of coronavirus COVID-19, the epithelial cells of respiratory systems are affected. So, x-rays can be used to analyze the presence of COVID-19. In the work to detect the presence, the dataset of x-rays of COVID-19 affected and x-rays of normal people is used to train the model for deep learning. Then with deep learning and CNN, the model was able to detect the presence of COVID-19 virus through x-ray image [25, 31]. Figure 1.4 shows the x-ray dataset of normal and COVID-19-positive persons, and Fig. 1.5 shows the detection of COVID-19 using algorithm.

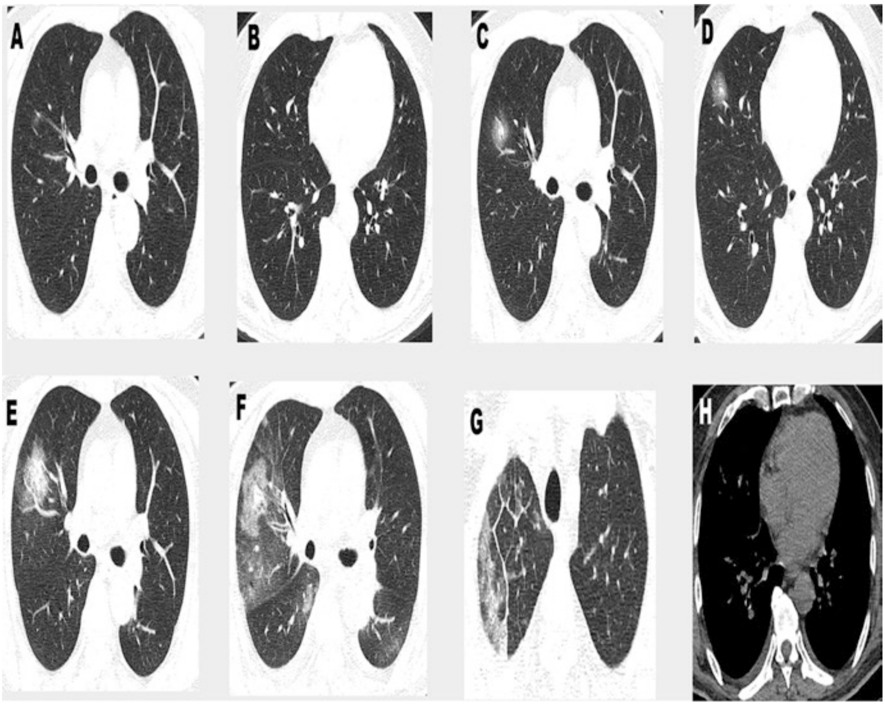

Fig. 1.3 CT scan images of a suspected COVID-19 case

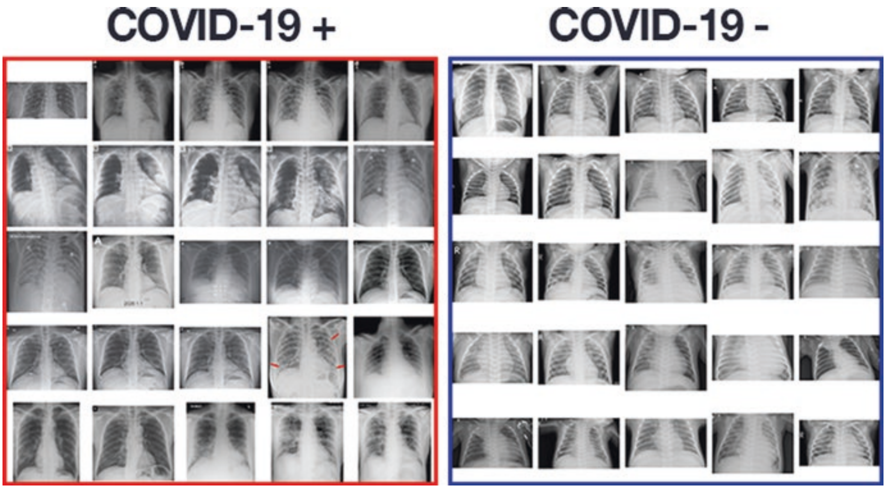

Fig. 1.4 Dataset of normal and COVID 19 persons

Fig. 1.5 Detection of the presence of COVID-19

1.5 Remote Screening Magnitude

Diagnosis methods are used for checking the absence and presence of disease. The screening objective is to detect the potential indicators with high sensitivity.

In addition to this screening, a methodology is sometimes carried out to remove any suspicion or doubts of diseases. As screening is economical, it becomes beneficial to diagnose a large target population that may contain fewer and small potential cases. Successful screening results in accurate identification and precise investigation and treatment of patients at risk. Seeing the prevalence and impact of coronavirus disease, rapid and effective methods are highly advantageous. This method is also useful for places where advanced and sophisticated facilities cannot be found. So by adopting the novel methods, we can overcome the hurdles like lack of medical equipment and experts in disease management. The nonexperts from remote areas can transmit the data to the expert via IoT-based technology. In the paper, a framework for remotely screening COVID-19 using wearable sensory devices similar to some of the prior approaches. Our proposed method, however, differs from previous techniques in that it includes several innovative aspects for starters, the sensors we are using are less expensive and can be simply incorporated to sense a variety of symptoms. Our devices sensors are inexpensive, costing only a few dollars each. The advantage is that if a gadget is found to be contaminated, it may be quickly discarded. The sensors can be replaced into a better gadget because they are generic. Second, method is unique in that the assessment can be performed by both professionals and nonexperts, and the findings may be deduced by anybody. The sensors and the supporting framework handle all of the processing. Third, the outcomes can be tracked and analyzed from afar [32]. That means the wearable device has application over long distances while the findings are monitored by professionals in medical centers and clinics across the country. Because the virus is spreading all over the world, governments have partial resources to deploy medical personnel to remote places; this is an extremely crucial part of disease diagnosis. With this method of solution, the signs may be patterned. This method is beneficial as a big variety of sufferers may be screened for the infection in a brief time.

Wi-Fi is connected to sensors which are required for transferring and sending the received information to the target without the manual intervention where the transferring is completed at near places in real time. The use of IoT infrastructure ensures efficient stream processing and data. The algorithm of this tool is faster and has a better response for any data scale. In addition, our scheme can be useful in identifying segments of the population in need of urgent treatment. By analyzing the data of many people in one area, the authorities can assess the severity of the disease and take urgent action depending on the result [33–39]. Finally, because the technique includes transportable devices, it is straightforward to move them from location to location, easily. The rules and regulations are code tips extracted from professionals to change a professional or lower the intervention of a professional, in scientific decision-making. These regulations permit categorizing someone as healthful or having a possibility of contamination with the aid of using the coronavirus [40]. The gain of the use of regulations for patient's category is that the regulations may be up to date and advanced with dynamic expertise from the mixing of latest scientific recommendations as new findings emerge from time to time.

1.6 Conclusion

Coronavirus or COVID-19 or 2019-nCoV is a contagious disease caused by a new virus. The disease affects the respiratory system with indications such as a cough, sneezing, high temperature, and lack of oxygen and in extreme cases, difficulty in breathing [41, 42]. It spreads from person to person when they cough or sneeze or through a surface or from objects that have the virus on them. As the disease has become epidemic, it is infecting more and more people day-by-day. It needs to be detected at the earliest and for that, the need of the day is to develop new methods and equipment. Computer-based technology is growing at a very rapid pace. The proposed framework with artificial intelligence and IoT-based sensors can be used in the medical field to visualize the medical information of patients in the presence of COVID-19.

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Chapter 2
Blockchain for Internet of Things (IoT): Research Issues, Challenges, and Future Directions

Shreya Karagwal, Sarvesh Tanwar, Sumit Badotra, Ajay Rana, and Vishal Jain

2.1 Introduction

The IoT market, which is largely unregulated, offers opportunities for device hacking. At a glance, the absence of safety can be a serious problem, particularly with smart home or smart car applications. [1–3]. For example, a hacker could steal an autonomous vehicle from someone or buy it according to the level of access granted to the IoT system. Increased security is essential, along with all data collected and transferred between IoT devices. As we are aware of some security-related recommendations such as dual authentication and biometrics, one of the potential solutions is IoT blockchain security [4]. The most well-known blockchain such as Bitcoin and Ethereum grants a powerful solution for IoT security. The blockchain includes powerful protection for data modulation, which can lock access to IoT devices and shut down corrupted devices in IoT networks [5–7]. The name "blockchain" was derived by its form of technicality (chain blocks), which refers to the union of every block in association with the previous one. The whole blockchain idea is to interlink the relationship of data within clusters. By cluster, we mean a data structure including several monetary transactions, people, or entities [8]. The transactions are monetary and typical (smart contracts). Any institution can play the

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role of blockchain participants that takes protocol strings and assist in their development. These network organizers or those accountable for the maintenance of software do not share the blockchain.

Blockchain technology has evolved to provide convention validation technology over a network to ease peer-to-peer transactions and all monetary transactions. The procedure then minimizes the involvement of third parties in transactions that are monetary like banks, agents, intermediaries, or any other authorities required for the confirmation and completion of the data [4]. It is then ensured that every transactional currency is right and recorded as a fresh transactional block. Transactions recorded within the chain cannot be rewritten or canceled requiring a high level of needed transparency as well as security.

2.1.1 Key Characteristics of Blockchain

Figure 2.1 shows the characteristics of blockchain technology.

2.1.1.1 Decentralization

Through a believed agency (taking an example of a bank or government) in an earlier established transaction managing system, the transaction management has taken place. The result that comes with this centralization manner includes additional cost, single-point failure (SPF), and performance bottleneck at centralized service providers. The benefit of blockchain is that transactions can be validated between two peers without the need for authentication, jurisdiction, or intervention by the central agency, which results in a lower cost of service, SPF risk, and a reduction in performance bottlenecks [4, 8].

2.1.1.2 Immutability

As it has been studied that a blockchain comprises an associated chain of blocks, where every link is crucially an inverse hash point of the last block. The changes of any kind made on the last block will invalidate every consequent generated block.

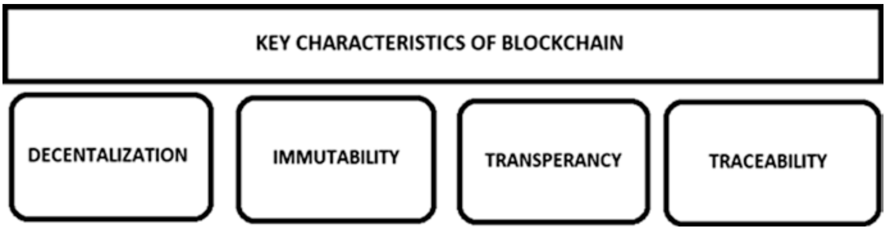

Fig 2.1 Various characteristics of blockchain technology

This approach allows for immutable recording of interactions as all interactions go through the blockchain. This approach allows you to query details on the blockchain, track all selected interactions, and add autonomy to IoT devices.

2.1.1.3 Transparency

The aid of public blockchain systems, for example, Bitcoin and Ethereum, gives the user accessibility and interaction with an identical right in the blockchain system. Also, each and every transaction performs validation and is saved in the blockchain making it available for every user [8]. Hence, the data in blockchain maintains transparency to those users who will be able to access and perform verification of performed transactions.

2.1.1.4 Traceability

A timestamp is attached with every transaction saved inside a blockchain. It is going to be easy for users to verify and can also track the birth of traditional data items following the analysis of the data in blockchain along with communicating timestamps. It can trace one thing on the web with the guaranteed traceability for transactions, which assures clear transactions, succeeding the feature of security.

2.1.2 Idea of Blockchain in IoT

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IoT interconnects smart devices for gathering data and making decisions accordingly. When we merge blockchain along Internet objects, things will remove the lacking security in web objects as this technology needs design with security. Blockchain traits like incompatibility, transparency, readability, encoding, and flexibility of operation will be getting utilized to overcome IoT difficulties. One of the advantages of using blockchain in many applications, not just IoT, is that there is a record of all transactions in between. Once these records are posted to the ledger, no one can change them. This is proof of the effectiveness of hacking. Additionally, IoT on the blockchain allows for a much trimmer process from producer to receiver and at every stage [8]. One of the reasons that older systems do not perform well is the fast document processing. It is much faster because now everyone has a simple and secure way to access and sign documents.

Table 2.1 indicates the differences between IoT and blockchain.

Table 2.1 Difference between IoT and blockchain

Blockchain	IOT
Decentralized	Centralized
Resource consuming	Resource restricted
Block mining is time-consuming	Demands low latency
Scale poorly with large network	IOT considered to contains large number or devices
High bandwidth consumption	IOT devices have limited bandwidth and resources
Has better security	Security is one of the big challenges of IOT

2.1.3 Merits of Blockchain in IoT technology

2.1.3.1 Interoperability

This refers to the capacity to communicate along with physical systems and transfer data between IoT systems. The hybrid layer of blockchain is located on the peak of an overlapping peer-to-peer network along with consistent reachability across diverse IoT devices.

2.1.3.2 Scalability

With the growth of IoT networks, the authentication and authorization on every device become tough on a centralized network due to the large amount of resources required. Hence, there comes a need of a large number of strong services to overcome this. Combined with blockchain technology, it solves the problem by validating all devices. It also eliminates the urgent need for large gateway devices [9].

2.1.3.3 An Efficient Supply Chain

The top priority for many companies is to make their supply chains more efficient. However, many economic and global issues make this process more difficult. By removing the middleman, blockchain and IoT can improve supply chain efficiency, speed up transactions, and reduce costs. With a blockchain that acts as an auditor to some extent, there are no fees associated with each jump, as unreliable parties can exchange data directly with each other.

Reliability

The reliability of information is trustworthy, involving asymmetric encryption algorithms.

2.1.3.4 Better Security of IoT Systems

The blockchain can protect IoT data because it is encrypted and stored as a blockchain transaction that is digitally signed with an encryption key. Also, with the well-suited integration of blockchain technologies (such as a smart contract) in IoT, an automatic update of IoT device firmware takes place for preventing risky breaches, resulting in overall system security.

2.1.3.5 Cost Reduction

Reduction of operational costs is one of the most needed features for an enterprise. The blockchain allows data to be transferred on a peer-to-peer basis by not needing centralizing control, giving lowered business costs. With the automation of validating the transaction and purifying each blockchain step, the ecosystem as a whole can be created proactive at less cost.

2.1.3.6 Tolerance of Fault

Decentralized devices rely on a large number of independent components, which reduces the chance of inadvertent harm. The blockchain is a decentralized point-to-point network in which each device has a copy of the same data; hence, a single node failure network is unaffected. As a result, blockchain eliminates the possibility of a single point of failure.

2.2 Motivation

Since IoT and IoT security are the recent areas in the direction of improvement and research, it is a need to bring some light to this strong combination of blockchain with IoT. The research of this study will help with a fresh construction IoT framework with blockchain technology for existing education systems. In the future, researchers may improve this study so that it can be applied to the whole kingdom. Some points below recommend using my approach to work in the IoT security and its environment using the blockchain approach:

(a) How does blockchain integrate IoT to secure data and make data privacy possible?
(b) What are the new developments underway inside the field of IoT and blockchain technology? Also, what are the new areas of future growth for?
(c) What are the applications of the above techniques to the new researcher and the challenges of the new field of research?
(d) In what fields can IoT and blockchain technology be applied?

(e) Are there any future boundaries and directions for developing in the dual areas?

The present centralized IoT design relies on a centralized third-party instance with complete control over data collection and a slew of IoT devices, with no clear restrictions on how the information gathered may be utilized. As a result, the central IoT agency uses a block box, which is a desirable situation for the vast majority of IoT device owners. By leveraging the processing power of all contributing users in a decentralized manner, blockchain technology, on the other hand, provides a self-sufficient and trustworthy decentralized ecosystem. This increases productivity while removing single points of failure.

Recent reviews of blockchain research show that most academic research focuses on improving and challenging current protocols, mainly about cryptocurrencies in general, especially Bitcoin. There is little research on the potential of blockchain. Research in some areas, especially cryptocurrencies and payments, is well developed, but usually lacks a complete understanding of its applications and use cases.

The analysis is divided into three parts:

1. Architecture
2. Recent challenges and blockchain in IoT applications issues
3. Future trends

2.2.1 The Blockchain-Related Pattern for Numerous IoT Fields

This technique is employed succeeding to more than a single domain and scenario. It has been studied that the development within the applications of blockchain started after Bitcoin as blockchain v1.0 and so on, and it got modified with sensible conventions as blockchain v2.0 and later on showed progression to justice, efficiency, and blockchain v3.0.

2.2.2 Examples of Blockchain Applications in IoT

2.2.2.1 The Energy Sector

The era of blockchain can ensure better executions in this situation, by removing intercessors and lowering the price. Transactive energy, while enabling the devices to trade energy, also ensures good executions removing exceeding price [9].

2.2.2.2 Maintenance and Equipment Operations

The provision of blockchain gives tamper-resistant maintenance records and operational data. Organizations can use IoT devices to effectively monitor the health and maintenance records of safety-critical machines. Third-party staff can monitor preventative maintenance and update blockchain maintenance data instead of manual maintenance programs or manual record keeping. Then you may share your activity logs with regulators to make sure you comply [9, 10].

2.2.2.3 Smart Contract

Despite the actual thing that blockchain delivers several answers to the IoT problems, the peaked procedure demands want resource taking procedure not much time and price effectiveness. Ethereum is supported for the implementation of smart contracts for blockchain in IoT [9].

2.2.2.4 Decentralization and Expandability

As we are aware of the centralization of IoT, which creates a difficulty level by making an ascendable ecosystem in IoT. But with the emergence of blockchain with IoT, this scalability issue can be solved. With the replacement of the possession of homogeneous blockchain-to-blockchain IoT devices, bottom-up peer-to-peer recognition procedures are planned [11].

2.2.2.5 Industrial IoT

An overall change can be brought by IoT in the blockchain, health care, etc. Smart manufacturing is achieved, assets are tracked, latency is reduced, and supply chain is managed. Due to the immutability and information provenance of blockchain, it has the potential to protect industrial IoT devices.

2.3 Research Gaps

The encouragement of IoT technologies in the field of manufacturing has resulted in industrial automation as well as digitization. A large amount of modern IoT apps have been successful in boosting the features like quality, scalability, and flexibility of manufacturing infrastructure resulting in error reduction, saved cost, increased performance level, and better security in the industrial as well as the manufacturing process. Centralized data centers rely on IoT architectures to perform sensor data storage and processing functions, which can pose a danger of security breaches, single-point errors, and DDoS. The following risks not only make the services unavailable but also lead to the deluge of sensor data, overweighing the crucial benefits of the IoT system [4, 8].

Also, there arrives a question of collected data reliability when there is a possibility of data interception in transferring the data between IoT devices. The idea of uniting blockchain in IoT has been gaining architecture in the eyes of researchers to look after the mentioned issues. The adoption of blockchain is not easy as it holds some challenges such as the capacity of unequal resources in IoT devices as well as the nodes of blockchain as well as dissimilar mining rates.

As IoT continues to spread its reach across the world, a lot of restrictions and security issues come along associated with IoT such as the privacy of data, security of data, heterogeneity, confirmed working of a secure IoT system working, efficient data management, and timely delivery of data.

(a) How is it possible to achieve scalability for IoT security with the help of the blockchain approach?
(b) Prevention of malicious nodes for the security of IoT devices for the users, who are authorized, and the systems?
(c) How will the IoT devices be able to manage the heterogeneity
(d) How can IoT get benefitted from the smart contracts of blockchain?

2.4 Objectives

The primary objective is to study why the blockchain approach is needed to overcome the issues in IoT. The following objectives are set for this chapter:

(a) To study the integration of IoT and blockchain, knowing the blockchain functionalities and differences between IoT and blockchain
(b) To study the advanced application areas and research challenges and issues in terms of technologies for new researchers
(c) To research recent developments in the sectors of IoT and blockchain technology, as well as to identify new subjects for future scope
(d) To study any recent transformation of blockchain in IoT that took place in the pandemic

2.5 Architecture

Multilevel architecture can be described as modular architecture where each level is separated from the rest of the classes to add new modules or replace them without affecting the rest of the classes [12].

Figure 2.2 shows layer-based IoT blockchain platform architecture

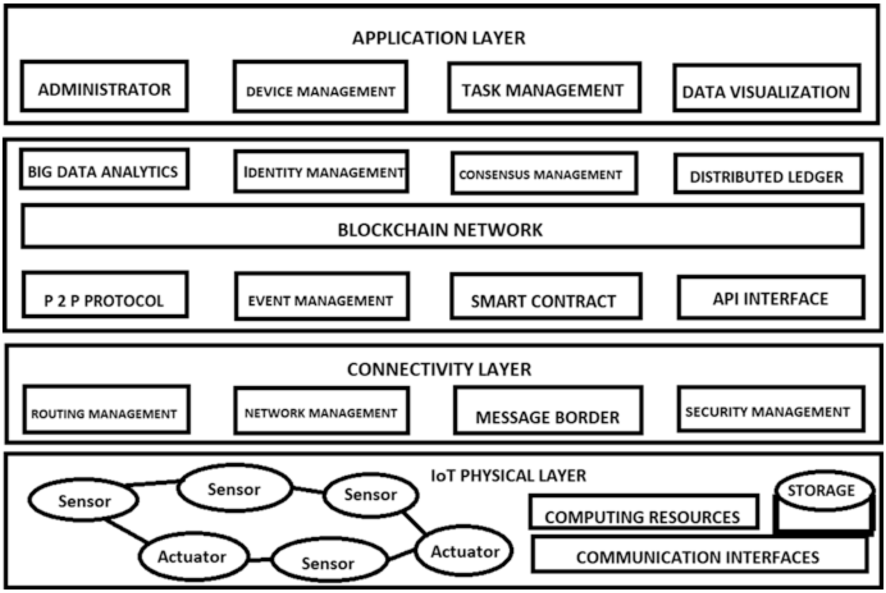

Fig. 2.2 Layer-based IoT blockchain platform architecture

(a) *Physical Layer*

This layer includes many connected devices along with the capability of communicating, computing, and storage of data.

(b) *Connectivity Layer*

The common functionality this layer gives is routing management keeping the requirement of automated organization as the physical devices have no global Internet protocols. It involves some different modules for the provision of mentioned resources:

- Network management
- Security management
- Message broker
- Routing management

(c) *IoT Blockchain Layer*

This layer has all the modules that sequence the common services to give many benefits of blockchain techniques as:

- Identity management
- Consensus
- Peer-to-peer (P2P) communication

- Distributed ledger

(d) *Big Data Analytics*

It makes blockchain an ideal medium for data storage done online. Many transactional data from several parties are kept in structured forms of ledgers, making it a convenient resource for extended research. These parties have accessibility to a single network and can track them as and when they choose.

(e) *Smart Contract*

It may be a business operation that is called by an external client application for controlling both access and charge inside the ledger. Installation and instantiation are carried out on each network peer.

(f) *Event Management*

It sends the event whenever a new block gets added to the ledger.

(g) *API Interface*

The function of this is exposing the servicing given by the network of blockchain as the services that may get invoked by the client application for accessing and managing the network.

(h) *Application Layer*

It is the topmost layer, in which many interfaces are needed for data visualization with the help of physical devices to control the devices.

2.6 Challenges and Issues of Blockchain in IoT

2.6.1 Challenges in IoT

2.6.1.1 Authentication

It is a condition making sure the unique identification of every entity [13].

2.6.1.2 Authorization

It makes sure that the accessibility of IoT entities is given to only authorized users [13].

2.6.1.3 Availability

It makes positive that even if the malicious attacks happened to the services and networks ought to be obtainable regularly.

2.6.1.4 Confidentiality

It makes positive that solely authorized bodies should be aware regarding the data [13] as well as routing information.

2.6.1.5 Integrity

The transfer of knowledge ensures that all the involved routing information has not been altered by a mediator or a malicious individual.

2.6.1.6 Privacy

It assures that the identities of the IoT entities ought to be extremely protected against negotiation.

2.6.1.7 Trust

It confirms that a relationship between every involved node in a network is trustworthy. The basic challenges related to security for IoT environments are as follows:

(a) There lies a major challenge for device authentication, identification, and protection because the number of devices in the infrastructure is growing rapidly.
(b) Maintaining, extending, and managing a centralized security model are extremely complex.
(c) With the infrastructure of centralized security, it is a single point of failure and a very simple target as a DDoS attack.
(d) It becomes challenging to generate a centralized infrastructure for an industrial environment where centralized nodes are inherently growing.

2.6.2 Challenges of Blockchain

2.6.2.1 Privacy

The users of blockchain are aware of their public keys. This indicates that obscurity was not accomplished as the entire transactions are shared and third parties can investigate as well as determine these transactions and infer the participants' identity [14].

2.6.2.2 Energy Efficiency

Blockchain in IoT endpoints generally gets benefitted from the giver of power-based powerful instrumentation with batteries. Therefore, for permission of long-run node placement, energy efficiency was needed.

2.6.2.3 Security

For a single user, the desired security idea is to ideally manage the specific keys of the user in his possession, because the criminal would like in combination with the public key to steal something from him [14].

2.6.2.4 Throughput and Latency

The position in blockchain for IoT could need a blockchain network capability to come up with vast "amounts of transactions per time element in clear networks. As for the assent latency, it should be determined that the issue of the agreement procedure was a lot of vital concerning latency than uncommon hashing."

2.6.2.5 Block Size

The transaction is maintained by miners, requiring a longer initial handover time, making the most of the most powerful miners.

2.6.2.6 Bandwidth

Transactions are maintained by miners, requiring a longer initial handover time, making the most of the most powerful miners.

2.6.2.7 Multichain Management

In numerous ways, the spread of blockchain slammed from the need to negotiate with several of them at once. This is also possible only in the case of blockchain in IoT [14].

2.6.2.8 Autonomy and Enforcement

The rules emphasize that smart contracts must be legally implemented and dispute resolution development should take place.

2.6.3 Challenges of Blockchain in IoT

2.6.3.1 Processing Time and Power

The processed power and the needed time required to implement encryption for every entity related to blockchain-based ecosystems. The IoT ecosystem is diverse. Unlike typical computer networks, IoT networks consist of every other devices with computing capabilities, and not everyone can run the same encryption algorithm at their own pace [15].

2.6.3.2 Scalability

Blockchain-related scalability issues that may result in centralization are casting a shadow on the future of cryptocurrencies [15].

2.6.3.3 Storage

Storage is also an obstacle. The blockchain does not require storing transactions and device IDs on a central server, but the public ledger must be stored on the nodes only [15]. Ledger grows in size over time. This extends beyond the capability of a variety of smart devices, such as low-capacity sensors.

2.6.3.4 Lack of Skills

Not many people are aware of the working of blockchain technology when you add IoT to your mix that ratio drops sharply [16].

2.6.3.5 Legal and Compliance Issues

Because this industry is new in every way, there are no rules or compliance standards to follow. This is a key issue for manufacturers and service providers. This impediment alone will frighten many organizations that do not adopt blockchain technology [15, 16].

2.7 Current Role of Blockchain and IoT in Transforming Health Care and Finance

COVID-19 has presented a logistical nightmare for vaccine distributors and healthcare professionals around the world. The two most common vaccines, Pfizer and Moderna, should be stored at a temperature less than 0 degrees Celsius. Otherwise, it will deteriorate. The vaccine-related challenge is a great example of integrating blockchain and IoT working together to streamline operations and improve deployment. The manufacturers of vaccines may place the IoT sensors in countermeasure packages as well as single vials for permitting the distributors to track and monitor delivery locations and temperatures, allowing them to quickly detect and resolve issues [17]. As soon as the vial reaches the vaccination center, health-care professionals may scan the packaging for instant access to essential information about vaccine quality.

Blockchain and IoT are also powering the financial revolution with the help of smart payments. For example, the blockchain payments were recently tested by JPMorgan Chase and Co. between satellites orbiting the Earth. In a few experiments, the bank worked with a tiny satellite company named GOMspace to give the power of running software on the satellite. The following practical showed that blockchain networks can facilitate transactions between devices, creating a marketplace where satellites can pay each other and send data [18]. For example, such a system could order IoT-connected smart refrigerators from an e-commerce site when food is scarce and allow autonomous cars to buy gas.

Individuals and companies alike are affected by the COVID-19 influenza strain. Globally, the Internet ecosystem has played a critical role. Our dependency on Internet enterprises has risen tremendously as a result of the COVID-19 pandemic.

BFSI, health care and life sciences, manufacturing, automotive, retail, transportation, logistics, etc. use the Internet to provide the services they need. Vendors have noticed a decline in demand for blockchain IoT systems. Globally implemented lockouts are influencing the supply and demand of various hardware components required for the IoT blockchain. Some agencies like health care and the government are expected to experience adequate global recruitment to protect hospitals, government buildings, and civilians during the pandemic and disasters in the near future with the help of IoT sensors and blockchain.

The global IoT blockchain market will witness a growth of $ 32 million in 2018 to $ 5.82.7 trillion by 2026, with a CAGR of 91.5%. The Asia-Pacific blockchain in the IoT market is expected to grow rapidly over the forecast period, reaching $ 159.8 million by the end of 2026 with a growth rate of 9.8%. This is mainly due to the rapid development of infrastructure and manufacturing sectors in various developing countries such as India, China, and South Korea. The North American IoT blockchain market dominated the global IoT blockchain market in 2018. The region's market growth is 90.1% and is expected to reach $ 17.65 million by 2026. Higher growth rates are expected during the forecast period, mainly due to key factors such as increasing IoT deployments in various end-use industries. Another key driver for the growth of the market in the near future is the growing need for IoT security to improve work efficiency and streamline business processes on a global scale [19]. In addition, the main growth prospects for the IoT blockchain market include rapid growth in the adoption of blockchain services for digital identities and increased government initiative and contracts.

The Internet of Things adorns titles used in commercial- and industry-based applications. According to an IDC survey, spending on IoT hits $6 trillion between

2015 and 2020, integrating IoT into everyday applications in more industries. Blockchain, on the other hand, is becoming more and more popular as manufacturers in more and more industries understand how to use it to improve their business. If we consider Gartner's research, blockchain technology will add up to $ 3.1 trillion in business value by 2030. Blockchain technology and IoT are growing exponentially in the market and this is just the starting. The most interesting development is how the two technologies are brought together [18, 20]. Because of the characteristics of blockchain technology and IoT, both merge. While hurdles remain for blockchain and IoT, the merging of the two could have fundamental implications for our world. By the end of 2026, hardware will be the most profitable sector.

Figure 2.3 shows the future of blockchain in IoT market.

The integration of blockchain with IoT is the most significant technological advancement since the merging of IT and transaction processing systems. Because their acceptance has such a significant influence on our society, it is impossible to imagine a future in which blockchain and IoT are not deeply intertwined in our everyday lives. No other technological breakthrough in the last decade is projected to have the same impact on our lives as these two. "Blockchain adoption and IoT adoption are merged – and flourishing," according to a poll.

Various present and potential use cases of blockchain where IoT and blockchain technology combine are more or less common; therefore studying why and where IoT implementers in the United States are employing blockchain technology is fascinating, but not particularly unexpected.

As you may be aware, there are several initiatives in the IoT and blockchain sector where one may put their faith in security and reliability right now. The majority of respondents cited "improved security and trust" as a primary or secondary reason for integrating IoT with blockchain networks [21] (almost a third of respondents to b).

According to research, approximately 75% of those who have implemented IoT technology in the United States have either used blockchain or aim to do so by the end of 2020. Of those who have used blockchain, 86% use both technologies together in a variety of initiatives. Blockchain adoption is not uniformly strong

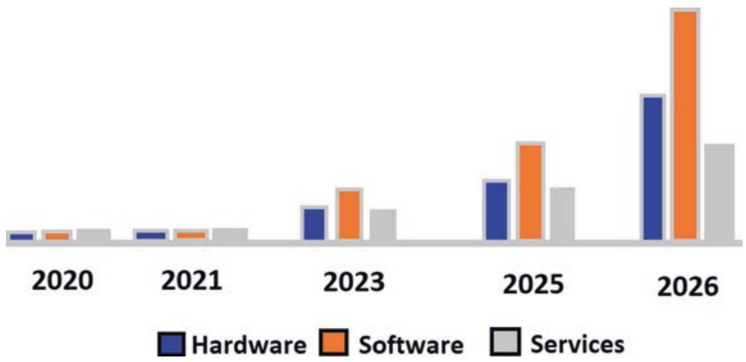

Fig. 2.3 Denotes the future of blockchain in IoT market

across all industries where respondents have required IoT. While security is a must in many businesses, in some, trust and security are more crucial [22]. Blockchain adoption is strongest in prescription drugs, energy, natural resources, utilities commerce, and transportation, according to Gartner [21].

According to Gartner, the adoption rate of blockchain will be highest among IoT implementers in the areas of prescription medications, energy, natural resources, utilities, and transportation.

2.8 Conclusion

This analysis has bestowed a scientific perspective in the eyes of researchers within IoT and blockchain integration. Research shows a good sign for technology on an individual and collective basis. With the Internet of Things and blockchain, security and privacy [23–26] are still key considerations that businesses should consider. Furthermore, research reveals that combining blockchain and IoT items can give several alternatives that will be useful in identifying exact solutions to blockchain security concerns. IoT objects. The integration of each technology can solve the current security problem of primarily IoT-based fields.

2.9 Future Directions

The blend between IoT and blockchain can propose a well-built methodology by creating a new path for business models and extended applications.

2.9.1 Smart Devices Becoming Smarter

IBM and Samsung collaborated to launch the ADEPT (Automated Decentralized P2P Telemetry) platform. It is tested on a "connected washing machine" that can track detergent usage, order bitcoins, and purchase paid detergents. It just happens automatically.

This is a great example of how blockchain technology is functional and truly self-sufficient from smart devices using IoT. It offers powerful self-maintenance, M2M communication, and the potentiality of peer-to-peer transactions. In smart homes, blockchain-based IoT infrastructure can improve device efficiency/productivity while minimizing power, and energy consumption. Private blockchain can be used to enhance the security of "connected homes" using user biometric data stored on the network (worked by Australian telecommunications company Telstra) [21]. This technology can also be used to improve the performance and reliability of self-driving cars.

2.9.2 Voting Transparency

Electronic voting methods are now plagued by a design problem. A single provider has control over the code base, database, and system outputs by design. The monitoring tools are controlled by the same vendor. Due to those centralized arrangements, there is a lack of confidence that voters and election organizers demand [20]. In this situation, blockchain can assist in the creation of a secure transaction database that can be used to log votes and audit vote outcomes in a more reliable manner.

2.9.3 Edge Computing

It is a scalable virtual system that enables the processing and capacity between buyers and also the server of the cloud computing system. No strangers request, fog devices can talk to each other. Blockchain can be used to accommodate the mismatch between fog centers and blockchain in IoT utilities. Information store can manage various information assets for blockchain in IoT data storage frameworks. Consistent approaches to sharing and securing this important information are key issues in storing both the information [20, 21].

2.9.4 The Data Will Be Exchanged for Digital Currency

IoT and blockchain will change monetization by sharing IoT data generated by device and sensor owners in exchange for small payments made in real-time. Tile pay, for example, provides a secure and decentralized online marketplace that allows users to register their devices and sell their data in real-time. As a result, they receive digital currency.

2.9.5 The Technical Challenges of Decentralization

Most of the IoT blockchain applications that have come so far from concerns of scalability, security, and privacy have required some form of blockchain focus added. Research and investigation should be conducted to support the decentralization of blockchain in IoT applications and the transition to a truly decentralized, scalable architecture.

2.9.6 Peer-to-Peer-Based Data Transactions

The number of connections and transactions through the IoT system is growing exponentially. As a result, the demand for computing/processing power continues to grow. Using blockchain requires a consistently high level of CPU performance. The system can solve this problem by opening the ability to buy and sell anonymous data from connected devices (i.e., data monetization). In addition to all authorized independent third-party resellers, OEMs and data providers can also conduct these data transactions (of course, payments are made via Bitcoin). Purchasing and making this data accessible will power the entire blockchain and IoT setup by motivating external parties to power more CPUs and invest in technically renewable resources.

2.9.7 Security

Design limitation is often faced by the technology of blockchain, in the process of implementing smart contracts.

2.9.8 Blockchain in IoT Intrusion Detection

BIoT system can implement a few numbers of proposed methods which are established by machine learning techniques [22]. These intrusion detection systems identify attacks on networks and systems [20]. Signature-based and anomaly-based are the two common ways of detection. An IDS of any kind can identify attacks dependent on anomalies, signatures, or both.

2.9.9 Blockchain in IoT and Real-Time Video Delivery

The top media circulation in BIoT that network service providers have recently experienced has provided for a decentralized media transfer brokerage methodology that supports collaborative blockchain.

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Chapter 3
Smart Health Care by Harnessing the Internet of Things (IoT): Applications, Challenges, and Future Aspects

C. V. S. Aishwarya, J. Caleb Joel Raj, Sanjeeb Kumar Mandal, C. Nagendranatha Reddy, and Bishwambhar Mishra

3.1 Introduction

Internet of Things (IoT), a groundbreaking technology of today's world, is a form of the Internet's sway beyond computers and smartphones, influencing communication technologies considerably. When viewed from IoT's perspective, every object in the universe becomes a "smart" one. So, when put into simple words, it is a network where things are connected, work together, and perform a task by sharing information using set standards and protocols of communication. Aided by a greater number of smart devices, IoT has succeeded in gaining much popularity and trust among people and is widely being used today in various forms [1–4]. These devices may range from something as small as a wearable fitness device such as a smartwatch to a large machine that analyzes and computes a huge set of information and data. The true potential of IoT has always been realized when it interacted with other disciplines in the world of science. It has helped open new perspectives to approach problems of the real world. IoT has come a long way right from its very first Coca-Cola vending machine to artificial intelligence (AI)-aided procedures for treatment and diagnosis in the health-care industry [5, 6]. With the increasing popularity of smart cities and smart homes, the Internet of Things (IoT) has emerged as an area of incredible impact, thus paving the way into our future.

Production, automotive, and health-care industries are a few of many fields where IoT has played a major influence in reimagining how problems are tackled. Farming is one of the sectors that will be highly benefited from the Internet of Things. Modernization of tools and devices for understanding crop patterns, water

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distribution, and drip irrigation has allowed farmers to come up with more fruitful produce as a result of this while utilizing their resources more efficiently and cutting down wastage to the minimum. All these developments make headway toward "smart agriculture" [7, 8]. This chapter examines how the Internet of Things (IoT) and its various features can be used to improve health care. In recent times, health care has become the next big opportunity for the Internet of Things (IoT). IoT solutions of today have a huge potential to boost health-care operations more than ever, thus improving results, expenditure, and efficiency alike. By integrating devices such as sensors and actuators [9, 10] in patients and capturing medicine intake data for monitoring and tracking purposes, smart health care plays a vital part in health-care applications. Clinical care employs the Internet of Things to monitor a patient's physiological conditions by collecting and analyzing data from qualitative sensors and then transmitting the processed data to processing centers to take appropriate actions [11]. These devices are valuable for everyone who wants to keep track of their health, not just patients. IoT technologies such as cloud computing, wireless sensor networks, micro-electromechanical systems (MEMS), and the future Internet enable communication anytime, anywhere, known as the "Internet of Everything" [12].

In the health-care industry, there is a growing demand for connected devices. In health care, IoT has a wide range of applications. Apart from remote monitoring and tracking of patients' health, health-care equipment is being upgraded with IoT, such as smart beds that detect occupancy, smart pill dispensers that monitor the patient's drug intake and send alert signals to the caregiver, and so on. IoT can also aid in the early diagnosis of specific patient health issues and give timely responses to medical emergencies [13]. As a result, it has proven to be useful in diagnosing and treatment of disorders. It is feasible to collect evidence and diagnose numerous digestive and gastric illnesses using swallowable sensors in a far less-invasive manner.

3.2 Evolution of IoT in the Field of Medical Science

3.2.1 History of IoT in the Field of Medical Science

The Internet of Things has amended the health-care industry with its immeasurable applications. The implementation of IoT in health care first began with its usage in remote patient monitoring and retrieving data from devices that were placed on the bedside of the patients. These helped doctors and physicians to make the right medical decisions, abolishing any kind of human errors. IoT has immense potential in the provision of advanced health-care devices and equipment. To the health-care industry that had almost given up hope due to the surging prices spent on treatment due to the increase in chronic diseases, IoT became the source of light with the introduction of its X-ray machines to monitor patients and thus enhance the mode of operations. Ever since, IoT has made a remarkable contribution in making health-care

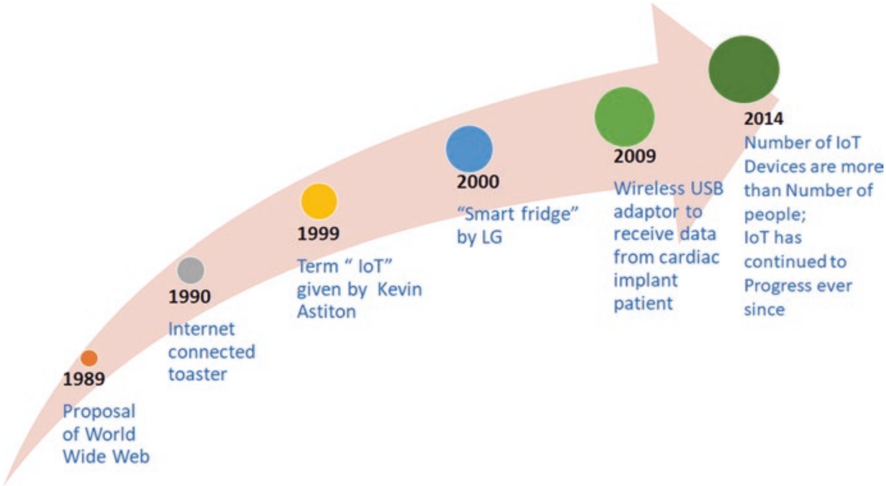

Fig. 3.1 The timeline of major events in the history of the Internet of Things (IoT)

services more cost-efficient and accessible. Figure 3.1 depicts various innovations made by leveraging the Internet of Things (IoT) in various fields.

Today, IoT in health care is an industry with rapid growth. Especially with the COVID-19 pandemic on the rise, the need for IoT-based services has been accelerated further. The usage of IoT in the domain of medical science has brought applications that were thought to be fictional into the dominion of reality. This will continue to expand more and more as rapid advancements and enhancements in technology progress further. It is also claimed by scientists that this rapidly growing technology will soon give rise to a future where insentient objects will be able to discern, think, and function on their own.

3.2.2 Predominant Techniques

Internet of Things (IoT) technology has been molding today's world. Connectivity, interaction, and efficient data sharing have been key aspects of IoT's success. IoT cannot be just a device or a piece of data alone; it is the fluently orchestrated interface between devices, technologies, and vital data, rightly calling it the IoT ecosystem. An (IoT) ecosystem consists of smart devices and systems that run on the Internet, like sensors, processors, and communication devices that act on data extracted from different environments that they are used in IoT devices connect to an IoT gateway or other devices. Here, the data is stored in the cloud and may be analyzed later or locally [14]. This is how the devices share data. Figure 3.2 depicts the advantages of various IoT-based medical technology for the stockholders.

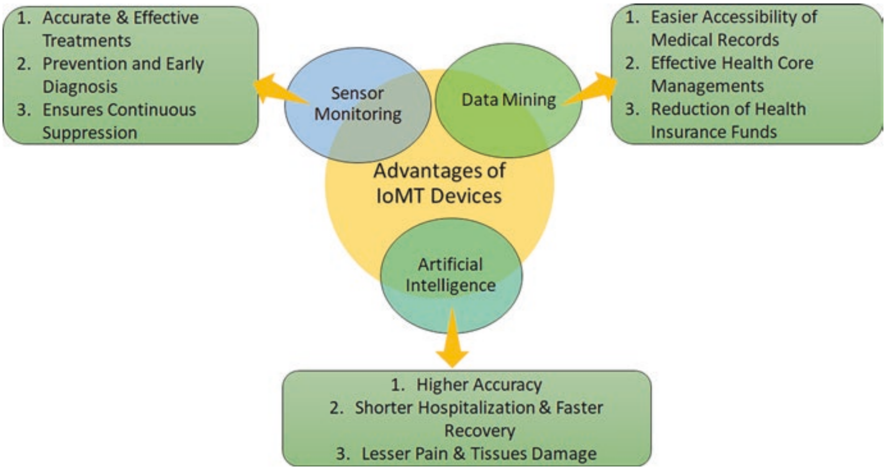

Fig. 3.2 The advantages of IoMT devices and technologies and how they benefit all the stakeholders in the health-care sector

3.2.2.1 Data Mining

Data mining is the processing of huge amounts of data that helps companies to troubleshoot, cut down on risks, and explore new opportunities in a variety of fields. This branch of data science draws similarities to mining a mountain for ore; the only difference is that here we search for important information in a large database, hence the name data mining. This is not a technique that was founded during the digital age [15]. Data scientists now play a vital role in various business organizations across the globe as companies try to stay ahead of the competition, which has increased the importance of data science more than ever before. Data mining can solve various problems that were too impossible to solve traditionally and were often time-consuming when done manually. A large range of statistical techniques is used to analyze data in various ways, whose findings can now be applied to predict future outcomes and take the necessary actions to achieve them [16].

In health care, data mining has become increasingly popular and would not be wrong if we said it is increasingly essential. As mentioned in Fig. 3.2, data mining can benefit all characters involved in the health-care industry greatly. To put things into perspective, data mining helps health-care insurers to detect insurance fraud and abuse. Health-care organizations make customer-physician relationships and management decisions better, help provide treatment effectively, and make health-care services affordable for the com. The humongous quantity of data that is generated by the health-care transactions is way too complex to be processed and analyzed by standard traditional methods [17, 18]. Data mining provides us the methodology and technology to transform this mammoth amount of data into useful and accurate information for decision-making.

3.2.2.2 Artificial Intelligence

In the medical world, smart devices have been crucial for monitoring patients in the intensive care and continuous supervision units. Artificial intelligence enhances the ability to identify deterioration and deviation from normalcy and senses the development of complications. This significantly reduces fatality risks and hospital-acquired conditions. Neurological diseases can disable patients' speech, mobility, and interaction with their surroundings. However, brain-computer interfaces (BCIs) have the potential to restore these fundamental experiences to those who lost them forever [19, 20]. Artificial intelligence also has the potential to bring the next generation of radiology tools into active usage, making them good enough to replace the tissue sampling from biopsies that could be risky in some cases [21, 22]. Electronic health records (EHRs) have been an important part of the health-care industry's digitization journey, but the changeover has resulted in a slew of issues such as cognitive overload, endless documentation, and user burnout. Artificial intelligence is now being used by EHR developers to provide more intuitive interfaces and automate time-consuming repetitive operations. Artificial intelligence can help process routine inbox requests, like regular med supply and notifying about results. Artificial intelligence has now won the trust in taking over tasks that require the intensive clinician's attention [23].

3.2.2.3 Sensors and Monitoring Devices

Almost everyone nowadays has access to devices with embedded sensors that collect useful information from the user. From cellphones with distance trackers to wearables that monitor heart rate around the clock, a significant amount of health-related data is created "on the go" [24]. Wearable biosensors have attracted a lot of attention because of their ability to give consistent real-time, precise data through noninvasive assessments of biochemical indicators like sweat, tears, and saliva, among other things. We can now infer data about metabolites, microbes, and hormones, thanks to recent improvements in electrochemical and optical biosensors, as well as advances in the noninvasive monitoring of biomarkers [25]. Integration, miniaturization, and mass manufacture of biosensor devices have all been achieved using micromachining, which is also known as microfabrication [26]. In Fig. 3.2, we see that sensors and monitoring devices have helped increase the accuracy of diagnosis, which in turn increases the effectiveness of treatment provided and reduces errors and complications to a great extent. In the last few years, tremendous advancements have been achieved in the design and development of biosensors [27]. The biosensor market has grown significantly as a result of recent advances in molecular biology. Biosensors are anticipated to play a significant role in the detection of diseases and microorganisms such as HIV and COVID-19 in the future. The global biosensor market is expanding at a breakneck pace, with projections of $50 billion by 2025 [28].

3.2.3 Trends of Today

Traditional health care will not suffice the needs of everyone owing to the increasing growth in population. Medical services are not accessible to people despite advanced technologies and excellent infrastructure. The IoT-based health-care system not only helps monitor patients, reducing the cost of care provided but also helps the physicians to expand their services without being limited by any kinds of geographical barriers. Its broad range of applications enhances the lifestyle and communication of people, especially those in need of special care [29]. With the idea of "smart cities" in trend, a smart and effective health-care system will improve the lives and health of people. Today, our health care has become more expensive than ever. The use of devices that allow remote monitoring of patients can be beneficial in cases where they require hospitalization during treatment. IoT technologies thus make it possible to cure any ailments before they become critical and move out of hand. This is why there is an utter need for several IoT-based technologies and applications to be developed, especially in the field of health care. Figure 3.3 illustrates the expenditure on IoT solutions from 2017 to 2025.

The following are the trends of IoT:

- Apart from artificial intelligence, virtual reality, robotics, and quantum computing, the "Internet of Things" is one of the trending technologies, according to a 2018 research by Accenture, encompassing 25 countries Tech Vision.
- Just in the European Union (EU), the number of IoT-based fitness and health-care units has nearly increased by twofold from 2017 to 2020.
- By 2023, the number of devices connected to the Internet of Things throughout the world is expected to reach 43 billion, nearly a threefold increase from 2018.
- By 2021, the investments being made in the field of IoT-based technology are expected to grow at an average rate of 13.6 percent per year.
- The total number of business organizations that make use of IoT-based technologies today has increased drastically from 13% in the year of 2014 to 25%.

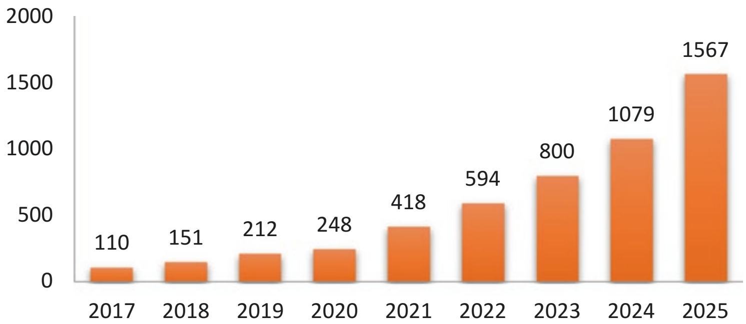

Fig. 3.3 Forecast end-user spending on IoT solutions worldwide from 2017 to 2025 (in billion US dollars). (Source: https://www.statista.com/)

- According to IoT analytics, the number of active IoT devices hits 9.5 billion in 2019, up from the previous estimate of 8.3 billion.
- According to Vodafone, more than one-third of the companies today use IoT solutions.

The ongoing pandemic (COVID-19) has also accelerated the need to adopt a more technology-driven health-care system. The number of online appointments with health-care professionals in the United States is estimated to be over 36 million. In actuality, this figure is close to 1 billion, and it will undoubtedly increase as infrastructure and patient knowledge improve.

Devices that allow older individuals to remain independent while at home have shown strong growth as well. These include AI-aided tools to detect any changes in the daily routines and immediately alert the health-care providers.

3.3 Real-Time Applications of IoT in Health Care

3.3.1 Sensors and Monitoring Devices

Monitoring patient data is an integral part of the health-care industry. Thanks to IoT's health devices, the patient does not need to be physically present in the hospital premises for a health checkup. A small device placed on the patient's skin can now enable doctors to monitor the patient's real-time status including blood pressure and heart rhythm. And not just the doctors, but even the patients can have a look at their health status on their smartphone. In the coming years, health care will undergo a drastic transformation for the better with IoT-based technologies. IoT is expected to majorly impact telemonitoring of patients in homes and hospitals alike [30]. Figure 3.4 shows the basic principle that is used in the working of the Internet of Things.

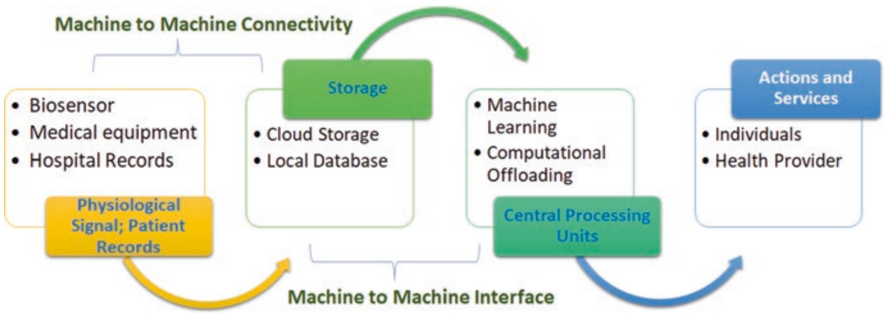

Fig. 3.4 Basic principle of IoT in health care

3.3.1.1 Remote Patient Monitoring

Remote monitoring of patients not only increases the quality of health care but also reduces costs by recognizing the diseases and preventing any critical situations [31]. The reliance of the health-care system on IoT-based technologies will increase further because this sector always pushes for advanced and improved services.

3.3.1.2 Wearable Devices and Sensors

These IoT-based devices like blood pressure (BP) monitoring and fitness tracking devices are extensively used to maintain one's health by self-care principles throughout the world. Developments in Radio Frequency Identification (RFID) tags, imaging devices, and biosensors are among the major causes for the increase in the number of predominant medical prototypes. Most wearables rely on a variety of biosensors such as pulse sensors that have pressure, ultrasound, and radiofrequency (RF) sensors. These have been useful in detecting cardiac arrests. Sensors that have been created to record the respiration rate in humans have the potential to identify respiratory illnesses like asthma, lung cancer, etc. Other sensors like EEG and pulse oximeter are also gaining popularity in the market. Consolidation of this data in an organized manner can be used to predict future trends by detecting health patterns. The combination of these sensors can also highly reduce the risk of sudden infant death syndrome (SIDS) [32].

3.3.1.3 Ambient-Assisted Living (AAL)

Systems with the ability to address critical health conditions providing independent lifestyle especially to the elderly people are known as ambient-assisted living (AAL). This makes use of the idea of keep-in-touch (KIT) and closed-loop health-care services and devices. Recent neurotechnology-based innovations make use of sensors that can control neural functioning. Moodles is the umbrella term for devices that help enhance patient mood. They help improve and repair brain processes. Halo Neurosciences and Thync are two leading companies that make wearables that are designed to elevate an individual's mood by sending low-intensity current.

3.3.2 Disease Diagnosis and Mobile Health Care

Different dimensionalities and online services of mobile health care (m-health care) are made possible with the application of IoT [33]. For various fatal and chronic diseases, it is considered indispensable to diagnose diseases and monitor patients' health conditions continuously before any serious disorder or infection occurs. IoT gives this challenge a solution through various techniques like artificial intelligence and ingestible sensors [34]. Ingestible electronic devices are small capsules that comprise a microprocessor, a power supply, sensors, controller, etc. which are all made of biocompatible materials. These components enable the devices to transmit signals and data to physicians for the diagnosis of diseases and their monitoring. These devices are noninvasive, real-time health-care technology that show potential for far-reaching implications, more than what current sensors and monitoring devices are capable of. The market for ingestible sensors has been estimated to be around $491 million (2016), which is expected to increase at an annual growth rate of around 19% by 2024 [35]. In an article cited the journal "Science" dated May 2018, an innovative ingestible micro-bio-electronic device (IMBED) was presented by researchers. This device can be used to monitor the health of the gut. Researchers created a "heme-sensitive probiotic biosensor" that can detect gastrointestinal (GI) bleeding [36]. Previously, ingestible sensors were limited to just pH sensing, temperature measurement, and blood pressure indication; with these ingestible sensors, we can push toward particular diagnostics. Bacterial species can also be modified as a nanobiosensor. Certain bacteria can sense a surfeit of both exochemical and physical conditions via specific metabolic pathways. Scientists use the heme-sensing genes of *Lactococcus lactis* and *Escherichia coli* O157:H7 bacteria to sense blood and associated components in the external environment. A modified output signal is then produced. This signal is observed as bioluminescence (*Photorhabdus luminescens* luxCDABE) [37]. This system is later inserted into gut-friendly bacteria. This pill works on an energy source that runs on the acid present in the gastric cavity. Our gut can synonymously be called a hot soup of life; food boluses undergo various chemical and physical reactions and changes. This is why real-time monitoring of our gut provides a wide range of gut events that have never been observed. Gases released in the gut can be measured to indicate the bacterial biomass present and identify the bacterial metabolites present in the gut. Hence, analysis of the gas in the gut can be used for the development of biomarkers to treat gastrointestinal tract disorders [38].

3.3.3 Artificial Intelligence-Assisted Surgery and Treatment

During surgery, surgeons are always expected to maintain precision while making incisions or performing other surgical operations on a patient. Tasks like these that constantly require repetition are very challenging and demanding. To assist surgeons with maintaining such precision, the industry is now using artificial intelligence (AI) and robots in surgical procedures [39]. Surgical robots can control the depth, speed, and trajectory of their hydraulic maneuvers with much greater precision. They are customized specially for such repetitive movements while working without fatigue. Robots can still go where traditional surgical tools cannot and can remain completely still for a longer duration of time [40]. Experience is invaluable for any surgery, but they are also physically demanding, and fatigue is always a limiting factor. The skillset and the knowledge that surgeons have amassed throughout their careers are overshadowed by a limited motor ability. These collaborative robots can help eliminate the problem of hand tremors and avoid collateral tissue damage that is often unintentional. Manufacturers have now realized that observatory data and deep machine learning data are more important to automate over a machine programmed by a software engineer who does not know about real-time scenarios [41]. AI can also be used with a machine for the analysis of scanning images which helps detect malignant tumors, ulcers, and other orthopedic issues. Laparoscopic analysis of surgeries such as sleeve gastrostomy procedures helps identify unexpected process deviations in real-time. Robots are capable of repeating the exact motions without variation in force or displacement. This makes it extremely useful for repetitive and precise procedures like hair transplant surgery.

3.3.4 Fitness and Nutrition

People are getting more aware of their health and are very conscious about maintaining a healthy and proper physical shape. This is why the products that aid them in this process are also on the rise. Due to the continuous drift toward digital fitness tools, various devices including wearables like smartwatches, fitness trackers, smart shoes, and IoT-powered gym machinery have emerged in recent times and will continue to grow in number and efficiency. IoT-based devices in the fitness industry:

1. Help in providing enticing training employing technology based on virtual reality. For instance, headsets provide the opportunity to the users to exercise in any suitable environment they prefer whenever they want.
2. Help in personalizing the workouts according to the individual needs. The integration of IoT in training centers and gyms works based on the data received from sensors and smart equipment. Thus, the exercises can be customized according to the needs of the person using them. Such devices also make it easy to track the progress and consequently the health of the users [42].

Tables 3.1 and 3.2 summarize some of the popular IoT-based fitness devices being used extensively by several fitness enthusiasts. IoT devices used in the fitness realm provide health and body's endurance status including how much proteins, fats, or carbohydrates are being consumed in a diet, thus enhancing the work of both fitness trainers and nutritionists. For one to stay fit, sleep and rest are also equally important. IoT fitness devices monitor how much sleep an athlete or even an individual, in general, should have and for how much time they should go on with their workout and training. When such devices are integrated into the body of the individual, they can control all the related variables on a smartphone by themselves [43]. In the case of athletes, the risks of getting injured or even death due to strenuous pressure on the body can be avoided.

IoT fitness apps enable users to share their current status with friends and others. This can be an excellent source of motivation for any fitness enthusiast. These apps can provide the user with an online trainee who guides them with personalized

Table 3.1 Some IoT devices used in the fitness industry along with their key features

S no	Company	Device	Key features	Price	Website
1	Polar	Polar Verity Sense	Optical heart rate sensor with options for viewing and recording workouts	$130	https://www.polar.com/en
2	LARQ	LARQ Bottle PureVis	Make use of a UV C-LED chip to eradicate odor-causing germs	$120	https://www.livelarq.com
3	Kolibree	Ara	First-ever AI-connected smart toothbrush	£129	https://www.kolibree.com
4	Tellspec	TellSpec Preemie Sensor	Analyzes the ingredients in one's meal through an app connected via a smartphone	$320	https://tellspec.com
5	FoodMarble	Food Marble AIRE	Measures the hydrogen released by undigested food particles and helps find what is right for the gut	$299	https://foodmarble.com
6	Beddit	Beddit sleep monitor	Tracks sleeping pattern, snoring, heart rate, and breathing while sleeping	$150	https://www.beddit.com/
7	Nima	Nima gluten sensor	Detects gluten. Uses capsules and associated apps to track the data	$229	https://blog.nimasensor.com/
8	Yogifi	Smart yoga mat	Detects when the person is out of alignment and gives real-time feedback on how to correct the pose	$297	https://www.yogifi.fit/
9	JAXJOX	Kettlebell Connect 2.0	6-in-1 adjustable kettle bell with real-time performance tracking	$249	https://jaxjox.com/

workouts. For example, Google Fit is one such application that tracks heart health and other related activities through the sensors present on the wearable [44].

3.3.5 *IoT in Pharmaceuticals*

Quality control and pristine production are always one of the major challenging tasks in the pharma industry. In the production of a potentially life-saving product, one of many parameters could go wrong and these may include leakage of a dangerous liquid or gas, a fire hazard, and improperly produced medicine becoming toxic, or even an equipment failure that could lead to the breakdown of the entire production. However, a network of several connected devices can greatly reduce these malfunctions and provide accurate production results by detecting and adjusting problems before they become major.

Technologies like 3D printing, artificial intelligence, and blockchain to improve various systems have innumerable applications in manufacturing and distribution alongside supply chain which help the industry to make its systems transparent and fast. Services like "Amazon Key" launched by Amazon are a great example of the

Table 3.2 Wearable IoT devices and fitness trackers

S no.	Year	Name of the device	Function
1	2003	Garmin Forerunner	GPS-based running watch that measures speed, time, distance, and heart rate
2	2009	Fitbit classic	A clip-on style fitness tracker that tracks sleep based on body movements
3	2013	Fitbit Flex	A wristband that automatically tracks all-day activities and sleeps. The LED display lights as the user progress toward a goal (a comparison of this with other similar devices is given in the table)
4	2013	Pebble watch	First commercially successful smartwatch with fitness tracking
5	2013	Motiv ring	It is worn like a ring and is a fitness tracker
6	2014	Moov Now	A waterproof fitness tracker that tracks various activities with an AI-enabled guide
7	2016	Misfit Ray	Looks like a bracelet. Can also be worn as a necklace. It tracks activities like running and swimming
8	2018	Apple Watch Series 3	Monitors steps and flights of stairs climbed and actively tracks all indoor and outdoor activities using GPS
9	2020	Amazefit Band 5	24/7 heart rate, sleep, and activity tracker
10	2021	Samsung Gear Fit2 Pro	The water-resistant smartwatch continuously monitors heart rate while swimming. It has automatic pace monitoring and stroke recognition. It also has built-in music storage and is GPS-aided

usage of network-connected tools in delivering fuss-free utilities to customers. Similarly, many industries are trying to harness IoT's potential for the benefit of their consumers, and the pharma industry is also one of those sectors striving hard to serve their consumers with a safe distribution of prescription drugs.

IoT is also employed in the production and delivery of drugs. It is used to track the quality and specifications of several drugs more accurately to ensure that the delivery of wrong drugs is prevented and the quality is maintained. To do so, each drug is made with a unique ID so that patients, as well as the professionals taking care of them, can keep a check on the drug's supply chain. These IDs not only provide information regarding where and by whom the drug was produced but also about what materials were used to produce the drug. All this information will collectively help patients to receive better and quality treatment and the health-care providers to make informed decisions [45]. Today, patients can get a vast variety of medicines through Internet-based services without the need to physically visit a medical or a drug store. The patients can also track their orders placed for their medicines far from home. The product price can also be viewed using bar codes, and all this has been possible only because of IoT.

Smart pills have been developed by leading pharmaceutical companies. These, when consumed, transmit signals to a sensor outside that monitors patient health to take prompt actions whenever the need arises. These are other examples of the growing influence of smart devices. The use of such smart devices in patient engagements, supply chain and clinical development not only helps reduce the time required for a specific drug to reach the market but also the real-time data produced can be reverted to detect active errors that cross the value chain. Data from wearable devices can be used by health-care professionals to prescribe personalized medicines (PM) that will improve the drug efficacy while reducing the time spent for the treatment otherwise.

3.4 Problems and Challenges

The expansion of IoT across the globe has been very rapid in a very short period. Almost every country has access to some form of smart device. IoT has also become an integral part of military and defense technology. With IoT setting a strong foot toward smart health care, certain challenges lie ahead from making it easily accessible to each and every person [46]. The Consumer Electronics Show that took place at the beginning of January 2017 in Las Vegas already showed us quite a few promising innovations in this field. It also proved that there are many missing pieces to the puzzle. Many IoMT initiatives that have been directed toward fighting chronic diseases still need more enlightenment [47]. This technology specialty will need to expand significantly before it can begin to provide consistent improvement results. Moreover, many devices are said to be highly accurate based on their theoretical probabilities. On-field testing and variable factors that affect the performance are always in question [48]. There are many unforeseen and unexpected situations or outcomes of these devices, and they are hard to predict which need the most care and supervision to avoid them. In an industry like health care where there is no margin for error, such factors can make them unreliable, which in turn makes it hard to convince potential consumers to use them.

With many hardware platforms, there is also a lot of software to power and manage it all. To work effectively and keep up to date, this software and hardware should be periodically updated. And this is where regular updating becomes important, which will take time and work and may result in a slew of technological troubles [49]. The IoMT must yet be certified by international health-care regulatory agencies. Inventors and patent applicants find it difficult to procure parts and get approval for their novel technologies and gadgets because of the numerous laws and restrictions about ethical and legal issues surrounding that political state. This tends to demotivate independent innovators and all their ideas tend to remain in paper alone [50].

3.4.1 Big Data and Handling

The most common challenge in an IoT world would be the colossal amount of data coming continuously from several devices connected over a system. Managing this data is tactful. This myriad of information is collected in various forms that include sensor data, diagnostic data, digital pathology data, imaging data, and others which collectively lead to excessive accumulation of data. It will be critical to establishing approaches that allow for the translation of this raw data into meaningful information. Raw data should be translated into the concept of precision behaviors of a person, such as inadequate breathing, eating, or symptoms of depression or sickness, in the medical area, for example [51].

Although IoT has made huge advancements, with its techniques such as artificial intelligence (AI) in health care, several other streams of networks have to be enabled to act as primitives in case of any future inferences that are often unexpected. However, the reality that no reasoning technique is completely accurate still holds. As a result, users may be hesitant to trust the system if the analyzed data is ambiguous. This is why various medical organizations are still very skeptical about the usage of these advanced technology-based devices and are cautious when it comes to proceeding with such vulnerable system-connected equipment.

3.4.2 Security

As the Internet of Things (IoT) keeps growing in importance as a component of a regional and global network, the requirement for appropriate and efficient cybersecurity for IoT infrastructure becomes critical. Methods for cyber situation awareness must be designed to track IoT-based systems [52]. The most fundamental problem that is prevalent is the security attacks that need to be dealt with. Because most devices interact remotely, this is a concern due to the physical accessibility of items, sensors, actuators, as well as the openness of the systems. Any failures in the system built are viewed as vulnerabilities by cyber attackers.

Most IoT applications dwell on unattended operations and need to be handled virtually without relying on human control. They are expected to have a great deal of durability to meet the realistic system requirements. Hence, they must have the ability to work satisfactorily even in the presence of any security breaches and to recover effectively from any possible unanticipated attack on their own. This action may involve downloading a new code, and this itself is very much prone to the same security attack. Substantial IoT applications are becoming progressively prone to cyber and data theft. The database must have the capacity to be continuously available all the time and to support high-speed reads and writes to gather this data.

3.4.3 Privacy

Because much of the data in an IoT system, specifically when used in health care, may be personal, maintaining anonymity and restricting the processing of individual data are critical. To keep IoT devices prevalent, a variety of confidentiality considerations must be addressed, including:

1. Through the surveillance of IoT-related interactions, private information assumption can be avoided.
2. Maintaining privacy protection in situations when a person's location can be deduced from aspects connected with them.

IoT data is a critical component in providing improved services and managing the devices that can be connected to it. As a result, the huge amount of data including details on users' device usage must be safeguarded, which can result in privacy breaches, limiting the utility of IoT-based equipment and software.

3.5 Recent Innovations and Patents

Because of its automated sensor operations at relatively cheap prices, the Internet of Things (IoT) is increasingly popular in many sectors. In health-care applications, these devices form an ecosystem of connected technologies that sense a patient's pro-medical conditions such as blood pressure, oxygen level, heartbeat, temperature, and more. They can also take appropriate emergency actions if needed. Various systems have been presented to monitor a patient's state utilizing Wireless Body Area Network (WBAN) based on low-powered biosensor nodes [53]. With so many upgraded medical devices, technology-driven services in the health-care industry become pertinent to secure these innovative services and products. This is where a patent comes into play. A patent serves as a means through which an entity can get all the rights to their original idea and can also earn monetarily after due process of patent valuation determines its actual value in the market. In simple words, the inventor gets sovereign rights over his/her product and no other entity can make the same product or sell it unless they have the inventor's assent.

Medical devices are classified into three classes by the Food and Drug Administration (FDA), i.e., Class 1, Class 2, and Class 3 based on the field of usage and the risk level the medical device handles, i.e., Class 1 for low-risk scenarios, Class 2 for moderate risk involvement, and Class 3 for high-risk devices. As the risk increases from Class 1 to Class 3, so does the related control of the device. Within the FDA the Center for Devices and Radiological Health (CDRH) is responsible for ensuring the safety and effectiveness of the medical device and eliminating hazardous exposure to corrosive chemicals and electrically unsafe and radiation-emitting products. Class 1 medical device has the least amount of regulatory control, and these include about 47% of all medical devices [54]. For these devices, the "Pink Market" notification application and the Fixed Deposit (FD) clearance are not required, before marketing the devices. However, the manufacturer is supposed to register its establishment and raise its generic product with the Fulfillment by Amazon (FBA). Class 2 medical devices are those where general control is not enough to assure their effectiveness and the physician needs special control. These devices make up almost 43% of all medical devices. About 10–15% of clinical trials come under Class 2 devices. These are moderate-risk devices [55]. In the case of

Class 3 medical devices, the risk level is very high to the end-user and therefore requires general control, special control, and premarket control as well. Class 3 devices make up the remaining 10% of the medical devices. Normally all the Class 3 devices are generally life-supporting or life-sustaining devices [56].

The most relevant patent classifications (USC or US Class) are based on highly active patent classes:

340/572.1 – Communicational (on a protected article, a detectable device (e.g., a “tag”))
600/300 – Devices for diagnostic testing
600/509 –Heartbeat electric signals detection
600/508 –Devices for the evaluation of heart condition
607/36 – Electrical applications (stimulator housing or encapsulation feature)

Several notable medical patent developments have recently made headlines. Some of these medical patients include:

– The superbug test: Translational Genomics Research Institute (TGen) and Northern Arizona University (NAU) have secured an Australian patent [57].
– Reprogramming human skin cells: Converts human skin cells into engines of tissue regeneration (patent number 9,290,740).
– BioStack 4 Microplate Stacker: Automatic de-lidding and re-lidding of microplates is a one-of-a-kind technology (patent number 9,366,686).

Patents and innovations in the health-care industry improve the quality of medical facilities provided and improve the lives of hundreds of millions of people throughout the world. Challenges remain in finding the most effective device or technology that is error-free and 100% accurate and complete. Making these advances available to individuals in dire need while making them affordable and easily accessible is also important. The number of patent cooperation treaties (PCTs) has been exponential, and these ideals and devices are entering the consumer market and its popularity is increasing among business cooperatives and potential customers alike. The United States system governing innovation and implementation of medical patents insists on a balance between commercial interests and safety efficacy concerns; while time-consuming and expensive, this provides applicants a measured framework within which societal health care benefit through products created by them may be realized [57].

3.6 Conclusion

There are countless predictions about the potential of the Internet of Things (IoT) to bring about a revolution in the health-care sector by improving the quality standards while dramatically reducing the costs. As mentioned in the International Conference on Intelligent Computing and Communication Technologies (ICICCT), about 8.5% of the global population is of age 65 years or older and this is expected to rise to

17% by 2050. Life expectancy will increase from 68.6 years (as of 2015) to 76.2 years in 2050. This would mean more cases of chronic diseases in people and limited resources while society continues to have higher expectations from technology. Although, when compared to the other sectors, the market for IoT in the health-care sector is at infancy, it is still said to be growing considerably. With its increased sophistication in sensing, control, communications, and ability to handle mammoth amounts of data seamlessly, IoT is breaking the boundaries of traditional medicine while increasing accuracy and effectiveness and downsizing the number of errors. The ability and efficiency of different health-care organizations to convert the data gathered by IoT into significant insights will greatly influence the future of IoT. New challenges are bound to arise due to the gigantic number of devices, the connection of both the physical world and the world of the Internet. The transparency of systems and the ever-persistent problems of privacy and security may slow down the progress and popularity of these technologies.

However, these challenges will help expose flaws in these devices and push toward the advancement in the ever-transforming world of IoMT technology [58, 59] for the future. The implementation and the deployment of these high-end technologies, especially in the health-care sector will bring about more and more significant benefits to all the health-care stakeholders. IoT in health care is expected to flourish, overcoming all its challenges and transforming the conventional health-care models of today's world and making smart health care a ubiquitous reality of our future.

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Chapter 4
Applications of IoT in Smart Homes and Cities

Gunjan, Shristi Agarwal, Drishti Rai, and Sumran Talreja

4.1 Introduction

Smart homes and smart cities, as key components of IoT, efficiently serve customers by interacting with various digital gadgets that are based on IoT. All equipment in smart homes and smart cities interact with one another in the ideal vision of a wired future. IoT-based smart technologies have revolutionized human existence by bringing connectivity to everyone, regardless of their location and time [1–4].

4.1.1 Concepts

Due to the rapid growth in population density inside urban regions, substructures and services have been necessary to fulfill inhabitants' demands. As a result, the number of digital devices, such as sensors, actuators, smartphones, and smart appliances, has increased significantly, enabling the Internet of Things (IoT) broad business objectives to be achieved, as it is now possible to connect all devices and establish connections between them via the Internet. Combining these digital gadgets was difficult, if not impossible, in the past [5]. Obtaining their data is needed for both daily operations and long-term growth plans [6].

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Some public transportation data should be collected regularly, such as real-time location and usage, parking space occupancy, traffic congestion, and weather conditions. Several approaches have been used to handle each application's particular characteristics. The needed technologies span several levels and layers, from physical to data to application. IoT is defined by the power of smart devices connected to global grid infrastructures. It is a sort of physical device that is widely spread and has limited storage and processing capabilities. The IoT has three layers: perception, network, and application. It includes gadgets that can sense, detect, gather, and share data with other devices over Internet communication networks. The network layer's job is to transfer data from the perception layer to the application layer while respecting device, network, and application limitations. The capillary effect is used in IoT systems to transfer data from sensors to a neighboring gateway. Assembling smart homes and cities requires data collection and processing at the application layer. A huge quantity of data has been produced and is being used to make life safer. Problem-solving workers must be dedicated to the circumstance. The Internet of Things may lead to large smart devices in our environment. IoT in smart homes and smart cities has been discussed.

4.1.2 Motivation

In this work, IoT and its applications in smart homes and cities are the main works. This phrase excludes non-IoT smart house or city applications, such as smart grids, and nonapplication-based smart city usage. All IoT applications in smart homes and cities were considered. The digital India program will soon turn Indian cities into smart cities – a smart city where communication and services primarily rely on the Internet. As a result, IoT is vital in the development of smart cities. Smart homes are proposed as part of a smart city. This research aims to enable a smart home system for India's smart cities. Syed et al. highlighted future smart city features. Smart cities have smart people, energy, buildings, transportation, technology, health care, infrastructure, government, education, and security. Technology has built a substructure that allows numerous individuals to connect. It may become easier to create appropriate connections between objects as the Internet evolves [8]. The number of linked things exceeded the population in 2011. It may provide both virtual and real buddies in personal and home applications. Home energy management is enhanced with IoT-controlled equipment like refrigerators and washers. Expanding body area networks at home can monitor the health of the elderly, lowering treatment costs. Facebook can bring a city's people together for an event or celebration. It is helpful for texting, video, and phone calls with self-created groups.

4.2 IoT: Application Areas

IoT connects devices and things wirelessly. Data may be shared and transmitted through the Internet at any time and from anywhere [5]. The Internet of Things offers interconnectivity, security, heterogeneity, massive size, dynamic changes, and connection. The need to shift toward the latest tech known as the "Internet of Things" to improve productivity, efficiency, and global marketplace, as well as to reduce human involvement, effort, and expense. IoT is a connection of devices that allows data to be transferred without the use of wires [9]. It is utilized in real-time applications as described in Fig. 4.1.

- Internet of Things in Smart Cities Domain
- One example of an IoT smart city application is smart parking. Other IoT smart city applications include intelligent transportation systems and smart buildings. Smart cities employ RFID (radiofrequency identification), wireless sensor networks, and single sensors as IoT components [10].
- Internet of Things in Energy Domain

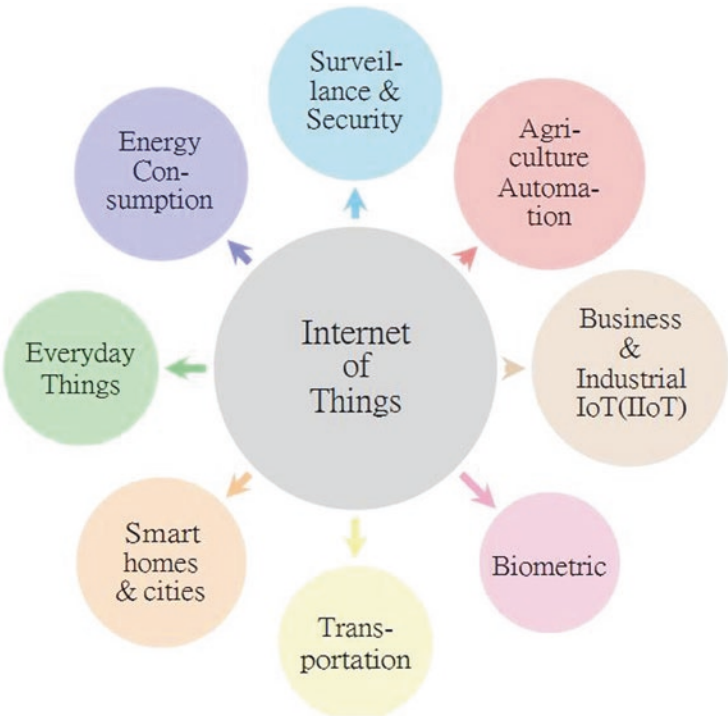

Fig. 4.1 IoT application areas

- IoT can help businesses save money on electricity and increase productivity. Energy management is becoming increasingly essential for utilities and businesses. The Internet of Things is changing energy management systems. It improves energy efficiency and introduces a new method for energy saving. This will help you to use less energy while saving money [11].
- Internet of Things in Health Care Domain
- Equipment integration and remote monitoring are examples of IoT usage in health care. It has the potential to change the way doctors treat patients while keeping them safe. A linked health-care system and smart medical devices can substantially improve people's health [12, 13].
- Internet of Things in Smart Homes Domain
- The smart connected home may integrate a range of smart home services to provide a more convenient, useful, and secure environment for the household members, as well as to assist them in doing household tasks more effectively. Four types of smart connected home systems exist: safety, medical services, energy, and entertainment content [11].
- Internet of Things in Agriculture Domain
- Because of the world's population, the need for food has expanded significantly. To increase the level of agriculture, advanced techniques are currently used in farming [14, 15]. It improves decisions, decreases cost, and boosts production.
- IoT in Biometrics Domain
- IoT is crucial in biometric security systems like eye scanners, fingerprint scanners, and voice recognition systems. Biometrics is a method of identifying a user based on physiological and behavioral features. Because these characteristics are unique to each person, they can be utilized as a safe authentication method.
- IoT in Transportation Domain
- The potential for safety is one of the most exciting aspects of IoT in transportation. Cars that communicate with one another would make up smart transportation via IoT. IoT's better navigation makes it easier for people to commute to work and enhances safety.
- IoT in Business and Industrial Domain

Wireless connections and protocols were designed for low-cost business strategies. We examine several sensor-linking methods. Because of its speed, accessibility, and remote work, IoT is vital in development. The Industrial Internet of Things (IIoT) is the newest buzz in the business (IIoT). And it is all because of industrial engineering and big data analytics.

4.3 IoT in Smart Homes and Smart Cities

4.3.1 IoT in Smart Cities

Some of the popular applications of IoT in smart cities are listed in Fig. 4.2.

Fig. 4.2 Application of IoT in smart cities

- Effective Water Supply

- The Internet of Things has the potential to fundamentally alter how cities manage their water resources. Smart meters can enhance data integrity and leak detection, decreasing revenue loss due to inefficiency and boosting productivity by lowering time spent entering and analyzing data. Additionally, these meters may be equipped with consumer-facing interfaces, allowing households to get real-time information.
- City Lighting
- Cities may utilize contemporary smart lighting to monitor the environment, enhance public and traffic safety, update connectivity as Wi-Fi hotspots, and provide location-based services such as smart parking and smart navigation.
- IoT in Road Traffic

Controlling traffic in cities is critical; else, massive traffic jams will occur. It can be controlled with the use of smart traffic lights. Roads and bridges can also have sensors placed in them to monitor their status so that they can be repaired if there is significant wear and tear. After all, potholes in the road are a big source of traffic.

- Security and Emergencies
- Perimeter access control, liquid detection, radiation levels, and explosive and poisonous gases are just a few applications of IoT technology in security and emergency scenarios. Unauthorized individuals attempting to gain access to restricted areas are recognized and controlled using perimeter access control [10].
- Smart Parking
- In smart cities, a cloud-based integrated parking system has been created. Smart parking lots are now being utilized to increase the reliability of smart cities. The parking lot application assists the user in determining the best parking area and location for their vehicle. This data is obtained from the map to locate the vehicle in the available space.
- Smart Environment
- It entails air pollution monitoring to mitigate CO_2 emissions from companies and pollutants emitted by automobiles. Forest fire detection is used to monitor and set alert zones for gas levels. Weather monitoring includes humidity, temperature, pressure, and early earthquake detection. Water quality evaluates the quality of drinking water as well as the suitability of river water.

4.3.2 IoT in Smart Homes

Some of the most popular application areas of IoT in smart homes are given in Fig. 4.3.

- Health Care and Smart Wearable
- The health-care services industry focuses on offering mobile health care and fitness support to those who wish to live healthier lives on their own. Sensors and software are used to collect data and information about users on gadgets. After that, the data is analyzed to obtain the necessary user insights. Smartwatches are the most common kind of wearable electronics. A fitness tracker is a piece of equipment that records your everyday activity. Google glass is a hands-free headgear that displays information and lets users communicate with the device by speaking instructions.
- Security Services

Remote entrance monitoring services for systems that automatically recognize physical dangers, such as a fire or a burglary, and take appropriate action autonomously are included in smart home security and safety systems. This section includes alarm systems, cameras, and smart door locks.

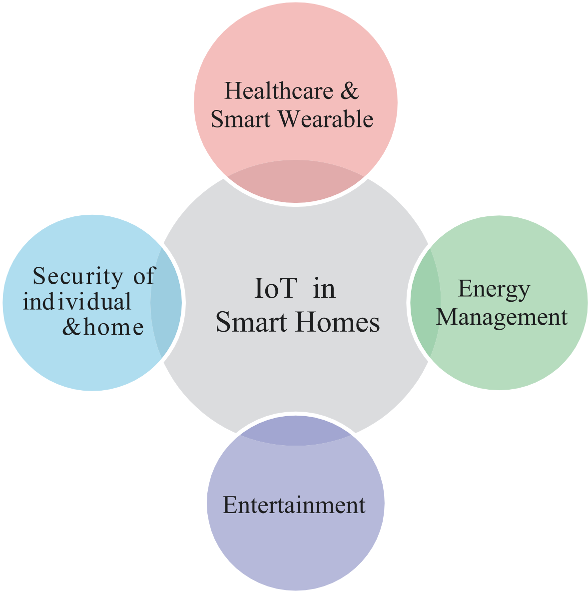

Fig. 4.3 Application of IoT in smart homes

- Energy
- The goal of energy systems for the home is to provide efficient energy usage and management. Smart meters, smart thermostats, and adaptive lighting systems are some of the examples used in the energy domain.
- Entertainment
- Smart speaker systems connected to televisions (TVs) and game consoles are all widespread in the entertainment industry. By analyzing the acquired data and presenting the appropriate information on the customer's table, the entertainment business can forecast and understand consumer behavior. IoT can give users highly adaptable and multimodal experiences by using sensors and actuators.

4.4 IoT Technologies for Smart Cities and Smart Home

IoT involves smart sensors and other gadgets. Weather data, for example, is accumulated at the corporate level of IoT. IoT provides metropolises with new opportunities to use data to manage traffic, reduce carbon emissions, make better use of infrastructure, and keep citizens nice and secure in short livable smart homes. IoT opens new possibilities, such as the capacity to constantly organize devices, as well as monitor and act on data from numerous real-time traffic data channels [16]. Cities are evolving because of IoT products that improve the structure, provide more functional and budget municipal services, improve transport facilities by reducing road congestion, and improve citizen security. Smart city technologies rely heavily on sensing. Sensors give the knowledge and data needed to develop smart city solutions. The authors have developed a methodology for studying IoT sensors, as well as a list of IoT sensors that they have identified in use [17].

- In the context of the IoT, RFID, which comprises readers and labels, is important. RFID may be utilized for several reasons in smart grids, including object detection and placement, health-care applications, parking spots, and investment management. Because each label contains not only manually entered data but also data such as environmental data, it may be used as a sensor. It will be able to automate their surveillance and issue a single digital identity to any of the things, as well as the network that is linked to digital information services [18].
- Near-Field Communication is a type of multimodal short distance communication technology that is commonly found in smartphones. NFC is bidirectional, and it can be used to transmit data, video, and files between gadgets [19].
- The low-rate wireless personal area networks (WPANs) can communicate across distances up to 15 km. This technology uses extremely little energy and has a 10-year battery life, according to Zhu et al. [20].
- Wireless sensor networks make various types of data accessible and can be used in a variety of applications such as health care, government, and environmental services [21]. The architecture of a WSN node is described in Fig. 4.4

IoT home automation refers to the capacity to operate household appliances via electronically controlled computer systems. It might involve preprogramming complex lighting and heating systems, as well as alarm systems and home safety controls, all of which are linked through a centralized site and controlled remotely via a mobile app [22]. The scope and diversity of this sector are immense. Some manufacturers concentrate on improving a specific aspect of the typical workplace, such as temperature regulation. Others create complete smart home hubs with many different touchpoints that hook up to other smart devices, such as Alexa Voice or Google Assistant. Examples:

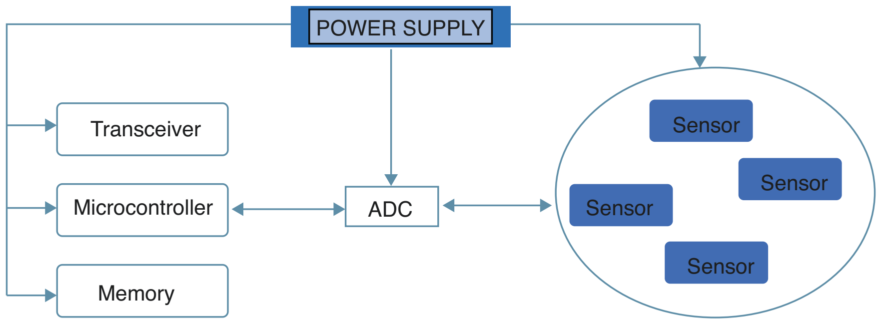

Fig. 4.4 Sensor node architecture

- Smart locks
- Sensor strips
- Wireless connectivity and power
- Solar powers

4.5 IoT Architecture

1. IoT Architecture for Smart City

   Typical features of the various IoT structures proposed for smart cities have been identified, allowing for the creation of a standard framework that collects relevant information in links that will include proposal formulation, as well as identifying various collaborative actors (users, businesses, governments, etc.) and develop the field of e-government, public services, public safety, health services, ICT business startups, traffic, smart buildings, and more. Figure 4.5 describes the IoT architecture for smart cities.

   Users generate data; devices gather data; technology transfers media, stores media, and organizes data; and apps provide the platform to create new applications under a framework that permits integration [23].
2. IoT Architecture for Smart Home

   IoT architecture for smart homes is built using global system for mobile (GSM) communication technology. With this suggested architecture and an Internet connection, users may manage and control smart objects. The graphic

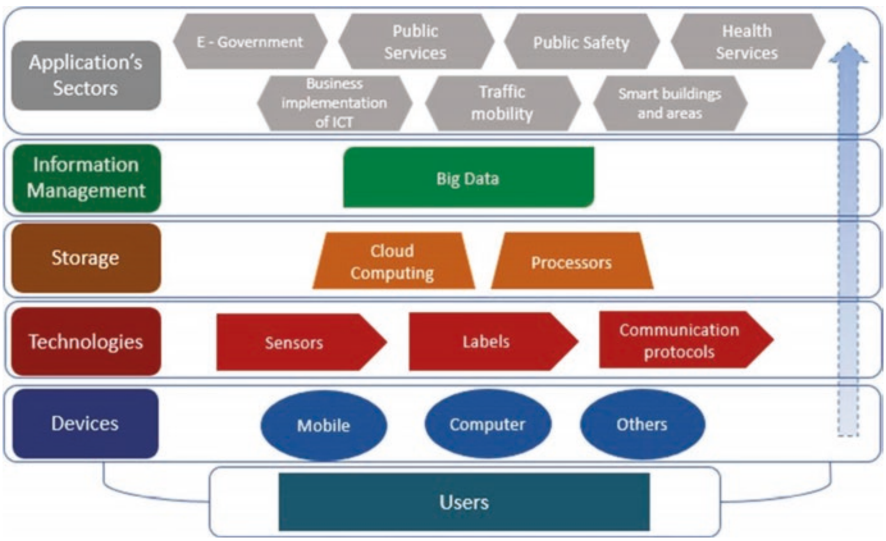

Fig. 4.5 IoT architecture for smart city

Fig. 4.6 IoT architecture for smart home

depicts the architecture of an IoT smart home. Figure 4.6 describes the IoT architecture for smart homes.

It links the smart home to its occupants through GSM wireless communication. The architecture is defined on the web by delivering SMS messages that are translated from the user's inputs and then transmitted to the GSM network, which controls electrical equipment.

It uses GSM SMS for data collection and transmission, as well as the capacity to identify and benchmark devices in a certain region using a pattern, for a variety of benefits including rapid delivery, data loss protection, cheap cost, and energy efficiency. IoT is a hardware and software gadget that continually monitor the webserver and GSM module [5].

4.6 Practical Experiences Over the World

A key source of economic advantage for the USA according to the National Intelligence Council is IoT. People, organizations, and communities across the world are advocating for a better IoT experience.

Table 4.1 Some more examples of IoT impact in cities and countries

Amsterdam [24]	Reduced traffic, energy efficiency, and more security are all goals
Fujisawa in Japan [25]	Reduce carbon footprints
Santander in Spain [25]	Smart parking systems
Stockholm [24]	Providing Stockholm with global fiber-optic networks
Italy [26]	Providing Stockholm with global fiber-optic networks.
Barcelona [26]	Sensor technology implementation, data analysis of traffic flows to create a new bus network and smart traffic implementation
Santa Cruz [26]	Analyze crime data to estimate police demands and ensure that officers are present when they are needed

1. Amsterdam, The Netherlands

   A city's status depends on artificial illumination, which affects the city's capacity to attract business and tourism visitors. This resulted in up to 80% energy savings and over 130 billion euros in savings, as well as increased security and visibility for people. These systems are also connected through the Internet, resulting in greater energy savings [25].
2. New York and Chicago, USA

   Resident-led groups utilize social media to share information and prevent crime in Chicago's inner city and South Side communities. Bus stops, shopping malls, train stations, and sports facilities all include smart displays. Using city-wide sensing and connectivity capabilities, these smart displays safeguard customers [25].
3. Padova, Italy

   Padova Smart City is an initiative of the University of Padova and the Padova City Council. It provides the infrastructure and financing, while the university is the theoretical party bringing the smart city concept to life. Street light pole sensors collect environmental and public illumination data via wireless nodes and link to the Internet via gateways [25].

   Table 4.1 enumerates a few more examples of cities and countries of IoT impact.

4.7 IoT Challenges

All areas of our existence will be digital because of IoT technology. The integration of technology is required to execute the smart city ecosystem. Many smart city implementations are now built on unique services and solutions, but these are not always applicable to other cities around the world and, in some cases, only cover a portion of the numerous components that should be considered.

Residents' opinions on smart city design should include consideration of life quality, with special emphasis paid to the privacy breach when personal identification information and domestic statistics on citizens are involved. This is particularly essential since citizens may oppose or consider the advent of breakthrough technologies as invasive [27]. Accordingly, the smart city concept calls for a shift in government models to be more flexible and integrate institutional policies with underside approaches, thus improving territorial cooperation, collaboration, and access to multiple entities while avoiding the proliferation of similar initiatives that do not work well together [28]. IoT is a technical realm that encompasses a variety of innovations that are as disparate as they are diverse. Because the concept is still being debated, establishing boundaries to evaluate which techniques fall under its scope is challenging, if not impossible [29].

1. Security: The proliferation of sensors in smart cities may expose individuals' daily activities to unwanted organizations. When all data is collected and processed on one IoT platform, the system is susceptible. Multi-tenancy in this system increases security concerns and data exposure [30].
2. Smart Sensors: Many modern computing protocols are designed for infrastructural networked devices that have a baseload; however in many instances, sensors in smart cities will be portable and thus battery operated. They will also have to test, distribute, and, in some situations, save the statistics they have gathered. This demands the development of innovative memory storage technologies, as well as reduced-power gadgets that extend battery life. In the IoT-based system, there have been certain dependability issues. For example, due to the vehicles' motion, contact with them is not always reliable. Furthermore, the proliferation of smart gadgets will pose significant issues in terms of system failures [24].
3. Networking: The ability of sensors and other devices to encrypt and transcript information to each other and the Cloud is critical to the IoT. Networking will focus on developing automated and efficient routing protocols that can meet limitations and function with both stationary and moving gadgets, which many current protocols lack [7].
4. Big Data Analytics: New data analytics methods must be set up to make use of this data and to consistently increase the efficiency and effectiveness in smart cities. With the diverse variety of characteristics monitored in smart cities, these algorithms must be adaptable to data of various types (descriptive and inferential) and improved data fusion techniques must be created to integrate them in significant ways and extract inferences and organize information. Another key factor to evaluate is if the generated algorithms are scaled, in the sense that they have enough specificity and can be applied across the entire program [31]. Figure 4.7 lists the various IoT challenges in the smart city domain.

Fig. 4.7 Challenges for IoT in smart cities

4.8 Conclusion and Future Trends

This article explores IoT integration in smart cities and smart homes. Following an overview of IoT as a key source of the city of the future and smart home services, we examine the smart city and smart home architectures and the challenges they face. Sensing and communication technologies in smart cities and households are examined [7]. Each submission's technology and design were reviewed to offer an overview of current research in IoT-based smart cities and smart homes. This study's application is not restricted to certain sectors. The Internet of Things is a hot study topic right now. The IoT is extensively utilized due to its many benefits, and this research attempts to provide an overview of different IoT systems. The facts are argued with the aid of its benefits. The findings suggest that new researchers may benefit from IoT technology in the future. The proposed technique is highly beneficial in monitoring and managing smart home and city environments. The work [32] is categorized as knowledge engineering, detection, analytical, and regulating. A literature study was conducted to identify and define IoT problems, limitations, advantages, and suggestions (Internet of Thing). We also offered suggestions for other factors/attributes to consider in resolving issues and future obstacles. This tendency is currently under study. But descriptions and limits are vague. It is vital to understand this new Internet trend. This article assesses and categorizes important research to give such insights. Data mining presents a difficult issue in capturing this hidden insights from IoT data. Some experts suggest that IoT data necessitates the development of a new class of data mining algorithms [33]. India's IoT-based smart home and smart city technologies may be deployed in the future [34]. Water and waste management services can be added in the future. One of the most exciting future developments is combining the IoT platform with other autonomous and intelligent systems to build smart and comprehensive applications. New coherent regulatory rules and viable business models are needed to enable the broader implementation of blockchain in real-world smart cities. New coherent regulatory rules and viable business models are needed to enable the broader implementation of blockchain in real-world smart cities. Machine learning techniques will be used in the upcoming IoT-based smart city solution. Ultradense cellular IoT networks based on high-performance machine learning algorithms will be used in next-generation smart cities.

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Chapter 5
Gesture-Based Smart-Assistive Device for Elderly and Disabled People Using IoT

S. Saraswathi, C. Gopala Krishnan, and Prasanna Venkatesan Theerthagiri

5.1 Introduction

Nowadays, home automation systems become more popular and are being installed in a growing number of homes throughout the world. It has tons of advantages to users, even more to the disabled and/or elderly users, and it can make it very easy for them to control their home appliances [1]. Use of wireless sensors to sense data and sends it to the base station in multi hop environment for which routing path is essential.

In this perspective, our project has been designed for disabled people and many elders would benefit in their day-to-day life. This is done with the help of sensors and a microcontroller [2–4]. Our project also aims at achieving automation using an android operating system. The home appliances and electrical devices can be controlled by Bluetooth wireless communication protocol and android mobile from anywhere out of the house when the appliances are not switched off.

The Internet of Things (IoT) is the network of home appliances, vehicles, physical devices, and other various devices that can be embedded with wireless sensors, actuators, electronics, connections, and software that can enable these devices to connect and exchange data [5–10]. Each device can be identified by the unique identifier through the embedded system and it can interact with each other within the existing infrastructure. The number of online accomplished devices can be increased 31%

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from 2018 to 8.4 billion in 2017. The estimation of 2020 IoT devices can reach about 30 billion objects. It can also estimate the global market values of IoT which can reach $7.1 trillion by 2020. In addition to using less human interaction, economic and accuracy benefits are possible [11]. The term "Things" in the Internet of Things (IoT) will be used to describe a variety of electronic items, including heart monitoring systems, streaming cameras for the live feed of wild animals, cars, DNA analysis equipment, and field operation equipment that helps firemen and rescue workers. The valid information can collect from IoT devices that can be used in the existing technologies and automatically data can transfer between other devices [12]. The name IoT was introduced in 1999 by Kevin Ashton of Procter and Gamble and later it changed to the center of Auto-ID at MIT.

5.1.1 An Overview of Technology Architecture

Internet, things, Internet of Things, Internet of Everything are some common words that may have been heard, read, and most likely uttered without interruption. IoT is not a keyword; it is a concept of technology and/or architecture that is a synthesis of already existing technologies [13]. Just as the Internet has changed the way we (humans) communicate through the World Wide Web, the IoT seeks to take this connectivity to the next level by connecting various devices to the Internet, making it easier for humans to interact with the machine. Visionaries also recognized that this IoT ecosystem has business applications in home automation, automotive, factory/assembly line automation, retail, health care/prevention, and more. Figure 5.1 shows the building blocks of IoT.

5.1.1.1 Sensors and Sensor Technology

The sensors ate used to sense a variety of information ranging from location, weather/environmental conditions, network parameters, movement on an assembly line, and jet engine maintenance data to basic patient health information [14–16].

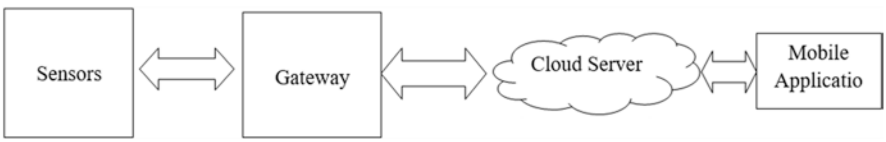

Fig. 5.1 Technology architecture

5.1.1.2 IoT Gateways

An IoT gateway, as the name suggests, is a gateway to the Internet through which things/devices can communicate with each other. Gateways help connect the sensor nodes which are in the internal network to the external Internet or the World Wide Web. It collects data from sensor nodes and transfers it to the Internet infrastructure. The evolution of the IoT gateway determines the success of the IoT deployment. The design of the gateway depends on the area of application.

5.1.1.3 Cloud/Server Infrastructure and Big Data

The data sent over the gateway is safely stored and analyzed using big data analytics in the cloud infrastructure [5]. This data can use to perform intelligent actions, making all of our devices "smart."

5.1.1.4 End-User Mobile Apps

End users will be able to manage and monitor their devices (ranging from room thermostats to jet engines and production lines) from remote areas using the easy smartphone apps. These apps deliver critical information to your mobile devices and assist users by sending commands to smart devices.

5.1.1.5 IPv6

IP addresses are the backbone of the IoT ecosystem. The Internet only cares about IP addresses, not whether you are a human or a money lender. There are very few IPv4 IPs, but there are 3.4 * 1038 IPv6 IPs [17].

5.2 Proposed Methodology

The elderly and/or disabled people can control their home appliances. Home appliances can also be controlled via mobile phones from anywhere away from the house through the Internet. The home appliances and electrical devices can control by Bluetooth Wireless Communication Protocol and android mobile phones from anywhere out of the house when the appliances are not switched off. Home automation for people with disabilities and elders can provide a better quality of life for those who may need care or nursing facilities.

Advantages of Proposed System

- Android application is user-friendly.
- Disabled/elderly people can be independent.
- The status of our home appliances can be known and they can be controlled.
- User-friendly.

5.3 Architecture

Figure 5.2 shows the main module of the product which has a PIC microcontroller, which acts as the main functioning object, a Bluetooth module that connects the PIC with the android mobile phone, and an LCD that helps to show the message. The message can be sent from the client system (android mobile) which can be received at the server end (android) and is then transferred to the kit via a Bluetooth module to the PIC microcontroller. The PIC microcontroller controls the system by sending data to and for the system.

Data from the server device that is an android device can receive from the microcontroller and sends to the LCD which shows the electronic device that glows at present and also to the electronic device. The message sent from the client is received at the server end and is then transferred to the PIC microcontroller and which turns to give the respective electronic device to perform the respective operations.

Consider all the devices are turned off. Now in the android application, all the buttons would be in the OFF state. Now click the start button in the android application from the client end. This would start our device and the system. Now there are respective buttons for all the devices that are to be controlled. Consider a device A that is to be controlled. Now the button is in OFF state. By toggling the button the device is switched ON.

This data is transferred from the client end to the server end and the device via the PIC microcontroller. Thus the data reached the respective device A and that

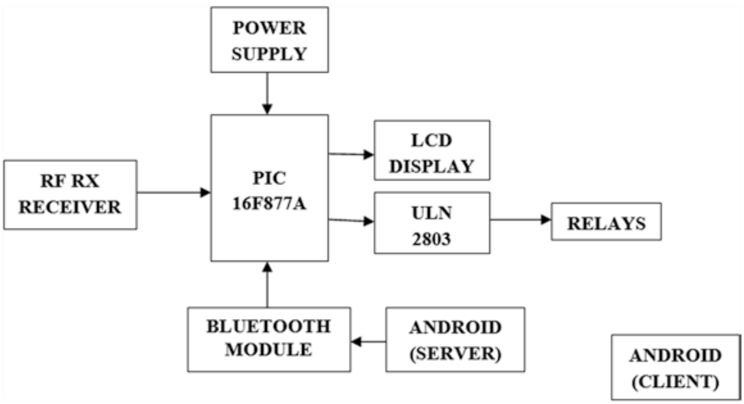

Fig. 5.2 Architecture diagram

particular device turns ON. This can also be turned off from the same application by simply toggling the same button which indicates the OFF stage on the application and transfers data to the device through the PIC microcontroller. When the devices are turned ON the application in the client end shows the status of the device as ON and shows OFF when the devices are turned OFF.

5.3.1 Flex Module

Flex module consists of a flex sensor, PIC microcontroller, and RF TX transmitter connected as shown in Fig. 5.3. The flex module is a passive-resistive device that can be used to detect flexing or bending. The flex sensor is bidirectional which decreases the resistance in the proportion of amount it is bent in either direction. PIC microcontroller is the main module used to transfer data between sensors and the modules. The transmitter is used to send data from the sensors to the electronic devices. The flex sensor is moved so that it sends signals to the PIC microcontroller and this signal is processed and sent back to the electronic device via the Bluetooth module. This signal is then received at the receiver kit which in turn is processed through the PIC microcontroller and then sent to the electronic device that it was indented to.

Consider a flex sensor that was used for an electronic device (say fan). Now, this flex sensor is moved so that an electric signal is generated and is sent to the PIC microcontroller that was connected to it. This signal is then sent to the Bluetooth module that was connected to the main module. This signal that was received from the Bluetooth module is then sent to the PIC microcontroller that was connected to this Bluetooth module. Then this signal is again transferred to the respective electronic device that it was indented and expected to. Thus the electronic device is powered ON. Then again the same sensor can be moved to send another signal that would go through the same Bluetooth module and a PIC microcontroller. This signal is then sent to the Bluetooth module that was connected to the main module. This signal was received from the Bluetooth module is then sent to the PIC microcontroller that was connected to this Bluetooth module as shown in Fig. 5.2. Then this signal is again transferred to the respective electronic device that it was indented

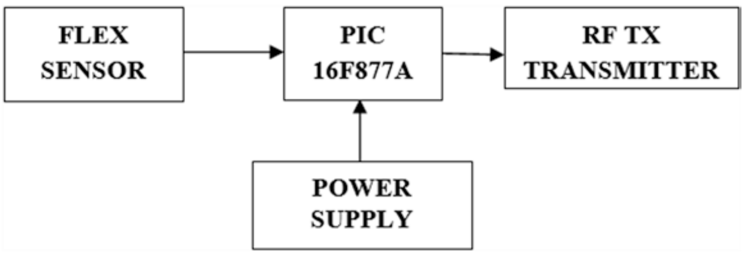

Fig. 5.3 Flex module

and expected to. Thus the electronic device was powered OFF. This way the flex module works for all the other flex sensors that were connected to it.

5.3.2 RF Transmitter and Receiver

The RF module name recommends because it will work in radiofrequency. The radiofrequency range between kHz and 300 GHz [18]. The digital data can represent with various amplitude frequencies. This type of modulation is known as amplitude shift keying (ASK).

The data transmission can take place through the RF which is greater than infrared (IR) because of various reasons. The first and foremost signal of RF can use for long distances and it will be reasonable to use in long distance applications. When there is a break in communication between the transmitter and receiver, the RF can still operate in that mode. As a result, RF transmission will be more reliable and stable than infrared transmission.

The RF module consists of RF transmitter and RF receiver (as shown in Fig. 5.4). The transmitter and receiver can be represented as Tx/Rx which has pair of works at the frequency of 434 MHz [19]. The sequential information can receive by the RF transmitter which can communicate remotely through RF associate with pin number 4. The transmission can take place between 1 Kbps and 10 Kbps. RF can get communicated information and work with various frequencies of the transmitter. This module often utilizes encoders and decoders. The use of an encoder can get the encoding information which can transmit while collecting the decode by the

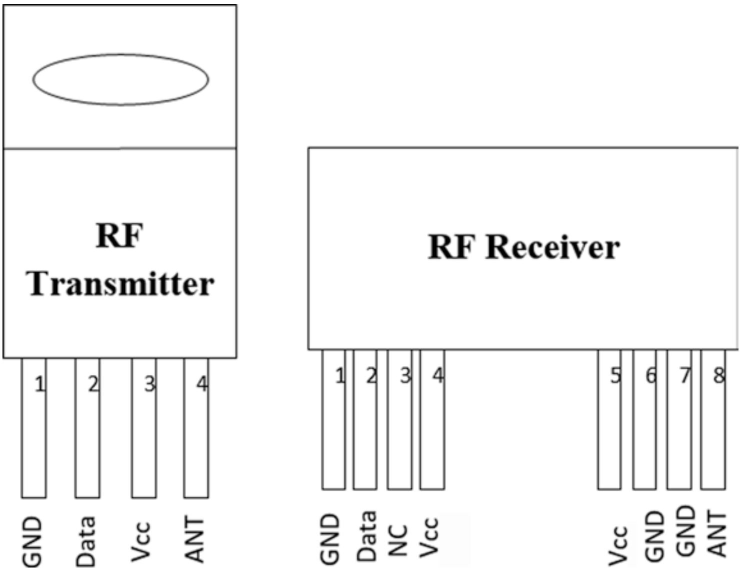

Fig. 5.4 RF Transmitter and receiver

decoder. HT12E-HT12D, HT640-HT648, and so on are some regularly utilized encoder/decoder pair ICs.

5.3.2.1 Pin Diagram

5.3.2.2 Pin Description of RF Transmitter

Table 5.1 shows the various pins of an RF transmitter.

An RF transmitter comprises four pins which are Vcc, data input, antenna yield pin (ANT), and ground (GND) as displayed in Fig. 5.4. The Vcc pin has a wide reach input voltage from 3V to 12V [20]. The transmitter burns through a base current of 9 mA and can go as high as 40mA during transmission. The middle pin is the information pin to which the sign to be communicated is sent. This sign is then regulated utilizing shift keying. The speed at which it can communicate information is around 10 Kbps.

5.3.2.3 Pin Description of RF Receiver

An RF receiver module gets the tweaked RF signal and demodulates it. Recipient modules are normally executed close by the equivalent microcontroller which will give information to the module which can be gotten. The beneficiary module has eight pins as displayed in Table 5.2 The Vcc pin ought to be controlled with a directed 5V stock. The working current of this module is under 5.5 mA. The pins data out and linear out are shorted together to get the 433 MHz signal from the air. This sign is then demodulated to get the information and is conveyed through the information pin. The RF getting recurrence is 433 MHz [21]. The other four pins that are associated with the RF collector are the Vcc (supply voltage), two ground pins, and a receiving wire input pin. The Vcc pin has a wide reach input voltage from 3V to 12V. The RF recipient gets the tweaked signal through the receiving wire; plays out a wide range of preparing, sifting, demodulation, and so on; and gives out sequential information. This sequential information is then changed over to a level rationale information, which is the very information that the client has input.

Table 5.1 RF Transmitter pin description

Pin no	Function	Name
1	Ground (0V)	Ground
2	Serial data input pin	Data
3	Supply voltage; 5V	V_{cc}
4	Antenna output pin	ANT

Table 5.2 RF receiver pin description

Pin no	Function	Name
1	Ground (0V)	Ground
2	Serial data output pin	Data
3	Linear output pin; not connected	NC
4	Supply voltage; 5V	Vcc
5	Supply voltage; 5V	Vcc
6	Ground (0V)	Ground
7	Ground (0V)	Ground
8	Antenna input pin	ANT

5.3.3 Bluetooth Module

Bluetooth is a wireless technology for trading information over brief distances (utilizing short-frequency UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and cell phones and building individual region organizations (PANs) [22]. Concocted by telecom seller Ericsson in 1994, it was initially considered as a remote option in contrast to RS-232 information links. It can associate a few gadgets, beating issues of synchronization.

Bluetooth UART enables you to wireless transmit and receive serial data. Devices equipped with Bluetooth technology support wireless point-to-point connections, as well as wireless access to mobile phones. This can use it as a serial port that can replace and establish a connection between MCU and PC for data transfer. It delivers the received data and receives the data to be transmitted to and from a host system through a host controller interface. Bluetooth module is shown in Fig. 5.5.

Features

- The supply voltage is 5VDC.
- The range of distance can be 20m.
- It can easily pair with a mobile phone.
- It has a distance range of 20 m.
- It has UART interface.

Applications

- It is used in wireless telemetry.
- It can support data logging in a remote system.
- Robotics.

5.3.4 Flex Sensor

The flex sensor (shown in Fig. 5.6) by Spectra Symbol is a 4.5″ bendable substrate that offers increased resistance measurements as it flexes tighter [21]. The output feedback of this 10 K sensor requires very little power. The resistance can rise to five times its base or flat state value. Resistance can be used to calculate the degree

Fig. 5.5 Bluetooth module

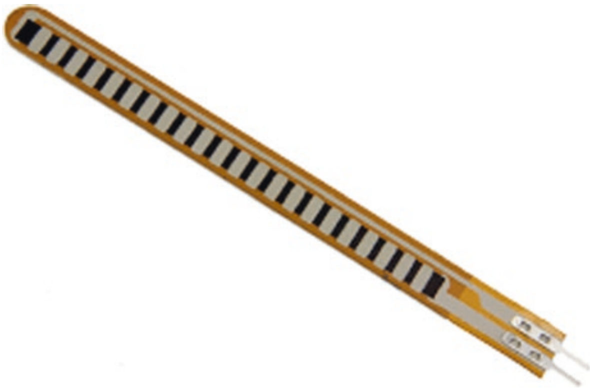

Fig. 5.6 Flex sensor

of flexure or the bend radius. Measuring finger traction, robotics, and gaming are all common applications. The flex sensor's low profile allows it to wrap around objects and fit into tight areas. Its durability is ideal for a wide range of consumer applications, with a life cycle of over 1 million flexes.

Flex sensors are passive-resistive devices that detect the bending or flexing of objects. It is a bidirectional flex sensor with resistance that reduces in proportion to how far it is bent in either direction. On a thin flexible substrate, the flex sensor achieves a wonderful form factor. The sensor gives a resistance output. The higher the resistance value, the smaller the radius. It is possible to connect it to a microcontroller. The sensor produces an analog output.

Flex Sensor Features

- 5v voltage for input.
- The output will be in analog.
- Tolerance of resistance can be ±30%.
- The resistance range for the bend is 45 K to 125 K Ohms (depending on bend radius).

Flex Sensor Applications

- Gaming gloves
- Auto controls
- Fitness products
- Measuring devices
- Assistive technology

5.3.5 Relay

A relay is a switch that is constrained by power. An electromagnet is utilized in many transfers to precisely working an exchanging instrument, yet elective working standards are likewise utilized. Transfers are utilized when a low-power signal is needed to control a circuit (with ideal electrical detachment between controlled circuits and control) or when numerous circuits should be constrained by a solitary sign. The first transfers were utilized in significant distance broadcast circuits, rehashing and once again communicating the sign starting with one circuit then onto the next. Transfers were broadly utilized to lead consistent activities in phone trades and early PCs.

A contactor is a sort of transfer, which can deal with the high power needed to control an electric engine or different loads straightforwardly. The solid-state relays utilize a semiconductor gadget to execute exchanging as opposed to moving components to oversee power circuits [23]. To defend electrical circuits from overburden or deformities, transfers with adjusted working attributes and frequently a few functional loops are utilized; computerized instruments alluded to as defensive transfers satisfy inflow electric force frameworks, comparative capacities.

5.4 Results and Discussion

The system built is capable of helping elderly/disabled people in switching on/off the home appliances in the home. It also features IOT using an android application to know the current state of a home appliance and to change the state. Using mobile devices, we can control home appliances via Bluetooth. The smart home system can be used to supervise the home appliances that can operate remotely and we can monitor the home security through smartphones in real-time.

Some of the systems can allow multiple users to control the home appliances using android applications through the website Home computerization and security assist impaired and old matured individuals, which will empower them to control home apparatuses and alarm them in basic circumstances. The home devices are associated with ADK and set up with the smart mobile phone. The module of GSM can be conveyed to send all collected data by this module.

The primary aim of this report is to build the home automation system based on wireless communication that can manage by the smartphone especially android smartphone, and it can develop and implement at an effective cost with an efficient home automation system. This study paper contains a GUI that can support a user-friendly and secure system, operate home appliances, and assist the elderly and the disabled. Use MP LAB, a free integrated development environment (IDE) created by Micro Technology, to develop embedded applications for dsPIC and PIC micro-controllers. The latest version of MPLAB is X, and it is developed on the Netbeans platform. Both versions, MPLAB and MPLAB X, can support project management, debugging, code editing, and programming of a microchip that can support 32 bit, 8 bit, and 16 bit PIC microcontrollers.

For programming and debugging PIC microcontrollers using a personal computer, MPLAB is meant to work with MPLAB-certified devices such as the MPLAB ICD 3 and MPLAB REAL ICE. MPLAB also supports PIC kit programmers. The MPLAB code configurator and MPLAB harmony configurator plugins in MPLAB X provide automatic code generation.

5.4.1 Local Application

Figure 5.7 shows the screenshot of the local application that controls the electronic devices around a range of 100 m via Bluetooth module. The start button initiates the connection between the application and the kit that sends data to the electronic device. Using of PIC microcontroller, we can control the electronic devices where the received signals from the application via the Bluetooth module was connected with the main module. The application consists of buttons that toggle between ON and OFF for each electronic device.

First, turn ON the Bluetooth in the mobile phone where the application was installed in. The search icon in the top right corner of the application is clicked for the first time for the configuration of the system. Then the device is connected by pairing it with the android phone. Then the android device was connected to the kit via Bluetooth. Once connected a message “connected to the device” popup would be shown and also the description below the main heading “Home Control” would change from “not connected” to “connected to the device name.” Thus it would be known that the device is connected. Then the start button in the android application was clicked so that the connection established between the application and the electronic device was started. Now there are respective buttons with toggling capability for each of the electronic devices that are needed to be controlled. Consider an

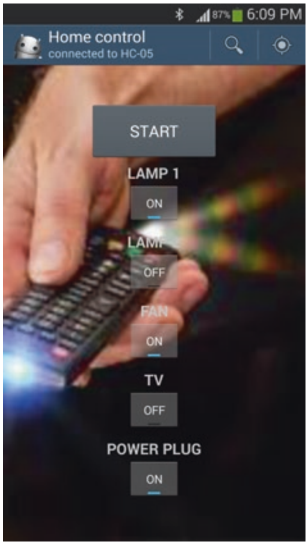

Fig. 5.7 Local application

electronic device A (say fan). There is a button for the electronic device A. This button is initially in the OFF state. Now toggling ON the button would send a message to the receiver kit (main module) which in turn is sent to device A as an electric signal. Thus the device A is powered ON. Now again toggling the button corresponding to A would again send a message to the receiver kit which in turn sends an electric signal to turn OFF the system and thus the device A was powered OFF.

5.4.2 Server Application

The application that would be used to control the electronic devices from outside via the Internet is shown in Fig. 5.8. Here too there is a start button that would initiate the system and run the system. There are respective buttons for each of the electronic devices that are needed to be controlled via the Internet as shown in Fig. 5.8. The electronic devices were controlled with the help of the PIC microcontroller where the signals are received from the application via the Internet. The application consists of buttons that toggle between ON and OFF for each electronic device. First, the Internet is turned ON in the mobile phone in which the application was installed. Once the device is connected to the Internet, it would also connect with the receiver kit. Then the android device was connected to the kit via the Internet. Once connected, a message “connected to the device” popup would be shown and also the description below the main heading “Home Control” would change from “not connected” to “connected to the device name.” Thus it would be known that the device is connected to the receiver kit. Then the start button in the android application was clicked so that the connection established between the application and the electronic device was started. Now there are respective buttons

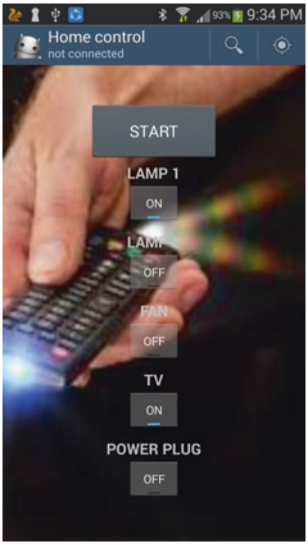

Fig. 5.8 Server application

with toggling capability for each of the electronic devices that are needed to be controlled. Consider an electronic device A (say fan). There is a button for the electronic device A. This button is initially in the OFF state. Now toggling ON the button would send a message to the receiver kit (main module) which in turn is sent to device A as an electric signal. Thus the device A is powered ON. Now again toggling the button corresponding to A would again send a message to the receiver kit which in turn sends an electric signal to turn OFF the system and thus the device A was powered OFF.

5.4.3 Working Module

Figure 5.9 shows the working model for the kit controlling the electronic devices. In the model, there are four bulbs, say A, B, C, D, which act as electronic devices. There is a display to show the message of which bulb is glowing at the moment. Say if A is glowing, the message would be A in the display and if A is in OFF state then “a” would be shown in the display. By this, the electronic device being controlled at the moment would be known instantly. Once a message or electric signal is received from either the Bluetooth module, Internet, or the flex module, the PIC microcontroller would process the message and shows the respective electronic device in the display and send the signal to the respective devices as well. There is a reset button to reset the device when needed. Relay can operate by the electric switches. Many relays utilize an electromagnet to work an exchanging component precisely; yet other working standards are likewise utilized.

Fig. 5.9 Working module

5.4.4 *Flex Module*

Figure 5.10 depicts the flex module for the kit. The flex sensors are connected to the kit as shown in Fig. 5.10. It consists of a PIC microcontroller that controls the flex module and is also responsible for the sending and receiving of messages/signals to and from the receiver kit. The flex sensor on any motion gives away electrical signals. These electrical signals are then sent to the PIC microcontroller which reads the signal and finds the device to be controlled and sends the message to the receiver kit. Then the signal is transferred to the respective electronic device that was meant to be controlled and for which the flex sensor is connected. The display in this flex module is used to show the details of the sensors that are moved up at the moment. It would show the position of the sensor and as the sensors are moved the values would change in the display instantly. By this, the sensor values can be obtained. Once obtained, the sensor values could be used while controlling the device via these sensors so that no two sensors can have the same electronic device controlled. There is also an RF RX transmitter which is used to send the data from the flex module to the receiver kit. This transmitter sends the signal from the sensors to the receiver kit. Once the sensors are bent, an electrical signal is generated which is then sent to the receiver kit via the RF transmitter.

5.4.5 *Main Module*

Figure 5.11 shows the main module which consists of the PIC microcontroller that is used to control the entire kit and relay to switch between the devices and also some electronic devices; here we consider bulbs are electronic devices. The main module is where the electronic device is controlled through the PIC microcontroller. A Bluetooth module is also used to receive the signals from the other modules such as the android application, flex module, etc. When any modules send messages/

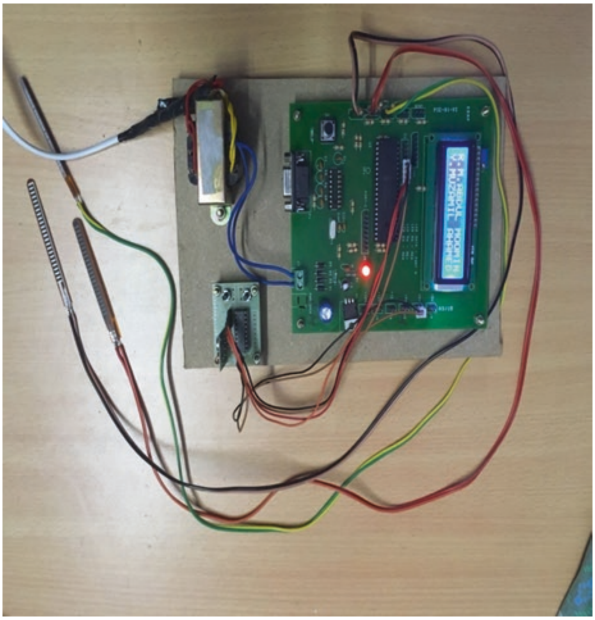

Fig. 5.10 Flex module

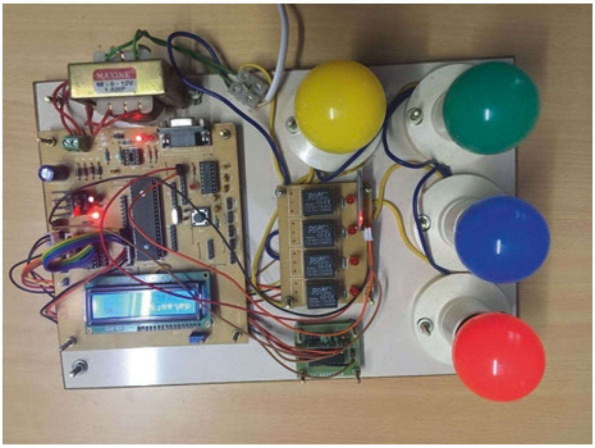

Fig. 5.11 Main module

signals to the kit, the Bluetooth module receives the message and sends it to the PIC microcontroller which turns signal to send to the electronic device needed to be controlled. Consider an electronic device A that is needed to be controlled. This electronic device A that is connected to the kit of the receiver. Now a signal would be received from any of the modules, and this signal would be read from the Bluetooth module and is transferred to the PIC microcontroller. Then the signal is received by the microcontroller and sends it to the respective electronic device A. Now the device is turned ON. Simultaneously a message is sent to the application of android mobile that the device is powered ON which shifts the state of the button shown in the application from OFF state to ON state. Again another message signal to turn OFF the device A could be sent which again goes through the PIC microcontroller and turns the device OFF. Again a message indicating the device is turned OFF and is sent to the application.

5.5 Conclusion

This research concludes the objectives of this paper are met which are the following:

- A wireless home automation system was constructed and controlled using an android smartphone.
- Designed and executed a cost-effective yet efficient home automation system.
- Protected framework and easy to use to control the various devices in the home especially to help the elders and physically challenged people.

This system would help many elderly/disabled people who need others to help them. This would help the elderly people to be free without the help of others for controlling the appliances around. The disabled people can also move freely and operate the appliances freely on their own without disturbing others. In future enhancements, the kit would be reduced to smaller in size using the latest technologies and making it even easier to use by all who feel comfortable to control the appliances from where they are without moving.

5.6 Future Work

The future work of this paper can create a solution for the cross platform that can be used in various platforms like Windows and iOS. This work's limitation is that it only controls a limited number of devices that can be removed by further automating other household equipment [24, 25]. The module can be flexible to support both technologies such as Wi-Fi and Zigbee.

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Chapter 6
IoT-Enabled Intelligent Traffic Management System

Subodh Bansal and Amit Gupta

6.1 Introduction

During the last decade, the trend has been to transfer computers, controls, and data stores to the cloud. The main data center, backbone IP networks, and cellular core networks have in particular been converted from storage, shops, and network management functions. Nevertheless, cloud computing today faces growing difficulties in meeting various evolving IoT new requirements. There are many technological challenges [1] in the IoT, which create an immense network of trillions or thousands of "things" that interact with each other. The IoT in the global information industry after the Internet is perceived as a technology and an economic stream. IoT [2–5] is intelligent by agreed-upon protocols, and Internet-enabled network enables information exchange and communication through information sensing devices. The aim is to define, locate, map, control, and manage matters intelligently. The network that enhances the connectivity from humans to people and things or things and stuff is the Internet-based network [6].

Wireless sensor network (WSN) consist of sensor nodes that can be utilized via Internet connectivity in various areas of applications (e.g., health care, militants, and agriculture), which establishes a sense of IoT. As a result of the Internet of Things (IoT), physical objects with embedded sensors, actuators, and network communication can process and share data. Among the WSN system's parameters are energy consumption and scalability.

The IoT refers to a widening network between physical objects and other Internet devices and systems that have an Internet protocol (IP) interface between them. The

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fundamental aim of IoT is to allow things to be linked to anything and anyone who ideally utilizes all paths, networks, and services [7].

6.1.1 Characteristics of IoT

The basic characteristics of IoT are as follows [8]:

Network interconnection: The key theme of IoT in recent years has been the exponential rise of Internet-based applications. The vast variety of IoT-technology implementations means that the requirements can vary greatly, but the most basic features are shared. The IoT is feasible for many innovations. The network used to communicate between IoT installation devices, a function that can be played by multiple wireless or wired technologies, is of key importance.

Sensing: Without sensors that can identify and measure any environmental changes, IoT will not be able to produce data that can map or communicate with the environment. Sensing technologies provide the medium to construct capabilities that reflect the physical world's real knowledge and consciousness.

Heterogeneity: One of the key areas of the IoT is heterogeneity. IoT equipment is built on certain hardware and Internet platforms and can connect with other service platforms or devices through distinguished networks. IoT helps to interact directly between the heterogeneous networks. The design specifications for heterogeneous objects and their IoT environments are scalability, expandability, interoperability, and modularity.

Connectivity: Connectivity allows the IoT to bring everyday artifacts together. Such objects' communication is critical as basic experiences on an entity level lead to collective knowledge in IoT networks [9]. It provides links to a network and makes everything stable. This connection enables the networking of intelligent objects and applications to generate new business opportunities for the IoT.

Security: IoT devices are, of course, exposed to network security threats. As people gain efficiency, novel experience, and other merits from IoT to forget about the security concerns accompanied with it. IoT has immense security and privacy levels issues. It is crucial to secure the data, networks, and endpoints that are allocated across all of these means constituting a security paradigm. The IoT has a large array of technologies that enable its productive operation. The above features of IoT technology build value and promote human activities. Through shared collaboration, they further improve the IoT network capability and become part of the overall structure [10].

Intelligence: IoT comes with a computer, hardware, and software combination that makes it intelligent. Environmental intelligence in IoT maximizes its capabilities, enabling the intelligent response of objects to unique situations and allowing them to perform special tasks. Despite the popularity of intelligent technology, IoT intelligence is only concerned with computer interaction, while standard input methods and a visual user interface allow user interaction.

Dynamic nature: The primary task of IoT is to collect data from its surroundings, accomplished by dynamic interface changes. Such devices adjust the status dynamically, including the temperature, position, and speed of their devices, e.g., sleep and waking connects and/or disconnects. In addition to the device state, the number of devices varies dynamically with the user, position, and time.

Enormous scale: There will be a far greater number of devices to control and communicate with other devices associated with the current Internet. For applications, it is more important to control and analyze data generated from these devices.

6.1.2 Advantages and Disadvantages of IoT

The IoT provides numerous benefits in the business sector's everyday lives. The following are some of the benefits and challenges of IoT:

Automation: Because physical objects are digitally controlled and connected to wireless networks, a great deal of automation and operational control exist. This allows all machines to communicate without human intervention, which speeds up production.

Cost-effectiveness: When used in everyday life, it allows electronic devices to interact with one another efficiently, conserving energy and reducing costs. By permitting data to be exchanged and transmitted between electronic devices, IoT makes our systems more productive.

Time: The time saved in supervision and the number of other trips will be immense.

Cost-effectiveness: M2M, or machine-to-machine communication, is one of the most well-known examples of IoT. As a result, physical devices can stay connected and comprehensive transparency can be achieved with less inefficiency but better quality.

Money: One of the key advantages of the IoT is that it allows for significant cost savings. So far, IoT has been widely adopted if the cost of tags and monitoring equipment is less than what is saved. In the long run, the Internet of Things is a boon to people because it allows appliances to communicate with each other efficiently, economizing energy and money. In addition, it improves the efficiency of our systems by allowing data to be exchanged across devices.

Monitor: Monitoring is the second most evident benefit of IoT, just after security. Knowledge of someone's home exact supply levels and air quality can offer you the additional information that was previously difficult to collect. By knowing when your milk or printer ink runs out, you may avoid a trip to the store in the near future. Determining expiration dates for products is another way to ensure customer safety.

The disadvantages of IoT technology are mentioned below:

Overdependence on technology: Depending on the information it makes available daily could lead to destruction by taking decisions on technology. There is no stable, faultless framework.

Complexity: All sophisticated systems have flaws. There is a greater chance of something going wrong. Failure rates could skyrocket with the IoT. Imagine that a couple both receive a notice that the milk has expired, and they both have to stop at a supermarket on the way home to buy milk together. The circumstances benefit both you and your spouse. Another possibility is that your printer orders a new ink cartridge over several days, every hour.

Privacy and security: In today's technological world, every computer that is used by a person is connected through the Internet. This maximizes the likelihood of critical data loss. The exchange of information is a major disadvantage, as sensitive information cannot be secure and can easily be compromised by third parties.

Compatibility: Unfortunately, no international standard exists for identifying and assessing compatibility equipment at present. This, in my opinion, is the most easily overcome disadvantage. Manufacturers want to agree on a standard, such as Bluetooth or USB. This is not a novel or original idea that needs to be implemented.

Less employment: Workers and helpers who are not skilled may lose their jobs as a result of the automation of everyday activities. This can lead to a rise in the number of unemployed people in society. With the advent of any technology, this is a problem that can be overcome through education. Due to the automation of daily tasks, there will be a decrease in the demand for human resources. This may lead to a rise in the number of unemployed people in society.

6.1.3 Application Areas of IoT

The IoT application area is very diverse and IoT applications are used by different users. There are dissimilar categories of users with different driving needs. The IoT framework covers "smart" spaces/environments in areas like transport, construction, regional, lifestyle, retail, supply chain, agriculture, emergency, health care, and manufacturing [11, 12]. Table 6.1 shows some areas for IoT applications [13].

6.1.4 IoT Open-Source Platforms

A vital role is played by open-source implementations when it comes to sharing to accomplish multivendor interoperability. It is worth noting that there are several places in the world where small cities can develop quickly and easily.

Table 6.1 Application areas of IoT

S. no.	Applications	Smart objects used
1	Internet of Battlefield Things (IoBT)	Sensors, weapons, vehicles, human-wearable devices
2	Internet of Medical Things	Medical wearable devices – diabetes, heart rate, electrocardiography (ECG), insulin, and inhalers
3	Internet of Underwater Things	Underwater sensors, autonomous underwater vehicles (AUV), ships, smart buoys
4	Internet of Animal Things	Smart cattle collars, animal farming, offspring care
5	Internet of Waste Things	Smart bins, RFID tags, actuators
6	Internet of Nano Things	Nanosensors, actuators, nanorouters, nanomicro interfaces, bio-FETs
7	Internet of Smart Environment	Weather monitoring, air pollution monitoring, water quality
8	Internet of Smart Energy	Wind turbines, powerhouse, smart grid, photovoltaic installations
9	Home Security	Sensors, real-time video surveillance
10	Internet of Smart Industries (IoSI)	Maintenance and repair, explosive and hazardous gases

FIWARE

FIWARE is an open standard platform for applications in smart cities, was launched by the European Commission, and plans to grow new technologies in the IoT prototype. On the other hand, it relies on a set of software components called generic enablers. To increase interoperability, these components have several functions in common to the various vertical segments of an organization, as well as the ability to communicate between them. FIWARE-enabling technologies for IoT are categorized into seven major technological categories: cloud-hosted applications and services, data conveyance, data/context management, security interfaces to networks and devices, enhanced web, and IoT services enablement. FIWARE lays out an easy-to-use collection of APIs that facilitate the creation of smart applications. The lack of a complete set of functions is a major concern despite several benefits of FIWARE.

OCEAN

KETI (Korea Electronics Technology Institute) and the Korean government launched OCEAN (Open Alliance for IoT standard) in January 2015. As a global alliance, it works to develop open-source solutions for smart cities based on IoT standards. It also seeks to promote the creation and commercialization of platforms, products, and services through the widespread use of IoT standards that are open-source. As part of the global cooperation, when it comes to distributing the source code for IoT standards with manufacturers and developers, OCEAN is in charge.

CONTIKI
CONTIKI is also an open platform that allows for the quick and easy development of a variety of IoT-based smart city applications. Tiny microcontrollers can use it to communicate with the Internet, and it operates at a very low cost and power. Furthermore, it is compatible with IPv4 and IPv6, including user datagram protocol, TCP, and HTT. It also provides support for the most recent low-power remotes and mobile networks, such as 6LowN and RL multi-hop routing protocol. A wide range of smart city applications can benefit from its very efficient memory allocation techniques.

OM2M6
When the ECLIPSE Foundation started this project, it intended to provide an open-source implementation of the standards One-to-One and SmartM2M. The project is funded by the ECLIPSE Foundation and the European Commission. By offering a horizontal OM2M service platform for designing services independent of the underlying network, this endeavor will facilitate the implementation of vertical apps and heterogeneous devices. This initiative is funded by the National Science Foundation. As a result, the horizontal Common Service Entity (CSE) is provided by this ECLIPSE that could be deployed in a M2M device, a gateway, or a worker. The key CSE functions are application enablement, starting up, notification, security, persistence, between working, and device management RESTful interfaces are also provided to provide synchronized and asynchronous interactions and bunch association.

Following is a breakdown of the rest of the document. The role of traffic management in IoT is defined in Sect. 6.2, and the literature evaluations are discussed in Sect. 6.3. Section 6.4 discusses the system's methodology. In Sect. 6.5, an experimental finding is discussed. Last but not least, the final section discusses the study's limits, future directions, and implications.

6.2 Role of Traffic Management in IoT

IoT is a new research methodology, and the information related to IoT seems to be in its early stages. As a result, the precise description, design, scope, and norm are still unknown. Most academics, on the other hand, agree on the importance of extending and understanding Kevin Ashton's groundbreaking philosophical description of IoT, which he described as "a systematic way for computers to understand the real world." People with disabilities and diabetes can benefit from IoT in a variety of ways, as well as miners who can benefit from safer mining operations and people who can benefit from an intelligent relationship based on responsiveness and intelligence in the workplace to support human decisions and/or operations. The only difference is that for Ubicomp there is no requirement for an Internet connection so that objects can communicate with one another. It is used to define smart ecology in a wider context than IoT. Applying sensor technology to collect data to make a specific response, for example, is Unicom but not IoT. IoT can be related to human sensors. Humans, for example, have biological sensors such as ears, eyes, skin, taste buds, and other sense organs that enable them to perceive what is going on around them. Humans use their bodies to produce and obtain sounds, and they need a name for others to pay attention to them. Communication is only possible when a communication channel, such as a telephone network, a mobile network, or the air, is available. Sensors must be attached to physical objects being regarded for them to have human-like properties. Objects must have both sender detail and recipient detail, and only digital communication is required. The contact between cars, processing units, and traffic lights is the subject of this paper. Each vehicle serves as an eye in this scenario, transmitting traffic data. The contact is built through socket programming over a Wi-Fi link, and the ports serve as the sender and receiver's respective "mouth" and "ear." By calling the RFID reader name, vehicles can "name" each other. In this instance, IoT can be used to replace human workers in undertaking repetitive, time-consuming tasks. For example, traffic statistics may be acquired and sent out regularly, which is nearly difficult with manual interaction [14].

6.2.1 Traffic Management

Transport, travel, and roads are an integral part of every country and make a difference in every citizen's life. The well-being and development of a country significantly depend on the road and traffic of the country. One of the most significant infrastructure challenges that developing countries confront today is traffic management. Developed countries and smart cities are already leveraging IoT to reduce traffic-related challenges. The car culture has spread rapidly among people from all walks of life. People in most cities prefer to drive their cars regardless of how good or poor public transportation is or how much time and money it would take them to get to their destination.

IoT has proved its potential in vehicle maintenance, navigation, and monitoring leading to improved transportation [15]. IoT can improve road transportation in the following ways:

6.2.1.1 Intelligent Traffic Lights

Intelligent traffic lights interface with the sensors of connected automobiles, providing the driver with important information about the traffic light state, such as color or time to green. This aims to reduce accidents around traffic lights and reduce their violation too through better real-time monitoring.

6.2.1.2 Telematics

Various transportation agencies and fleet management companies use telematics to understand, manage, and improve driver behavior. Telematics employs the usage of a “black box” in a vehicle that is using GPS. The idea is to use the mobile phone network to measure speed, acceleration, braking, and cornering movements. This data is then transferred to servers, where it is analyzed to provide driver feedback. This encourages better driving practices and closer monitoring.

6.2.1.3 Autonomous Cars

To sense their environment, self-driving or autonomous vehicles employ a range of sensors. Radar, Lidar, sonar, GPS, odometry, and inertial measurement units give information required for appropriate navigation pathways. Sensor data is interpreted by advanced control systems to identify impediments and relevant signage.

6.2.1.4 Improved Emergency Services

In case of emergency, connected cars send automatic messages and warnings to emergency services, assisting in providing rapid attention to reduce accident-related death rates. A specific Internet of Things (IoT) gadget, Raksha SafeDrive, acts as an accident management system in the vehicle. Using Raksha SafeDrive is possible in a wide variety of vehicles such as cars, auto-rickshaws, bicycles, and lorries, among other things.

Nowadays, some vehicles are incorporated with fatigue sensors that can detect deviations in the driver’s normal behavior pattern and raise the alarm in danger or if the driver falls asleep. Such intelligent vehicles can make decisions on their own with the data that they receive in real-time. This improves the overall driving experience and enhances safety.

6.2.2 Advantages

Here are some of the advantagesof IoT enabled traffic management:

6.2.2.1 Communication

Device-to-device communication, also known as M2M communication, is enabled by the IoT. Since physical devices may interface with one other, perfect transparency and efficiency will be achieved.

6.2.2.2 Automation and Control

Physical things will be linked and operated digitally, centrally, and wirelessly. Without human intervention, machines will communicate with each other and produce goods faster and more efficiently.

6.2.2.3 Information

It will give additional information to help you make more informed choices, for example, deciding the things to buy in the supermarket or determining if your firm has adequate widgets and supplies; information is power, and more knowledge makes you stronger.

6.2.2.4 Monitoring

Monitoring is IoT's second most important feature. To be able to accurately estimate how many goods we have on hand or the air quality in our home will provide us that information. As an example, knowing that there is milk or printer ink nearby will allow you to avoid making a trip to the store soon. As an added security measure, keeping track of expiration dates could be beneficial.

6.2.2.5 Efficient and Saves Time

Machine-to-machine communication is efficient and saves time. Sensors will be active only for collecting the instantaneous data which makes it more energy-efficient.

6.2.2.6 Better Quality of Life

This technology will promote comfort, ease, and management, all of which will improve people's quality of life.

6.2.3 Disadvantages

The following are some drawbacks of traffic management system:

6.2.3.1 Compatibility

No international standard exists for marking and tracking equipment compatibility at this time. Equipment manufacturers need to make decisions such as Bluetooth or USB. There is no open IoT platform till now.

6.2.3.2 Safety and Privacy

As more IoT data is exchanged, it increases the chance of a privacy breach. As an example, how secure will the data be stored and transferred if it is saved and transmitted securely? Because all domestic appliances, industrial equipment, public sector services such as water supply and transportation, and a variety of other Internet-connected gadgets provide access to a wealth of information. This material is likely to be targeted by hackers. Unauthorized intruders gaining access to private and sensitive information would be disastrous.

6.2.3.3 Less Manpower Employment

Unskilled workers and assistance may lose their jobs consequently of daily operating automation. As a result, there will be a societal unemployment crisis. Due to the automation of daily operations, there will be less demand for human resources, especially employees and less trained personnel.

6.3 Smart Traffic Management-Based IoT

Smart traffic management [16] regulates traffic flow as needed, as a result of the centrally controlled system of traffic signals and sensors. An automated algorithm and sensor data will be used to construct a smart traffic control system to keep traffic flowing more smoothly. To track the movement of vehicles, a smart traffic signal monitoring (TMS) system based on IoT is deployed at the lights. For real-time traffic monitoring, powerful data analytics solutions connect GIS-enabled digital roadmaps with traffic lights and traffic control rooms.

6.3.1 Working of Smart Traffic Management System

Traffic lights, subsurface queue detectors and/or cameras, and a central control system are the three components. The queue detectors provide information to the control system on the flow of traffic on all of the city's principal thoroughfares. In turn, the system manages the traffic signals to guarantee that traffic flows smoothly around the city. Every 2 seconds, the algorithm evaluates whether modifying the phasing of any of the lights is advantageous using a model of real-world situations.

An intelligent IoT-based TMS system collects the image of traffic (which serves as input) at a crossroads using digital image processing technologies. The system then employs wireless sensors to transmit data (serving as output) to the control room or users.

Along with RFID tags and scanners for car tracking, the system can minimize traffic congestion at intersections, trace a stolen vehicle, and free up traffic for emergency vehicles. The emergency vehicles must be equipped with RFID tags for RFID readers to track them in real-time by scanning the signal. Because of this, emergency vehicles can be given priority.

6.3.1.1 Benefits of IoT-Based Traffic Signal Monitoring System

- It helps reduce traffic congestion at traffic lights and on the roads.
- Monitoring of real-time vehicle movement.
- The signals can accommodate a huge number of vehicles.
- Using RFID to track down lost cars.
- Well-organized and precise monitoring of traffic.
- Clearance of traffic for emergency vehicles.

6.3.2 IoT Applications in Smart Cities

The Internet of Things (IoT) makes use of the Internet to connect various diversified devices. All current things must be connected to the Internet in a convenient way and by the rules of the game. For example, to improve energy efficiency in smart cities, sensor networks [17, 18] must be connected online to remotely monitor their treatment. Data may be gathered and analyzed by adding sensors at different locations. Below are a few of the important goals in this branch of knowledge:

6.3.2.1 Smart Parking

To assess whether parking spaces are occupied or available, smart parking systems use GPS data from drivers' smartphones or road-surface sensors put in the ground on parking spots to create an interactive map of available and occupied parking spots in real-time. As a bonus, drivers are alerted when the closest parking spot becomes available, allowing them to use the map on their phone to find a parking spot faster and easier rather than driving around aimlessly.

6.3.2.2 Public Transport

As a result of IoT sensors, it is possible to identify patterns in how citizens use public transportation services. Public transportation operators can use this data to improve the traveling experience, as well as safety and punctuality.

As an example, several London-based train companies postpone passenger car loading for excursions in and out of the city. Ticket sales data, motion sensors, and TV cameras located along the platform are all combined. Using this information, train operators can predict how many people will be in each car at any given time Passengers are encouraged to spread out while waiting for a train to be fully loaded before it leaves. Because they maximize available capacity, train operators avoid delays.

6.3.2.3 Street Lightning

Smart cities based on IoT make road maintenance and control simpler and more cost-effective. The use of sensors in streetlights and their connection to a cloud-based management aids in the adaptation of lighting schedules to the illumination zone.

Data about illumination effect and movement of people and vehicles are gathered by smart lighting solutions, and it should be used in conjunction with historical data such as special events, public transportation schedules, time of day and year, etc. This means that smart lighting tells a streetlamp to fade, light up, or turn on and off dependent on the surrounding conditions.

Some examples include turning on a more dazzling setting when people are crossing the street or when a bus is expected to arrive at a stop, turning on a brighter setting than those further away, and so on.

6.3.2.4 Waste Management

Empty containers are used by most waste collection operators according to predetermined schedules. This is not a particularly efficient approach because it results in unnecessary trash container use and unnecessary fuel use by waste collection trucks. IoT enables smart city aid in waste collection process improvement by measuring waste levels and offering route optimization [19–21] and operational insights. Garbage containers are equipped with sensors that measure how much waste is in them. Whenever the waste management system is approaching a given threshold, it receives a sensor record, processes it, and then sends a notification to everyone. As a result, rather than emptying a half-full container, the truck driver dumps a full one.

6.3.2.5 Environmental Issue Arrangement

Smart city solutions powered by the Internet of Things (IoT) enable the tracking of parameters essential to maintain a healthy environment at an optimal level. Cities can install a network of sensors across their water system and connect them to a cloud-based management system to monitor water quality. Some sensors can tell you how acidic or alkaline the water is. Leakages and chemical changes in water cause cloud platforms to commence an output that is characterized by clients.

6.3.2.6 Air Quality Estimation

The monitoring of air quality is another example of a possible application. On busy roads and around plants, a sensor network is set up. A central cloud platform analyses and visualizes sensor readings so that platform clients can see an air quality map and utilize this data to target problem regions, while sensors measure oxygen, nitrogen, and sulfur oxide concentrations in the atmosphere.

6.3.3 Practical Experience Around the World

6.3.3.1 Amsterdam, the Netherlands

Countless tasks were dispatched in 2006–2007 in Amsterdam, the Netherlands, including interlinked lighting inside the savvy city. Consequently, there were LED illumination used with brilliant regulators for diminishing the force utilization, which can save energy up to 80% and monetary investment funds of around 1300 million euros, giving further developed security to residents as well as greater deceivability. Besides, there is a relationship between these frameworks by incorporating controls using the Internet which gives rise to energy reserve funds. Also, energy use was around assessed before; however, presently keen meters precisely figure the energy utilization. Additionally, lights are darkened or power diminishes to save energy during low traffic hours or upgraded when expected to further develop well-being.

6.3.3.2 Chicago and New York, USA

In Chicago City and Chicago's South Side, utilizing IoT-based instruments including the portable, web, and SMS, people groups like residents, associations, and public networks attempt to trade data and beat vicious wrongdoing. This undertaking was upheld by the University of Chicago by creating trust among neighboring urban communities and neighborhood associations. Moreover, unique information gathered by the police, clients, and foundations will be accessible for a cell phone application client that utilizes a straightforward planning interface and GPS. In New York City, an application called City24/7 has been made to educate, secure, and saturate the city. Furthermore, public correspondence can be accessed at any time, on any mobile device, so that the stage can combine datasets derived from publicly available, neighborhood inhabitants, and organizations to provide data. As a result, this program communicates information that people should be aware of. To obtain this information, certain sharp screens can be found in bus stops, train stations, shopping malls, and sports offices. This could be retrieved over Wi-Fi on cell phones or other mobile devices. These clever screens spotlight individuals with data identified with their genuine closeness and security by offering nearby cops and a local group of firefighters citywide detecting and correspondence powers.

6.3.3.3 Busan, South Korea

In Busan, a city in South Korea, the overseeing body perceived the potential for working with open positions for college graduates and financial development through ICT. Busan has made a decent correlation framework which empowered the public authority to extend the cloud foundation. It associates different organizations like colleges, businesses, residents, and government for driving manageable metropolitan turn of events. These days, the cloud framework interfaces the Busan neighborhood government, Busan Mobile Application Center (BMAC), and different colleges. BMAC provides an actual workspace like task and meeting rooms for normal application improvement, cloud stages for Windows or Mac OS gadgets, counseling places for new businesses and little office experts, the library for applications, different instruments, an API for openness to nearby city information which gives. It can assist with working on the city's essential activities and personal satisfaction.

6.3.3.4 Nice, France

At a recent conference in Nice, France, the potential of the Internet of energy (IoE) was examined, and the IP-enabled innovation engineering model, financial model, and social benefits of IoE were tested and accepted. Then, four astute city administrations were established, including brilliant lighting, astute course, astute waste administration, and astute natural observation. For example, information obtained by sensors for traffic examples can also be used for halting and natural observing through a standard stage that can collaborate with the city to fabricate keen city administrations.

6.3.3.5 Padova, Italy

In Padova, Italy, the University of Padova, as part of a joint venture with the city, a project called Padova Smart City was launched. This project is funded by the local government as a financial sponsor. The college serves as a theoretical partner and helps to further develop smart city concepts.

6.3.4 Challenges

The rising usage of automobiles has resulted in massive traffic congestion. Several countries are addressing this traffic issue by extracting data from CCTV feeds and communicating vehicle-related data to city traffic management centers to aid in the development of changes. As a result of better-organized traffic infrastructure, there are fewer cars, buses, and trucks stuck in traffic jams. All of this results in shorter run times, more efficient use of natural resources (gas), and lower emissions. The amount of gas emitted is highest during stop-start driving, which occurs in regions where traffic is controlled by lights. As a result, opting for smart traffic helps to reduce pollution around the city [22].

Smart traffic management, on the other hand, includes features such as smart parking sensors, smart streetlights, smart motorways, and smart accident assistance, among others.

6.3.4.1 Traffic Lights

To smooth traffic flow, traffic lights that use real-time data feeds are being used. Sensors set in strategic locations can collect data on busy traffic intersections and regions where vehicles are steered away from these sites using IoT technology. Big data may be used to further analyze this information and discover alternative routes, as well as improve traffic signaling to ease congestion. Meanwhile, weather sensors installed on roadside lights allow them to operate. The light dims not just as a result of the day-night cycle but also when the sky darkens. These signals can be detected by roadside light sensors, which can then turn the lights on and off as needed.

6.3.4.2 Smart Parking

In the urban planning context, parking has become an Achilles heel. Parking shortages, as well as parallel parking, have exacerbated traffic congestion at important metropolitan junctions. In parking lots, IoT-based sensors can provide real-time information on available parking spaces to vehicles approaching from a considerable distance. This type of sensor has previously been installed in European cities such as Paris, France, and Kansas, USA. They have all had excellent outcomes, with a double-digit percentage reduction in parking complaints documented in a year.

6.3.4.3 Smart Assistance

Road traffic accidents are one of the biggest causes of death in the globe. However, what contributes to this bleak figure is the victims' inability to receive prompt care and support in these catastrophes. Roadside CCTV and sensors can assist in detecting accident sites and communicating them to the local emergency rooms. Everything else will be easier to handle once this contact is established.

6.4 Research Challenges

There must be proper feasibility in the various fields for some of the IoT's potential applications. For IoT to succeed, it must overcome its limits and limitations. IoT technologies have made enormous strides over the past few years, but there are still several issues that need to be addressed, clearing the way for new types of research to be conducted. An inescapable set of research difficulties arises as a direct result of the Internet of Things' reliance on heterogeneous technologies for data collection and management as well as processing and action. As a result, there are a variety of research difficulties that need to be addressed in a wide range of research fields [23].

6.4.1 Privacy and Security

With its expanding use, IoT has become a critical component of the web's future, necessitating the need to appropriately address There must be proper feasibility in the various fields for some of the IoT's potential applications. security and trust functions. Currently, researchers are aware of the flaws in various IoT devices. In addition, IoT's foundation is based on existing remote sensing networks; therefore it is protected by the same level of privacy and security vulnerabilities as WSN. IoT frameworks have been subjected to several attacks and flaws, proving the need for comprehensive security plans that maintain the security of data and from beginning to end. A comprehensive security solution is needed to close this gap, which includes research into effective cryptography for data and framework security, non-cryptographic approaches, and frameworks. There is a need to do additional research on cryptographic security services that can work on IoT devices with limited resources. This would make it possible for clients with specialized skills to safely hire and deploy. There are IoT frameworks available for all IoT devices, even though the client interfaces are not very good. Additionally, the Internet of Things has protection and security components, and there are other areas such as confidentiality in communication, trustworthiness, and authenticity of communication protocols and message trustworthiness, which are all important. This should contain the capacity to prevent the communication of various parties, for example. Examples include preventing competitors from gaining access to secret information in smart devices during commercial transactions and subsequently exploiting this malicious knowledge to their benefit [24].

6.4.2 Processing, Analysis, and Management of Data

Problems arise owing to the heterogeneous nature of IoT and the huge amount of data created in this "big data" era. Now, the vast majority of cloud-based frameworks are geared toward dumping data and conducting computationally heavy tasks on an international cloud. However, standard cloud architectures have been criticized for their inability to handle the huge amounts of data produced and consumed by IoT-enabled devices, as well as the associated compute. The majority of frameworks are addressing this issue by depending on current solutions such as mobile cloud computing and fog computing, two technologies that are based on edge processing.

6.4.3 Monitoring and Sensing

While monitoring and detection technologies have made enormous strides, they continue to evolve, focusing in particular on energy efficiency and shape. It is common for sensors and tags to be on all the time to collect vital data, making this feature necessary for energy management. Progress in nano-/biotechnologies and miniaturization have permitted the development of actuators and sensors at the nanoscale at the same time.

6.4.4 M2M (Machine-to-Machine) Communication and Communication Protocols

IoT-oriented communication protocols such as Constrained Application Protocol (CoAP) and message queuing despite the existence of telemetry transport (MQTT), there has yet to be a standard for a completely open. It is true that all items require connectivity, but that does not mean that all objects must be web-capable, because some objects only require the ability to place their data. Lora, IEEE 802.15.4, and Bluetooth are also choices for acceptable remote technologies, while the availability of these technologies is unclear.

6.4.5 Interoperability

Web interoperability has always been and will continue to be a vital goal because the first prerequisite in Internet connectivity necessitates that "connected" frameworks can "speak the same language" in terms of encodings and protocols. As of right now, various companies employ several standards to support their applications. This is due to the sheer volume of data and the variety of different devices, using standard interfaces in such a variety of substances is highly significant, and much more so for applications that support cross-organizational, in addition to traditional applications. Because of this, IoT frameworks are being redesigned to support far higher degrees of interconnectivity than before.

6.5 Related Work

Kadar Muhammad Masum et al. [25] proposed leveraging the IoT and data analytics to create a real-time TMS. Traffic density is measured using ultrasonic sensors. Following an examination of the sensor data, the system controller uses a traffic management algorithm to regulate traffic signal timing and transfers data to a cloud server via a Wi-Fi module. Using the proposed method, traffic congestion at the crossing can be predicted ahead of time. To allow an emergency vehicle to proceed through a junction with a long signal time, the emergency vehicle must be identified. A car that violates a traffic signal can be identified, and a fine is levied, which is paid via the Traffic Wallet smartphone app. As a result of this work, a system that is low cost, easy to install, as well as easy to maintain has been presented.

Sarab et al. [26] proposed a system paradigm based on IoT for collecting, analyzing, and storing real-time traffic data. Traffic monitoring in real-time with this technology sends traffic information to drivers via roadside messaging devices. Authorities can also send notifications to the corresponding messaging units about VIP visits or medical emergencies or accidents, which will assist the people to make informed decisions and save time on the roadways. Magnetic sensor nodes are used to capture real-time vehicle data in the proposed system. Most likely, the technology will be considered for inclusion in any smart city endeavor, in the form of an intelligent university campus or other intelligent closed facilities.

IoT systems for traffic management were promoted by Chong et al. [27]. Microsoft Azure IoT cloud server with Intel Edison monitors real-time traffic flow. As traffic increases, the cloud server assigns priority to each road-bound. Greenlight phase time (GLPT) is determined using the dynamic approach in MATLAB. The line length and waiting time at a traffic intersection is reduced by 68 and 67 percent, respectively, when using dynamic cycle TLS. According to simulation data, for each road bound for dynamic cycle TLS, the queue length and waiting time are significantly reduced when compared to fixed cycle TLS. Currently, traffic cops are on duty in the morning and evening rush hours. E, S, N, and W are the four route directions with a maximum backlog length of 75 vehicles. The use of the Microsoft Azure IoT cloud server significantly increased TLS security. As long as this technology is installed at every road crossing in urban areas, traffic congestion can be alleviated to some extent.

Using light intensity, Saifuzzaman et al. [28] developed an intelligent lighting control system that can determine judgments (ON/OFF/DIM). To distinguish between day and night modes, set a specified infrared sensor which can be used to regulate the street light, and the LDR sensor can be used in this scenario. Installing solar cells for power is the most intriguing element of this project; however, if the solar cells fail, then a secondary DC will take over. In addition to the autonomous traffic signal maintenance, the complete system can be monitored through the Internet by installing surveillance cameras. Effortless and economical components are used to build a trustworthy intelligence system.

According to Al-Shammari et al. [29], a WSN gateway access element provides an overlaying access channel between MTDs and EPS, as a traffic flow management strategy. It distributes and organizes network resource sharing for MTC traffic flows within the evolved packet system. It also addresses the influence and interaction of application, service, and terminal device heterogeneity, as well as the related QoS issues among them. By preventing network performance deterioration, this study solves the issue of network resource depletion. Using simulation, the suggested traffic flow management strategy beats the current traffic management policy, according to the study. For example, the proposed model has a 99.45% decrease in packet loss ratio (PLR) and a 99.89% decrease in packet end-to-end (E2E) delay as well as a 99.21% decrease in packet delay variability, according to simulation results (PDV). Because of this, it was established that the proposed policy for managing HTCs and MTCs traffic flows inside the LTE-APro network infrastructure outperforms the current approach in terms of NQoS levels.

Using IR sensors, Rani et al. [30] developed an automated traffic control system. The previous approach has a fundamental disadvantage in that it changes the traffic controller in a clockwise direction, which does not account for traffic density. The traffic density is calculated, and the timer display shifts dynamically. This significant advantage eliminates the possibility of an "unwanted wait" for automobiles in congested areas.

Das et al. [31] provided an efficient algorithm that meets criteria such as low cost, simple installation, and good traffic management. Measurement, control, and traffic avoidance are all addressed by the suggested system, which meets all the requirements.

Kadar Muhammad Masum et al. [25] advocated using IoT and data analytics to construct a real-time TMS. Ultrasonic sensors are used to determine traffic density. Following the analysis of sensor data, the system controller uses a traffic management algorithm to regulate traffic signal timing and transfers data to a cloud server via a Wi-Fi module. Using the proposed method, traffic congestion at the crossing can be predicted ahead of time. To allow an emergency vehicle to proceed through a junction with a long signal time, the emergency vehicle must be identified. A car that violates a traffic signal can be identified, and a fine is levied, which is paid via the Traffic Wallet smartphone app. As a result of this work, a system that is low cost, easy to install, as well as easy to maintain has been presented.

Mostafa et al. [32], heavy loads without having to transfer to a higher layer or cloud distant from the edge, minimizing network traffic and latency, on horizontal offloading in FC.

Internet of Things (IoT) initiatives for demand- and supply-side mechanisms were implemented in Vietnam, according to Le et al. [33]. The authors advised a BMC output for emerging economies to adopt an integrated global value chain vertical integration strategy and improve IoT-based competitive advantages.

6.6 Limitations

As exciting as IoT and big data are for smart traffic management and solutions, they are not without their drawbacks as well.

(i) With the introduction of IoT technology, modern cities already face infrastructure issues such as road design, zoning, and other construction-related hurdles.
(ii) As a result of the high-speed data transfer required by these advanced high-tech solutions, they can only be used in cities with good Internet access [34]. In the event this connectivity is broken for any reason, the entire smart city might come crashing down.
(iii) Thirdly, the increased number of devices that may connect to the central network means that hackers have more opportunities to launch malicious attacks on the central network [35]. It will be necessary to add a layer of protection on top of the standard one to establish a hacker-proof smart traffic solution. Privacy must be safeguarded, which means both politicians and technologists must be involved.

6.7 Summary

Data is essential in every field of work in today's age of new technology. IoT has proven its worth in vehicle maintenance, navigation, and monitoring, resulting in better mobility. Despite significant developments, the signals are still managed manually by humans in the hub. People encounter traffic congestion, particularly in downtown regions. The wide variety of motors on the street has risen dramatically in current years. Congestion is a rising issue that everyone faces daily. Manual site visitor management via site visitor law enforcement authorities is no longer proven to be effective. A version is intended to effectively resolve the aforementioned issues through the use of the Internet of Things.

This paper examines the limitations of conventional traffic management systems, as well as smart traffic control structures used in a few cities. RFID and big data analytics can help you achieve your goals, as well as IoT, and an effective framework is proposed. The proposed system's architecture and functionalities are defined, as well as how supervised learning was used to decide traffic management attributes. When introduced, this advanced device would significantly reduce traffic congestion in major cities while also improving vehicle protection. Cars increase on the road as people move from rural to urban locations. It places strain on transportation infrastructure, particularly traffic management practices in cities and towns throughout the metropolitan area.

Moreover, in this work, the difficulties which happen while executing the IoT framework were clarified. As a feature of our future work, we intend to overview the various answers for existing issues and proposals to moderate a few difficulties of IoT and keen urban communities.

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Chapter 7
A Survey and Challenges: Embedded System on IoT

P. Venkateshwari and Suresh Subramaniam

7.1 Introduction

Individual organizations are encouraged to set up their system. That system should be able to retain the data before its memory fades away [1]. The system which could retain the data is called as Internet of Things, which has become a platform for the transmission of the data nowadays. Internet of Things is the name first termed by Kevin Ashton in 1999 [2]. It deals with the history of information to make any decision related to the dedicated application [1]. IoT is a quickly growing technology and it brings more security problems. Internet of Things connects billions of devices for data collection and sharing of those data [3–6]. But at the same time, it puts highly sensitive data at risk [7]. According to the statistical record, it seems that the number of connected objects increases to 75.44 billion in the year 2025 [8] and the estimated economic growth due to the impact of IoT increases to 6.2 trillion by the year 2025. IoT is a device that has a unique identification and connects to the Internet [9]. Forbes has estimated that 2.5 quintillion amounts of data are produced each day by people, machines, and things.

IoT has an impact on many applications like smart home, smart wearable, smart city, smart farming, smart agriculture, industry automation, health care, etc. Smart wearables are classified into four types based on their applications like health, sport, tracking, and safety [10]. There are several IoT applications out of which require very short response time to accomplish, some need private information from other sources and some require a larger amount of data which could lead to a heavy load

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of a system and it takes longer time for processing [11]. Nowadays based on the application domain, application-specific IoTs (ASIoTs) are designed. The ASIC is used to design different applications because each application requires different design parameters. ASIoT is an emerging research area and it works on different applications like Underwater Things, Medical Things, Battlefield Things, Waste Things, Nano Things, Animal Things, and Mobile Things [12].

IoT technology offers many opportunities. Multiple communication standards, messaging protocols, security algorithms, computation technologies, sensors, and devices for IoT are under development. Communication standards are classified into short-range and long-range. Short-range communication standards are BLE, WiFi, Zigbee, RFID, Z-Wave, etc. Long-range communication standards are Sigfox, LoRa, GSM, 3G, 4G, 5G, satellite communication, NB-IoT, etc. IoT applications use different messaging protocols like MQTT, XMPP, DDS, AMQP, HTTP, and CoAP. Various security algorithms for IoT applications are Blockchain, DES, AES, RSA, Twofish, Triple data encryption standard, etc. IoT uses computation technologies such as edge, fog, mist, and clouds to store and process the data. The types of sensors used for IoT applications are temperature, position, motion, pressure, proximity, chemical, humidity, moisture, etc. [13]. The different vendor processors used in IoT are ARM, Intel, Altium, Atmel, Silicon Labs, Texas Instruments, Samsung, NVIDIA, etc.

The most primary requirements of IoT are computation and communication standards. The resources of IoT should be utilized efficiently otherwise it causes resource constraint issues in handling applications. There are many constraints in IoT devices like interoperability, heterogeneity, robustness, energy efficiency, and other issues like data and device management. Quality of service parameters need to be considered and privacy and security. This paper deliberates about the system architectural comparison, interrupts, task execution, scheduling, switching tasks and latency, prioritization of tasks, real-time tasks, real-time operating system, multitasking, sensors, actuators, memory footprints, and communication standards.

7.1.1 Comparison of Survey Papers

There are several survey papers published in this area that covers the various characteristics and technical parts of an IoT. F. John [10] discussed the various wearable devices and their classification based on the type of application. The author has also discussed wearable challenges and issues. Narasimha Swamy [14] discussed the various communication standards, functional pillars of IoT, various privacy and security issues, three- and five-layered architecture and also the emerging applications and classifications. K. K. Goyal [15] discussed the five-layered architecture and four main technologies used for communication like RFID, NFC, M to M, and V to V and also its applications and challenges are discussed in the work. Mohammed El-hajji [16] discussed the generic IoT architecture and the issues and requirements of each and every layer in the IoT architecture. Hamdan Hejazi [17] provided a detailed survey of the components of an IoT platform necessary for all kinds of applications. Routh et al. [18] proposed technology challenges of IoT and also analyzed several survey papers from a business point of view and also analyzed the various social limitations in which IoT lags. Liya et al. [19] focused on single communication technology over IoT, i.e., LoRaWAN. Rafique et al. [20] focused on software-defined networks and edge computing to solve the complex IoT management. Subbarao et al. [21] proposed a green campus and intelligent campus by surveying several papers on smart campus systems using IoT and also discussed the working model of a proposed system. Dhanalaxmi et al. [22] focused on the system of IoT and discussed the DMA controller in IoT. Dhanalaxmi et al. [23] discussed the network management protocols and their challenges. IoT devices management and its taxonomy are discussed in their work. Datta et al. [24] provided a simple survey on IoT architecture, protocols, SMART IoT-based applications, and security policies.

7.1.2 Motivation

IoT applications and devices made up of IoT are increasing day by day. In most of the literature, the authors described the various strands of IoT. However, none of the works described the IoT system design in deep. Therefore, more attention to be imparted in the system design concepts. Hence, this survey provides a detailed study of a system in IoT.

7.1.3 Contribution

The IoT-based smart devices are used in various applications and it provides a lot of research opportunities. But, still, many of the research works did not address the current issues and developments. This paper provides the levels in architecture, communication standards, computations, scheduling, and RTOS. In summary, this paper aims:

- To review the IoT architectures and examines the relationship of each layer with IoT device
- To analyze the various communication standards and application layers in IoT
- To review the computing standards like edge, fog, mist, cloudlet, and cloud
- To analyze the different OS for IoT
- To analyze the various scheduling methods of IoT

The other remaining parts of this paper are organized as follows. Section 7.2 provides the architectural design of IoT. Section 7.3 provides the task scheduling policies of an IoT. Section 7.4 provides computing methods of an IoT. Section 7.5 describes the processors. Section 7.6 describes the RTOS of an IoT. Section 7.7 describes the issues and future directions. Finally, Sect. 7.8 is concluding the remarks of this article.

7.2 Architecture of IoT

Architecture is generally called an organization of the system. It presents the abstraction of any technology to be implemented [25]. The most commonly used architectures are three-layered and five-layered [26, 27]. IoT follows different kinds of an approach like machine-to-machine- and human-to-machine-based connectivity for heterogeneous types of machines to support a variety of applications.

IoT-embedded node consists of devices, firmware, middleware, and application software.

Devices: Devices are processors or system on chip that captures the data, process the data, and sends and receive the data from interfacings. Devices may be used for any kind of application, even for smaller to large-scale industrial applications. IoT devices can be resized according to the requirements, and its size may vary from microlevel to megalevel. IoT devices are connected with sensors and actuators. These IoT devices can be controlled manually by a human controller or automatic controller by doing the program on the SoC [28, 29].

Firmware: It is a kind of software that provides low-level control on a special type of hardware designed for an application. This software should be located in the OS kernel to operate the low-level hardware. Firmware is most often used in memory hardware. Firmware contains a fixed code to control and monitor a special type of hardware. It always serves for a single purpose application. Firmware is used in routers, switches, and firewalls. Commonly used firmware are LibreCMC, openwrt, IPFire, etc. [30].

Middleware: It is a kind of software that supports multiple applications and hardware to function. It provides connectivity between multiple devices in the distributed network. Middleware comes along with the operating system to provide communication between hardware. Middleware is a mediator between the application and the database. Different types of middleware are available like database middleware, transaction middleware, embedded middleware, content-centric middleware, and portals. It works in the application layer of the network model. There are different middleware packages based on the different platforms and languages. Middleware is just like a library file added in the OS to serve the application [31].

Application software: The application software is mainly to support the consumers and end-users to meet their needs. The main objective of the application software is to collect the data from the connected sensors, preprocess the data, and extract the required information from the preprocessed data. Finally, the processed data is given as an input to the hardware and the actuator responds as per the given input.

Three-layered architecture: It is the most basic and reference architecture model. It consists of three layers like perception, network, and application layer (Fig. 7.1). *The perception layer* is a physical layer used to connect and collect data from the connected end-node sensor devices. *The network layer* is acting as a bridge between the perception and application layer. It helps in transmitting data to the

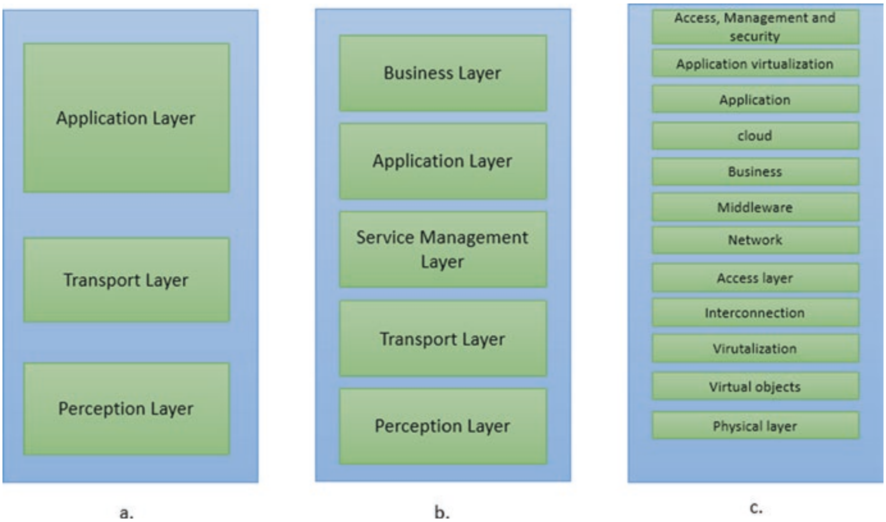

Fig. 7.1 IoT-layered architecture. (**a**) Three-layered architecture. (**b**) Five-layered architecture. (**c**) Twelve-layered architecture

application layer. This layer is responsible for storing and processing the data with middleware support. *The application layer* is the layer responsible for delivering the data in the application-specific user format [32–35].

Five-layered architecture: Five-layered architecture is consisting of business, application, service management, transport, and application layers [32–35]. *The business layer* is used to build business-oriented models, graphs, and flow charts. This layer is specifically used to analyze the data received from the application layer. *The service management layer* is also called a processing layer. This layer provides services in storing, processing, and analyzing the data. *The transport layer* works the same as a network layer in three-layered architecture (Fig. 7.1).

Twelve-layered architecture: This architecture is more focused on the cloud environment [36]. Layers are classified based on their syntactic and semantic analysis to understand the functionalities of each layer [37]. *Layer 1* (physical layer) is used to connect sensors required for the application, connect all the hardware, and help to build an IoT structure for an application. *Layer 2* (virtualization technologies) is used to virtualize the connected devices using the technologies interconnected with the architecture. *Layer 3* (virtualization infrastructure) is used to instantiate the virtual objects. *Layer 4* (interconnection) is used to interconnect the devices by using short-range communication standards. *Layer 5* (access layer) is used to access the gateways, routers, and switches. *Layer 6* (network layer) is used to store and process the data in the server. *Layer 7* (middleware layer) is an application peripheral interface layer used to provide interoperability between the network and the service providing layer. It manages the services for storing, processing, and analyzing the data. *Layer 8* (business layer) is used to build a business model for the end-user. *Layer 9* (cloud layer) is used to store, process, and analyze the data fed in the cloud. This layer is also called as data center. *Layer 10* (application layer) is used to deliver the data to the platform accessed through a specific application by the end-user. *Layer 11* (application virtualization) is used to virtualize the application. *Layer 12* (access, management, and security) is used to provide access to the applications (Fig. 7.1).

7.3 Scheduling of IoT

Real-time systems function not only depends on their correct result but also on their response time. The real-time embedded system computes the results and meets its requirements within the specified time limit. To accomplish the requirements within the given time limit, the system divides its process into several tasks and schedules these tasks in such order to execute within the given time frame. The real-time task should be completed within a given time frame otherwise it misses its deadline, which causes partial function or complete failure of the system [38, 39]. There are many different sensors used for different applications of IoT. Many sensor devices are utilized in real-world applications. Most of the control system includes periodic and nonperiodic tasks. Periodic tasks work with respect to time. The periodic task activation rate always depends on the state variable of an application. If this activation rate increase causes the system utilization factor to increase beyond the limit. An increase in system utilization factor beyond the limit is called an overload condition. The overload condition makes the control system to malfunction. To reduce the overload condition, delays can be introduced but it generates a functionality loss of a system [40]. So better scheduling can reduce overload and offload conditions.

Rate adaptive task: Giorgio C. Buttazzo proposed the rate-adaptive task method [41]. This method adjusts the rate of activities by itself. In this paper, the RAT method is used to control the speed of the engine. The engine operates at different speed intervals for different levels of functionality. These scheduling method results are derived from the EDF method, and it works for both steady-state and dynamic conditions.

The CPU utilization to handle ‘n’ number of tasks in steady-state condition is given by

$$U_i^* = \max_{\omega_i \epsilon \Omega_i} \left\{ \frac{\left(\omega_i C_i\left(\omega_i\right)\right)}{2\pi} \right\} \tag{7.1}$$

where U is the utilization factor, ω is related to angular velocity, C is the execution time, and Ω is the switching speed with respect to ω.

The worst-case utilization to handle dynamic changes is

$$U_i^*(\alpha) = \max_{\omega_i \in \Omega_i} \left\{ \frac{\alpha C_i(\omega)}{\sqrt{\omega^2 + 2\alpha \Delta\theta} - \omega} \right\} \tag{7.2}$$

where α is the acceleration and θ is the rotation angle.

The minimum switching time between tasks is

$$T_i^{(k)} = \frac{2\Delta\theta C_i^{(k)} / U_i^d}{2\Delta\theta - \alpha\left(C_i^k / U_i^d\right)^2} \tag{7.3}$$

where U_i^d is the maximum task utilization factor.

RMS Scheduling with Rhythmic Tasks

Junsung Kim proposed a new task model called the rhythmic task model for analyzing and understanding the task based on its physical events. Rhythmic tasks response time is analyzed for three different engine conditions like constant speed, accelerating, and decelerating the speed. The rhythmic task is classified into three categories based on the worst-case execution time as constant computation, constant utilization, and general computation rhythmic tasks [42].

The maximum value of worst-case execution time of one rhythmic and one periodic task is

$$C_1^* = \frac{T_2 - C_2}{\frac{T_2}{T_1^*}} \tag{7.4}$$

where C_1^* and T_1^* is a rhythmic task and $C_2 T_2$ is a periodic task.

The positive acceleration is an event from the scheduler's perspective, where α is the rate of a period of a task. f_c^* is a function that returns the computation time of different cases such as constant computation, constant utilization, and general computation. n_p^a is the number of preemption which periodic tasks experience in decreasing the time of a rhythmic task.

$$\sum_{i=0}^{n_p^a - 2} \left\{ f_c^*\left(T_1^{*,i}\right) \right\} + C_2 \le \sum_{i=0}^{n_p^a - 2} T_1^{*.i} \tag{7.5}$$

The negative acceleration is an event of an engine to decelerate the speed. n_p^d is the number of preemption which periodic tasks experience in increasing the time of a rhythmic task.

$$\sum_{i=0}^{n_p^d-2}\left\{f_c^*\left(T_1^{*,i}\right)\right\}+C_2 \le \sum_{i=0}^{n_p^d-2}T_1^{*,i} \tag{7.6}$$

EDF Scheduling
In EDF the priority of the task is based on its deadline. If any task has the earliest deadline, then those tasks will be scheduled first. EDF algorithm works for the periodic tasks. But the IEDF (improved earliest deadline first) tasks are nonperiodic in nature [43], and their priority depends on static priority, deadline, and execution time together.

Least Laxity Scheduling
The least laxity tasks are executed at any time in a given time frame. It is a dynamic priority-based algorithm. The laxity means the urgency of a task.

$$L(i)=D(i)-C(i) \tag{7.7}$$

where L is the laxity, D means deadline of task i, and C is the computation time of task i.

A task with zero laxity is executed first and any task with a negative laxity value is stopped due to deadline miss. The least laxity algorithm changes the priority of the job at any time [44].

The least laxity first algorithm works optimal for the uniprocessor system and it outperforms in multiprocessor jobs with fixed priorities. LLF causes more context switching if more than one job has the same laxity. This problem is overcome by using the MLLF algorithm, and if more than one job has the same laxity, it uses priority inversion to avoid context switching time [45].

EDZL Scheduling
The LCPS system has enough computation power to handle all real-world data received from sensor devices. Tseng-Yi Chen proposed an early deadline first until zero laxity scheduling algorithm to ensure the sensor jobs reduce the deadline miss in the LCPS system. EDZL method works better than the EDF method. Earliest deadline first is the scheduling algorithm, which cares for and handles the deadline miss operation. In EDZL the urgent task is serviced first than the normal task. If there is any positive laxity or zero laxity, it preempts the current task in a system. If J jobs in a m process unit miss their deadline, then zero laxity scheduling will be applied. The system services m + 1 jobs at some time before the time t. EDZL schedule uses priority promotion. If a greater number of jobs have higher priority than other jobs, those jobs are scheduled as priority promotion [46].

7.4 Computing Methods

IoT offers different types of computing technologies like end node, mist or edge, fog, and cloud computing. End nodes are sensors and signal conditioning circuits, and these are deployed in massive numbers to capture various physical parameters of the environment. End nodes have sensed raw data. These end nodes are further connected to an edge node. The edge node is also called a mist node. Edge node is comprised of processors or an embedded device. This embedded device will process the sensed raw data. To communicate processed data to a router, bridge, hubs, or gateway, the edge is connected to a fog node. A fog node is a device that provides long-range communication. The computing resource is available in between data source and cloud. Cloud computing is used for larger storage of data. The service cost needs to be paid to the service providers. Cloud computing is an on-demand delivery of data.

End nodes: It is generally a sensor; signal conditioning devices are connected to collect various physical parameters measurement of the environment. These end nodes are gas input to the edge nodes for further computation.

Edge computing: End nodes are grouped connected to an edge node. Edge node serves as the head of that group. It preprocesses the data before transmitting. It processes the data directly from the connected devices in a faster manner. IoT devices determine where to store data either locally or in a cloud. Edge computing supports all real-time analytics and it helps in optimizing performance. Edge computing is having interoperability issues and it is incompatible to serve cloud-based services. And also, the edge computing devices never support resource pooling.

Mist computing: It uses sensors and microcontrollers for collecting and processing the data respectively. Mist computing architecture uses microcomputers and microcontrollers to transfer their data to the cloud for storage and further processing. It uses microcontrollers to make decisions locally. It helps in saving bandwidth and battery power by transferring the data to the cloud. It uses a data access layer to ensure the safety and security of the data at the local host level. This kind of computing is used for limited applications not suited for high-end processing [47].

Fog computing: This is an architecture used for data storage. Any device which is capable of computing, storage, and network connectivity can use this method. This method is used in routers, switches, gateways, and cloud services. This method is used for real-time data analytics to store the data in the cloud. It has a low latency to compute and process the data. It can process larger data compared with the above computing methods. The disadvantage of this method is that it uses multiple links to transfer data from the physical layer.

Cloud computing: This architecture is mainly for sharing the resource pool. It provides five main types of cloud services like a service provider, consumer, broker or agent, carrier, and auditor. The cloud service provider is used to provide a cloud service for the interested groups. A consumer is a unit that is used to provide business-related services. A broker or agent is a unit that acts as a mediator between service providers and consumers. A cloud carrier is a unit that acts as an intermediate in proving connectivity and delivery of cloud-based services [48].

7.5 Processor

The processor is a component required for computing the received inputs and takes decisions according to the results. Processors are used in various applications for processing variants of data. Most of the IoT devices are from 8/16/31 bit processors like Arduino, ARM, PIC, and Intel Galileo. There are several criteria's need to be checked before designing any system like power utilization, device performance, integrability, time to market, and cost [49].

Tables 7.1 and 7.2 indicate the reasons for selecting a lower DSP and commonly used controllers used in IoT respectively.

7.6 IoT Platforms

The OS is the most essential part of any IoT device, which acts as an interface to connect the physical world with the user applications. The kernel is the main core of the OS and it is a central part of a system. The kernel permits to access the resources in the system. System shell can be used to access the kernel for granting the resources to perform any task. Software utility takes care of the system software like assembler, compilers, and code debuggers. Some of the low-powered devices' IoT OS are discussed.

Table 7.1 Reasons for selecting a lower DSP

Processor	Power rating	Performance rating	Integrability rating	Market on time rating	Cost rating
ARM and DSP (for performing floating-point operations)	5	3.5	3.5	5	3.5
ARM and DSP (for fixed-point applications	5	3.5	3.5	3.5	5
ARM+audio coprocessor	5	2	3.5	5	3.5
ARM only	3.5	2	2	3.5	3.5
High-performance DSP (fixed point operations)	5	3.5	2	3.5	5
Low-power DSP+coprocessor	5	2	5	3.5	3.5
High performance ARM+DSP+coprocessors	3.5	5	5	3.5	2

Table 7.2 Popular controllers used in IoT

Device name	Controller type (bits)	Architecture based on compiler	RAM on chip	ROM on-chip
Arduino REV3	8	AVR enhanced RISC	2KiB	32KiB
PIC32MM0256GPM064	32	RISC	16KiB	64KiB
MSP430F5438A	16	RISC	16KIB	256KiB
CC2640	32	RISC (ARM Cortex-M series)	20KIB	128KiB
Raspberry Pi Zero	32	RISC	512MiB	Variable in size

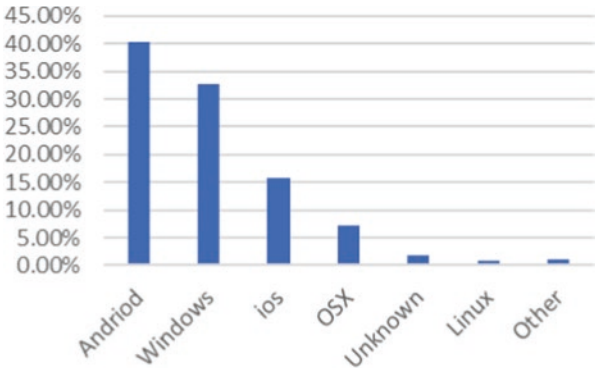

Fig. 7.2 According to the StatCounter data released about the operating system market share worldwide

Contiki Os is more or less like windows and Linux. This OS is used in building up a highly complex wireless system. This OS supports network simulator Cooja, which is used to create, analyze, and test the network scenario. Figure 7.2 shows that the android OS is used 40% than the other OS. Network memory can be accessed for storing and processing the data. This OS is used most of the smart device-based applications to operate the system remotely. Its configuration has 2KB RAM and 40KB ROM [48]. FreeRTOS is a freely available OS. This real-time operating system is used for microcontrollers to make an edge computing device operating at low power for any applications. This OS is used to connect all the devices using the cloud. The most used cloud services are AW IoT and AWS IoT Greengrass to store the message, process the message, and route the message over trillions of devices connected across. It needs 6-15 Kb memory to run an OS in a microcontroller. It has limited computing power and memory capacity [50, 51]. RIOT requires less memory space and it handles the architecture with 8 to 32 bit wide instructions [52]. It has a low-level address space management, task management, and resource management. Tiny OS is a component-based OS. If the devices are similar in the sense, tiny OS programs can be reused on the other devices. It is mainly used in a small sensor-based network [53]. The size of the OS is around 400B. Windows 10 IoT is a part of Microsoft Windows 10 OS. OpenWrt is another

Table 7.3 Popular OS for IoT devices

OS	Type	Application coding language	Usage
Contiki	Open-source	C codes	Network memory is used in constrained devices
FreeRTOS	Open-source	Mostly C codes and certain functions are architecture-specific scheduler	Tiny memory to support edge devices
RIOT	Open-source	C and C++	It supports multithread programming
TinyOS	Open-source	nesC, optimized c code to run on sensor networks with limited memory	Portable to operate in similar devices
Micropython	Open-source	Devices largely compatible with python 3	It is in rapid development
Windows 10IoT	Proprietary	C# and VB	It is used for heavy-duty industrial applications
OpenWrt	Open-source	Lua Programming	It used in routers devices
Embedded Linux	Open-source	Linux kernel	Versatile to operate in various devices X86, ARM, and Power PC

open-source type of Linux OS. It is mainly used in routing components and switches to transfer the data securely over a network. Micropython is very compact. Python coding is used in microcontrollers. It is built up with the combination of low-level C/C++ and faster-level python programming. Embedded Linux is specially built for embedded devices and it is a Linux Kernel variant. It runs on high-end processors like the cortex-A series.

Table 7.3 shows the famous operating systems for IoT devices.

7.7 Issues and Future Directions

In earlier discussions, a brief study is made on IoT architecture, scheduling algorithms, computation, and IoT platforms.

IoT Architecture

IoT architecture is not having any standard form; it varies with the applications, computation, security, firmware, middleware architectures, etc. Practically all the applications would not follow the same architecture. So, integration is not possible in IoT. IoT applications are increasing year by year and these devices are having high mobility. Mobility-based architectures need to be designed. That architecture should address the power constraints and the infrastructure constraint when it operates in several modes like ideal, sleep, awake, block mode, etc. The middleware security policy should be improved to provide real-time secure services in privileged applications like health care, military application, disaster management system, etc.

Scheduling Methods

Scheduling algorithms developed for any basic OS are not applicable for real-time applications. RTOS uses the preemptive scheduling algorithm; it preempts the resource forcefully from the running process and handover it to a high priority process. Because of this preemption, sometimes the high-priority task may not execute on time and the low priority task may wait for a longer period. So the primary concern is that designing a context-aware scheduling algorithm and its compatible OS should be developed. Based on the type of application, suitable scheduling algorithm should be chosen and operated by the system itself

Computing Paradigms

Edge computing depends on the edge node. Edge node provides quick response, fast data analytics, highly intelligent, and most secured [54, 55]. Nowadays, deep learning, machine learning, artificial intelligence, and soft computing are used in IoT applications. DL, ML, and AI algorithms are complex and time-consuming, and it will consume more energy to execute the code in IoT. So, these algorithms should be designed in such a manner as to improve energy efficiency and reduce computation time. Edge computing should support various features like computation time, mobility, scheduling, resource utilization, and scalability because it works on the edge node. Edge nodes are nothing but the embedded system; embedded system has all these characteristics. Fog, mist, and cloud are depending on the server; if the server faces any downtime issues, security issues, and limited control over any services, then this computing suffers a lot and takes much time to respond.

IoT Platforms

A wide range of OS is available like Linux, Ecos, FreeRTOS, CosCox, Rocket OS, QNX, VxWorks, safe RTOS, Tiny OS, RIOT, Contiki OS, Lite OS, Ubuntu, Android, etc. IoT protocols should also be added to the OS like DDS, WebSocket, AMQP, etc. Interoperability issue is there to integrate multiple applications carrying different OS. As per the IEEE spectrum report, the most commonly used programming languages are Python, Java, C, C++, Javascript, C#, R, SQL, etc. The prime concern is to develop an RTOS compatible with all these languages.

7.8 Conclusion

In this work, the basic understanding of IoT and the embedded system is discussed. The architecture of IoT is discussed in the next section and later its issues are also addressed. Then various scheduling algorithms are discussed and its challenges are also addressed. Next computing paradigms are discussed and each computing is explained in a detailed manner. Edge computing issues are also addressed. If edge computing issues are resolved, then it will be useful for developing better IoT. The characteristics of an embedded system and IoT are the same [56]. So embedded system plays a major role or pivotal role in IoT.

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Chapter 8
Integration of Big Data and IoT in the Modern Era

Ashwani Kumar, Deena Nath Gupta, and Rajendra Kumar

8.1 Introduction

IoT has emerged as a result of technological innovations and rapid integration of wireless communication, digital signal, and micro-electromechanical processes (MEMPs) technology. The number of items linked to the Internet has surpassed the total number of people on the planet. IoT is made up of Internet-connected objects such as PCs, cell phones, tablets, WiFi-enabled gadgets, smartwatches, and domestic appliances [1, 2]. The majority of IoT apps do not just monitor discrete occurrences; they also mine the data collected by IoT objects. In the IoT world, the majority of data gathering instruments are sensor-equipped devices that require specific protocols, such as MQTT (message queuing telemetry transport) and a data distribution platform. Because sensors are employed in practically every industry, the IoT is expected to generate a massive amount of data. The data received from the sensors can be utilized to identify possible study trends and investigate the consequences of certain events or decisions. Different analytical tools are used to evaluate this data [3, 4].

Although IoT has generated new prospects for increasing income, lowering expenses, and improving efficiencies, simply collecting a large volume of data is insufficient. To reap the benefits of the Internet of Things, businesses must develop a platform that allows them to gather, manage, and analyze a large volume of sensor information in a modular and valuable manner. In this environment, having a big technology platform that can help with ingesting and reading a variety of data

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sources as well as speeding up the data collaboration is critical. Organizations may use connectivity and analytics to transform their business processes. These businesses can employ data analytics solutions to turn a large amount of sensor-collected data into insights that help. This related matter focuses on current improvements in advanced analytics management in the IoT paradigm, given the intersecting existing research in these domains [5–7].

Information management and smart sensors are the major parts of this linked subject. The analytics are done in real-time so that they may be used to monitor the level of oxygen, fumes, gases, and brightness in various regions of the smart cities. The issue is handled in the Cloudera Hadoop package, with PySpark being used for analytics. The findings indicate that the subject can be used for IoT-enabled big data and analytics. This topic is tailored to smart buildings, but it should be broadened to include other IoT applications such as smart cities and smart airplanes. The industrial advanced analytics system incorporates numerous data processing components in the form of reconfigurable and convertible modules to fulfil varied business needs. This chapter discusses how to handle business informatics using sensors, locations, and unstructured data for knowledge discovery. IoT devices and sensors are used to collect real-time traffic data. Low-cost vehicle detection sensors are implanted in the middle of the road over a distance of about 1000 meters. The data is subsequently delivered to analytics systems, which assess traffic density and propose solutions through advanced analytics [8].

In an IoT-based, interactive contextual setting, this technology allows for distributed information processing and transmission. This subject brings together physically dispersed data by giving end-users virtual data perspectives through predefined interfaces. Several interfaces are made up of several operations and data sets. By bringing processing closer to the data generators in the edge network, Firework hopes to reduce data access latency. Numerous stakeholders must enroll their data sets and accompanying functions, which are structured as data views, in a Firework instance. All members in the same platform instance have access to these content views, allowing them to combine multiple data sets. Climate and water levels, vehicular communication sensors, security objects, intelligent home sensors, and parking space sensors are among the sensors used to collect data. In a real-world setting, a system design is executed utilizing MapReduce, an existing technology [9].

Data generation, data collection, data merging, data categorization, data preparation, and decision-making are all steps in the system implementation. Energy over Hadoop is used to process large amounts of data quickly. To construct a smart city as a software process, smart systems are used as sources of national data. This case emphasizes the importance of open data and norms, including gateways and interfaces, for IoT-based systems to permit the following innovation while avoiding manufacturer lock-in. Based on this concept, the matter will design and construct a Green IoT platform that can be used anywhere in the globe to determine the benefits of open systems and big data for smart city development. However, some procuring rules for open information systems, such as uniform data formats and open application software, must be developed [10].

Data gathering, extract-transform-load (ETL), semantic-rule processing, learning, and action are the five levels in this case. The framework's data collection layer, which accepts data from many sources, can be thought of as an input layer. Sensor drivers are provided by the ETL layer to process signals obtained from various types of sensors. The conceptual reasoning allows a reasoning engine to derive inferences from data collected from the ETL layer's resource analytic framework. The learning layer takes numerous features of the data and turns them into device designs. They concentrate on this architecture for hosting IoT cloud-based services to merge modern centralized network technologies to provide multi-tenant massive data processing, enhanced querying techniques, multiprotocol connectivity, and software solutions [11].

This research focuses on securing data and heterogeneous data transformation from many sources. They emphasize the importance of establishing advanced data discovery techniques as well as executing real-time processing and data handling. They use statistical operators in the database management system engine to input statistical operations into IoT-StatisticDB. Combining these huge data sets with electronic health records (EHR) and providing this data to specialists on a real-time basis are both difficult tasks. They offer a sensor integration paradigm based on this data, which suggests a cloud infrastructure platform that can provide a systematic view of the EHR sensor system. Large volumes of data are processed in real-time using Apache Kafka and Spark. Although monitoring patients' health in real-time can aid in the detection of emergency circumstances, this approach lacks a security program [12]. They also look at the network that urban areas and big data have generated. Some possible objects in an IoT environment are shown in Fig. 8.1.

Consider comparing the results of different machine learning methods, such as k-nearest neighbor (KNN), Naïve Bayes (NB), support vector machines (SVM), and randomized forest, in another domain. The test findings demonstrate that among all classifier models, the NB method has the lowest accuracy, while the randomized forest approach has the best accuracy. They look at how different technologies like advanced analytics may be employed in the smart world to obtain situation facts and perform appropriate responses. They develop a gaming-based crowd sourcing framework for completing certain control tasks by utilizing intelligence. They want to find a good analytical solution that can handle the demands of processing and evaluating massive amounts of data. Because of the reasonable efficiency of parallel data analysis algorithms in an IoT setting, their qualitative examination yields interesting results. Future research should focus on the challenges that prevent this paradigm from being implemented in the context of fog computing. They detect, classify, and define privacy issues from the perspective of data and analytics, as well as expose potential problem areas [13, 14].

They enable things to react to the environment in an urban planning setting, lowering the cost of gathering data generated by mobile devices and gaining information from data if the data is collected and analyzed in real-time. The lower tier is responsible for data generation and utilization; the alternate tier 1 enables interaction among sensors, relays, core networks, and the Web; the alternate tier 2 is responsible for big data processing using the Hadoop framework; and the top tier is

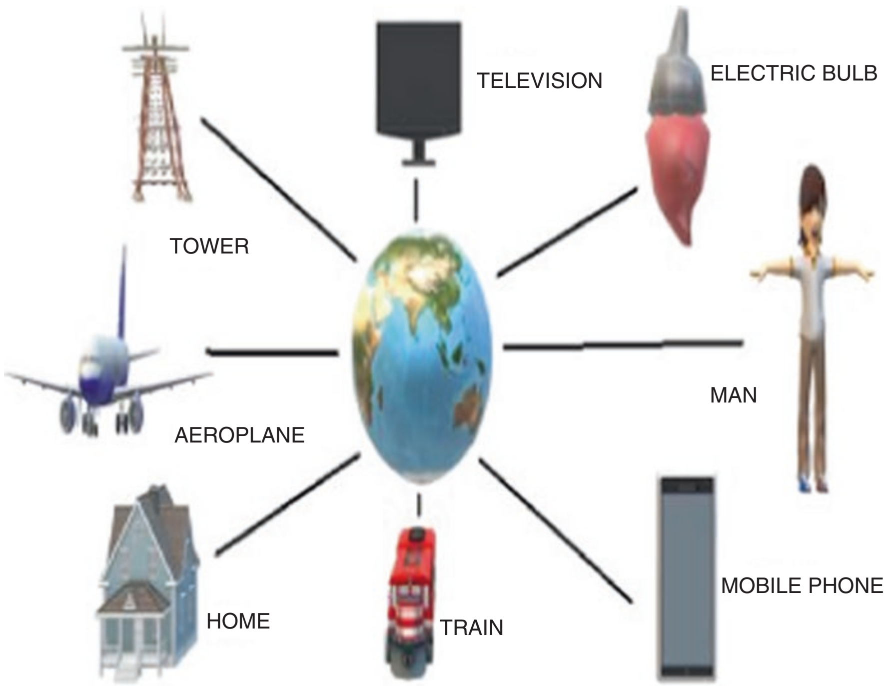

Fig. 8.1 Objects in an IoT environment

responsible for the information analysis techniques and production. According to analysts, IoT deployment in the industrial industry has the potential to change older methods into contemporary ones. Furthermore, such transformations result in a data generation process that converts data sets into corporate massive data, which is rendered meaningless in the absence of analytics capability. Adopting data science can help businesses come up with new content strategies for dealing with competitiveness. The authors also investigate the current state of India's energy projects and the benefits that can be acquired through cloud applications and analytics [15, 16].

The rest of the chapter is organized as follows. Section 8.2 describes the architectural elements of an IoT environment. Detailed information about big data can be found in Sect. 8.3. In Sect. 8.4, the authors discuss the processing of data in an IoT environment. A large chunk of Sect. 8.5 is concerned with big data integration into an IoT environment. In Sect. 8.6, the authors conclude their chapter.

8.2 IoT Architecture

Now, IoT can be used in many different ways. IoT applications operate in different ways based on their structures. IoT does not have a defined system of global adaptability yet. Its usefulness and applications in various industries are determined by its architecture. Four layers of IoT architecture are presented in this chapter. Among the layers are the perception layer, the network layer, the data processing layer, and the application layer. Sensing devices, such as detectors, transducers, and transducers, make up the sensing layer. Data is taken in by these detectors or actuators (physical properties), computed, and then transmitted. Data acquisition systems (DAS) and WWW gateways make up the network layer. Data acquisition and transformation are the responsibility of DAS. A few examples include capturing and integrating data, converting analog signals from sensors and sensors to digital signals, and so on [17–20].

Smart sensors are often connected to the Internet using advanced gateways, which also provide fundamental gateway functions such as virus prevention and filtering, judgments based on incoming data, and data case management. Among the functional units of an IoT environment, the data processing layer is the most important. Various evaluations and preprocessing are done before data is sent to the data center. A software package called a business application retrieves information and prepares the data for further processing. Thus, edge IT or edge analytics becomes relevant. A cloud server is an information management system that continuously collects and encrypts data to be made available to end-users through applications like farming, aviation, and agriculture [21]. It is the application layer that handles the functionality of these applications. IoT is depicted in Fig. 8.2 as architecture.

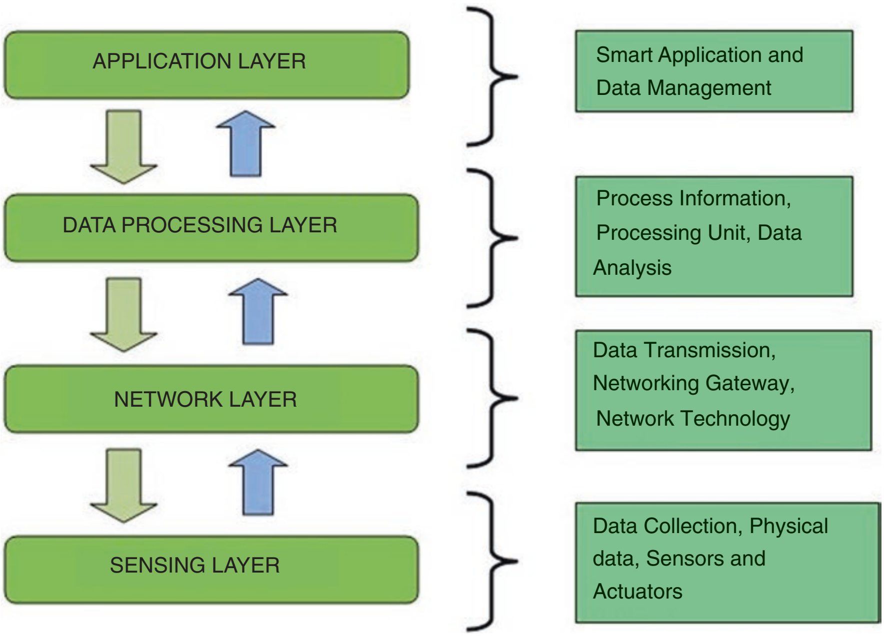

Fig. 8.2 The four layers of IoT architecture

8.2.1 Security Challenges in an IoT Environment

An IoT environment involves “things” that communicate with the Web without human intervention. There is always a connection between these “things” from a refrigerator sending an alert about meals inside to a car sending signals about oil levels to a specialist. As a result, IoT ecosystems, from their makers to users, continue to experience many security issues. Readers will be exposed to some important topics in this article.

8.2.1.1 Checking and Upgrading Are Inadequate

One of the major issues with these technology companies is that they are too sloppy when it comes to dealing with security vulnerabilities related to devices. It appears that the majority of these gadgets and IoT goods are not being changed enough, and some are even getting no modifications at all. It means that a device that was previously considered to be secure when it was purchased becomes insecure over time, leaving it vulnerable to attacks from cyberspace and other sources. Cyber-attacks pose serious risks to corporations, so each device must be thoroughly tested before being released to the public and updated periodically [22].

8.2.1.2 The Use of Brute-Force Attack and Preset Credentials

The makers of IoT devices should not default devices to administrator logins and/or passcodes, as detailed in various declassified documents. In any case, these are only suggestive measures at this point, and there are no legal sanctions in place to encourage producers to stop using this harmful strategy. Credential phishing and brute force attacks in IoT systems are almost universal because weak passwords and login data make them easy to target. Firms that use factory default settings for their devices expose their enterprise and its properties, as well as their clients and their sensitive information, to brute-force attacks [23, 24].

8.2.1.3 Malware for IoT Devices and Extortion

A conventional ransomware program securely encrypts files to prevent people from accessing their computers and other devices. Interestingly, however, hybridized spyware and extortion variants are being developed that attempt to combine the two kinds of attacks. By reducing or blocking the functioning of devices, ransomware attacks can collect user data as well as restrict or block device functions. Cameras can then be blocked and films send to a corrupted website, which can use the ransomware access point to retrieve sensitive information and then seek compensation so that the cameras and data can be unlocked. Future attack possibilities will become increasingly unpredictable as the number of gadgets continues to expand [25].

8.2.1.4 Cryptocurrency-Focused IoT Botnets

Identities, credentials, and secret keys are already being retrieved by social engineering. The hijacking of IP cameras and even video cameras is part of a cryptocurrency mining strategy. Breach of blockchains, IoT botnet mining, and data security modifications represent a significant flood damaging the cryptocurrency market and upending cryptocurrencies' already unpredictable value and architecture. For blockchain platforms and IoT applications based on blockchain technology to avoid future security concerns, they should be tested, monitored, and maintained regularly [26].

8.2.1.5 Considerations About Integrity and Confidentiality

IoT devices make up a wide range of devices used by large enterprises that constantly capture, handle, keep, and process information, including smart TVs, amplifying systems, lighting systems, linked printers, HVAC systems, and home automation. The data and information relating to customers are frequently distributed to numerous companies and even sold to them, breaching customer privacy and information security rights and leaving the public in fear. To achieve proper separation of IoT data payloads from personal information, it is necessary to establish privacy guidelines to redact and anonymize confidential information before gathering the data and trying to separate the data from payloads. Cached data that is no longer necessary should be disposed of safely [27].

8.2.1.6 Small-Scale IoT Assaults That Go Undetected

Micro-breach attempts will almost certainly increase in the next few years, according to the computer science community. As opposed to employing the largest weapons, attackers are most likely to use smaller stealth attacks that are tiny enough just to be able to allow data to trickle out instead of collecting thousands upon thousands of records all at once [28].

8.2.1.7 Intelligence and Robotics

Artificial intelligence (AI) and automation are already being used to sort through large amounts of data, and in the future, they may assist IoT administrators and network security personnel with enforcing data-specific policies and detecting anomalous data and traffic patterns. Using independent infrastructure to ensure independent decisions which impact millions of activities across large infrastructures like health care, power, and public transit, however, is unwise, especially when users consider that just one small bug or one badly coded algorithm can bring the entire architecture to a standstill. Usually, the bulk of the security solutions focuses on two categories: shielding IoT devices from attacks and safeguarding the security of user data [29].

8.2.1.8 Attack of the Home

Among the most frightening concerns that IoT could present is the possibility of a domestic dispute. Several IoT devices have now been widely adopted for use in homes and offices, leading to the development of building automation. Despite the proliferation of IoT gadgets, their security is a major concern because they may reveal the IP address of their user, which can be linked directly to her home address. It would be easy for hackers to sell this vital information to underground websites which are safe havens for criminal gangs. Furthermore, if she uses IoT devices in her security systems, she runs the risk of them being hacked and her home compromised [30].

8.2.1.9 Automobile Approach from the Distance

The idea of connected vehicles is beginning to become a reality with the help of IoT devices. Despite its IoT capabilities, its connection makes it more vulnerable to car thefts. The remote access feature of the smart automobile could be used by an advanced hacker to take control of it. It is an extremely dangerous position as anyone can use the vehicle, making the user vulnerable to deadly threats [31].

8.2.1.10 Information That Is Not Credible

Many IoT devices use the network without encrypting communications. Currently, IoT security issues are one of the most significant threats facing the industry. The time is now for all businesses to ensure that the cloud and their devices are encrypted to the highest degree. The easiest approach to avoiding this issue is to utilize transport protection and protocols such as TLS. It is also possible to use separate networks for different devices [32].

8.3 Big Data

Big data is a group of massive data that cannot be processed with typical computing methods. It is no longer a single approach or tool; rather, it has evolved into a comprehensive subject encompassing a variety of tools, techniques, and contexts. The data generated by various devices and systems is referred to as big data. Several of the fields that fall within the big data category are social media data, stock exchange data, power grid data, and transport data. As a result, big data encompasses a large volume, velocity, and diverse range of data. There will be three different categories in it, viz., structured data (relational data), unstructured data (word, PDF, text, media logs), and semistructured data (XML data) [33].

Structured data is any data that can be maintained, retrieved, and analyzed in a predetermined format. Over time, computer science talent has become more successful in inventing approaches to working with such material (when the format is fully understood in advance) and extracting value from it. However, we are already anticipating problems when the bulk of such data expands to enormous proportions; ranges of approximately are in the tens of terabytes of data. An example of structured data is given in Table 8.1.

Unstructured data is any data that has an undetermined shape or organization. Unstructured data, in addition to its enormous bulk, faces several handling obstacles in extracting value from it. A mixed data source including a mix of text-based files, photos, videos, and other types of unstructured information is a good example. Firms nowadays have a lot of data at their disposal, but they do not know how to make a profit from it because the data is in its original form or unprocessed format. An example of unstructured data is shown in Fig. 8.3.

Both types of data can be found in moderately data. Moderate data appears to be structured, but it is not defined by a table specification in a relational database management system. A data set contained in an XML file is a form of semistructured data. An example of semistructured data can be seen as personal data stored in an XML file. For example, <rec><name>UmeshKumar</name><sex>Male</sex> <age>33</age></rec> OR <rec><name>Pratiksha Joshi</name><sex>Female </sex><age>31</age></rec>.

In the era of IoT, big data developments include universal wireless connection, authentic analytics, machine learning, and feature extraction elements such as affordable detectors and embedded devices. IEEE 802.15.4, IEEE 802.11, IEEE 802.15.1, and IEEE 802.16 are the most widely utilized universal wireless technology protocols for transmitting massive data in IoT. The large data generated by IoT devices are available to use as soon as it enters the system, thanks to real-time processing. A level of technological readiness that is either immediate or virtually

Table 8.1 Example of structured data

Emp_ID	Emp_Name	Gender	Department	Salary (PM)
1931011	Umesh Kumar	Male	Finance	65,000
1931012	Pratiksha Joshi	Female	System admin	45,000

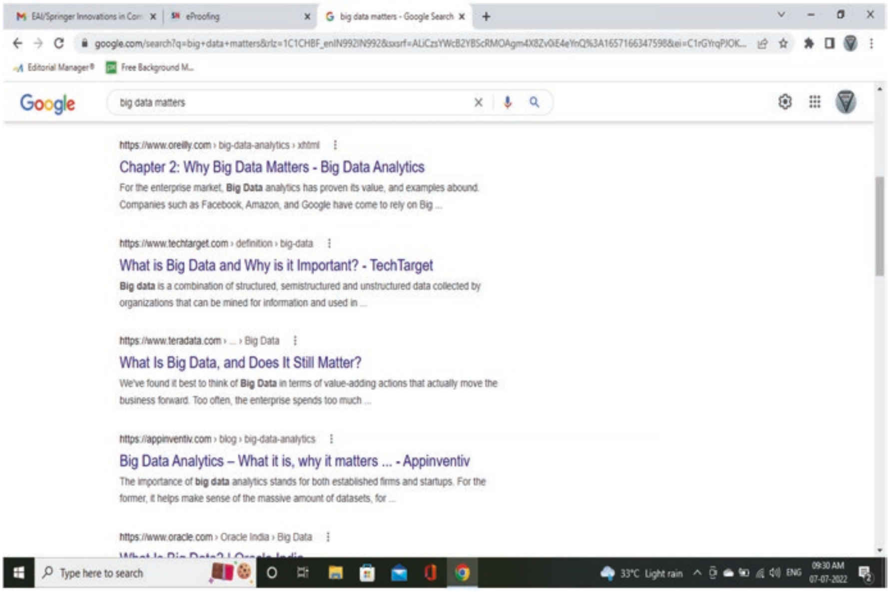

Fig. 8.3 Example of unstructured data

immediate is referred to as real-time. Computer science, unlike conventional analysis techniques, can uncover hidden ideas in big tools for extracting values from large data sets with minimal interaction. Because of the various data sources and the large volume and variety of data included, machine learning is well suitable in the IoT environment. Many sensor nodes are used to acquire massive data in IoT. This sensor technology plays a vital role in data collection and transmission to neighboring edge services for computation [34].

The many big data technologies include a range of events, strategies, and approaches that are used for a variety of goals. This section looks at several previous studies on big data operations and explores different actions for categorizing big data techniques utilized in IoT. The two major aspects of big data processing are (a) data management and (b) data analytics. Data management is the process of obtaining, keeping, cleansing, and extracting data for analysis and preparation. Data analytics, on the other hand, is focused on extracting intelligence from the obtained output through modeling, analysis, and investigation. The exploitation of big data offers several enticing possibilities. Professionals and researchers, on the other hand, have a variety of obstacles when it comes to analyzing big data sets and extracting knowledge and information from data analysis. Data ensnaring, saving, accessing, publishing, analyzing, managing, and imagining all contribute to the chunkiness. Furthermore, with decentralized data-driven systems, there are both privacy and security concerns. The following are the key issues that big data presents [32].

A huge volume of information refers to a large volume of information that is sometimes referred to as "tonna bytes" to refer to the true measurement device where the volume of information becomes denigrated, particularly in the context of creating domain-relevant data. Variety refers to dimensions, combinatorial explosions, a variety of additional data types, and a variety of data representations. Velocity is the rate at which data items enter and exit the system in real-time. Sometimes is referred to as throughput. The system may be threatened by a high frequency of data transmission. Veracity says that it is critical to have enough data to evaluate a variety of assumptions, as well as large training blocks for microscale model development and model validation. Validity refers to data integrity, accountability, and master data (MDM) on large, diverse, scattered, as well as divergent, "dirty" data sets.

The value defines the company's worth and the potential of big data to transform the organization from beginning to end. Variability refers to changeable spatial-temporal data, longitudinal data, periodic data, and a variety of other nonstatic features in information sources, clients, research objects, and so on. The venue represents incongruous scattered data from numerous platforms collected from various owners' systems, each with its access and requirements. Vocabulary denotes schemas, statistical models, ontologies, semantics, classifications, and other content. Context-based metadata is an example of vocabulary. They try to describe the data's format, syntax, content, and provenance. Vagueness encapsulates the perplexity surrounding large data semantics [35]. The ten Vs of big data is summarized in Fig. 8.4.

8.4 Processing of Data in an IoT Environment

The processing of data is important before its use in the environment. It saves a lot of energy from the devices at run time. The processing can be achieved in six steps, viz., extraction, loading, preprocessing, processing, analysis, and transformation and visualization. The technique or act of extracting data from data inputs for processing or storage is known as data extraction. Data transformations, as well as the probable incorporation of metadata, are thus pursued in the transitional organization before transferring to any other level in the workflow. Data loading is the process of loading changed data into a location where consumers can interact with it. Preprocessing stage is a data mining technique that turns original information into a more understandable format. Practical data is frequently contradictory, incomplete, or lacking in several ways. Data from the real world may have several mistakes. As a result, data preparation is a tried and true way for tackling these challenges [36].

Data processing is the collection and modification of data pieces to generate useful information. It is possible to think of it as a subset of data processing. Data analysis is a method of analyzing, manipulating, and modeling data to uncover usable information and support decision-making. In the fields of science, marketing, and sociology, data analysis entails a variety of methodologies and approaches.

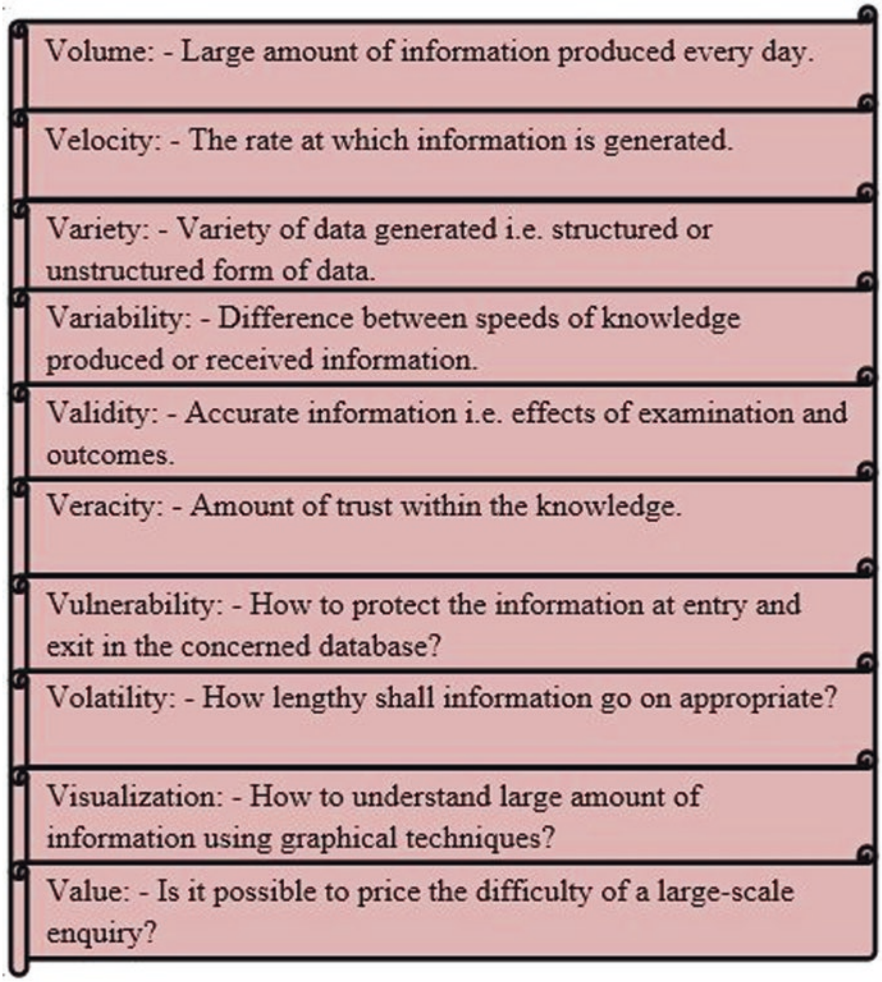

Fig. 8.4 The ten Vs of big data

The process of changing data from one format or structure to another is referred to as data transformation. Many data integration and data management jobs, such as data manipulation, data storage, data transformation, and application integration, follow this general trend. Any endeavor to help individuals consider the interpretation of data by putting it in correct apparent reference is referred to as data visualizations [37]. The steps involved in data processing are presented in Fig. 8.5.

1010data is a columnar database that primarily works with quasi data, such as data from IoT devices. This tool offers complex analytic services, such as optimization [38–40] and statistical methods, in addition to data visualization, reporting, and integration. Increase the capability is also well supported by 1010data. To communicate with back-end systems, this tool likewise functions in a centralized manner

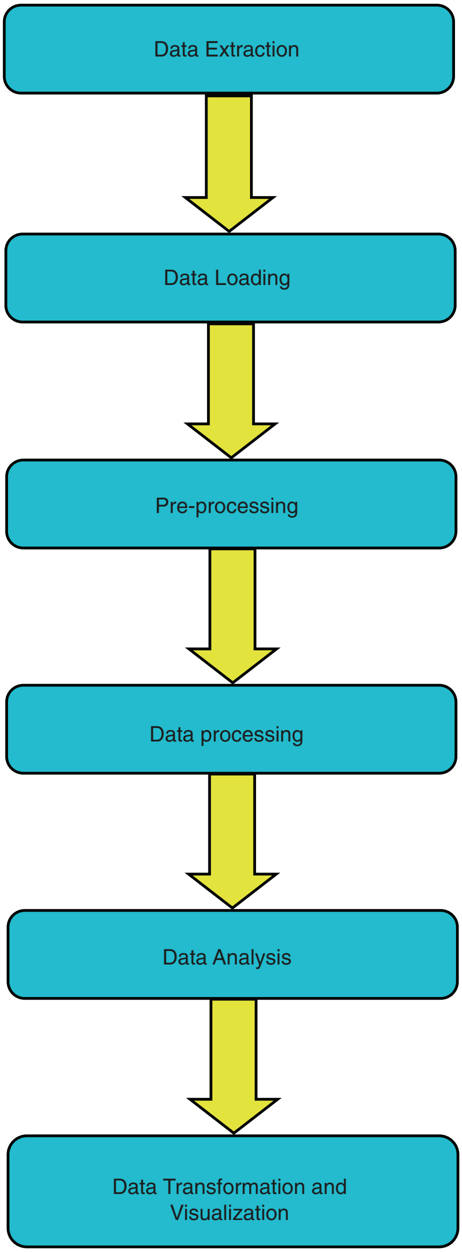

Fig. 8.5 Processing of data in an IoT environment

and employs access controls. With its extensive analysis capabilities, 1010data can meet customer demand. In terms of data extraction, modification, and loading, however, 1010data is deemed ineffective. Hadoop is an open-source data processing platform that uses commodity technology to store and process huge amounts of data. The Hadoop Distributed File System (HDFS) and the MapReduce programming style are the two most significant pieces of the Hadoop architecture. The data is stored in HDFS, and MapReduce is used to handle it in a distributed way.

Hadoop, despite its several benefits, lacks privacy at the network and storage levels, has limited flexibility, is unsuitable for tiny data volumes, and has a large I/O overhead. HP unveiled Hadoop Autonomy Vertica Enterprise (HAVEn) security, a new big IoT data framework paradigm for a wide range of HP systems that can be used with a wide range of applications. For the major Hadoop application developers, HP supplies reference hardware configurations. Vertica is an analytical database management system for a tabular database with highly parallel computing that seeks to speed up the analysis of large structured data sets. To supplement traditional enterprise data centers, HP HAVEn is presently partnering with several companies. HP has added a "Flex-Zone" to make it easier to explore enormous data sets before deciding on a database scheme.

8.5 Integration of Big Data Into an IoT Environment

IoT consists of smart sensors connected by various protocols, such as Bluetooth, ZigBee, and GSM, among others, which provide a tremendous amount of data every second. It is no wonder that big data and IoT are redefining industry and technology at such an accelerated rate, and the benefits it offers to organizations and individuals are increasingly fast. In the last decade, IoT has generated unprecedented quantities of data that have changed the face of big data. As a result of massive volumes of data collected from numerous sensors, big data analytics has become very challenging. Depending on the data collected, complex optimizations or simple drill-downs can be conducted.

A health-care system powered by IoT can collect data from multiple sensors placed on a patient's body to diagnose and treat them. An example of this kind of analytics is a system that utilizes sensors to generate an automatic response based on the collected data. One of the most significant features of such a system is the ability to collect real-time information from sensors and run processes that can immediately identify situations in which medical aid is needed [41]. If a crisis is identified, health-care professionals or emergency service providers should be notified immediately. As every second could be the difference between life and death here, the analysis-response phase should only take a few seconds [42].

There are several ways to implement the real-time layer. Spark or Storm are faster real-time engines that could be added to the Hadoop ecosystem. Apache Storm, Kafka, and Trident allow data processing of large volumes of fast, high-velocity data in real-time. These tools provide highly scalable, reliable, distributed, fast, and real-time computing. Live data stream processing is made possible with Spark Streaming, a SparkAPI plugin that is fault-tolerant, scalable, and high-throughput. Figure 8.6 shows a possible scenario of big data integration into an IoT environment.

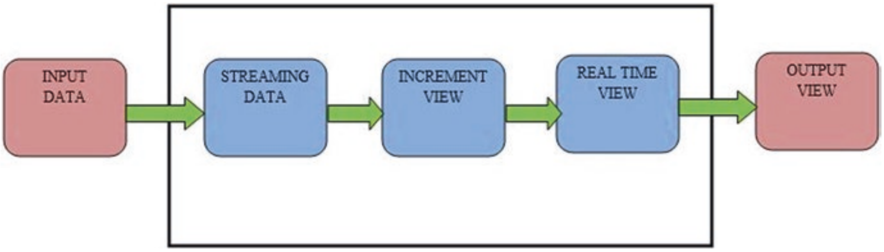

Fig. 8.6 Integration of big data into IoT

The term smart sensor refers to sensors that continuously collect information from numerous active heterogeneous systems. Adding devices to IoT solutions increases the possibility of data influx, which will require scalable solutions. Businesses can generate useful results using these analytical systems, giving them the edge over their competitors. Data should be bifurcated to get the most value from it because it can be obtained based on its nature. Analyzing stream analytics data combined with academic archive data reveals patterns extracted from sensor stream data in an unordered form. An analysis that is conducted in real-time with this method can be useful for applications in fleet monitoring and bank monitoring.

Because IoT data is received through many different channels and has many types, it is difficult to receive and combine. Analytical systems must make sure that the data they receive can be accessed and interpreted effectively. Machine learning algorithms and text mining algorithms are frequently used to retrieve text data from the sensors. In contrast, obtaining data from photographs and videos may take a considerable amount of time. Systems containing IoT data frequently contain sensitive information that must be protected from outside intrusions. As a result of their limited capability, these technologies rely on third-party technology, which can demonstrate security weaknesses.

Supermarkets could be a good example of how IoT and big data can be integrated. A supermarket is a place where anyone can purchase anything they might need, whether it be food items for kids, baby items, or items for young adults or older adults. A camera is installed in every supermarket location, and it is connected to a server room. All activities performed by various individuals in the server room are recorded on the server. A future supermarket will provide off-the-shelf technology, airy design, easy-to-reach products, and informational screens above the customer's head, making it easier and more enjoyable to shop. Imagine learning all the details about the food you are purchasing, including the climate and physical conditions under which it was grown, as well as the organic and chemical treatments it underwent during the journey to reach the shelf right in front of you. For example, the supermarket offered by Cooper Italia is designed to offer customers a diverse range of products. Figure 8.7 presents a possible scenario of a supermarket.

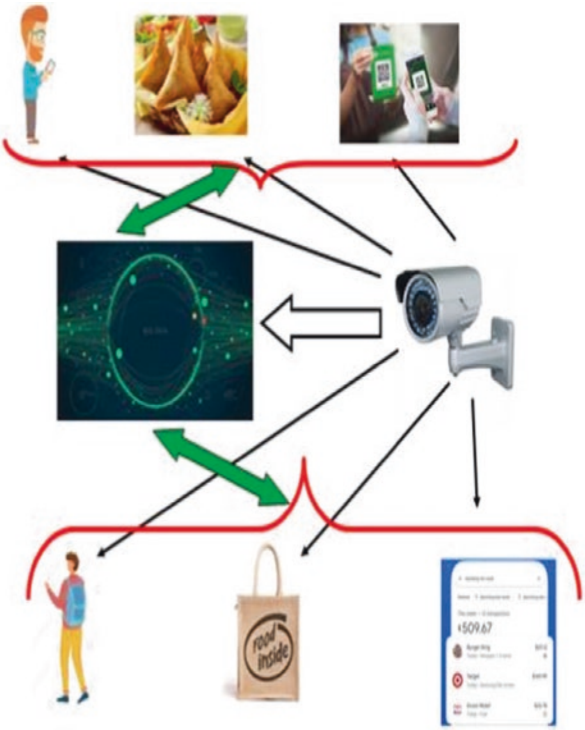

Fig. 8.7 A possible scenario inside a supermarket

8.6 Conclusion

IoT comprises different sensing devices that generate a large amount of data that sometimes are too big to be handled. This huge amount of data needs to be taken care of wisely. There should be a mechanism to intelligently disburse the data. In an IoT environment, the data from heterogeneous sources possess serious threats [43]. In the presented chapter, the authors explain the architecture of IoT in greater detail along with the common security threats to the IoT environment because of the generation of an exponential amount of data. The concept of big data is also elaborated in greater detail along with the details of different types of data. The authors also presented the processing methods of data generated from heterogeneous sources to make them suitable to be used in an IoT environment. At last, the integration of big data into an IoT environment is discussed with the help of many real-time examples.

The future scope of research in this field is everlasting since the generation of data cannot be stopped and the need for its intelligent use will always be welcomed by the constrained devices. The future of computation lies in sensing. Almost every industry now moves toward the concept of IoT and wants their applications to adopt the same. The integration aspects work well in this case. There are many existing mechanisms to solve the problem of big data. The researchers can get some insights from them to integrate the concept of big data into IoT. Scholars can also work with different industries to make a case study on their data generation and uses.

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Chapter 9
Internet of Things (IoT) for Sensor-Based Smart Farming: Challenges and Opportunities

Jaspinder Kaur, Sudeep Yadav, and Harjot Singh Gill

9.1 Introduction

The global population is increasing rapidly and it is estimated that we will be more than 9 billion by 2050. So, to feed such a mass, we have to increase productivity by 75% which can only be possible with the introduction of technology in farming [1, 2]. Technology like the Internet of Things (IoT) can do a great deal of work and can minimize the labor cost by nearly 80%. Internet of Things (IoT) is a modern-day solution to different problems of the modern world.

The usages of the Internet of Things (IoT) can be imaginable in every sector that one can think of; from the automation industry to smart agriculture, the Internet of Things (IoT) can be applicable everywhere. It is a modernized technology concerned with the use of various types of sensors and electronic devices connected via the Internet [3–7].

Internet of Things (IoT) in farming concentrate is on automating all the possible aspects of the farming techniques to make the operation more effective and efficient. With the network of sensors, the Internet of Things (IoT) can make anything possible and help cut down the waste caused by the conventional method of farming, making the process more productive. Not only that, but it also helps in the better yield of the crops as the condition of the crops are monitored priorly, and by analyzing the data collected through various sensors and sensing devices, farmers can give the command to a device that will irrigate the land or spray insecticides/pesticides on the specific part of the field [8, 9].

Thus, the Internet of Things (IoT) can be the turning point in modern farming and with the use of this technology, farmers can enhance their standard of living.

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Applications of IoT in agriculture encompass monitoring of soil moisture and monitoring of plants, monitoring of livestock, monitoring the environment of green and its management systems, monitoring the food supply chain, and so on. Precision agricultural tools along with the sensors placed in the ground will help in better understanding of the crop condition as they all are connected through the Internet, and so, already collected data can also be fruitful in the whole process and each part of the field can be adjusted the way it farmed [1, 10, 11]. For instance, if some area requires more nutrients, then the IoT-based device will spread some extra fertilizer on that specific area only. The application of IoT is not only constrained to agriculture but are widely used in various other sectors and delivers its best viable attempt to supervise the concerns associated with data/information security [12, 13].

The remaining of the chapter is laid out as the concept of IoT in various sectors such as manufacturing, automobiles, etc. is discussed in Section 2. The requirement of IoT in smart farming is given in Section 3. In Section 4, the IoT structure for smart farming is presented. Sensors and devices used in smart farming are discussed in Section 5. In Section 6, the software used is well described. In section 7, applications of IoT advancements in smart farming are given. In Section 8, we explore the challenges of IoT in smart farming, and in Section 9, we make conclusions.

9.2 Concept of IoT

The phrase "Internet of Things" (IoT) was coined by a British techie named Kevin Ashton in 1999 to describe a scenario wherein sensors are connected with real-world objects via the Internet. Nowadays, the term "Internet of Things" (IoT) is commonly used to describe systems that have Internet connectivity as well as computational capabilities that include a wide range of gadgets, objects, sensors, and ordinary things [14–16]. Ashton used the phrase "Internet of Things" to illustrate the feasibility of linking RFID tags used in commercial supply chains to the Internet to count and monitor goods without the need for human intervention. The Internet of Things is currently a frequently used term to describe situations in which Internet connectivity and processing capability proliferate to a wide range of objects, gadgets, sensors, and everyday commodities. When it comes to monitoring and controlling things using computers and networks to keep track of and control equipment, the phrase "Internet of Things" is relatively new.

As an example, during the late 1970s, commercial systems for remotely monitoring electrical grid meters through telephone lines had already been developed. Enterprise and industrial M2M (machine-to-machine) equipment monitoring and operation solutions became common in the 1990s, thanks to improvements in wireless technology. Many of these early M2M solutions, on the other hand, instead of IP-based networks and Internet standards, they depend on industry-specific or proprietary standards [17–19].

In the public's mind, the World Wide Web is practically identical to the Internet. The majority of interactions between people and material are facilitated by web technologies, which is a distinguishing feature of today's Internet experience. The active participation of consumers accessing and creating content via computers and cellphones characterizes the Web-based experience. If IoT growth forecasts come true, we could witness a move toward more passive Internet engagement by users with items like vehicle components, household amenities, and self-monitoring gadgets; devices like these transmit and receive data on behalf of the user with little or no human participation.

If the most common engagement with the Internet – and the data created and exchanged as a result of that interaction – is passive involvement with connected devices in the environment, a paradigm shift in thinking may be necessary. The Internet's open nature, which imposes no fundamental constraints on the applications or services that may use the technology, is a testimony to its global goal.

The Internet of Things (IoT) refers to a global network of interconnected gadgets. We have omnipresent computers, ubiquitous communications, and ambient intelligence all bundled into one. Things, such as household appliances, furniture, clothing, automobiles, roadways and smart materials, etc. may be accessed and/or control over the Internet in an IoT world. All of this lays the groundwork for a host of new applications like energy monitoring and transportation safety. A multitude of sophisticated applications will be made possible by the convergence of wireless sensor networks, identification technologies, nanotechnology, and intelligent devices. Technologies like NFC, Bluetooth, RFID, and ZigBee are being used in new and innovative ways, resulting in a new value proposition for IoT stakeholders [20].

Nanotechnology, embedded systems, sensors, and wireless sensor networks will combine to create the IoT, which will link the world's items in a cognitive as well as a sensory manner. RFID tags were mandated by the US Department of Defense and Wal-Mart in 2005 for their key suppliers and contractors to keep track of their inventories. IoT began to take shape after RFID's explosive growth in 2005 [21, 22].

9.3 Requirement of IoT in Smart Farming

IoT would enable the exchange of knowledge on traditional sustainable farming practices, techniques, equipment, advice, etc., as well as offline data entry and interactivity for aggregated information uploads through a crowdsourcing platform that is accessible, affordable, and interactive. Farmers must have access to cloud computing and Internet of Things (IoT) for agriculture additional information/services such as microfinance services, third-party agriculture, etc. [2, 9].

On top of that, it must serve as an information clearinghouse for a wide range of data, such as crop diseases and traditional sustainable farming techniques. It must also offer multilingual support for traditional traditions with modern value and allow for interactive farming. As a result, the system should fulfill the following criteria:

(i) *Robust models*: Agricultural characteristics such as complexity, spatiotemporal variability, diversity, and uncertainty must be taken into account while producing the proper goods and services.
(ii) *Affordability*: Budget-friendliness/affordability is the secret to success. The expense must be reasonable and the benefits must be considerable. It is possible to reduce costs by using standard platforms and tools to produce more products and services in greater quantities.
(iii) *Sustainability*: Economic pressure and worldwide rivalry have made sustainability a critical concern.
(iv) *Scalability*: Farms range in size from small to big; thus the solutions should be adaptable to accommodate this. The design should be able to scale up in stages with low overheads to scale up progressively.

9.4 IoT Structure for Farming

Smart farming technologies has embraced the Internet of Things (IoT). In the system's design, there are three levels: the sensor, transport, and application layers. Each of them has the following functions:

(i) *Information collection layer*: The fundamental purpose of this layer is to automate and transfer real-time physical figures of agricultural production into digital information that can be handled in a virtual environment using various methods. Sensor-based farming system collects the following types of data:

- Information from the agricultural sensor: pressure, temperature, moisture, vital signs and dissolved gases, etc.
- Name, feature, price, and model of agricultural goods are some of the attributes that may be gathered.
- Working conditions in agriculture (e.g., equipment and machinery operating parameters).
- Geographical data about agriculture (e.g., products' origin).

  There is a layer of information collection that is responsible for marking various types of information, collecting physical information and marked information from the actual world using sensing techniques, and converting them to digital data to be processed. Two-dimensional code readers and labels, cameras, terminals, RFID tags and readers, wired networks, GPS sensors, and wireless networks are all part of the information collecting layer.

(ii) *Network layer*: As the name suggests, the primary function of this layer is to gather and summarize agricultural data collected for processing, the sensor layer. It is also known as the transport layer which is the central nervous system and brain of IoT for agriculture, transferring and processing information. They comprise Internet and telecommunications networking, intelligent processing centers, management centers for network operations, and information centers.

(iii) *Application layer*: The primary function of this layer is to evaluate and analyze the acquired data to create a digital acknowledgment of the real-world environment. It is a mixture of agricultural market intelligence (AMI) and the Internet of Things (IoT).

9.5 Sensors and Devices Used in Smart Farming

Some of the sensors and devices used in agriculture and smart farming such as soil moisture sensors, soil water monitoring sensors, etc. are described as follows.

9.5.1 Soil Moisture Sensor

This very sensor is used to evaluate the moisture content of the soil as shown in Fig. 9.1. When water is deficient in the soil, the output of the module is high, and when it is abundant, the module's output is low. Through the use of this sensor, it is possible to automatically water a flower or any other type of plant that requires an automated watering approach. This module offers three output modes: digital output is the simplest, the analog output is more precise, and serial output provides precise readings and measurements.

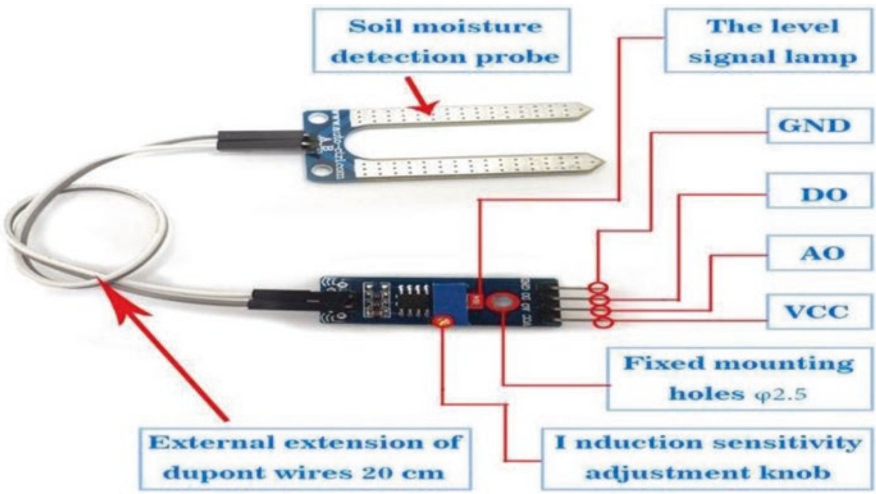

Fig. 9.1 Soil moisture sensor

To aid with irrigation scheduling, soil moisture sensors provide information on when and how much to irrigate. That way, water is used efficiently, enough to fulfill crop demands without applying excessive or insufficient water. Increased pumping expenses and fertilizer loss from runoff and leaching raise the cost of output when excessive irrigation is used. Waterlogging and soil nutrient leaching can also reduce production. If fertilizers and pesticides are washed into sensitive areas, excessive runoff can be detrimental to the ecosystem. When plants are under-watered, they get stressed, which can affect the production and quality of their crop. When utilized appropriately, these soil water monitoring tools can help producers prevent over- and under-watering, according to this information sheet [11].

A thorough understanding of the effects of soil water availability, irrigation application, and soil moisture depletion is required before using soil moisture sensors to measure soil moisture. Making irrigation management decisions will be easier if you understand a few fundamental words, definitions, and ideas. As an example, consider the following:

- *Saturation*: There is no air in the pore space of the soil when it is saturated. Most agricultural soils include 40 to 50% (4.8 to 6 inches/foot) voids filled with air and/or water.
- *Available (usable) water*: The water content of the soil is nothing but the difference between field capacity and permanent wilting. When the soil water content reaches a permanent wilting point, plants get stressed which means that plant is no longer getting the remaining water.
- *Field capacity*: Water content in the soil after gravity has drained it. Most agricultural soils have a field capacity of 20 to 45% by volume (2.4 to 5.4 inches/foot).
- *Allowable depletion*: Plants may access the soil's water content without generating stress that reduces crop production or quality. The allowed depletion depends on the crop growth stage, crop type, and the environment. Crops that are sensitive to tiny variations in the moisture of the soil can be allowed to deplete 25% of their available water, whereas crops that are less susceptible to water stress can deplete over 50% of their available water.
- *Permanent wilting point*: However, plants or crops are unable to get moisture from the soil. It is estimated that the permanent wilting point of most agricultural soil is between a 0.8 and 2.9-inch-per-foot range for soils that include 7 (sand) and 24 (clay).
- *Soil porosity*: The ratio of a soil sample's pore volume to its overall volume.
- *Dry bulk density*: If you want to calculate the oven-dried soil weight, you will need to know the length and diameter of a sample tube (e.g., the sample diameter and length).

9.5.1.1 Soil Water Monitoring

The soil water monitoring process is shown in Fig. 9.2. Soil water monitoring may be done in a variety of methods, each with variable costs and accuracy. Although producers frequently estimate soil moisture based on feel, look, or the duration between watering sessions, by utilizing the soil moisture monitoring devices, moisture of soil can be measured more effectively and reliably. The placement and installation of the monitoring system determine its effectiveness. The sensors should be representative of the whole field, garden, or landscape. Do not place the sensor on a hill or in a depression where there may be changes in temperature owing to shadow, adjacent structures, or nearby structures. We advocate using many sensor locations for big fields because there is a lot of variabilities. Sensors and samples should be placed by soil type, plant distribution, and water conditions. Sensors need to be correctly placed and in excellent touch with the soil to be effective. As soon as the sensor has been installed, pack the earth around it tightly to prevent undue compaction. Care should be used while installing access tubes or sensors in a crop that is growing so as not to harm the plants. To get accurate readings, but the sensor behind a plastic sheet if the crops are being planted on Mulch made of plastic. Plant sensors in the crop's root zone (usually between 12 and 18 inches). In the case of row crops, sensors must be placed 2 to 3 inches apart from the plant rows. They include porous blocks, heat dissipation, dielectric sensors, tensiometers, and gravimetric. Aside from the gravimetric technique, the systems will provide an indirect measure of soil water (calibrate to a soil water term after measuring a property of the soil water). As a result of the porous blocks, dielectric sensors, and tension sensors, automatic recording and watering may be set.

Fig. 9.2 Soil water monitoring process

9.5.1.2 Characteristics

- It is possible to alter the sensitivity level.
- Comes with a set screw hole for easy installation.
- The threshold level may be adjusted.
- There are three output modes on the module: digital, analog, and serial output with accurate readings.

9.5.1.3 Significance

- Agriculture
- Irrigation for landscaping

9.5.1.4 Functioning

This type of sensor detects the water quantity inside the soil. Multisensor soil moisture probes are used to measure the soil moisture. A capacitance sensor, for example, is a popular form of soil moisture sensor in a commercial application. A neutron moisture gauge is another sensor that uses the neutron moderator characteristics of water to measure neutron moisture.

To find out how much moisture is in the soil, two electrodes are inserted in the soil and their capacitance is measured. Moisture content is directly related to the dielectric constant in soil with a high fraction of free water, for instance, sandy soils. For the measurement of the dielectric constant, the probe is usually stimulated by a high-frequency signal. In addition to soil type and temperature, the water content and readout from the probe do not have a linear connection. Calibration is therefore necessary, although its long-term stability is in doubt.

9.5.2 Rain Sensor

Rain detection is made simple using the rain sensor module as shown in Fig. 9.3. It may be used as a switch and for monitoring rainfall intensity as raindrops fall through the rainy board. The module has a separate rain board and control board for convenience, as well as a power indicator LED and a potentiometer for adjusting sensitivity.

Rainfall droplets are detected using the analog output. When the LED is connected to a 5V power supply and the induction board does not have a raindrop and the DO output is high, the LED will illuminate. The switch indication turns on when a little amount of water is dropped and the DO output is low. When the water droplets are brushed away, the output level returns to its original condition.

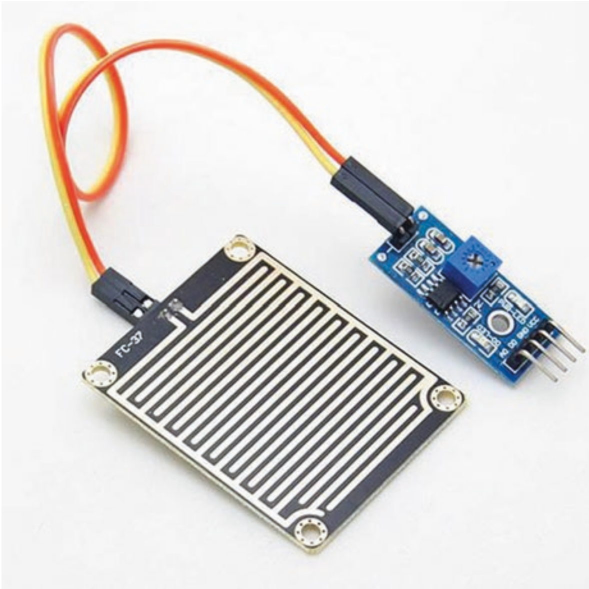

Fig. 9.3 Rain sensor module

9.6 Software Used in Smart Farming

9.6.1 SQL Server

SQL (structured query language) is a programming language for managing databases that allows you to create, delete, retrieve, and change data in databases. Although SQL is an ANSI (American National Standards Institute) standard language, there are several SQL variants.

9.6.2 About SQL

A relational database uses SQL to store, manipulate, and retrieve information. SQL is the standard programming language for relational database systems. There are several RDMS (relational database management systems) such as MS Access, Oracle, Postgres, Sybase, MySQL, Informix, and SQL Server that employ SQL as their basic database language. There are also a variety of dialects that they use, including:

- T-SQL with MS SQL Server.
- PL/SQL with Oracle.
- JET SQL is the MS Access SQL version and so forth.

9.6.3 Significance of SQL

SQL is widely used for the following reasons:

- Users will gain access to knowledge kept in electronic information service management systems.
- User-friendly interface for describing the data.
- Users can define and manipulate data in databases.
- SQL libraries, modules, and precompilers can be used to integrate SQL into other languages.
- Provides users with the ability to build and delete databases and tables.
- Provides users with the ability to construct database views, stored procedures, and functions.
- Permissions for tables, procedures, and views can all be adjusted by users.

9.6.4 SQL Methodology

When you run a SQL command on any RDBMS, to execute your order, the system chooses the optimal method, and the SQL engine determines how to decipher the job. This procedure includes several different elements. They are as follows:

- Dispatcher of queries
- Engines for optimization
- Query engine (classic)
- Query engine for SQL

As for non-SQL queries, a query engine that supports SQL will take care of them, but not logical files.

9.6.5 SQL Commands

Some typical SQL commands for working with relational databases are CREATE, INSERT, DELETE, DROP, SELECT, and UPDATE. Based on their nature, these instructions can be categorized into the following ways: Some DML (data manipulation language) commands, DDL (data definition language) commands, and DCL (data control language) commands are shown in Tables 9.1, 9.2, and 9.3, respectively.

Table 9.1 DML: Data manipulation language

Command	Elucidation
SELECT	Obtain specific records from one or several tables
INSERT	Creates a record
DELETE	Deletes records
UPDATE	Modifies records

Table 9.2 DDL: Data definition language

Command	Description
CREATE	Creates a new table, a view of an existing table, or another database object
ALTER	A database object, such as a table, gets modified
DROP	Removes a complete table, a view of a table, or other database objects

Table 9.3 DCL: Data control language

Command	Elucidation
GRANT	Allows the user to have a special ability
REVOKE	User credentials are revoked

9.7 IoT Applications in Smart Farming

Climate change, weather, soil conditions, waste reduction, and green housing are a few of the difficulties that may be solved with smart agricultural techniques. Things like sensors, self-driving automobiles, control systems, and robots comprise the Internet of Things. Listed here are the many stages of agricultural forecasting from farm to fork [18].

(a) *Monitoring climate conditions, soil, and plants*

A dramatic shift in the environment and natural catastrophes have a significant impact on plant growth and agricultural productivity in the United States. It is also possible for numerous sensors to collect and store information on a wide range of environmental variables, which may then be transmitted to the Internet of Things.

Using sensors, soil and nutrient data are gathered and stored in integrated databases. Fertilizer levels will be established and administered based on the soil profile. Agriculturists must install mobile apps on their phones and register with the cloud using a mobile app, called MobileApp. Climate, soil conditions, irrigation levels, and plant development and damage are all stored in the cloud.

In addition, it collects information about farmers, marketing agents, and agro vendors and service providers, along with information regarding government initiatives for the agricultural industry, such as bank loans for farmers and discounts on seed and/or fertilizer purchases. Sensors gather data from soil and environment samples regularly, which is then updated and utilized to regulate the smart farm's operation.

When it comes to monitoring plants and recognizing illnesses and insects that are harming their growth, the Internet of Things plays a key role. Sensors can produce alarms and notifications if the degree of pest control exceeds the set range, alerting farmers to take action. It is also possible to communicate to farmers and agriculturists the best time to grow crops, control pests and plant diseases, as well as harvest.

(b) *Water irrigation and waste reduction*

An Internet of Things can monitor tank levels and arrange irrigation schedules to control water use for maximum plant growth. It is also important to keep an eye on any undesirable leaks. All of this is available through business cloud-hosted web and mobile applications. IoT technology assists farmers and agriculturists in reducing waste and increasing output. It is a method of farming that makes the process of growing crops more regulated and precise. After harvesting, the temperature, pressure, humidity, and light levels of the grains must be regulated in silos and grain elevators for agricultural storage.

(c) *Livestock monitoring*

Farmers and agriculturalists keep track of their cattle's whereabouts, health status, and feeding schedules. IoT-based sensors are also used to locate sick animals in the herd before they infect the rest of the herd. By continuously monitoring them and recovering the others in the huge group, it would dramatically decrease livestock losses and expenses.

(d) *Smart greenhouse*

Solar-powered IoT sensors will be used to build modern, cheap, and healthful green homes. Information regarding temperature, pressure, humidity, and light levels may be gathered from the sensors, according to the company. They are monitored by sensors and operated either by control systems or manually through the use of a remote-control system. Water irrigation is also done with smart sprinklers. IoT cloud server accesses the data and provides farmers with cost-effective alternatives.

9.8 Challenges in Smart Farming

Technology dissemination in agriculture has been hampered by a lack of land holdings, which has hampered long-term productivity increase. When it comes to high-yielding seeds, all of our technologies were developed for irrigated areas, even though 48 percent of the land we seeded was unirrigated land.

People own 80% of the land with a small plot of land, according to the 2016 Agricultural Census. Most farmers are tiny or marginal. There are presently just

1.15 acres of land on each farm. Only 5% of farmers work on property larger than 4 ha, according to the USDA. Initial beneficiaries include farmers who were able to pool their fields into larger plots of land, increasing their farm size to at least 100–200 acres. Comparatively, just 5% of farmers own landholdings that are greater than 4 acres.

Large agribusinesses are often the ones who make use of smart technology rather than farmers. There are several of these techniques that are utilized by farm-loan businesses as a means of risk management. Aside from that, conventional tactics are not enough to tackle the problems. Easy-to-deploy and cost-effective solutions are needed for tiny embedded devices' security concerns.

9.9 Conclusion

Farmers are now able to distribute crops straight to customers, not just in a narrow area like retailers, but also in a much larger area thanks to the Internet of Things. As a result of this, the whole supply chain, which is currently dominated by huge corporations, may become a more direct and shorter connection between producers and customers. When it comes to agriculture, cloud computing enables businesses to offer low-cost solutions to farmers.

Agribusinesses and farmers benefit from IoT technology since it integrates all devices to a digital level in a wide range of directions [23]. In the future, smart farming and global food production will be aided by Internet technology, social networks, integrated databases, and on-demand information availability. To enhance the quality and quantity of agricultural produce, smart farming uses sensor technologies [24] to help farmers become more intelligent and connected. As a result, new IoT applications will be developed to address these challenges and assist improve the quality, quantity, sustainability, and cost-effectiveness of agricultural output. Using the Internet of Things, farmers can monitor soil conditions, moisture levels, animal feed density, and pest control levels, among other things. Developing and implementing new models will be a major emphasis in the near future [25].

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Chapter 10
Implementation of IoT in Various Domains

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10.1 Introduction

The term Internet of Things (IoT) is coined by Kevin Ashton in 1999 [1, 2]. The concept of IoT is presented as an idea to link radiofrequency identification (RFID) tags to the Internet [3–8]. The h-IoT is also known as the health IoT, which is a milestone of information systems development. It plays a major role in enlightening people's health levels and increasing the worth of life. It is a complex system that involves various systems like microelectronics systems, health and medical, computer field, and other engineering fields. According to the overall connection of the health-care system, the period from 2017 to 2021 is the growth phase of IoT in the medical sector. The h-IoT application and devices accelerate and shareholders also accelerate their efforts [9]. There is no doubt that IoT is transforming the medical sector and redefining apps, applications, and devices related to these people involved also. Thus, it's continuously provides gadgets to the medical sector for good take care of the patient. The use of computer's in the future is dominating human work and enhancing the capabilities of computer skills and coding such as the electronics

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devices being remote and Internet of Things and machines work automatically. This allows users to manage their electronic equipment on the Internet. Alexa is working with the use of the internet and is also an example of artificial intelligence and the Internet of Things. The Alexa bulb is also connected through Bluetooth and performs on human voice or command. This will also increase the use of the Internet and provide materials and services. The main challenge of IoT is to reduce the gap between the physical world and the world of news, such as how to process data obtained from electronic equipment and the interface between the user and the appliance. There are six layers of IoT and these are a coding layer, a perception layer, an application layer, a network layer, a business layer, and a middleware layer, these layers are used in a smart house.

The common IOT layer is divided into three layers: network layer, application layer, and perception layer [10]. The components are grouped in the three layers of the genetic IoT system as shown in Fig. 10.1.

10.1.1 Fog Computing

Fog computing is a computing architecture in which a series of nodes receive data from IoT devices in real-time [11]. It requires a high-speed connection from an IoT device to a node. Devices from the controller, switches, router, and camera act as fog computing, when an IoT device generates data, then the nodes receive signals

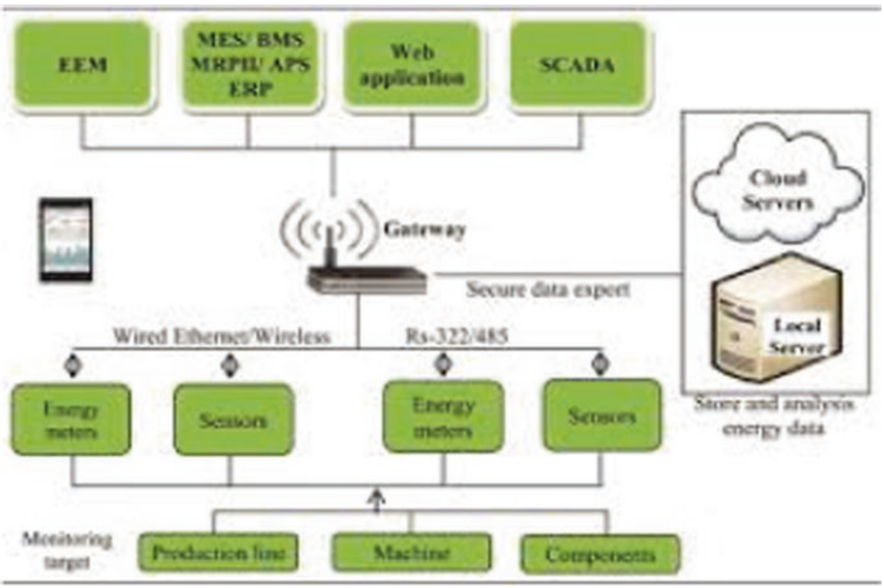

Fig. 10.1 Genetic architecture of an IoT system

and act as fog computing. Fog computing is used to improve efficiency and reduce the amount of data transported to the cloud for processing, and it is also used for security purposes.

Fog computing is comfortable in the case of IoT and industrial 4.0; in the case of the health-care sector, they use fog computing because it is easy and it is also threat-proof [12]. Fog computing is used for time saver and speed to process data. It is better than others like cloud computing. Fog computing is equal performer with edge computing like its go to the edge of the network's edge.

10.1.2 Linked Vehicles

Self-driven cars are now available in the market, producing a significant amount of data. The information has to be easily interpreted and processed based on the information presented such as traffic and information about weather conditions [13]. All this information is easily processed because of fog computing. Suppose suddenly the weather changes and rain starts pouring, then the car automatically starts its wipers, lights turn on, and goes on safety mode, so that the passenger will not lose his/her patience and remain calm.

Figure 10.2 shows the architecture related to IoT in health care (referred to as h-IoT) that will be discussed later in this chapter.

The rest of the chapter is organized as the implementation of IoT in various sectors such as manufacturing, automobiles, etc. which is discussed in Sect. 10.2. The five-layer architecture of IoT is discussed in Sect. 10.3. In Sect. 10.4, directly implementable IoT applications in the health-care industry are presented. The IoT implementation in health care is discussed in Sect. 10.5. In Sect. 10.6, some challenges of the Internet of Things are discussed. In Sect. 10.7, the future scope of IoT advancements in health care is given. The advantages of IoT in health care are discussed in Sect. 10.8. Shortcomings of IoT in health care are defined in Sect. 10.9, and finally, conclusions are drawn.

10.2 Architecture of IoT

A common three-layer IoT architecture consists of the network, the perception, and the application layer. The first layer known as the perception layer is the lower most layer in the IoT architecture where the actuators, sensors, and other connected devices are present where they collect the information that is very necessary for the network [14, 15]. The network layer connects the devices in the network to other devices to handle the transmission of information. The third layer, the application layer, provides specific services to the user by providing data analytics, data reports,

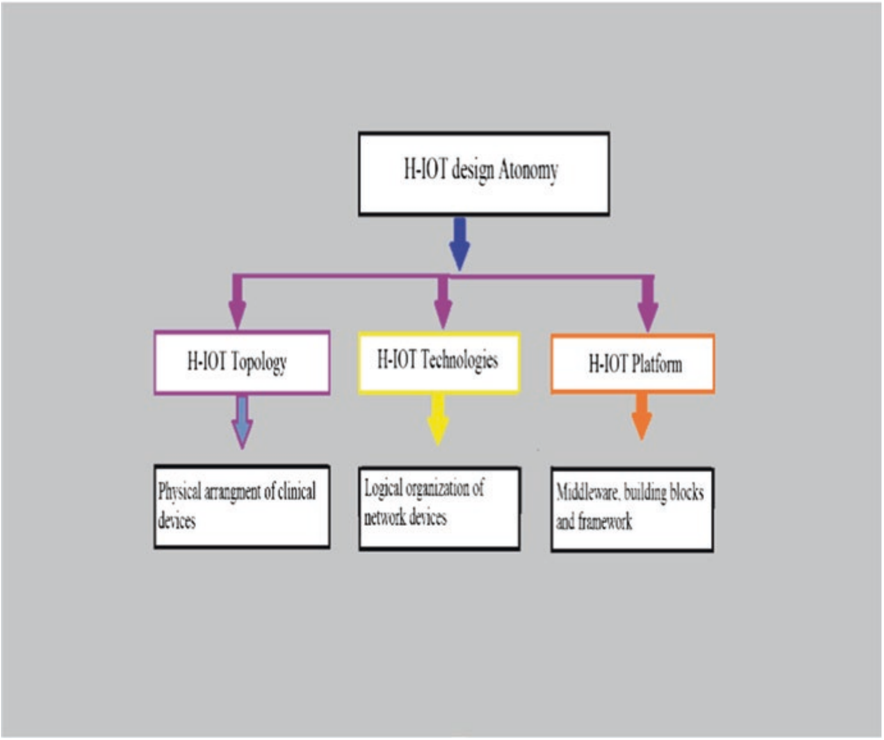

Fig. 10.2 H-IoT architecture

and control over the devices [16]. The three-layered architecture is then upgraded to five layers with the addition of two more layers, namely, the business layer and the processing layer. A five-layer IoT architecture comprises the perception layer, the network layer, the processing layer, the application layer, and the business layer [16].

10.2.1 Application Layer

The application layer is the topmost layer of the five-layered IoT architecture. The application layer provides the global management of the applications. A few examples of applications implemented through IoT can be listed as smart home, smart farming, smart health, smart city, intelligent transportation [17], etc. The functions of this layer range from designing applications for all types of businesses to performing some smart calculations.

10.2.2 Network Layer

The second layer recognized as the network layer usually is an amalgamation of local area networks, access, and core networks. The main function of this layer is unique addressing and routing which will make sure that integration of many devices is possible into a single application [18]. The network layer is also called the transmission layer because it transfers the data securely from the devices to the processing system. Thus, the network layer transfers the information from the perception layer to the middleware layer [19].

10.2.3 Perception Layer

The perception layer which is also known as the third layer is the lowermost layer and most prone to various kinds of attacks. This layer includes various physical objects and sensor devices like an RFID, 2D barcode, infrared sensors, etc. This layer's basic functionality is to recognize what object it is and to help with the identification. The collected information is then passed to the network layer for its secure transmission to the information processing system [20, 21].

10.2.4 Processing Layer

Then comes the middleware layer wherein the devices over the IoT implement different types of services. Each device connects and communicates with only those other devices which implement the same service type. This layer is responsible for service management and has a link to the database. It receives the information from the network layer and stores it in the database. It performs information processing and ubiquitous computation and takes automatic decisions based on the results [22].

10.2.5 Business Layer

The business layer is responsible for the management of the overall IoT system including the applications and services. It builds business models, graphs, flowcharts, etc. based on the data received from the application layer. The real success of IoT technology also depends on good business models. Based on the analysis of results, this layer will help to determine future actions and business strategies [23].

The five-level architecture of IoT is shown in Fig. 10.3.

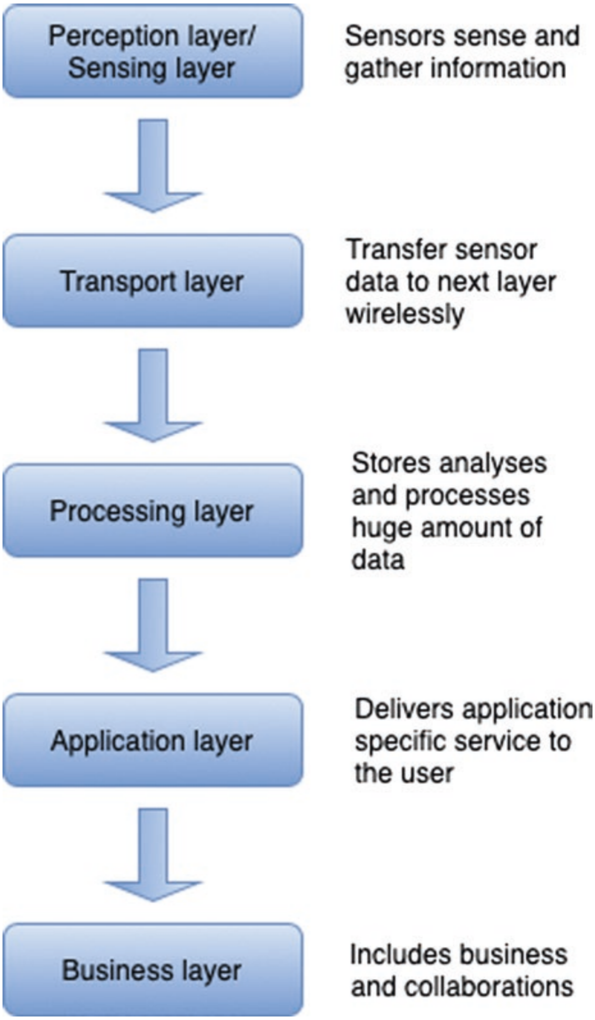

Fig. 10.3 The five-level architecture of IoT

10.3 Some Important Applications of IoT

Smart Home Fog computing used in smart homes and smart cities. Because fog computing is good in safety and security, it is used in the smart house and smart cities. In smart houses always use real-time data from the efficiency of the system. In smart home IoT devices and all devices connected to the network, for example, Alexa, Siri, Google, etc., are used as a smart home device, all the time live real-time monitoring and autonomous vacuum cleaner, and Internet devices are also included in the smart home device [24]. IoT-based automatic watering system for plants is used for plants through mobile phones; in this, we control the water level and moisture of the soil. With the help of IoT, we monitor our house through cameras and wireless all-time monitoring robots, and we also record our favorite shows and movies in a set of boxes and also we connect the phone with TV or smart LED. Nowadays, home security is the most and first thing in the home; smart door locks and cameras and security robots are monitoring the home 24/7 [24]. We easily monitor the house and all the things seating everywhere because of IoT.

Smart Cities Security crosses the limit day by day especially in smart cities, for example, if anyone is missing or the police want to check the location of the thief so they use IoT; with the help of IoT, they can easily track the location in just seconds and with the help of the Internet of Things, we also are able to manage traffic, electricity, waste, and wastewater. Nowadays, traffic lights are also controlled by IoT and the Internet, and infrastructure is also made according to all edges and in a good manner. Currently, now we proudly say that we are going towards all automatic nation like cooking automatic and road making automatic and house and building also made automatic.

Self-Driven Cars We will see a lot about the self-driven car. Previous day's news coming in newspaper that Tesla tested a self-driven car and also heard that now Uber also come with self-driven mode [25], it is a benefit for girls who are feared to travel in night time in Uber, because they feared the Uber driver because in case the Uber driver does not do any silly things with her, so parents also do not allow her to travel in the night time, so it is a benefit for girls and it also benefits for those in pandemic time, people do not use Uber or any cab because COVID-19 spread through touching and in air, so in case anyone takes uber to go somewhere and he is suffering from COVID-19 and after that another passenger came and sit in Uber he/she also effected from COVID-19, so self-driven cars are beneficial for us, it is safe because in this many sensors are present in car and cameras also present in it, so u just put your location and go.

Farming Farming is a working sector that is most beneficial with IoT; in the future, they promise that they will develop farming tools [26, 27]. Nowadays, farmers are using IoT in farms; they use sensors to check the soil moisture and also plant drip system there. If in the old times, farmers use scarecrow, nowadays they use drones for surveillance, protecting yield of animals and fire and also implant automatic compost given to plants or yield if required. Before, in one season farmers fired the field because they want to clear the field; nowadays they do not do that because of global warming; so with the help of IoT, they now use thin tube fire system, in which they fire in limits and the task is also completed. With the help of automatic robots, farming is easy and less time-consuming, because they now know how to give water to yield and how to plant all setups, and from time to time robots check the soil value and also for fertilizers and compost. When the yield is ready for cutting, robots easily and safely cut the yield and place unused substances in an empty side, and the yield is collected in a container and is ready to sell in the selling station.

Smart Supply-Chain Management (Farm to Falk) Nowadays, it is in trend because, in this pandemic, people are not allowed to go outside, and so they use Amazon and other sites to order pantries or buckets. With the help of IoT, they can track their items in their phone, and in 2 or 3 days they receive their parcel, bucket or pantry. It is safe and a touching proof. In case your item or something gets damage in between travel, so you easily replace and reorder items from their initial stage. Shopkeepers also do this thing to sell their items online and give a discount so people can easily find them and buy their products. It is working like customer contact with producer and producer contact with the supplier. If we select cash, then the courier collects the cash from the customer and give to a producer, or if we select online payment, then the cash is automatically transferred to the producer [28]. China and Japan take experiments on automatic delivery robots, and these robots arrive at the customer's location and show him/her the QR code so customers can scan the code and the delivery code will generate and the robot will put the parcel on the doorsteps and go to the next location. It is also beneficial in during the CPVID-19 pandemic or lockdown situations, wherein the use of this type of robots will take a step toward stopping the spread of the virus. Smart supply chain management is shown in Fig. 10.4.

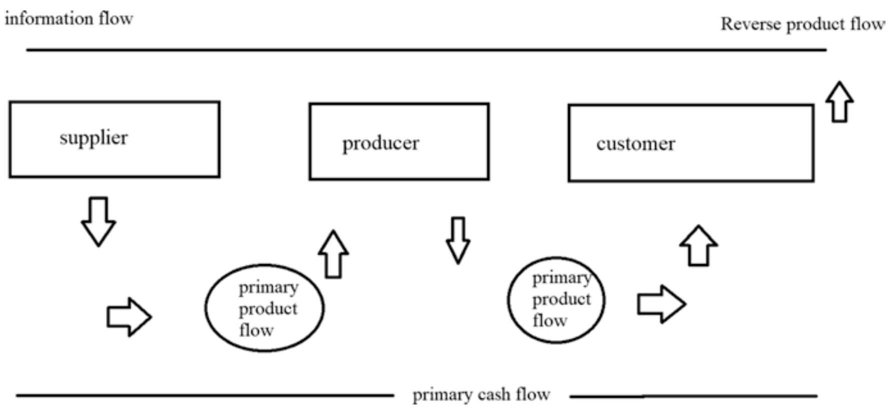

Fig. 10.4 Smart supply-chain management

10.4 Challenges Still Faced by Internet of Things

1. *Security issue:* In the twenty-first century, IoT devices are now popular, and it is also a headache work to do, twenty-first century cybercriminals group people's families increasing day by day and those who want to hack or break home security or bank security hire cybercriminals or cyberhackers [29].

IoT devices cannot easily be hacked but cyberhackers find the loophole and break the security of IoT devices; governments apply strickness on cyberhackers but they still work in the down of their nose.

In 2017, a case registered against the cyberhacker's like parents said they apply home security and for his child, they apply all the security and they also apply 24/7 monitoring robots so hacker breaks the monitoring robot's security and talk to the child every day when parents realize this they fill case against him and the security company. It is not easy to break the security of IoT devices but still, they want to work upon those areas [29].

2. *Compatibility:* Nowadays, home networks and Bluetooth devices are not easily connected because of user increase or their bandwidth size is small and that is why we face this issue. Maybe the IoT device is not up to date from the user side, so it is also an error to connect the device. Or sometimes the user's phone is also not up to date and that also creates a problem to use or connect the device. It is compulsory to update their device and update their phones or laptops or any devices to use better.
3. *Limited bandwidth:* Connectivity is a bigger challenge for the Internet of Things as you expect because there is an increased user from one device or one network and that is why they cannot use the Internet in a better manner or they suffer from buffering [30]. People face this buffering problem, and people cannot even download or see a video on YouTube or any website because of this buffering. One source is divided into many parts so that's why internet speed is low, or we can say his bandwidth is limited.
4. *Expectation:* With such strong competition in the market, companies all the time promise that they will be giving better products but it is difficult for people to compare two or more devices because each brand want to make or give a new and better product in the market. Take for example Oppo smartphone; they use or make a cheap product, and people know how they make cheap products, so 90% of people avoid Oppo. Now I compare it with Apple. Apple launches one mobile phone per year, and they easily crack their expectation limit and people also love to use Apple because it is a bigger brand than Oppo. And people drop their expectation from Oppo and they were dissatisfied from IoT devices.
5. *Business:* The bottomline is a motivation for starting, investing, and operating any business with a sound and solid business model for IoT [31]. This model must satisfy all the requirements like e-commerce, vertical market, horizontal market, and consumer market. These category also follow's the victim of regulatory.

10.5 Advantages of IoT

1. *Saves time*: As reducing human effort, it saves out time. IoT devices are working properly and they reduce human effort and time. IoT devices compile code speed and is very good and it works very fast as compared to others. One way to leverage the power of IoT to increase company efficiency is to use it to cut down on repetitive or time-consuming tasks.
2. *Security*: Now we have a device interconnected to each other to improve security and efficiency [32]. In IoT all devices are connected, for example, Alexa; in Alexa all the devices like fans, bulbs, led, and phones are connected and they improve their efficiency and stability.
3. *Minimizes human effort*: The devices of IoT communicate and talk to each other and they work properly together, reducing human effort.

10.6 Disadvantages of IoT

1. *Privacy/security*: Hackers easily get excess to the personal information and also accounts information, so it is a disadvantage for IoT devices; hackers easily break home security. Nowadays, home security is on trend and hackers find the loophole and easily get excess to personal information [33].
2. *Connectivity*: Bandwidth of the network is very low and also Bluetooth devices connectivity problems arrive, and it is because they are not up to date or the phone or laptop is not updated; that is why it is difficult to connect with IoT devices in checking for updates [33].
3. *Expensive to implement*: Using Li-FI at home is very costly for normal people, and fully automatic and AI devices are very expensive to implement at home, for example, Jarvis.

10.7 H-IoT

H-iot refers to a device that collects health related data from an individual. The explosive growth in H-IoT to augment the delivery of healthcare is driving changes in clinical practice and patient-centered care, requiring new skills for providers [34].

IoT devices are tagged/connected with sensors for tracking medical equipment like medicines, wheelchairs, cloths, oxygen pumps, and others connected equipment. For example, in a URI movie, the nurse (played by actress Pallavi) attaches the GPS sensor on the old lady so in case if she goes outside and forgets the home then the nurse immediately tracks her and finds her and takes her home easily. We implement this thing in our daily lives especially in elderly people for their safety and for other reasons too. People these days prefer to take benefit of IoT and h-IoT. H-IoT provides us with very good service and comfort. Now it ties up with machine learning and artificial intelligence and shows a world in another level. In hospitals, it is used on ventilators and other machines like oxygen cylinder and temperature measure and heartbeat sensor, and for those who cannot walk, they can use an automatic wheelchair. With this, they can stand up and sit down, walk, and take the wheelchair on the roads because the wheelchair is fully loaded with sensors and cameras. Today, the technology completely changes how we see inside the human body through small cameras inserted inside the capsule which is taken by patients. So we get to see what is inside the human body including small and big intestines and how food processing looks like and even the damage inside the stomach if there is. With the help of h-IoT, operations are done easily such as heart operation, heart transplant, and brain surgery. We also get to see damages in the veins and liver. Now we can also monitor glucose and even monitor depression and mental health [35].

Importantly, h-Iot helps us when someone loses his hand or leg or any body part wherein it can provide us with a bionic hand, bionic leg, bionic shoulder, etc. bionic hand project I put reference on reference page go and check this out. Nerve cells are connected to the brain, and when the brain gives signal to the hand, bionics take the signals and convert signals to mechanical signals and bionics work [36].

10.8 Industrial 4.0 with IoT

Industrial 4.0 refers to a new phase of industrial revolution that focuses heavily on interconnectivity, automation, h-IOT, machine learning, and real-time data monitoring [37]. The revolution from industrial 1.0 to 4.0. is revolution in company they upgrade their machines or equipment and improve and distribute their products. Manufactures are enabling technologies such as the Internet of Things, machine learning, artificial intelligence, cloud computing, fog computing, edge computing, and analytics [38].

Now here the question arises: Are we in industrial 4.0 right now?

Today, we are in the midst of industrial 4.0 [39]. This is being driven by the global spread of the Internet. New technologies are rising such as wireless phone chargers, sensors and artificial intelligence, and machine learning. Industrial 4.0 will radically transform the way we live and work [39].

10.9 Conclusion

IoT is a system in which sensors collect the data and share it with a secure network. The process data is check through the various processor, in a case in somehow any impurity or any various occur then immediately alarm start and indicate the issue on display. These devices come under industry or medicine 4.0. The new automated devices come into the market like real-time monitoring and diagnosis powered by IoT or h-IoT [40]. This process is reviewed by various new technologies powered by h-IoT. Many architectures are using different computer applications powered by h-IoT. These architectures are driven by machine learning, artificial intelligence, edge computing, fog computing, cloud computing, and new technologies like blockchain. Machine learning work in the multiple-use case of h-IOT and maintaining the network and help them to achieve optimal network [41].

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Chapter 11
Application of IoT in Wearable Technology

Shivam Dhoot, Komal Saxena, and Ajay Rana

11.1 Introduction

Wearable technology or the so-called wearables is electronic innovations or incorporation of a variety of devices into wearables. These portable gadgets are used to track data continuously. They have motion sensors that preview your daily actions and sync them with cell phones or PCs. After the creation of cell phones, wearable hardware is the next breakthrough in innovation [1]. These gadgets are available in a wide variety of designs, such as watches, glasses, bracelets, or even ornaments [1, 2]. Wearable gadgets are characterized by six basic qualities which are non-hoarding, unrestricted, discernible, controllable, mindful, and informative. Improving the applications that can work with WT covers a wide area ranging from those focused on medical care and wellness to mechanical applications and even entertainment and expressions [3].

Wearable technology offers a new freedom to continuously monitor human movement with small, portable sensors installed, further developing competence, utility, administration, and commitment through initiatives. Despite this, there are a few difficulties observed in WT which are power consumption, pairing limit, plan limitations, and security concerns [4]. Due to the limited data transfer capability and preparation power, portable devices offer less security than other computer gadgets [5]. In the results, the exploited security breach opportunities increase the number of potential attacks that will endanger the well-being and protection of customers. Wearable registering brings new difficulties and opportunities for clients' authentication. Figure 11.1 shows different wearables developed for various applications [1].

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Fig. 11.1 Different wearable developed for various applications [1]

Wearable gadgets are not standalone gadgets and will need to be paired with other gadgets like smartphones to accomplish most functions, which is a basic test in taking on a reasonable approach to deal with a safe confirmation in wearable. This intricacy of correspondence makes security weaknesses like man-in-the-center assault. Envision a client who utilizes his smartwatch to control his keen home. The requirement for a correspondence between the smartwatch and the application which is put away inside the cell phone is inclined to data spillage prompting other security assaults through the craft of control of information. The lack of a console is also a problem, as even a touchscreen can occasionally fail to provide a confirmation method.

The work presents the expectation to present a brief review of security and insurance attacks occurring in the advancement of wearable devices to understand the security and safety gap that exists in wearable device development and present an assessment of security on various wearable development gear. A safety assessment is performed by evaluating three benchmark wearable devices such as Google Glass, Fitbit, and Smartwatch. The motivation driving IoT in wearables is the term to understand the components of wearable contraptions and future consequences of the advancement, advantages, and shortcomings. All the more profoundly concentrate on the advancement to be used in different spaces of the business.

11.2 Types of Wearable Technology

11.2.1 Smartwatch

The smartwatch is a small smartphone-like gadget that is worn on the wrist. Many smartwatches are paired with a mobile phone that notifies the customer of incoming calls, emails, and app alerts. Some smartwatches can even make decisions about the phone. Many smartwatches have a discreet display, but some popular models use a high-contrast electronic paper display [6]. The customer can operate the smartwatch via a touchscreen, actual stops, or a mixture of the two. Some smartwatches accompany pedometers and wrist displays to help customers monitor their well-being. Figure 11.2 shows a smartwatch [7].

One of the most punctual genuine smartwatches was the Microsoft SPOT (Smart Personal Object Technology) presented in 2004. The SPOT got data like climate,

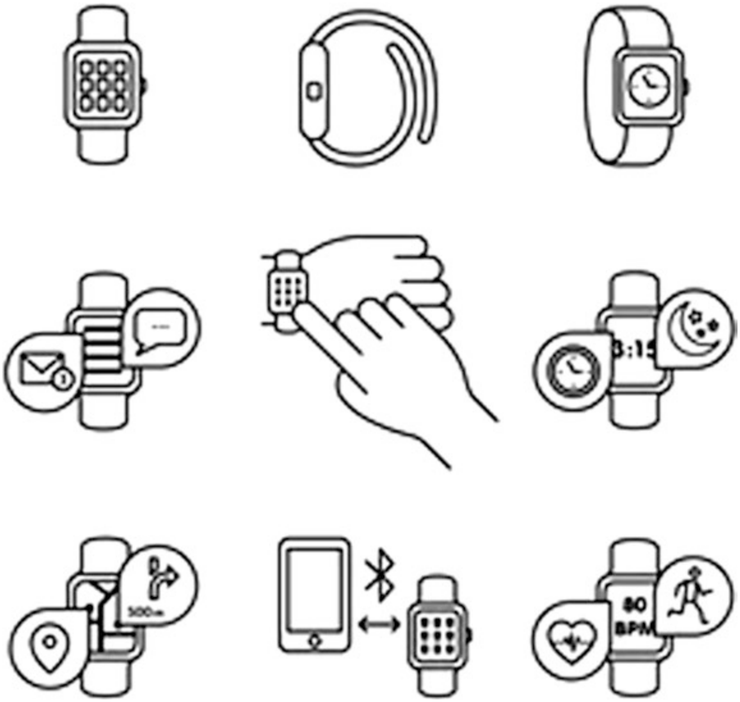

Fig. 11.2 A smartwatch [7]

news, and stock updates through FM radio. It additionally got email and texts, yet clients could not answer. With the ascent of the cell phone, smartwatches, for example, the Sony Ericsson Live View (2010), the Pebble (2013), and the Apple Watch (2015), arose that got information from a telephone. In 2014 Google created Android Wear—a form of its versatile working framework, Android—explicitly for wearable gadgets like smartwatches [6].

11.2.2 Google Glasses

Google Glass or just called Glass can say as the essential wearable contraption that dispatches the advancement of WT. Glass is an eyewear contraption that has a fundamental PC at the edge of two or three glasses [3]. It gives different innovative arrangements that make people's life more fun. In any case, numerous causes of stress have been raised as sources for specific issues that could undermine the wearer's security and insurance. Figure 11.3 shows a Google Glass [2].

There are relatively few assessment disclosures that point out some shortcomings in terms of well-being and insurance points on Google Glass. For example, Glass does not have a secured adequate PIN structure or approval set up right now [8, 9]. Other than approval issues, Geran et al. [9] found that the security of customer' appears in peril additionally by the eye following the advancement maintained in Glass. All the more fundamentally, there are a couple of certifiable cases concerning shortcomings related to Glass that were represented at the hour of Google release. Post Mobile [10] found a genuine security imperfection in how

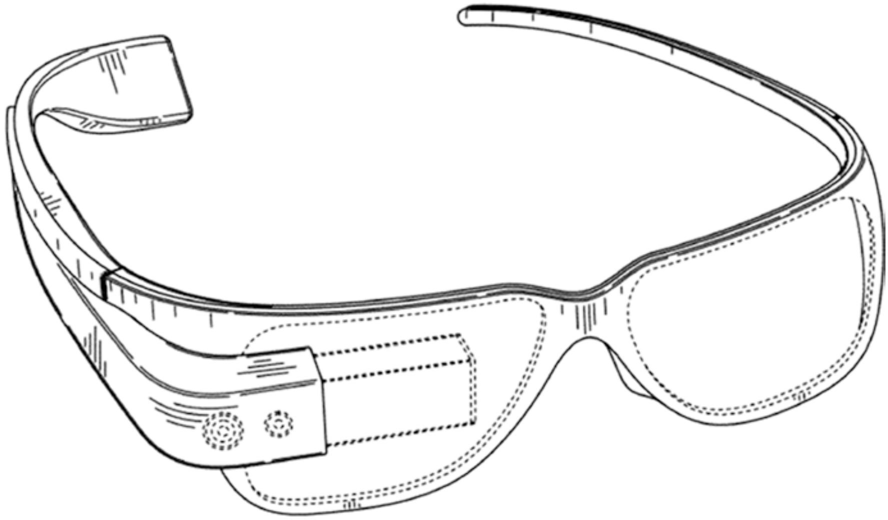

Fig. 11.3 Google Glass [2]

Glass disentangles QR (quick response) codes when it snaps a photo back in May of the year before. Utilizing a malevolent QR code, they observed that Glass could be connected up to a hazardous Wi-Fi organization, permitting somebody to remotely get root admittance to a Glass gadget and accept accountability for it without the wearer's information. Luckily, Google was made aware of the shortcoming and a cure was shipped off to resolve the issue without really wasting any time.

11.2.3 Fitbit

A wellness band that might be worn on the wrist is essential for Fitbit's item range. It estimates human mobility, for example, by counting the number of steps people walk, the quality of rest, and other measures of individual well-being such as heart rate and internal heat level. Be that as it may, one of the critical security shortcomings found in Fitbit is nonattendance of affirmation. Some researchers [11–14] introduced that Fitbit is the absence of confirmation potential and, on the tracker's side aggressor, can undoubtedly get the information from without the information on clients. For example, Mahmudur et al. [12] fabricated an instrument, Fit Bite, to trigger assaults on Fitbit gadgets, for example, information infusion assault, DoS, and battery channel hacks to exhibit the verbalization. The results showed that the container without Powerless Fitbit could allow malicious rebate programmers in Fitbit client recordings and arrive or even check their information to acquire financial bonuses. Because BTLE (Bluetooth Low Energy) innovation is harmed, Fitbit Flex is unable to expand. Since the security address [13] or MAC address [14] did not change, this might be effortlessly followed smitten by the Fitbit Bluetooth commercial. In outcomes, it might prompt protection break as outsiders will follow exercises for express clients. Insurance agencies may likewise exploit to create a "dark market" for obtaining clients' well-being information. Nevertheless, Fitbit gadgets might compromise clients' security hazards. For instance, it permits vindictive people to follow a client's space or spots visited to make phishing assaults, causing faux emails that give agreements with the connection, parenthetically that connected to spyware or infection [13]. Figure 11.4 shows a Fitbit device [2].

The differences between a fitness band and a sensible watch are shown in Table 11.1.

11.3 Classification of IOT Portables

To arrange the employments of wearable IoT first, the best-in-class research works, papers, to be published in this space were gathered. The associated works are requested in bunches as demonstrated by their question and each survey document is placed in one of the lots, as shown in Fig. 11.5 [3]. Certain groupings have a more extensive scope of utilizations because of their significance. Other than the

Fig. 11.4 Fitbit [2]

Table 11.1 Variations between a fitness band and a sensible watch [7]

Comparison parameters	Smartwatch	Fitness band
Definition	It combines the functions of a telephone, a watch, and a fitness tracker in a single device	This gadget measures fitness-related measurements and other information
Objective	Tracks fitness and sends alerts and updates	Only able to record fitness-related data
Display Technology	Display options include backlit LCD, OLED, AMOLED, and PMOLED. Display options include OLED, AMOLED, and PMOLED	OLED is the only type of display used
Size	Greater in size and thickness	Comparatively slightly less bulky
Weight	Heaviest	Lightest

fundamental bunches, it is not the only wearable IoT gadget out there that is utilized in different applications, for example, virtual games to improve the gaming experience, installment applications, and schooling. The scope of this evaluation includes the inquiry but excludes other use cases. In the accompanying segments, every classification is introduced by posting the main distributed work.

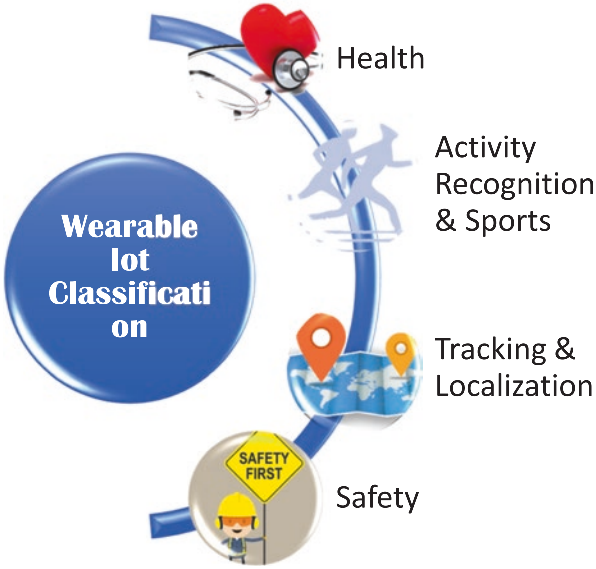

Fig. 11.5 Most researched wearable IoT clusters

11.3.1 Health

Preceding the Internet of Things, patients' participation with experts was confined to visits, tele, and text correspondences. It was incomprehensible that subject matter experts or clinical facilities could screen patients' prosperity reliably and make ideas fittingly.

Web of Things (IoT)-enabled contraptions have made far off checking in the region of the clinical benefits possible, delivering the likelihood to keep patients ensured and sound, and connecting with specialists to pass the sample review. It has furthermore extended patient responsibility and satisfaction as participation with experts have gotten more straightforward and more capable. Besides, far-off checking of patient's prosperity helps in diminishing the length of clinical facility stay and prevents reaffirmations [12]. IoT furthermore essentially influences decreasing clinical benefits costs on a very basic level and further creating treatment results. Table 2 addresses the synopsis of medical services' IoT sensors [3].

The IoT does not change anything in the clinical consideration industry in the space of gadgets and interpersonal relations by shifting the lines of action of clinical consideration. The IoT has applications in clinical consideration that benefit patients, families, specialists, crisis centers, and protection organizations.

IoT for Patients Gadgets as wearables like well-being gatherings and other remotely related contraptions, for instance, sleeves for a heartbeat and heartbeat estimation, blood glucose meters, and so forth, can give customized care to patients. These gears can be fine-tuned to memorize starch levels, hands-on control, action plans, sets of circulatory stress, and more. The IoT has changed individuals, especially established patients, by constantly engaging with disabilities. It fundamentally affects people living alone and their families. In the event of a negative impact or change in an individual's standard activities [1], the prepared framework conveys messages to interested family members and providers of prosperity.

IoT for Physicians By the utilization of wearables and different techniques for home stuff introduced with IoT, specialists can screen patients' prosperity all the more effectively. They can follow patients' adherence to treatment plans or any prerequisite for ensured clinical thought. IoT engages clinical consideration specialists to be more cautious and interface with the patients proactively [3]. When doctors utilize the information gathered from IoT gadgets, they might figure out what the ideal treatment measure is for their patients and show up at the normal outcomes.

IoT for Hospitals Aside from noticing patients' prosperity, there are various districts where IoT contraptions are incredibly useful in clinical facilities. IoT gadgets with sensor labels are utilized to follow the current scope of clinical hardware, like wheelchairs, defibrillators [12], nebulizers, oxygen siphons, and other observing gadgets. Sending of clinical staff at different regions can in like manner be inspected proceeding. There is an increment in infections and is a critical concern because of facilities. IoT-enabled neatness checking contraptions help in holding patients back from getting corrupted. IoT contraptions in like manner help in asset the leaders like pharmacy stock control and regular noticing, for instance, actually taking a look at refrigerator temperature and suddenness and temperature control.

IoT for Health Companies There are different opportunities for prosperity underwriters with IoT-related insightful contraptions. Protection organizations can utilize data got through prosperity noticing contraptions for their underwriting and claims exercises. This data will engage them to perceive blackmail declares and recognize opportunities for ensuring. IoT contraptions get straightforwardness among well-being net suppliers and customers the underwriting, assessing, claims dealing with [3], and danger examination measures. In the light of IoT-got data-driven decisions in every type of effort measure, customers will have acceptable detectable quality into principal thought behind every decision made and collaboration results.

Security net suppliers may offer inspiration to their customers for using and sharing prosperity data made by IoT contraptions. They can compensate customers for using IoT contraptions to screen their ordinary activities and adherence to treatment plans and reasonable prosperity measures [15]. This will help well-being net suppliers with diminishing cases through and through. IoT contraptions can in like manner engage protection organizations to endorse claims through the data got by these devices. Table 11.2 represents the summary of health-care IoT sensors [3].

Table 11.2 Summary of health-care IoT sensors

	Sensed parameter	Sensor	Connectivity	Mobile app	Node process	Wearable
Rehabilitation	Orientation, force, distance	RFID, IMU, load cell, ultrasound	Wi-Fi & Bluetooth	Yes	No	Walker
	surface electromyography	sEMG	BLE	No	Yes	Armband
	Face image, eye blinks	camera	Wi-Fi	Yes	No	Face
	Deflections, acceleration, orientation	Accelerometer, gyroscope. flex	Wi-Fi	No	No	Leg, hand
Monitoring	Heartrate	SFII 7051	Wi-Fi	No	No	Wristband
		ECG and temperature	Bluetooth	Yes	No	Wristband
		ECG & inductive sensor WHMIS	2G GPRS	No	Yes	Leg, hand, chest
	Respiratory	Passive breathing airflow temperature change	Back-scattering	No	No	headband
		Vibration (piezoelectric)	impulse-radio ultra-wideband transmitter	No	Yes	Chest
		Capacitive	Bluetooth	Yes	Yes	Smart vest
	Temperature	LM35	Wi-Fi	No	No	Finger
		IC mounted on tablet-shaped ingestible	magnetic-field coupling	No	No	Ingestible
	Blood Pressure	piezoelectric	Wi-Fi	Yes	Yes	Cuff
	Blood oxygen	Pulse-oximetry	GSM GPRS	No	Yes	Bracelet
	Blood glucose	Near Infrared radiation	Wi-Fi	Yes	No	Finger
	Mental well-toeing	Audio, accelerometer and gyroscope	Bluetooth	Yes	Yes	Wristband

11.3.2 Activity Sports

The arrangement depends on the use of portable devices that are worn during sporting activities to register different estimates of the client/competitor's activity to subsume their show. In addition, the uses of this meeting think of the collection of knowledge regarding the affirmation of step-by-step activities of persons and creatures [16]. While the business claim will have some uses in clinical medicine and the clinical benefits of downtime, applications have a place in this hood of yesteryear use case pack.

For sport exercises, estimating plenty the exhibition or effectiveness of activities known with a specific game and giving input on boundaries like planning, purpose, or live of applying or delivering an influence will assist with performing on the exactitude and execution. Utilizing these methods, players can get constant criticism of their exhibition and work on their presentation to create additionally predictable. There are a variety of various varieties publications out there that examine the employment of wearable gadgets for working on the character of exercises of a selected game or in any event, inflicting the user to accomplish one thing that may not be attainable while not sporting the wearable device. The wearer receives an insignificant message to help him understand the concept of execution or to offer assistance on the most suitable technique to proceed. These messages can be seen on the screen of the portable device or broadcast in several places. Likewise, it could receive messages or the sign of a tactile or audible abuse message. Presentation of the exercises known with various games is investigated, for example, court game [17], ball [18], paddling [16], swimming [19], hockey [20], sport [21], military acquisition [22], bodybuilding [23], court game [24], baseball [25], and golf.

11.3.3 Following and Localization

This grouping is employed usually for following humans and animals to settle on their space on the Internet. Discovering things of a private or creature who is sporting a wearable appliance is important in numerous applications. Considering the course trip of a bird, finding the area of a senior individual during a thought workspace, examining the advancement of individuals who are visiting a show or pet are a few of examples of these applications. A thorough report on restriction utilizing IoT innovation is distributed in Shit et al. [26]; however, the investigation does not specialize in wearable IoT. By and large, the restriction methods talked concerning in writing are separated into two elementary classifications. People that use are separated coming up with and the ones that while not victimization detached preparing will select the region. The readiness subordinate methods can be sorted out into three gatherings: (1) procedure, (2) stochastic-arranged models, and (3) machine learning plans. The procedure has been thought extensively using numerous forms of signs as well as general sign model, such as sound sign, video sign, and development [27, 28]. General sign model depends on indicator of signal strength received value of the faraway sign, during which the district finger impression is distinguished through web site outline and places away in a rare imprint knowledge base, generally. This one-of-a-kind imprint information is employed later by a limitation computation online to gauge the region. The procedure is used on visual information got on camera or sound signs got by an intensifier. The contraptions will in like manner use mixture restriction methods that depend on shared position assessment of every IoT device equally because of the general distance devices.

11.3.4 Safety

This classification has a place with the wearables that are utilized to give a protected climate to the clients. For example, a weakness checking framework can tell the caution the drivers who nod off at the worst possible time and advise the businesses [19]. Then again as another model, wearable contraptions can accumulate the air data in the mines to ensure the expert's prosperity and decrease dangers for earth-movers and costs for organizations [3]. Fall avoidance and identification particularly in older individuals are a significant problem, and there are for wearable gadgets that are utilized to identify or forestall falls.

11.4 Future of IoT in Wearables

At the point when we consider wearable innovation, the main things that strike a chord are smartwatches and remote earbuds; however, the fate of wearable tech holds a lot more extensive extent of uses, particularly in the work environment. Figure 11.6 [29, 30] shows the rise of wearable devices over the years.

Also, as independent gadgets that can be connected to clothing, IoT-viable innovation can be worked into coats, boots, and different things of attire. For the future of IoT wearables, this may mean:

11.4.1 Laborer Well-Being

Physical work ventures, for example, development and assembling are set to profit altogether from wearable IoT gadgets. Well-being guidelines in these ventures have since a long time ago incorporated the wearing of hard caps, defensive goggles, boots, gloves, and high-permeability clothing. Wearable innovation will improve the assurance of laborers much further. On building destinations, the utilization of robots can assist with delineating the region without hazard to specialist well-being, featuring any hazardous regions [31]. Maybe than simply imparting this data to a PC, it could likewise be imparted to wearables, for example, increased reality goggles, like the Google Glass, that can outline the region and safe courses around the site before the specialists' eyes.

Wearable IoT gadgets can likewise be utilized to follow laborer areas and recognize falls, which means mishaps can be more effortlessly forestalled and the reaction can be faster if they do occur [32]. In the form of trackers and other small

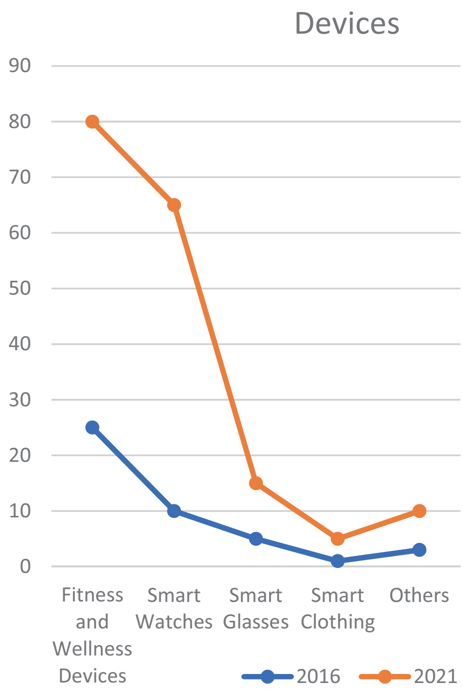

Fig. 11.6 Rise of wearable devices over the years [30]

gadgets that can be used cut to a belt, it is now a reality; however, with the headway of shrewd materials, it might before long be typical to have this innovation fabricated straightforwardly into work boots or coats.

IoT gadgets incorporated into hardware can likewise give alerts to the actual specialist. Gadgets can give perceptible or vibration-based alerts that caution laborers of perils like moving gear or hazardous territory, just as notice them of actual stressors like bowing, bending, and when they are experiencing weariness.

11.4.2 Planning and Training

Another utilization of AR goggles is for project arranging and worker preparing. For instance, with a venture that requires a scale model, wearable AR or VR headwear permits an individual to increase and move around a 3D model of the undertaking and make changes continuously by sending messages to an associated PC. This equivalent innovation could likewise be utilized to show an item more readily in a pitch or show setting.

A small amount of wearable technology is also being utilized to teach highly trained personnel. A few specialists are utilizing wearable AR to rehearse keyhole a medical procedure on models while the innovation reenacts a living creature. This reproduction can likewise be adjusted progressively from a PC to address the complexities that could happen. All things considered, these practices will before long be embraced by other profoundly talented callings too.

11.4.3 Medical Care

IoT wearables have additionally advanced into the clinical calling to comprehend a patient's physiology and give more customized treatment more readily [3]. Wearable tattoos are produced using a slim elastic fix that contains a circuit of adaptable electronic segments and is adhered straightforwardly to the skin.

These "tattoos" can be utilized to screen a patient's vitals and fabricate a total well-being profile on them throughout some period, with practically zero uneasiness to the wearer [33], and this data can be sent progressively to medical services experts.

Not exclusively do wearable tattoos give more precise and extensive information about a patient, yet they can likewise identify indications that the patient is suffering from a well-being profile that makes them vulnerable to specific illnesses or medical conditions. Approaching this information implies that some future medical conditions can be forestalled against ahead of schedule, just as giving specialists a superior thought of which therapies will be appropriate, as well as the patient might cause beforehand inconspicuous intricacies.

11.4.4 Analytics

Utilizing wearable IoT gadgets for investigation will have long-haul benefits outside of medical care as well. Having the option to follow specialist action, area, and feelings of anxiety will assist organizations with smoothing out their practices and create a better working environment effective in its format, just as seeing where time is squandered [31, 32]. Competitors are now utilizing insightful IoT innovation to quantify their exhibition and methods to see where enhancements can be made.

A few organizations might need to use wearable innovation to evaluate the wellness and prosperity in general of their workers. They can utilize it to make a steadier working environment that focuses on laborer fulfilment by decreasing openness to the circumstances that cause pressure.

A major portion of wearable IoT innovation is now in the form of external devices that clients need to furnish themselves, like goggles, smartwatches, or development sensors; however as the innovation advances, we will probably see an ever-increasing number of customary things of the dress being overhauled with IoT ability [19]. Even though wearable IoT is likely to be most beneficial to medical research and clinical enterprises in the short term, this technology is likely to become increasingly prevalent in all commercial sectors, as well as in the household.

11.5 Challenges of IoT in Wearables

The significant difficulties of the wearable IoT gadgets as displayed in Figure 11.7 [3] are recorded underneath.

11.5.1 *Information Goal of Sensors*

As it is important to be of great importance that the portable convenience is once brought by the customer and consumes an occasional proportion of energy, they are normally negligible, and even the sensors have lower objectives that seem different in this.

Fig. 11.7 Significant difficulties of IoT innovation

11.5.2 Power Usage

To restrict human correspondence and for wearable contraptions to figure for broadened periods while not superseding or charging the battery, extraordinary issues are to be thought of whereas composition the wearables. For example, low-power usage structures or energy-gathering methodology, for instance, smaller than expected magneto-electric, thermoelectric, piezoelectric, or photoelectrical gathering ways are some potential choices utilized in Wu et al. [33]. Among all energy harvest procedures, sunlight-based settled energy is taken into account as a powerful up-and-comer because it offers the foremost spectacular thickness. The defect of sunlight-based energy is its obstruction to day times and outside puts.

11.5.3 Wearability

The wearable IoT contraptions must be compelled to be rattling once worn by the client. It is essential to the approach that they are expected to not angry the standard exercises of the client. The trade-off between the multilayered arrangement of the calculations and also the wearable weight is one of every of the essential challenges. In Chen et al. [34], sagacious attire or wearable 2.0 for human-cloud compromise is recognizable that attempts to manage the problem with hassle accomplished by sporting numerous sensors uninterested piece of the body for clinical benefits application.

11.5.4 Well-Being

Technology IoT contraptions distant advancements to convey their distinguished information to a different center point, entrance, or base station. This far transmission incorporates radio repeat radiation, and this could contrarily influence the customer prosperity because of the telephone obtaining wires which are improbably on the point of his/her body. When wearables are worn on the top or eyes, the radiation perils it will be better. The security concern is especially cared-for [35] by evaluating the quality uttermost compasses of human openness to radio repeat magnetic attraction energy and dismemberment the radiation level of CIoT getting wires. It is shown that problems are often addressed by a lot of horrific once in which the wearable CIoT gizmo is imparted in districts with defenseless incorporation.

11.5.5 Security

The many-sided nature of the wearable IoT contraptions is conventionally diminished as a result of lightweight and fewer power-consuming plans. On these lines, there can be fewer attributes of solid security on such contraptions. One of the challenges within the field of wearable contraptions is that the methodology for death penalty security methodologies while keeping the multifaceted style of the structure is as low as may be anticipated. Typically speaking, wearables are easy hacking centers because of defenseless encoding and security.

11.5.6 Guideline

There is at this point a cutoff in using wearable IoT contraptions in numerous ventures because of the absence or presence of appropriate guidelines. For instance, in sports fields, the utilization of wearable IoT gadgets is mechanically attainable, yet it is not being utilized because of the group's guidelines.

11.5.7 Privacy

The consistent trade of individual information, for example, imperative good fortune signs, measurements, and house between technology and additionally the Internet center purpose, can establish a climate for security breaks. Conventionally, wearable IoT contraptions are on the imparted mode that produces them successfully determinable by varied center points among the association. Unapproved center points will take the singular information on the off likelihood that applicable security methodologies are not applied. In such transmission modes, the intrinsic hardware security development of the IoT contraptions probably would not guarantee the protection of individual information against breaks. In [36], a transmission ally IoT model is planned wherever the customers' personal information is only given to expected center points like clinical thought workplaces or contraptions supported by the customer.

Wearable IoT gadgets can have an incredible assortment of utilizations and openings. Exploitation 3D printing, the best-in-class age of those wearables, is going to be helped by localization of function of their arrangement, production, and scattering. For instance, by mishandling this development for the prosperity application, the patient can alter their disease profiles and transfer their mechanical sets from personal health care to printing for the home at insignificant cost. Batteries, the power of the extraclear method, are now allowed in portable IoT gadgets. This extends their self-regulation, carrying out the extraction and demand for parts and the rental and authorization of useful work of material resources. The essential likelihood in wearable IoT is going to be perceived once IoT wellsprings of knowledge and gadgets are accumulated and an incorporated IoT structure is made accessible.

11.6 Conclusion

The wearable can give relentless new opportunities [37] in some certifiable applications. Wearables have many prospects once the Associate in Nursing incorporated IoT framework opens. Thus, the real force of consolidating wearable and IoT has not been perceived [38, 39]. Wearable technology offers higher functionalities by giving constant information correspondence; nevertheless, it additionally represents an additional noteworthy security and protection hazards. Loads of individuals are disturbed regarding wearable security since the knowledge obtained may embody sensitive information about themselves and their environment, equivalent to character, health-related data, Mastercard number, and location [40].

Although this trend-setting innovation advantages people, there are still some security escape clauses and protection offer that necessary further thought and elbow grease of creators in designing wearable innovation models. A superior verification tool is going to be enforced as a result of this.

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Chapter 12
Role of IoT in Smart Homes and Smart Cities: Challenges, Benefits, and Applications

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12.1 Introduction

IoT directs a system of related and connected objects that are used to collect and transmit data over a wireless network. IoT devices collect data through a variety of advanced technologies and freely stream data between other devices [1]. IoT is known as an important part of developing Smart Homes and Smart Cities. To a large extent, Smart Cities fill the regions with nerves so that one can understand and control the environment. These days, a large number of people are moving toward IoT technology and transforming their homes into Smart Homes. For example, when you turn on the light in your room using a mobile app, it becomes an IoT device. Analysts predict that there will be 41.6 billion connected IoT devices by 2025. IoT is a simple concept where the IT world is connected to the real world of objects [2]. IoT-based Smart Homes allow us to control our household items via a cell phone. Smart Homes enable us to adjust the brightness and temperature of a room or an entire house; anyone can turn on and off the lights in our house and many other things by simply using our cell phone. If a stranger or a thief enters or tries to enter a house, the system immediately sends a notification to our smartphone. After receiving the notice, you can take the necessary steps against it [3]. Mobile applications are used to control and operate home appliances. For example, if you forget to lock any doors of your house, the system automatically locks the doors, or if you are

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tired when you return from the office, you can turn on the air conditioner with just your smartphone. For these reasons, a large number of people go to IoT-based Smart Homes. Smart Homes make our home life more comfortable and secure [4]. IoT-based Smart Cities use IoT gadgets like sensors, lights, and meters that gather and examine information. Cities then, at that point, utilize this information to further develop the foundation, resources, and many other things that help build Smart City. IoT-based Smart Cities make the lives of citizens much easier as it offers advanced technologies that help citizens in many ways [5]. Smart Homes are generally considered to be the foundation for the construction of Smart City. Smart City is also known as The Evolution of Smart Homes. Smart Cities aim to use billions of IoT devices in a common area. Smart Cities are helping the city work harder to make our lives more comfortable and secure [6]. Smart Cities enable us to prevent crime, environmental management, air quality management, smart waste management, smart parking, etc. Smart Cities are considered natural because they reduce the impact of greenhouse gases [7]. Smart Cities only work if there is government support that plays a major role in building Smart Cities. Without government assistance, one cannot develop Smart Cities as everyone needs funding for that. According to a recent report, Smart Cities have the potential to generate $ 20,000 in economic benefits by 2026. With the help of large corporations or MNCs and cooperative governments, one can see the development or transformation of Smart Cities over time [8]. As there is a need to use IoT in our Smart Cities and Smart Homes, one needs to be extra careful as they have weak security technologies. Malicious hackers and unauthorized persons can easily get into our system and easily manage our data. One can protect and maintain the privacy of our data by ensuring all required security agreements, maintaining a strong password, and installing all updates on your device as they are available to keep your system up to date [9]. IoT in Smart Homes and Smart Cities make our lives much better and will continue to do so in the future. Studies prove that in the years to come, IoT based on Smart Homes and Smart Cities will take over and make our world technologically advanced. Smart Cities and Smart Homes have become an important part of our lives. These days, the whole world is turning to Smart Homes and Smart Cities based on IoT because they make our lives easier, more comfortable, and more secure [10].

12.2 Literature Review

In this chapter, the author describes the concepts of Smart Cities based on IoT and the challenges they face while using Smart Cities based on IoT. It also discusses weaknesses or errors during IoT installation [11]. This tells us about the Smart Home-based IoT security system where it discusses the performance and implementation of Smart Homes and discusses the future of IoT [12]. As such, Smart Homes can be easily used so this paper tells us the security and privacy measures one should take while using IoT-based Smart Homes. As the demand for IoT devices grows these days, there is a need to make sure our data is safe and secure by taking all precautions [13]. This will focus on urban IoT systems and will also inform us of the adoption of advanced technologies, agreements, and the development of an urban IoT system. The urban IoT system will bring a large number of benefits to the management and expansion of traditional community services [14]. In this, the author describes the IoT technology used in the construction of Smart City and the various hardware and software components required for IoT technology in building the Smart City. We will also discuss vulnerabilities while using IoT-based Smart Cities and how we can overcome these weaknesses [15]. In this paper, one will understand how to control our household items via our smartphone via Wi-Fi or wireless network. It will tell us about the variety of computer and software tools required for IoT deployment on Smart Homes. It will also show us how IoT technology will become a very important part of our lives [16]. This paper explains the concepts of Smart Cities and their use. It also describes the advanced network technologies used in the construction of Smart Cities and also tells us about the major features of the Smart City operations. It also discusses the challenges and experiences in the world regarding IoT in Smart Cities [17]. This tells us about the control and operation of household items such as lamps, fans, air conditioners, and many other items called Home Automation. It also states that Home Automation must have a Smart Security system where the system can send an SMS or photo to our smartphone if something is found [18]. This paper describes IoT and the various uses of IoT in Smart Home Technology and tells us how to create and use this IoT-based Smart City Technology. It also suggests several ways in which one can improve Smart Home applications [19]. This will discuss the use of IoT and how IoT will affect our lives and become an integral part of our lives. It also describes the various IoT services based in Smart Cities that play a key role in the construction of Smart City. It also talks about the future of IoT-based Smart Cities [20]. This paper discusses various types of IoT applications such as Smart Home Automation System, Smart Cities, Smart Agriculture, Smart Industry, Smart Parking System, etc. [21]. This paper discusses the different types of challenges facing IoT architecture design in Smart Homes and Smart Cities and discusses the different types of security attacks on IoT systems and security measures [22]. This paper will tell us about the Smart Security and Home Automation-based IoT system that sends the user via Internet notification to a smartphone when there is an unknown input or when the door is opened. The user can receive messages on his phone when they are out of the house [23]. The author describes the challenges of future research and applications based on IoT, as well as the recent advances in IoT technology, and also talks about Smart Cities, Smart Agriculture, intelligent environment, and intelligent life [24]. This paper creates a Smart Home Automation System where anyone can control and use our home appliances such as turning on/off lights, fans, or air conditioners. It is, therefore, better to upgrade the Home Automation system for luxury living and to design an advanced Home Automation System via Wi-Fi or wireless network [25]. This paper discusses the Smart Parking System in Smart Cities based on IoT technology and discusses the functionality of the Smart Parking System. The IoT-based Smart Parking System allows the client to check the availability of a parking space and book a parking space [26]. This paper discusses a Smart Home

System that works with heat and gas leaks. It also helps us to take care of the plants by watering them from time to time. It is also helpful to use many of the household items everyone uses in our daily lives with a smartphone [27]. This paper tells us about security attacks using Blockchain, various types of IoT services and data security measures, and various IoT protocols used in IoT-based systems and also discusses data security and network security [28].

12.3 Working Principle of IoT-Based Smart Homes and Smart Cities

12.3.1 Smart Homes

Home Automation could include the significant expense of possession, resoluteness of interconnected gadgets, and helpless sensibility. When planning and making a Smart Home System, engineers consider a few components including versatility, how well the gadgets can be checked and operated, simplicity of establishment and use for the customer, moderateness, speed, safety, and capacity to analyze issues. Discoveries from iControl showed that shoppers focus on usability over specialized advancement, and even though customers perceive that new associated gadgets have an unrivaled cool factor, they are not exactly prepared to utilize them in their own homes yet. Truly, frameworks have been sold as complete frameworks where the buyer depends on one merchant for the whole framework including the equipment, the interchanges convention, the focal center, and the UI. There are presently open equipment and open-source programming frameworks which can be utilized rather than or with exclusive equipment. A large number of these frameworks interface with customer hardware like the Arduino or Raspberry Pi, which are effectively available on the web and in many gadget stores. Furthermore, home computerization gadgets are progressively interfaced with cell phones through Bluetooth, taking into consideration expanded moderateness and adaptability for the client.

12.3.1.1 Level 1: Data Gathering

At this point, raw data gathered from sensors is liable to additional preparation. Part of the arrangements in that split data gathered are CSV, tweets, arrangement charts, and texting. Organizations are gathered and altered utilizing the semantic web to change them over to a similar configuration. The accompanying level shows the strategies used to change over information into a similar arrangement.

12.3.1.2 Level 2: Executing the Data

Information gathered from the information assortment level was summed up before move, testing, and coordination at ceaseless levels utilizing semantic web advancement. The principal reason for this standard is to change over mass information into a comparable configuration, for instance, the Resource Description Framework (RDF). RDF [29] is the most generally utilized approach to trade information on the web and works with multidisciplinary information on the different spaces of Smart City. RDF likewise assists with isolating metadata about resources on the web. Different programming applications will want to utilize RDF information for basic reasoning errands. Pre-assembled RDF data created at this level will be manhandled using semantic data and coming about weakness rules with an evident level to set up obvious data recuperation.

12.3.1.3 Level 3: Data Integration and Consultation

Semantic web technology permits the abuse of explicit space information dependent on thoughts and associations between those thoughts. The methodology utilized at this level is summed up underneath. The language of web ontology (OWL) [30] is utilized to engender ontologies. Web Ontology Language (OWL) is an RDF diagram created utilizing RDF and ontologies and permits singular grouping/order. It likewise offers two distinct kinds of designs, which can be utilized to coordinate associations between various classifications, to determine a data resource and an object resource. At the point when isolation is done, the subtleties can be additionally upgraded by nearby specialists and vulnerabilities. Dempster-Shafer will be used here to enlighten advancement and learn new levels in a particular space of talk. In this paper, the Dempster-Shafer strategy is used to join material information [31] from various Smart Cities. This methodology will assist with learning new information through dubious deduction and by helping with the execution of a sharp framework.

SPARQL is the language of the RDF poll [32] used to inquire, get to, and deal with the data/records determined in the RDF plan. At the point when all set information is moved as the RDF increments essentially, SPARQL permits question and recovery of data in a similar arrangement. All things considered, this level ascents notwithstanding low-level data. New guidelines that function admirably during the undeniable level substance data cycle from the juvenile tangible information and would then be able to be taken out and used to fabricate information on the development of Smart City structures.

12.3.1.4 Level 4: Device Control and Warning

Information got from level 3 can be utilized for an assortment of web applications for shrewd working conditions. The information gathered can be utilized from numerous survey focuses like info/yield, informing, alarms, and cautions [33].

Communication Services

The communication place assumes a significant part in understanding the Smart City idea. Current correspondence benefits utilized based on Smart City are as follows: 3G (third period), LTE (long haul improvement), Wi-Fi (remote unwavering quality), WiMAX (all microwave access reconciliation), ZigBee, I - CATV (advanced TV), and satellite communication. The fundamental point is to associate an assortment of gadgets (sensors and IoTs) that can assist with making the presence of occupants more available and safer. The model is given by communication administrations in the home space for associating telephone and PC devices to the web. At the nearby government level, cloud and media communication administrations are coordinated to accomplish better administration. As a result of the well-being area, correspondence innovation can be utilized to interface well-being insights, medicine, and patient area from a distance to these lines to assist with accomplishing the Smart Health framework [34, 35]. Subsequently, with Smart City and interchanges innovation, one can give a protected and productive establishment for a superior life.

Customized Services

For instance, due to automobile and health areas, by joining tactile information, the impact of driver health limits on driving conditions can be quantified. Joining well-being hindrances, for example, hypertension and pulse in a vehicle, can help the driver by estimating their continuous disease, which can assist with establishing a more secure environment for drivers. Likewise, utilizing the vehicle's area, vehicle speed, and traffic volume at the intersection can assist with better screening the state of the vehicle. Due to the healthy climate, information gathered through remote nerve networks about a patient's health and work can assist an individual with an inability. Indeed, by joining the information on home and ecological spaces, the effect of warmth on a home exercise like eating, washing, resting, and cooking can be learned. This can help in tracking down a reasonable workplace, which can be a significant device for considering more established individuals and individuals experiencing dementia. Figure 12.1 shows Smart City architecture

Because of the normal and hierarchical climate, low-level information is gathered in a common habitat, for example, temperature and water will assist with acquiring profound changes over information. At the point when significant level modified information (like floods, tremors, timberland flames, torrential slides, and

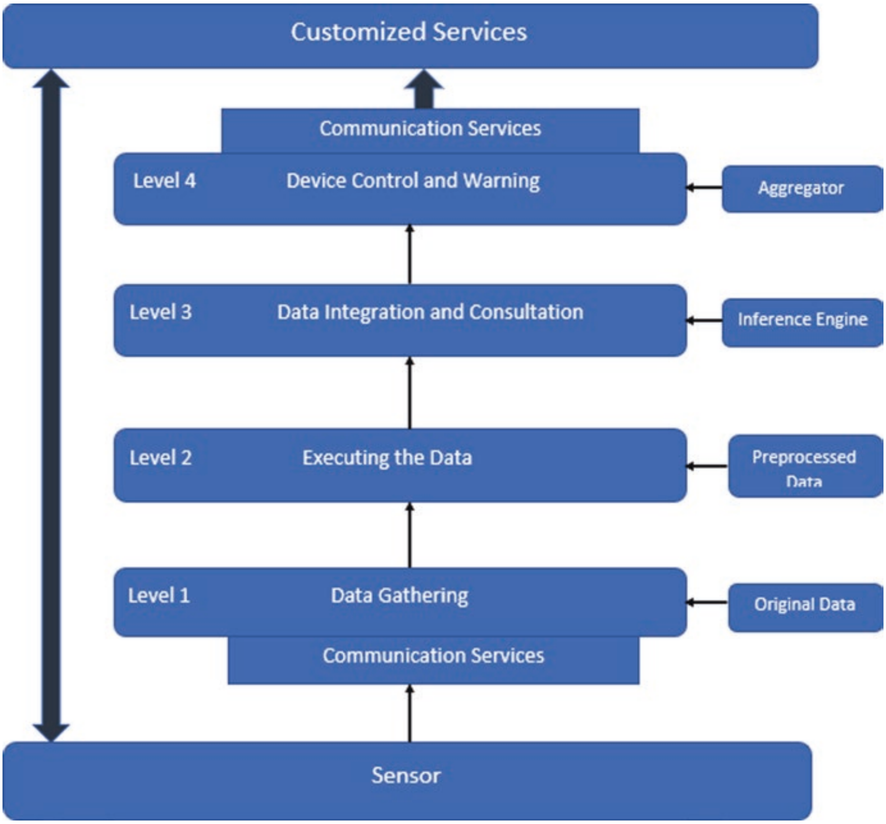

Fig 12.1 Multi-level Smart City architecture

other normal catastrophes) is coordinated into the city board, it can assist with saving lives. Essentially, for the modern area, setting up solid administration acquired by a mix of various information will assist with establishing a protected workplace for assembly line laborers. With normal testing, recording, and abuse of encompassing tactile data from an assortment of sources (e.g., gas weakness, mechanical conditions, and representative well-being) in a modern climate, a superior, more valuable and more secure working environment climate can be made [36].

12.3.2 Smart Cities

IoT-based Water Quality Monitoring System in Smart Cities system uses Arduino as a microcontroller. The whole program is designed to embed - C and match the code created using Arduino IDE. Data collection on PH, water level, temperature and air leaks, and water quality monitoring system uses sensors. This data can be accessed by authorized customers using a client ID and password on a web server by logging into their accounts. Collected data is deleted and broken and sent continuously. The rectifier, relay, and transformer are connected to the microcontroller. ESP8266 is a low-cost module consisting of a complete TCP/IP chip and an Arduino microcontroller chip, which works with data storage in the IoT cloud. The Wi-Fi module uses a serial transmitter and receiver pins to send and receive information, change wireless module settings, and change consecutive query orders. Data from the sensors will be displayed on the LCD. The boots from the external flash are straightforward while processing the system, which increases system performance and storage requirements due to their well-designed cache capacity. Finally, the information in the web application using individual android phones can be accessed [37].

Regulator The center or the fundamental regulator is the main piece of your Smart Home System whether or not you associate single or numerous workers. It's otherwise called the escape and is connected to your home switch through the Ethernet link. So, the web of things-based sensors gets or sends orders through the focal center. The center point imparts the yield to a cloud-based organization situated over the web. Along these lines, it is not difficult to speak with the concentrated center even from removed or far-off areas through your phone.

Smart Gadgets The IoT-based smart home gadgets involve a few smart gadgets for various utilizations of safety, lighting, and home diversion, among others. This load of gadgets is coordinated over a common organization set up as an escape and connected in a lattice organization. This implies it offers the clients the adaptability to work one sensor followed by the activity of the other. For example, when the windows/entryways' sensors of your primary entryway trigger at 7 pm, you can timetable to trigger the front room. For significant distances, these sensor center points assume a fundamental part in permitting simple transmission of signs to the sensors that are far away from the primary regulator however are near the sensor center [38].

Wireless Network The greater part of the IoT-based Smart Home Systems accessible today works on three significant conventions, specifically Z-Wave, Wi-Fi, and ZigBee. The Z-Wave and the ZigBee regulators are given organization IDs which are additionally dispersed over different sensors in the organization. Because of the accessibility of the most limited way, the sign from the regulator will go to the objective sensors either through signal bounces or straightforwardly. In the case any center sensor in the pathway is involved, the sign will look for another approach to show up at its last unbiased.

Associated with Cloud Cloud-based systems administration framework includes support and capacity of information over the web area. This permits clients to approach the information from any area in the world. With the assistance of IoT, home mechanization framework clients through the cloud association can send requests to the middle point even from a faraway or distant region. Then, at that point, the center will flag further to the proposed sensors to trigger and play out the client-mentioned activity. Whenever this is done, the center will refresh the move it has made, and through this, clients can screen and control each part of their smart homes [39].

12.4 IoT Challenges to Achieve Smart Cities and Smart Homes

12.4.1 Smart Cities

The main IoT issues arising from the acquisition of Smart Cities are the following:

- *Denial of service:* An exceptionally enormous number of Internet gadgets in metropolitan regions give a genuine assault vector to noxious clients [40]. For instance, in a major city, thousands or a huge number of gadgets all the while speaking with the two clients and between them, security ideas are tremendous. Smart Cities is an amazing system objective to make IoT bot organizations. The IoT botnet has compromised gadgets and is utilized to perform different undertakings without the information on their genuine clients [41]. This apparatus manhandles the shortcomings that exist in other related articles, for instance, the utilization of default passwords by clients. In this manner, IoT networks are gradually being utilized as an assault stage by pernicious clients.
- *Heterogeneity issues:* For the most part, in IoT cases, information is gathered from an enormous number of normally dispersed things. In any case, information gathered in various ways utilizing various gatherings generally has various designs. Thus, it is absurd to satisfactorily investigate, measure, and store such information without a particular association. This absence of extra terms makes joining information acquired from peculiar sources troublesome. Along these lines, make (1) rules for information mix and (2) data exchanging gatherings that will empower the creation of useful and reliable data between various IoT gadgets [42].
- Security issues

IoT security is undeniably challenging for the administration and supportability of associations and organizations. The US Federal Trade Commission (FTC) has delivered a report that the proper organization of IoT innovation will open up an assortment of well-being and security issues for IoT clients and ought to be more tolerant or settled. For a large portion of these fundamental IoT applications, the utilization of mistaken or adulterated data can have genuine results. Normal security settings like confirmation, privacy, and information honesty are crucial to IoT items, associations, and applications. If IoT objects have adequate memory and planning limits, existing security shows, and measurements might be suitable, yet as there are restricted IoT resource restrictions, these current security frameworks are exorbitant to IoT assets [43]. Security issues stay a significant obstruction to the selection and in general arranging of IoT. By the day's end, customers won't completely acknowledge IoT in case there is no assurance that it will ensure their security. Surely, the IoT can't help itself by warding off assaults for an assortment of reasons: (1) recurrence, objects utilize a ton of their force undetected, making actual assaults on them simpler; (2) most correspondence is remote, making man-in-the-middle Attacks, maybe assaults the most popular of such a program. Therefore, business messages might be dependent upon ensuing consistency, vindictive course, interruption of messages, and other security gives that might influence the well-being of the whole IoT; and (3) an assortment of variables, for instance, RFID marks have confined resources to the extent energy and computation power, which hold them back from executing advanced security game plans. Data security issues can be summed up in data privacy, data confirmation, data uprightness, and data refreshes. Cryptographic procedures are the best answers to help these security needs [44]. Cryptographic insights are the reason for the security and protection insurance of Smart City application administrations since they avoid the convergence of problematic gatherings during life-supporting cycles, preparing and sharing. In the space underneath, there is a need to sum up the cryptographic apparatuses as of now utilized in the Smart City designs and join a particular novel and promising turn of events. One can likewise utilize IoT-based frameworks, biometrics intended to demonstrate generally genuineness. Specifically, these advancements can be utilized to normally distinguish an individual with uncommon good and friendly characteristics. Bio-data is taken out from fingerprints, face, words, manually written imprints, and soon. Blockchain is the response to a basic trial of safety, security, and straightforwardness in this individual, hierarchical, and functional information. Various sorts of brilliant city trades can be recorded on the blockchain. Through smart contracts, complex lawful cycles can be made, and data exchange needs to happen accordingly. With shrewd agreements and appropriated applications, blockchain offers a significant degree of fulfillment to make brilliant exchanges during the smart city working cycle. Blockchain can offer features like predictable confirmation, protection, security, consistent arrangement, and streamlining [45].

12.4.2 Smart Homes

The biggest challenges faced when accessing Smart Homes are the following:

- *Relevancy of Extracted Data:* Information-driven strategies utilizing information mining methods or other AI procedures to collect decent data require experts to understand raw data [46]. One of the most difficult issues to distinguish is the duplication of data collected from sensors, which may be the next step in separating data. Therefore, studies are showing that ordering data extracted from low-level data and another very modest system of high-quality data at that time will completely provide details for high compliance [47]. Setting up sensory data will compare to different parts of the inevitable communication services. The data extracted to set the assumption becomes irrelevant if not used within a period, much of it having a separate component. A large part of the setting is given a dynamic category, for example, a real light spot for mobile or single gadgets [48].

- *User Acceptance:* Research shows that there is an absence of client acknowledgment tests conducted on innovation technologies. A highly customizable user interface should in any case have a degree of iterative improvement and therefore do not affect the services provided to specific clients, emphasizing the importance of availability and availability that are appropriate for specific situations. Further research focuses on greater efficiency in sensitivity, performance, and service delivery rather than contradicting user acceptance of services itself [49]. Setting up the interface of a focused and natural device is problematic considering that they constantly manage a variety of complex system connectors that prevent them from focusing on real work [50].
- *Commercialization:* Acquisitions from flexibility, for example, inaccessible technology or commercial delays that prevent a Smart Home from becoming famous. Most Smart Home appliances are quickly sold before being properly tested by customers. Research shows that technology developers also take advantage of the basic ideas of domestic customers, for example, who their clients are and how they will use Smart Home technology while they are quick to make the product marketable.
- *Failure to Respond to Invalid Programs:* Home adoption programs should have a model that is intended to show home clients the function of the system to enable them to respond to malicious programs. After that, repair plans should be made necessary. In the study conducted by the five components proposed as an integral part of planning, those are neighbors acquisition, central access control, local communication, road development, and service renewal management [51].
- *Cost:* In any technological change, the cost without a doubt plays an important role in purchasing or complying with that technology. The adoption of the technology focuses on showing that there have been concerns about expenses of buying, executing, using, and support [52].
- *Security and Privacy Measures:* Currently, all security systems ensure the well-being or prosperity of the occupants of the house. The default departments will allow the client to permit the person in the restricted area of the house instead of giving them the whole house as a part. Nowadays people wear smart bands; these can be used to open doors and, as a result, add easy access to the client. Nowadays, security is perhaps the most well-known concern in the general public because of the rising crime rate and the attitudes of the people who follow it. Smart Homes' security systems aim to stay away from unauthorized access. Smart Home will be notified in the case anyone is in the house at some point. Currently, there can be two cases where one person is available or no one is available. If they think there is a person (authorized person), they can give anyone who wants authorization access to the Smart Home app or simply accept that person. Currently, in such a case, very little is required, but one can add a few highlights as the image of any intruder will be removed (due to unauthorized person) assuming the authorized person requesting authorization will be given directly to him using

the same camera (i.e., using facial recognition). That access can be allowed anywhere by the client; this is used in the second case. Suppose no one is available at home (tested using infrared sensors), one can consider whether the assumption of individual authorization is valid or not; if so, it is permissible; otherwise the image of each individual's consent request will be sent to the authorized client to allow the category whenever needed [53].

12.5 Benefits of IoT-Based Smart Homes and Smart Cities

12.5.1 Benefits of IoT-Based Smart Homes

- *Easy to lock and open doors:* Safe homes are a vital part of any home. No matter how many keys you use in your home, the risk of burglars and burglars entering your home remains. However, having a Smart Home will reduce your chances of safety by providing safety warnings in the event of an unforeseen occurrence. Usually, if there should be an appearance of those people from your family, who constantly lose their keys or neglect to lock part of the key gates in your home, it may be a good idea to introduce a home security plan to build your home security. Suppose, for example, that if someone came to your home and you had not yet arrived, you could open the door to the talk with the help of smart cameras and a security password and your roommate or relative could stand inside. You can have navigation guides on your doors, gates, and garage that can be opened with a single click of a smartphone.
- *Save energy with Smart Energy conservation:* Energy-saving may be a major concern for each homeowner. With such well-equipped equipment, the amount of energy consumption is increasing dramatically. Therefore, you will always need to ensure that there is no amount of energy wastage and your home needs to meet the energy efficiency requirement. With Smart Home products, you can ensure that no lost cause is lost. Equipment and devices will all be able to be managed and shut down after use when you have a Smart Home product. In the case you are not in the room or you leave the room thinking that you will come back and thus keep the lamp or fans turned on or back where you may carelessly turn off the lights, you can benefit greatly from a Smart Home system that will help you increase energy efficiency.
- *Customize as per your convenience:* It is very helpful with home automation systems to customize smart appliances and devices in your home according to your needs. At a time when you need to build up your heating system or you need to reduce the temperature in an air conditioner or, on the other hand, you think you need to turn on the water heater before you get home or you need to turn off everything while simultaneously lying in bed, you can do it by clicking on your smartphone. This outstanding character is not at all like our traditional homes.

12.5.2 Benefits of IoT-Based Smart Homes

- *Smart Parking:* The most important problem in cities is more than 30% of travelers want to park. As many people move to cities more consistently, eventually, the number of cars is expanding. Smart IoT parking makes life much easier; parking spaces can be found and accessible online to book without delay. However, it creates a decent channel of revenue for you.
- *Smart City Infrastructure:* We have underground pipes, a telephone line, a water line, and electricity line, for example, how to track phone interruptions, water leaks, and blackouts. IoT can quickly follow a problem to determine. It can be scary ahead of time, in this case, to imagine how much time, effort, and human resources can be saved.
- *Public Transportation:* Many carriers can track and transport online now via GPS with IoT integration; they can no doubt follow their next move. As sensors can transmit about the maintenance of protective infrastructure, it is possible in natural environments and other systems. At present, railroads have not been able to benefit from complex collision-avoidance programs, such as those used by ships and aircraft, because the concept of railroads directs trains within inches of each other.
- *Weather Forecast:* Perhaps, we do not have to rely on satellites in the future for the weather. The weather can predict nerves. CO_2, moisture, and the temperature can be tracked by nerves. Because of the experience, we can deal with nature.
- *Traffic and Street Lights:* Traffic delays and other routes can be transmitted to cell phones, external sensors, and street sensors; turn on street lights and turn off when no vehicle is passing. Consider how much energy can be saved throughout the city [54].

12.6 Applications of IoT in Smart Homes and Smart Cities

IoT is one of the most significant technologies. It is viewed as an assortment of tangible and different technologies to associate and trade information with different gadgets and applications through the Internet. Some of the technologies have enabled IoT to gain access to low tech, communications, cloud computing systems, machine learning and analytics, and artificial intelligence. IoT contains many types of applications that are very popular these days and are used for the benefit of the people and the benefit of our country. IoT makes our lives much easier and more comfortable which is why we use IoT technology in different fields [55]. The most widely used IoT applications are smart houses, Smart Cities, IoT agriculture, smart industry, consumer electronics, etc. In this chapter there is a discussion about two major IoT applications, namely, smart homes and smart cities in detail. With the construction of IoT-based Smart Homes and Smart Cities, we need IoT devices; other than these devices, we cannot develop Smart Homes and Smart Cities. IoT devices are referred to as devices connected to a large central device. Examples of IoT devices are as follows with cameras, microphones, and RFID transmitters. IoT devices are said to be responsible for data collection and transmission. IoT devices used to monitor and control mechanical and electronic systems are used in a variety of formats. Home Automation that makes Smart Home is used to control household items such as lights, fans, air conditioners, and many more using different types of system control techniques. Smart Home these days is considered to be the most searched IoT feature available on Google. IoT companies make these types of IoT devices to make our lives much easier and safer. Smart Home products will save you a lot of time and money as mentioned by many IT professionals. The Smart Home program contains Security Systems, Smart Appliances, Automatic Lighting, Smart Grid, Sprinkler systems, Smart e-meter, Garage Door Opener, etc. lifelong experience [56]. Figure 12.2 signifies the Smart Home System which consists of Smart Appliances. These are home appliances like lights, fans, doors, etc. which can be controlled by a smartphone, Smart Grid which exchanges electricity and information, and Automatic Lighting in which the lights can be turned on or off via smartphone [57, 58]. Security System does not give access to an unauthorized person, garage door opens and closes via smartphone, Sprinkler System activates as soon as it indicates that there is a fire in the house, and Smart e-meter measures the usage of gas or electricity in the house.

Smart City is one of the most widely used IoT applications. Smart parking, environmental management, air quality management, and water distribution systems are some of the examples of IoT apps for Smart Cities. IoT will solve many of the big problems these days that most people face. Smart Cities will play a major role in the development of the country. The Smart City program contains the Internet of Things, Smart Government, Smart Travel, Smart Health, Smart Grid, Smart Homes, Smart

Fig 12.2 Smart Home System

Retail and Education, etc. Therefore, Smart Cities will make our lives easier, more comfortable, and safer [59–61]. Figure 12.3 shows the Smart City System which consists of Smart Energy which is the usage of devices for energy effectiveness, Smart Health which uses technology and the Internet for the treatment of the patients and connecting with patients, Smart Home which uses various home appliances that control and operate the home, Smart Government which relates to the government which supports the idea of Smart City and helps the engineers with resources in making it happen, Smart Mobility which indicates many different modes of transportation which reduces traffic and improves the transfer speed, and Smart Retail which refers to modern shopping technologies.

12.7 Conclusion

With the help of Internet of things, devices that can communicate with each other via the Internet, access to information on the Internet, storage and retrieval of information and communication with customers. The world has completely changed as a result of the development of online applications. Cooperation in all situations seems impossible without it. IoT can enhance its vision by enabling communication between intelligent objects. IoT dependent on a Smart Home System can simply work inside the eyes of the web. The quick improvement of IoT gadgets brings concerns and advantages. Except if Wi-Fi is accessible, we can go to 3G or 4G administrations. This is one of the significant advantages of IoT. In this movement, the utilization of a microcontroller camera can assist the customer with concluding

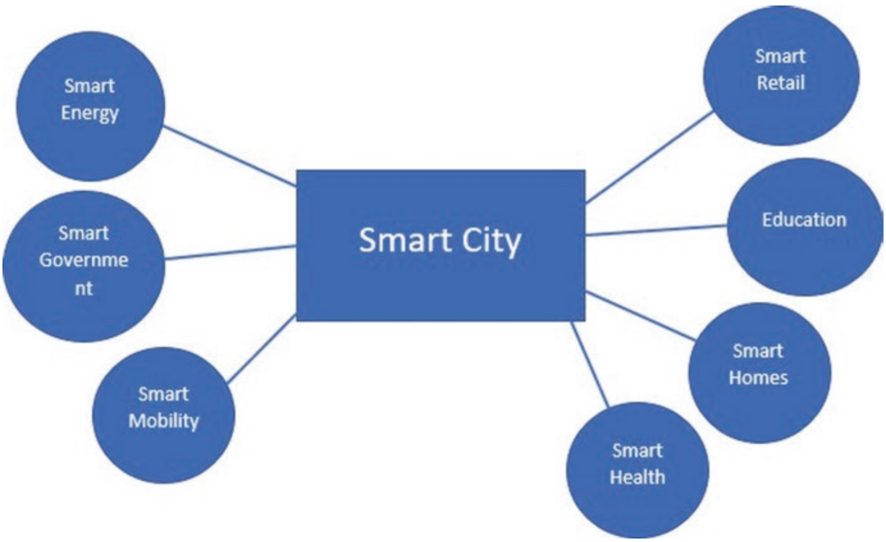

Fig 12.3 Smart City System

whether to welcome the following guest to get a caught picture of the visitor or the aggressor. Assuming the client sees that he is more peculiar, the client can add a similar picture to the police by explaining his status. IoT talks about the best way to make the city smarter. To be sure, IoT can be used in a variety of contexts, for example, building inspection and WSNs; environmental monitoring, for example, gas filtering, the water level of ponds or soil moisture, waste management, smart parking, and low CO_2 vision; or independent driving. It is expected that by 2050 most cities will be powered by smart IoT devices which make cities smarter. All used IoT equipment will assist connected technicians in managing and testing safety concerns for the city's residents. This ongoing infrastructure transformation will help city experts to ensure reduced costs and improve the quality of life of rural households [62]. It is clear that the IoT is the largest research subject and is important for those involved in science to understand the research practice. This paper provided an analysis of various IoT applications. This has led to a significant demonstration of the use of IoT-based Smart Homes and Smart Cities and their operational goal, implementation, targeted challenges, and benefits.

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Chapter 13
Investigating Role of IoT in the Development of Smart Application for Security Enhancement

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13.1 Introduction

13.1.1 IoT

The IoT is no more a technical hype. It's a technology that has been silently changing our future for some time now. It is for this reason that we choose to make our devices smart and take care of the things that will help us be more productive [1–3]. We've designed gadgets for collecting and sharing data and making accurate and educated judgments using machine learning as well as neural networks by connecting them and then with the Internet (complex mechanisms). The results it showed are spectacular. Figure 13.1 shows the IoT architecture.

IoT solutions give users the ability to automate, analyze, and integrate their systems more deeply [2]. They increase the scope and precision of these areas. Sensors, networks, and robots are all part of the IoT, which uses both established and new technologies. Software advancements, reducing expenses on hardware, and a modern approach toward the technology are all exploited by IoT. There is a huge shift in

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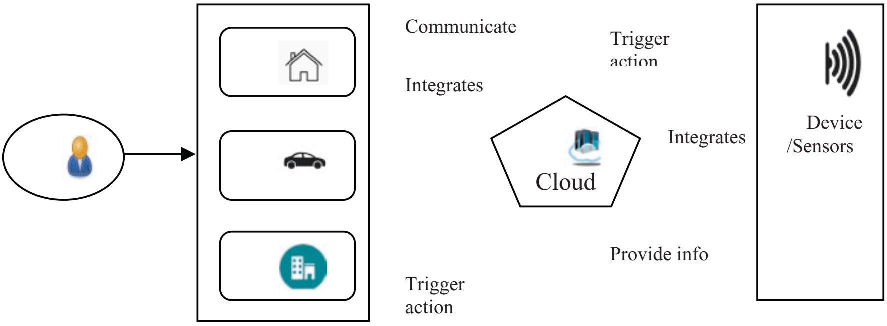

Fig. 13.1 IoT architecture

the field of delivery of products, goods, and services as a result of its new and advanced elements.

The "smart home" is an excellent illustration of IoT in action. It's possible to operate the "things" in a connected focal point (i.e., settings related to temperature, unlocking doors, etc.) through a mobile application or a website using Internet-enabled devices such as thermostats, doorbells, smoke detectors, and security alarms. IoT can be traced in a wide range of devices, industries, and settings, not just inside the home. From classroom smart boards to medical devices which have the potential of detecting symptoms of disease like Parkinson's, the IoT is rapidly making real and virtual worlds smarter [4].

13.1.1.1 Features of Internet of Things

Artificial intelligence, connectivity, sensors, and active participation are among the most important aspects of IoT. Here's a quick rundown of some key features:

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With the power of data collecting, AI-based networks and algorithms, the Internet of Things (IoT) makes nearly everything "smart" (as shown in Fig. 13.2), enhancing every aspect of our lives [1–3]. Simply adding sensors to your refrigerator and cabinets can help you know when your favorite milk and cereal are running short and automatically place an order with your favorite grocery store.

For IoT networks, this means that big providers are no longer the only ones who can connect to the IoT networks they provide. Smaller, more cost-effective networks can nonetheless serve a meaningful purpose. Between IoT, system devices are these small networks.

Small Devices
As expected, devices have shrunk in size, cost, and power over the years. To achieve its preciseness, scalability, and versatility, IoT relies on purpose-built tiny devices [4].

13.1.1.2 Advantages of the Internet of Things (IoT)

IoT's benefits extend to every aspect of daily life and business. The Internet of Things (IoT) has many advantages, including the following:

Enhanced customer engagement: At present problem-solving suffers from faults and substantial weaknesses in precision; also, as previously mentioned, customer commitment remains submissive. When it comes to engaging with audiences, IoT transforms this process.

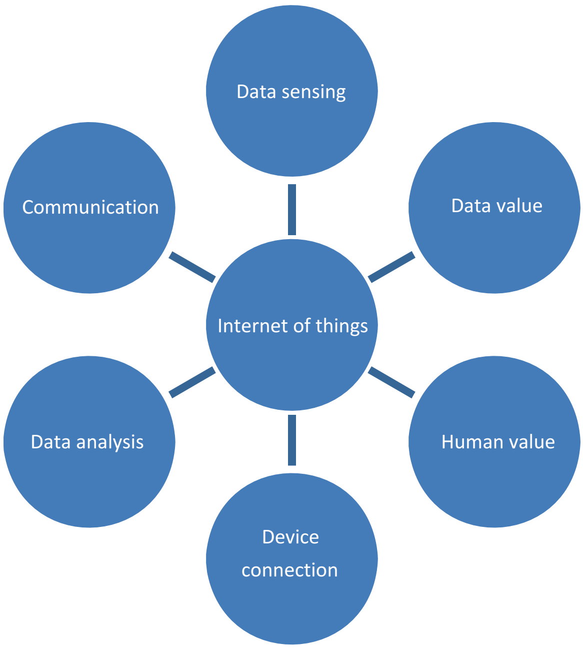

Fig. 13.2 Internet of Things from connecting devices to human value

Improvements in customer experience and device utilization are aided by both new technologies and data that optimize the technology. The Internet of Things (IoT) provides access for key operational as well as field data.

To reduce waste, the Internet of Things (IoT) identifies areas that might be improved. The Internet of Things (IoT) will assist in better managing our resources by providing us with real-world data. As a result of its limits and intended for passive use, modern data collecting suffers from a lack of innovation. There are areas in our environment where we want to look, and the Internet of Things (IoT) helps us get there. It provides an accurate depiction of the world around us.

Figure 13.3 depicts the important advantages and disadvantages of IoT.

13.1.1.3 Disadvantages of the IoT

Although the IoT offers many advantages, it also has certain drawbacks, such as the following:

IoT generates an ecosystem of connected gadgets that communicate via networks. This presents a security risk. It's difficult to exert any sort of control over the system, even with all the safeguards in place. As a result, users are vulnerable to a wide range of cyber-attacks.

IoT provides a wealth of personal information without the user's knowledge or consent. Several users remain apprehensive about the IoT system's ability to seamlessly interact with other systems. Concerned about having many systems that are either incompatible or locked, they try to avoid installing new ones.

As with any other business technology, the Internet of Things must adhere to rules.

13.1.2 IoT Hardware and Software

Key duties and operations, such as system activation, action definitions, transmission, and findings, are handled by these devices to support specified goals and actions. Sensors are a part of the Internet of Things. Sensors may be the most

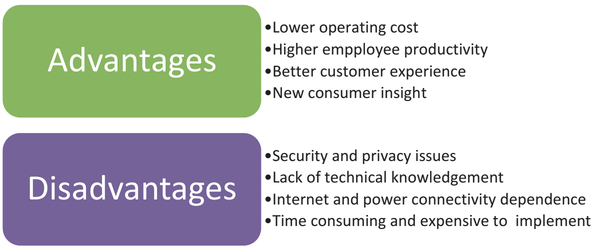

Fig. 13.3 IoT advantages and disadvantages

significant piece of IoT hardware. Power management modules, radio modules, and sensors are all included in these devices. The sensing module is in charge of a wide variety of active and passive measurement instruments that feed data into it. Accelerometers, temperature sensors, and magnetometers are only a few of the devices utilized in IoT. Other devices include gyroscopes and image sensors, as well as acoustical and light sensors.

13.1.2.1 Wearable Gadgets

As a component of an IoT system, smartwatches not only keep us connected but also provide them access we need to boost our productivity. With an IoT system, smart glasses allow us to get more out of our time by allowing us to experience more of the media and services we care about. Smart wearable gadgets currently on the market include the following:

Helmets, goggles, and other protective gear for the head are included.
Neck: Necklaces, cravats, and other garlands.
Watches, wristbands, and rings for the arm.
Outfitting, backpacks, etc. are all examples of the torso.
Feet: Socks and footwear.

13.1.2.2 Common Devices

The command center and remotes of the IoT remain desktop, tablet, and smartphone. In terms of system control, the desktop is the most user-friendly option. As a remote control, the tablet provides access to the system's most important functionalities in a manner that resembles the desktop. The phone has a few important settings that can be changed, as well as remote control capabilities. Other important connected devices include routers and switches, as well as other conventional network devices.

13.1.2.3 IoT and Software

Platforms, embedded systems, partner systems, and middleware all play a role in IoT software's major networking and action areas [2, 3]. Each of these individual and master applications collects data, integrates devices, performs real-time analytics, and extends applications as well as processes among the IoT network. Integrating with vital business systems (such as order management, robots, and more) is a key component of their work.

An IoT decision framework is shown in Fig. 13.4.

IoT Decision Framework		The IoT Technology Stack				
		Device hardware	**Device software**	**Communication**	**Cloud platform**	**Cloud application**
Decision areas	UX	Yes	Yes	Yes	Yes	Yes
	Data	Yes	Yes	Yes	Yes	Yes
	Business	Yes	Yes	Yes	Yes	Yes
	Technology	-	-	-	-	-
	Security	-	-	-	-	-
	Standard and regulation	-	-	-	-	-

Fig. 13.4 IoT decision framework

13.1.3 Compilation of Information

It helps sensors connect to real-time, machine-to-machine networks by employing certain protocols. That data is then sent by the parameters that have been established by the user. Similarly, it distributes data across devices in the other direction. A central server finally receives all of the collected data.

13.1.3.1 Integration with Other Devices

The IoT system's body is created by the software that supports integration, which ties all system devices together. The IoT network is defined by these applications since without them, the system is not an IoT system. To facilitate transmission for handling are numerous gadgets, protocols, and restrictions of every device.

13.1.3.2 Analytics in Real Time

Input from a variety of apparatus is sent into these programmers, which transform it into actionable information or clear patterns for human study. For automation-related tasks or industry data, they use various settings and designs to analyze information [5, 6] (indicated by Fig. 13.5).

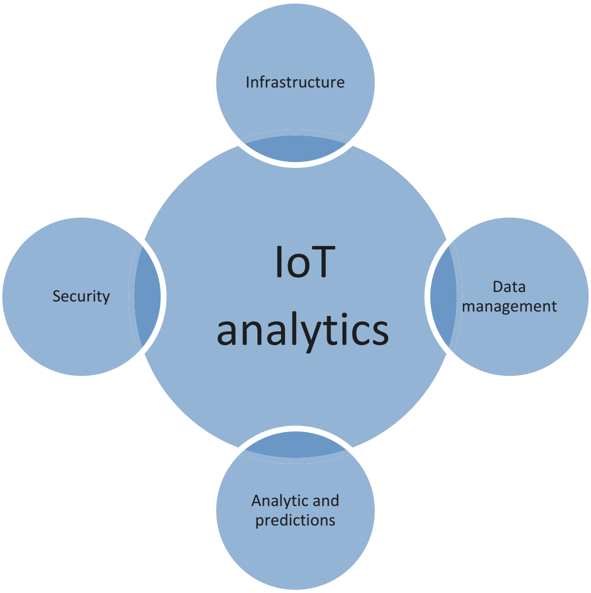

Fig. 13.5 IoT analytics

13.1.3.3 Adaptation and Enhancement

These applications provide for a broader, better-productive system through an increase in the reach of current systems and software. Predefined devices, such as mobile devices or technical tools, can be integrated for specialized applications. It aids in boosting capacity as well as chances for obtaining correct data.

13.1.4 Technologies Used in IoT

IoT technologies have been briefed in Fig. 13.6.

13.1.4.1 RFID and NFC

RFID [3] and NFC are easy, low-energy options for identification and access tokens, connection bootstrapping, and payments and use radio transmitter/receivers to identify and track objects. It's possible to communicate between a mobile phone and a computer using NFC, which is an established set of rules and regulations for this purpose.

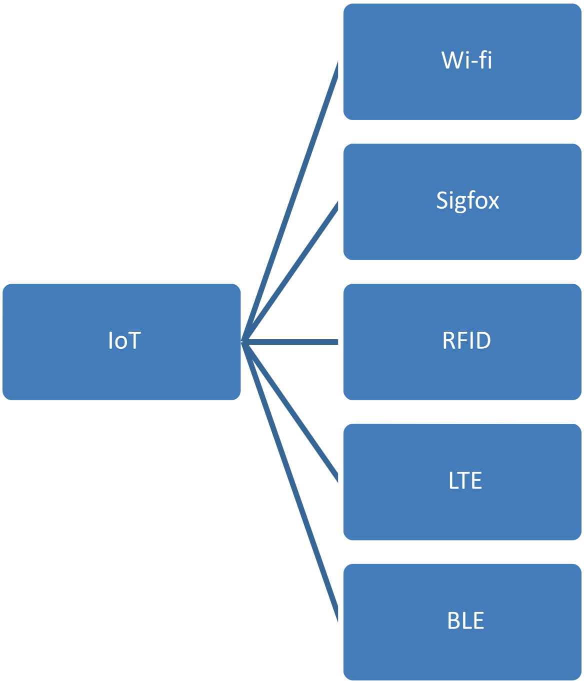

Fig. 13.6 IoT technology

13.1.4.2 BLE Device

The low-power, long-use requirements of the IoT function are supported by this technology, which exploits a standard technology that is naturally aided across systems. BLE is shown in Fig. 13.7.

13.1.4.3 A Wireless Low-Energy System

Communication links (e.g., wireless) must continue in hearing mode even when sensors and other elements are turned off. Additionally, less use means a longer lifespan for a device because of reduced energy consumption.

13.1.4.4 Protocols for the Transmission of Radiowaves

Using radio technologies like ZigBee, Z-Wave, and Thread, you may set up low-rate private area networks. Even though these technologies consume a small amount of electricity, they deliver a significant amount of data throughput. Without the usual expenditures, this boosts the power of small local device networks.

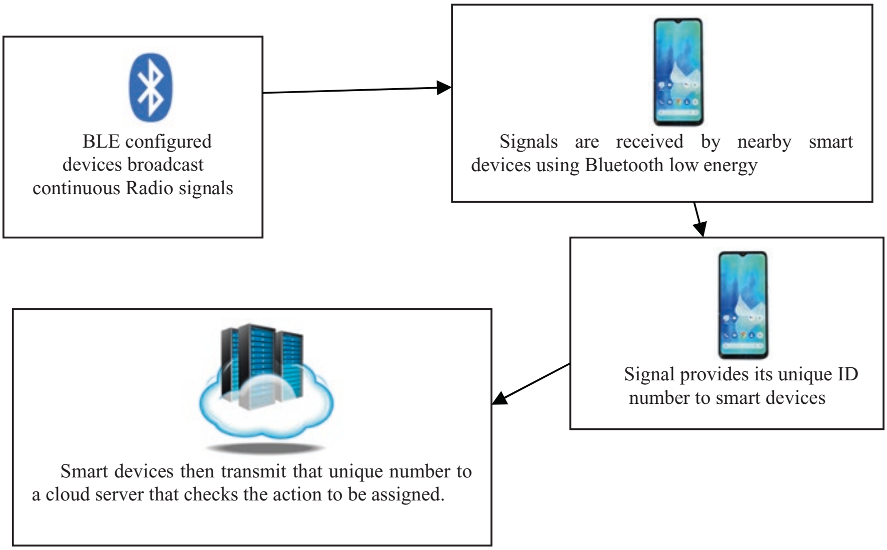

Fig. 13.7 Bluetooth Low Energy (BLE)

13.1.4.5 LTE-A

By enhancing both coverage and latency and improving throughput, LTE-A, also known as LTE Advanced, represents an important step forward for LTE technology. Expansion of the IoT's range, particularly in the automobile and unmanned aerial vehicle communication, provides it immense power.

13.1.4.6 Wi-Fi-Direct

An access point is no longer required when using Wi-Fi-Direct Wi-Fi-like speeds, and lower latency makes it ideal for peer-to-peer connections. A part of the network that frequently slows it down can be eliminated without sacrificing speed or throughput, thanks to Wi-Fi-Direct.

13.1.5 Smart Applications of IoT

There are several uses for IoT in every industry and market sector (shown in Fig. 13.8). Those who wish to save money on their utility bills to major corporations who want to simplify their operations are all included in the user base. When applied to government and safety, the Internet of Things (IoT) has the potential to improve law enforcement, defense, city planning, and economics. In addition to addressing many of the present shortcomings, new technology also broadens the field of possible undertakings.

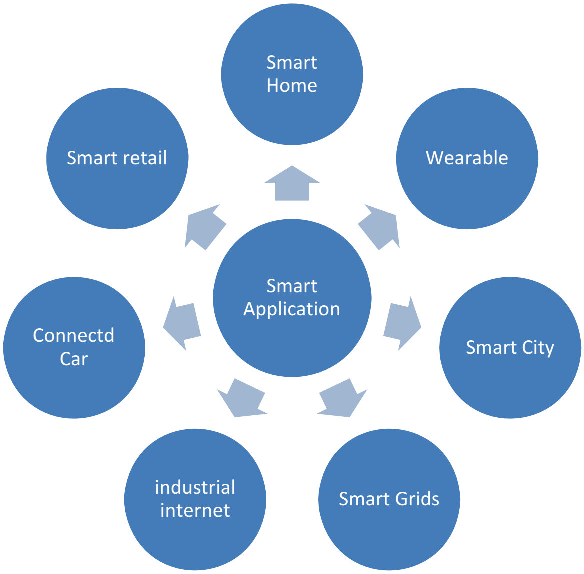

Fig. 13.8 Smart applications of IoT

13.1.5.1 Infrastructural, Industrial, and Engineering

Improving manufacturing, marketing, service delivery, and safety are all possible outcomes of IoT implementation. A robust way of monitoring numerous processes is provided by the Internet of Things, and actual openness enables more chances for improvement. A high level of control provided by the Internet of Things (IoT) enables speedy as well as effective action on opportunities, such as clear client requirements, nonconforming products, and malfunctioning equipment.

13.1.5.2 Safety and Government

The Internet of Things (IoT) can improve law enforcement, defense, city planning, and economic management when used to government and safety. The technology fills in the current gaps, corrects many of the current defects, and also widens the scope of endeavors.

13.1.5.3 Official and Domestic

Throughout our daily lives, the Internet of Things (IoT) provides a personalized experience, from our homes and workplaces to the businesses we commonly do business with. We are more satisfied, more productive, and safer as a result. As a result, the Internet of Things (IoT) can assist us in enhancing our work environments. As a case in point, Joan has a career in advertising. She walks into her office, and the system identifies her.

13.1.5.4 Medicine and Health

The Internet of Things (IoT) encourages us to envision a future in which medical gadgets are seamlessly integrated into a network. Medical research, devices, care, and emergency care will also gain from the Internet of Things today if it is used properly and effectively.

13.1.5.5 Content Marketing and Distribution

Unlike current technologies, analytics, and big data, IoT acts comparably and more deeply. This data can be used to develop metrics and patterns over time, although it is generally lacking in depth and accuracy. With the help of IoT, this can be improved.

13.1.5.6 Enhanced Marketing

The current advertising model is plagued by overexposure and a lack of specificity. Adverts still fail, even with the help of today's advanced data. Instead of one-size-fits-all advertising techniques, the Internet of Things (IoT) promises diverse and individualized advertising.

13.1.6 Threat to IoT System

An associated liability can arise from IoT's security weaknesses and its ability to perform specific activities. Device malfunction, attack, and data theft are the three key concerns. They can cause a wide range of problems.

13.1.6.1 Fault in the Equipment

A deeper level of automation is introduced by the Internet of Things, which may control essential systems and systems that have a direct influence on life and property. In the event of an IoT furnace control system malfunction, frozen pipes and water damage may result in an unattended home when the system fails or malfunctions. This necessitates the development of countermeasures by organizations.

13.1.6.2 Attacks Against Computer Systems

IoT devices put the entire network at risk, as well as anything that is directly impacted. A hacked stove or fire sprinkler system could be the result of tremendous integration and productivity, but it's also the perfect opportunity for mayhem. The most effective defenses target the weakest links and offer a range of customizable features, including monitoring and access privileges. Anti-attack tactics can be simple and effective. To protect yourself and your company, you should look for gadgets that have built-in security.

13.1.6.3 Theft of Personal Information

Many people are drawn in by the allure of data that comes with the Internet of Things. The importance of personal data to persons for crimes, stalking, and a twisted sense of gratification are just a few of the reasons these people are interested. This hazard can be managed with the same tactics used to combat attacks.

13.2 Literature Review

Prior research in the subject of IoT is the topic of this section. IoT was coined by Kevin Ashton. Many investigations into this topic have been conducted since then. A wide range of industries, including consumer, industrial, infrastructural, and even outer space, is already making use of IoT. This study focuses on the smart use of IoT. The following authors will be briefly discussed in the upcoming section:

The Internet of Things (IoT) smart home study by Mustafa Asaad Omran et al. [7] presented an overview of growing interest in IoT smart homes. IoT enables a home automation system to remotely monitor and operate various electronic gadgets (HAS). The rationale for using smart houses and smart home engineering is then discussed, as are the most commonly used wired and wireless communication methods for smart homes.

When it comes to IoT, B R Vatsala et al. [8] stated that it will play an important role in the near future. The Internet of Things (IoT) concept is that things, rather than humans, may communicate with one other over the Internet. With enhanced amenities like smart cities, homes, and hospitals, IoT can help people lead more comfortable lives. People's quality of life can greatly benefit from an examination of Internet of Things (IoT) applications.

Abhishek Khanna and Kaur [9] reviewed a wide range of contributions from researchers in diverse fields of application. In each application domain, these papers were tested on a variety of criteria. Existing issues in these fields are also discussed. For new researchers in this field, the study has also highlighted future IoT research prospects to better prepare them for evaluating present IoT standings and developing unique ideas.

In the premises of varied smart cities, Peng Su et al. [10] developed an SCI system stationed on information islands. The SCI system's smart monitoring of the environment, smart transportation, and prevention of epidemics in a smart way included a variety of application levels. The smart city information system was further optimized for efficiency utilizing a multi-objective optimization method using IoT and cloud computing technologies.

In S. Baskar et al. [11] developed trust model, different timely qualities are used to identify the service's reputation. The reputation was calculated based on the total amount of trust a person can place in a person over time and in different contexts. The service provider's attributes and the unknown features were recurrently examined using deep machine learning to fuse the data. Confidence in service and application responses was reduced by using a data fusion method to estimate trust levels. False positives, ambiguity, data loss, computation time, and service dependability were used to evaluate the suggested method's performance.

Internet of Things (IoT) authentication mechanisms was thoroughly surveyed by Yang and his colleagues [12]. These protocols were grouped into four categories: (a) M2M, (b) Internet of Vehicles (IoV), (c) Internet of Energy (IoE), and (d) Internet of Sensors (IoS). Presentations on IoT authentication protocols' threats, countermeasures, and formal security verification methodologies were given at the conference. For the IoT, an authentication protocol taxonomy and a comparison of those protocols created for IoT networks were offered.

Interconnections between numerous objects and intelligent devices are provided by the Internet of Things (IoT), according to Fadhil [13]. In IoT, data collection, processing, and transmission are the three main pillars. Home, healthcare, telecommunications, environmental management, industry, construction, and energy use IoT. The use of embedded devices in IoT technology is distinct from the use of computers, laptops, and mobile devices. Security is becoming increasingly important for IoT systems because of the exchange of personal data generated by sensors and the ability to combine real and virtual worlds. Lightweight encryption methods are also needed for the Internet of Things. That is why their research needed to focus on IoT-specific security concerns and issues and then develop authentication methods that would help implement safe IoT services.

Yu Liu and colleagues [14] used lightweight block ciphers that were specifically built for IoT, such as radiofrequency identification and sensor networking. Bansod et al. proposed NUX, a 31-round iterative ultra-lightweight cipher. Using differential and linear analysis, they tested NUX's resilience to these methods and searched for 31-round differential properties and linear approximations. It was claimed during the specification of design that the 25-round NUX was capable of withstanding both asymmetrical and linear attacks. Their 29-round differential attack on NUX, which was four rounds greater than the limit set by authors, was a success thanks to the 22-round differential feature they discovered in their work. A 19-round linear approximation of their paper which was a key recovery attack on NUX was also revealed. Full NUX with a data complexity of 8 was also used to develop a distinguishing attack, which utilized the property of differential propagation over NUX to build its distinguisher.

Reinforcement learning principles for smart city applications using IoT were presented by R. Dhaya et al. [15]. Smart city applications and their interaction with IoT are discussed in the first section. The smart city advances were discussed in the next part, which included information on deep learning and reinforcement learning. Experts in open fields (typically, neighborhoods or regions) faced a major challenge in the efficient management of information that could aid new services in most cases. In addition, it has defined an intellectual approach for inquiry obligations that was trained using machine learning (ML). Mathematical functions were used to bring a well-structured framework to remodel the decision-making process in any game or task with greater complications.

The problem of energy harvesting about the Internet of Things with amalgamated users was studied by Desheng Wang et al. [16], with three types of single-antenna users: ID users who get information only, EH users who solely get energy, and ID/EH users who get information and energy from a multi-antenna base station at the same time via power splitting. With this goal in mind, they worked together to create the transmitter power allocation and receiver power splitting technique to maximize the minimal SINR for the two groups of ID and ID/EH users, both of whom had to meet strict energy harvesting limits. To address the non-convex issues, they used SDR, ZF, and MRT methods.

It was suggested by Ahmed Abdelgawad and Yelamarthi [17] that an SHM platform with embedded IoT could determine the magnitude and location of damage in structures. Among the components of the suggested platform are a Raspberry Pi computer, a Wi-Fi module, analog-to-digital converters, a buffer, and a piezoelectric sensor. Pairs of piezoelectric sensors were inserted into the framework, to measure vibrations. Data gathered from piezoelectric sensors was utilized to calculate the extent and location of the damage. By using a Raspberry Pi computer, the mathematical model could determine if any structural damage had occurred and where it might be located. Remote access to the data was made possible by storing it and making it accessible from any mobile device. Using a lab testbed, the system was proven to be reliable.

For Pallavi Sethi and Sarangi [18], the term IoT describes a paradigm in which physical objects outfitted with sensors, actuators, and computers may exchange data with one another. This new growing field was thoroughly surveyed for the most up-to-date methods, protocols, and applications. An IoT taxonomy was developed in this study, identifying some of the most essential technologies and highlighting specific applications that have the potential to significantly improve the lives of people, particularly those who are differently abled and the elderly.

It was reported by Olutosin Taiwo and Ezugwu [19] that a cloud-based intelligent home automation system had been designed and developed. Mobile applications regulate monitors and take account of the defense of residential surroundings. Two modules work together to regulate and monitor the home's electronic equipment and environmental conditions, while one module monitored the defense system of residence by detecting movements and taking photographs. Motion-activated cameras were utilized to collect photographs of items that had been spotted. Using machine learning, they were able to distinguish between photos of normal house inhabitants and those of an intruder. These findings were presented in this study using the support vector machine technique, which was used to categorize aspects of the images captured and assess whether or not the images were taken by an intruder. Graphical representation of household activities was provided by the mobile application's design.

IoT-based technologies for geriatric healthcare applications were thoroughly reviewed by Deblu Sahu et al. [20], who presented current and comprehensive knowledge. Geriatric healthcare using IoT technology was also mentioned as a current trend, concern, challenge, and future research field. Using the information in this study, future solutions and cost-effective healthcare services can be developed for the underserved. IoT's influence on many healthcare areas, including AAL, telemedicine, automated technology, and wearable sensors in the senior census, was also addressed by their paper. Additionally, the study reviewed the status of IoT-enabled healthcare systems which address a variety of healthcare challenges, such as serious disease management, neuro- and psychiatric ailments, cognitive disease, and diagnosis.

By using the Internet of Things (IoT), Biljana Risteska Stojkoska et al. developed a hierarchical method for home healthcare systems [21]. A three-tier data management model, consisting of dew computing, fog computing, and cloud computing, was established for optimal data flow in IoT employing residential care systems. They employed a distributed fuzzy logic approach to testing their model in the context of a quick fire detection system. Fire detection IoT systems with dew and fog computing were shown to be very accurate, with minimal data delay, according to the results.

A strategy named SCIB was proposed by Zhanyu Liu [22] to improve performance and to expand the smart city industry even using big data analytics. They started with big data and then moved on to digitalization of the data. It was then uploaded to the cloud and stored there. The data processing, decision-making, and data transfer processes were now completed by the application user's requirements. Simulated results were used to determine how well the proposed technique performed in terms of delay, lifetime (duration), failure rate (frequency), congestion rate (frequency), and throughput (throughput rate). At the same time as increasing throughput and life expectancy, the SCIB technique minimizes the delay, failure rate, and congestion.

A proposed agent-based architecture for knowledge discovery by Sajid Hussain et al. [23] was utilized to extract knowledge from the fluctuation in the received signal strength indicator (RSSI). An in-house experiment was undertaken to demonstrate how RSSI may be used to uncover new information in an indoor environment. Using Moteiv's Tmote Sky sensors, a WSN was set up in a person's bedroom to monitor their sleeping habits and other physical activities. A WSN was also used to track a person's movement throughout a room and determine whether chairs were occupied. Knowledge discovery and data mining will increasingly rely on fuzzy logic and other machine learning approaches in the future. Context-aware services and applications for end-users could also exist.

To figure out who is behind many virtual accounts, Kaikai Deng and his colleagues [24] believe there must be a method to do it. In their investigation, a random forest confirmation algorithm concentrating on stable marriage matching was recommended since the many-to-many technique of user identification had a poor accuracy rate. The random forest model was constructed using a user similarity vector training set; subsequently, the candidate matching pairs were joined with the secondary confirmation of the random forest model to form the final set of matches.

Insaf Ullah et al. [25] suggested that a person or party might delegate their signing power to a proxy agent. Existing methods of proxy sign-encryption security rely on RSA, bilinear pairing, and elliptic curve cryptography (ECC). A reduced key size was utilized in the hyperelliptic curve cryptosystem simultaneously paying due importance to preserve the same level of security. To test for IND-CCA and enforceability under adaptive chosen message assaults, the random oracle model was used to evaluate the proposed scheme's resilience (UU-ACMA). Security analysis and comparisons with current schemes were carried out to demonstrate the relevance of the proposed scheme. According to the findings, the suggested system provides excellent safety while decreasing computational and communication costs.

It was postulated by David Perez Abreu et al. [26] that a new architecture for the Internet of Things infrastructure may improve its resilience. Furthermore, technologies for implementing the architecture's components were proposed. Within the scope of the SusCity project, they presented their idea. They discovered that a single IoT island may be linked to many gateways on various cloudlets, as well as to each other. If there is a failure in the connection between a cloudlet and the cloud, this gives an additional level of resilience.

Henry Tseng invented Multipath Load Balancing (MLB) Routing to replace AODV routing for Zigbee [27]. He presented two major MLB concepts: layer design and LOAD BALANCE. Nodes are arranged in layers based on the distance from an IoT gateway to each node. There are multitudes of ways that IoT data may be supplied to a node. This data is used by LOAD BALANCE to anticipate the load of the next-hop layer nodes in the following cycle. MLB enables nodes to pick the neighbors with the least traffic as their next-hops to minimize bottlenecks and distribute the load. Zigbee's AODV and multipath variation of AODV were shown to have lower load balancing, higher packet loss rates, and lower routing connectivity ratios than MLB in the grid and random uniform topologies. Compared to other suppliers, MLB's routing solution for IoT applications was more compelling.

A SHSec-based architecture was presented by Pradip Kumar Sharma et al. [28] to secure and manage the smart home network more efficiently and precisely while also lowering deployment costs and performance overheads. Middleware SHSec was used to assure the interoperability of various resource-constrained smart home gadgets. An important part of SHSec's mission was to generate and deploy security measures, such as threat prevention and mitigation. They tested the proposed model in a real-time scenario in the hardware and software environments. A real-time SHSec detection system has been demonstrated to be able to identify such assaults. The SHSec was also found to be efficient and accurate, with minimum overhead costs, according to their evaluation.

Three kinds of CSMs were used with an alignment extraction method to estimate the ontology alignment in Yikun Huang et al. [29]. With their compact PSO, they improved CSM aggregating weights and an alignment filtering threshold to assure high-quality outcomes. According to the experimental results, the cPSO method outperformed other state-of-the-art sensor ontology matching techniques in terms of the quality of the alignments it produced.

High-quality and sophisticated fire alarm systems that employ a variety of sensor values (such a flame detector, humidity, heat, and smoke detectors) to identify true incidents of burning are necessary to assure safety [30]. Their study led to the development of an adaptive neuro-fuzzy inference system (ANFIS) that can detect fires and deliver warnings. Sensor nodes acquire essential data, in which fuzzy logic transforms into a linguistic variable educated in ANFIS to determine the likelihood of a fire occurring. In addition, a message was sent directly to the user's smartphone as part of their concept. Their technique makes use of small, low-cost sensors and guarantees the reproducibility of the result. The experiments were carried out using a MATLAB-based simulation, and the output was satisfactory.

Electronic Long Cane was described by Alejandro R. Garca Ramirez et al. [31] to create communication architecture for visually impaired individuals in their environs based on IoT, as well as modifying the gadget for the human-smart cities' context. As a result, visually impaired people can access information, enhancing the capabilities of the electronic cane that was previously developed. To ensure the long-term viability of the project, green IoT considerations were taken into account by reducing power consumption and using cane parts that could be recycled. Solar batteries, for example, might be used to extend the battery life of the electronic cane and increase its environmental sustainability.

According to Vikram Puri and colleagues [32], blockchain technology could be used to remove security and privacy concerns. It was a self-enforcing agreement implanted in computer code governed by a blockchain that they created regulations around. Hardware security, device safety, access and authentication policies, and application security for the IoT network were all included in their proposal. It is possible that blockchain-based solutions could provide the most effective ways to address the security and privacy concerns related to the IoT network. In addition, they assessed the IoT with blockchain network's throughput and latency and compared the IoT device's power consumption during data requests with other proposed systems.

Using contemporary web technologies, Edgardo Avilés-López and García-Macías [33] proposed a framework and user-interaction model for the Internet of

Things apps. To illustrate their contributions, they used a case study to highlight the user-interaction model and how it relates to the framework.

With the support of notable IoT innovators, Dimitrios Georgakopoulos and Jayaraman [34] have offered the most effective answers to these technical issues and have referred to them as the IoT platform. Several smart agricultural, smart grids, and smart manufacturing applications have already been implemented using the proposed IoT framework. Future studies and a vision for IoT infrastructure were also highlighted.

According to Anuradha Singh [35] and her team, an intelligent waste alert system collection was developed by delivering an immediate dust bin clean and garbage fill level information to a municipality website. An Arduino Uno (Arduino) is attached to a sensor composed of ultrasonic waves that monitor dust bin levels as well as send a notification to the municipality's web application when the bin is full. An IoT-enabled integrated module was used to assist the entire process. The municipal officials could keep tabs on the state of rubbish collection in real time thanks to their system.

To decrease the number of time individuals spend waiting and boost their productivity, Bhavani Ratakonda et al. [36] devised an innovative solution that also reduced traffic in the exit area. In today's environment, both the Internet of Things and distributed computing are major innovations that cannot be ignored. Connected devices and things may interact with each other through the Internet of Things (IoT). We simply pay for what we use, since everything can be hosted on the cloud. As soon as the automobile is put into the park, the obstacle sensor sends data to the cloud about the presence of any obstacles. Entry and exit also use IoT technology to alleviate payment processing bottlenecks and enable consumers to enter/leave the shop space more quickly and efficiently.

13.3 Statement of Problem

It has been observed in previous research that if smart applications for security enhancement are performed, then the process takes a lot of time [37, 38]. Moreover, the security applications are unable to resolve hacker attacks. In previous researches, there is no investigating role for security. On another hand, if researches focus on IoT system, then it ignores the performance and enhancement of security for the smart application. Researches that have integrated both approaches lack in rendering efficient performance. Considering all these aspects, there has been a need to introduce a hybrid approach that could retain the performance of the system along with security. Thus, the investigation of IoT mechanisms has been proposed for enhancing the security of smart applications.

Table 13.1 shows the differences between previous research and proposed work.

Table 13.1 Comparison between previous research and proposed work

Features	Previous researches	Proposed research
IoT	Yes	Yes
Camera surveillance	Yes	Yes
Image capturing	Yes	Yes
Image compression	Yes	Yes
Edge detection	No	Yes
Performance enhancement	No	Yes
Security enhancement	No	Yes
Deep learning	No	Yes

13.4 Proposed Work

IoT-based camera surveillance has been made automated and fast in the proposed work. In the case of a traditional camera surveillance system, a person is required to observe any suspicious activity. Moreover when the high definition recording of 11 days gets completed, then the removal of the recording of the previous 11 days takes place. Thus existing camera surveillance is suffering from the issues such as manual observation, lack of storage, and delay in notification. The proposed work is going to eliminate the need for human intervention as well as other issues. Moreover, the signal of suspicious activities is sent at remote locations. The proposed work has also made use of an edge detection mechanism that has reduced the time consumption of frame comparison. Moreover, the storage cost gets degraded as the frame that would be captured is compressed and only the edge of the frame is considered, as this system is going to notify of suspicious activity.

The details of the proposed work are highlighted in Table 13.2.

In Table 13.2, the area of surveillance, simulation tool, and technology has been defined. Moreover, the objective of the research has been specified with the expected threat. A surveillance camera has been used as a sensor.

13.4.1 Process Flow of Proposed Work

In the proposed work (shown in Fig. 13.9), the captured image is compressed, and an edge detection mechanism is applied to it. If there is any suspicious activity, then an alarm is triggered to notify the administration. But if a fire pattern is detected, then the fire brigade is also informed. The fire pattern would be detected using a deep learning approach.

Table 13.2 Highlights of proposed work

Particular	Details
Area of surveillance	Financial institutions
Simulation tool	Matlab and. NET
Technology	Edge detection, image comparison
Objective	Camera surveillance to eliminate the need for human intervention
Expected threats	Loss by fire, loss by theft
Sensor	Camera
Neural network	CNN

13.5 Results and Discussion

Simulation of time consumption has been performed during a comparison operation. The simulation of frame capturing has been presented in two sections.

13.5.1 Simulation of the Size of Image Frames

In Table 13.3 the time taken during frame comparison has been considered at an interval of ten frames for the previous model where edge detection is not used and the proposed model that is using edge detection before comparing frames. Its graph is also displayed in Fig. 13.10.

13.5.2 Simulation of Space Consumption During IoT Operations

In Table 13.4, the space consumption by different image frames in the case of the previous model where edge detection is not used has been compared to the proposed model that is using edge detection before comparing frames. Its graph is also displayed in Fig. 13.11.

13.6 Conclusion

It has been concluded that the proposed work has taken less time and space as compared to the previous model. Moreover proposed work is providing a versatile solution of fire detection along with suspicious activity detection. The Internet of Things (IoT) is the result of human curiosity and a desire to live a more comfortable and connected lifestyle, which reduces effort and eliminates the risk of human mistakes.

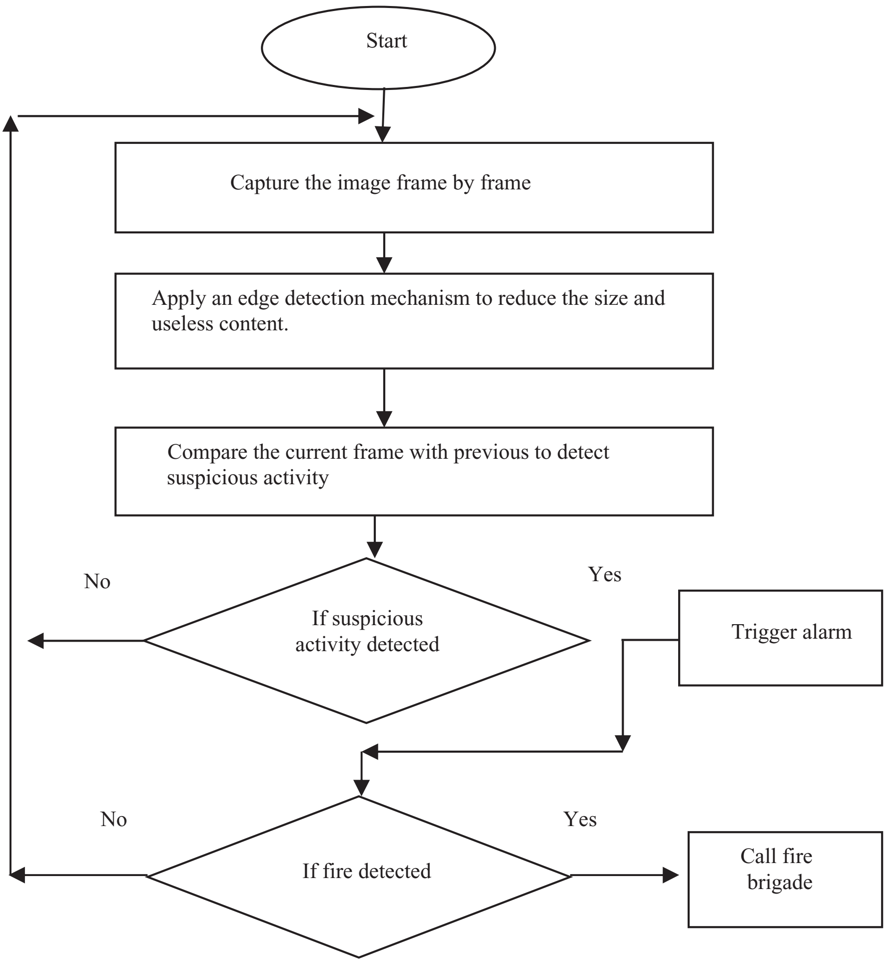

Fig. 13.9 Process flow of proposed work

IoT solutions enable customers to automate, analyze, and integrate their systems to a greater extent. They broaden the breadth and accuracy of these fields. The Internet of Things includes sensors, networks, and robotics, and it employs both old and new technology [39, 40]. IoT makes use of software developments, lower hardware costs, and a contemporary approach to technology. As a consequence of its innovative and sophisticated aspects, there has been a significant change in the sphere of product, commodities, and service delivery. Every company and the market area may benefit from the Internet of Things (IoT). The user base includes everyone from individuals looking to save money on their power bills to large organizations looking to streamline their operations [41]. Since then, a slew of studies have been undertaken on the subject. IoT is already being used in a variety of areas, including consumer, industrial, infrastructure, and even outer space.

Table 13.3 Comparison of time consumption during image frames

No of frame	Time consumption in the case of the previous model	Time consumption in the case of the proposed model
10	0.966658222	0.551569117
20	1.843754857	1.74376778
30	2.82880451	1.87343453
40	3.777246169	3.318623205
50	4.656744668	3.824756566
60	5.516195574	3.698658403
70	6.431297648	4.991517911
80	7.402817028	4.059193998
90	8.404293782	5.886622256
100	9.632456691	4.958826222
110	10.25887972	5.232755072
120	11.44347676	8.085869875
130	12.8636452	8.130052399
140	12.96247828	8.014916809
150	13.64430648	7.461030612

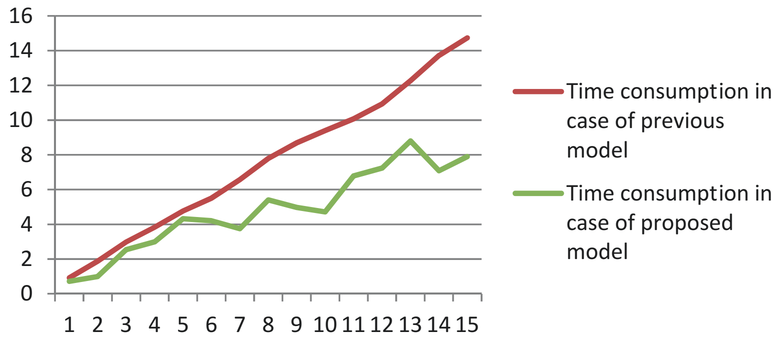

Fig. 13.10 Comparison of time consumption in the case of previous and proposed work

13.7 Future Scope

In the future, the breadth of this approach will be critical for IoT security. This technology has the potential to improve the security of smart applications for the IoT system. Using an IoT system, this model's safety might be improved even further. Furthermore, a biometric system based on IoT might make use of such a paradigm.

Table 13.4 Comparison of space consumption during image frames

No of frame	Space consumption in the case of the previous model (kb)	Space consumption in case of the proposed model (kb)
10	54.41942074	41.01702195
20	112.0340152	73.283476
30	177.3438181	124.431124
40	209.9487461	202.7771261
50	279.4367488	213.5147352
60	338.2866169	185.0689427
70	352.2988554	191.8548029
80	439.570015	305.5664928
90	484.4827014	267.5939985
100	530.0156333	374.5855323
110	644.2014136	332.6032638
120	604.077562	476.8484771
130	672.7053676	411.7619094
140	770.080673	621.0938358
150	784.3614932	402.2631252

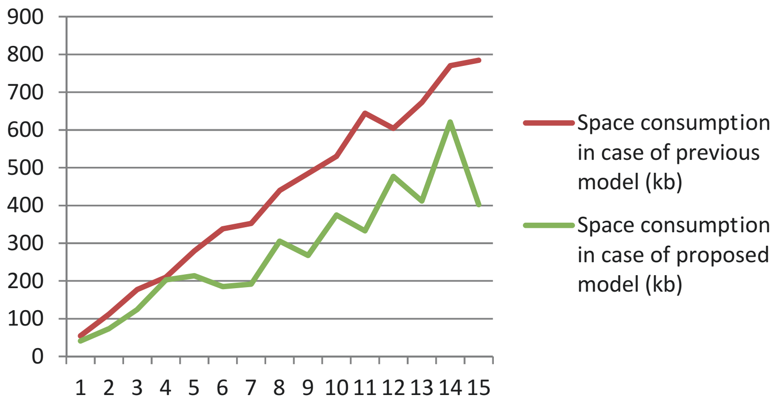

Fig. 13.11 Comparison of space consumption in the case of previous and proposed work

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Chapter 14
Role of Augmented Reality and Internet of Things in Education Sector

Monika Nijhawan, Nidhi Sindhwani, Sarvesh Tanwar, and Shishir Kumar

14.1 Introduction

Overlaying virtual objects on physical objects for a better experience of reality is called augmented reality (AR) [1]. This allows the user to feel that the digital and physical objects are in the same place. This technical concept requires triggers that can be run in marker-based, markerless, position-based, image-based, and position-based AR. In marker-based technology, marker recognition, camera calibration, marker position calculation, and virtual object-orientation are important aspects when developing AR must be taken into account. When this technology is connected to mobile devices, it is called mobile AR (MAR), and in recent years users have become more interested in learning various AR-based mobile games [2, 3]. Marker-based mobile AR applications have proven to be very effective and promising, especially for toddlers in a variety of subjects, such as notation and the concept of vowels in poetry [4–7].

Recently, this technology has been attracting attention as a key element for digitizing the world with more intelligence and interaction using augmented reality (AR) and the Internet of Things (IoT). The connection between the sensor and the physical world over the Internet is called IoT [8–12]. Augmented reality (AR) is a type of interactive media that talks about computer-generated data spatially registered in the real world to enhance a person's world experience. AR enhances people's understanding of the world and their mental ability to solve real-world problems. The Internet of Things (IoT), on the other hand, is itself a network of

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physical devices built into certain computer devices for collection, communication, and understanding. Interact with them. AR, when integrated with the IoT and vice versa, helps develop platform solutions for current and future challenges arising from the gap between device data and human perception [8].

Even after the coronavirus, the educational sector had already become more technologically savvy. For this reason, the industry is currently focused on evaluating and adopting new technologies such as AR and IoT integration. This brings new awareness and visibility into the existing environment and allows us to enter the world of smart and digital education [13]. Many industries are implementing these technologies in education and training, different age groups, and different devices to improve and motivate users' learning concepts in different subjects and languages [6, 7, 14–16]. This research will help users understand the role of IoT and AR in the education sector and the perceptions and challenges they face when using these technologies. The objectives of the study are given below:

- Understanding the role of IoT in the education system
- To study the role of AR in IoT in enhancing the education sector
- To study the existence of AR in the education sector and the different challenges faced by users

14.2 Literature Survey

Studying is a very important part of a student's life. The theoretical and long text appeals boring especially to kindergarten children. This paper is evaluating how much work is done in different subjects for these preschoolers in the past 10 years in the educational sector. Many studies found that when the students get exposure to learning different subjects like story reading and English vocabulary in an augmented reality environment, then this will influence the reading habits and retelling and recalling skills [17] as compared to learning the same concepts using the traditional approach. Another important thing that came out from the literature review is the importance and usage of AR, which has shown better results in almost all the cases in the past few years in the education sector. It has been identified by many researchers that still a lot of research is required in designing the content for preschoolers to get maximum advantage of augmented reality.

Work on augmented reality has been done on different age groups in different subjects:

14.2.1 Augmented Reality for Preprimary Education

Researchers have researched many subjects and topics like vocabulary, learning vowels, art, story reading, puzzles, flashcards, match cards, and educational toys for kindergarten students. Many studies found that when the child gets exposure to learning different subjects like story reading and English vocabulary in an augmented reality environment, then this will influence the reading habits and retelling and recalling skills of children as compared to learning the same concepts using the traditional approach. Another important thing that came out from the literature review is the importance and usage of AR, which has shown better results in almost all the cases in the past few years in the education sector. Superimposing of objects on the devices has shown great interest especially in kindergarten children.

14.2.2 Augmented Reality for Middle-Level Education

Lots of studies have shown the remarkable results of AR in subjects like mathematics and science as compared to other fields like humanities, art, or social studies. The use of mobile AR (MAR) is showing a tremendous impact on students' learning, recalling, and thinking abilities. AR is also shown a boom in game-based learning, especially in younger children.

14.2.3 Augmented Reality for Higher-Level Education

AR in higher education is also used in the fields like science and technology or engineering as compared to other streams like business, law, humanities, or art. Due to increasing advancements of smart objects, sensors, big data, etc., the enchantment in IoT is also getting increased in the teaching, learning, management, and training sector [12]. Users' growing interest is seen in STEM (science, technology, engineering, and mathematics) education in many countries by combining IoT-based framework with their lab-based practical and problem-solving projects. This is showing the great scope for IoT in constructing smart education.

14.2.4 Technologies Used in Augmented Reality and IoT

Augmented reality or IOT uses hardware and software both of which are integrated and finally used by the users. The devices used in AR are computer systems, tracking devices, display devices, etc. Monitor-based displays and video-based displays are the two important and main displays used in AR [18]. Lots of studies show that mainly three types of AR categories are used in AR in the education sector [19].

(a) Marker-based AR
(b) Markerless AR
(c) Location-based AR

Marker-based technology is proven to be the most popular method among children. All the 3D objects, 3D scene, background music, and narrator's voice are the different functions and features of AR mobile application which can be done using Unity game engine and visual studio for programming. Vuforia framework is used for projecting the 3D objects. For eye-catching graphics, the blender is used. Lots of mobile application has been implemented on the same platform and framework [12].

14.2.5 Head-Mounted Displays

These devices are worn by the user on his/her head to get the experience of AR. Here will show small images or videos in front of the user. Handheld devices are the types of devices that users can hold in their hands like mobile devices or tablets to get the experience of AR in the 3D or video view.

A lot of spatial devices like projectors, hand gloves, or pinch gloves are used in the education system where there is no need to hold anything or wear it on the head. These devices are quite becoming popular these days. Many schools and institutes have started teaching practical things to children using this mode of technology. With the modernization of these upcoming technologies, it has been found that children get more interest in learning the subject as compared to an older model of teaching. Similarly, IoT uses advanced RFID sensors and other hardware devices with the help of the Internet to build smart glasses, smart campuses, and smart education systems. Lots of scope and challenges have been seen in implementing IoT in the education system [12].

14.3 Research Methodology

The research methodology followed by this study is given below:

(a) Identifying relevant articles and journals from different databases which are published between 2011 and 2021 in AR and IOT in the education sector was done based on the given selection criteria:

Criteria selected for research	Criteria rejected for research
Focused on the education sector	Rejected for other domains like military, robotics, manufacturing, etc.
Language English	Others rejected
Enabled students	Disabled students
Accepted for the education field	Rejected for other streams
Innovations	Rejected for the traditional approach of learnings

(b) The research was done on secondary data using the above parameters.
(c) Research objectives were identified based on the literature review.
(d) This study is also based on primary data which was collected from different graduates from Delhi NCR. The relevant questionnaire was prepared to find the awareness, how often these technologies are used, comparison from the traditional approach, impact, and perception to continue to learn with these technologies in the education sector.

14.4 Importance of AR in the Education Sector

The augmented reality era isn't a brand-new issue. It has been utilized in fields such as military; medicine; engineering design; robotic; telerobotic; manufacturing, protection, and restore applications; patron design; mental treatments, etc. Technologies and net are popular, as realistic scenarios humans nonetheless opt for analyzing books in preference to going through monitors and textbooks are nonetheless broadly used. Another exciting utility of this era is in augmented truth textbooks [17].

14.4.1 Advantages of Augmented Reality in the Field of Education

– People who have no computer background can have still rich interactions with augmented reality [20].
– Augmented reality helps kindergarten students in improving their memory skills [18].
– Augmented reality helps in learning languages like Chinese [21].
– It enhances interaction and attention and facilitates learning, creativity, and spatial ability.
– It helps to inspect 3D objects from different angles which improves understanding concepts.
– It increases motivation and concentration level.
– It assists in establishing a link with real-life experiences.
– It facilitates emotional attachment, more involvement, and participation in dramatic play [19].
– It improves technical creativity, sound, and engineering [18].
– It also helps to improve retelling, recalling, and comprehensive skills in stories.

14.4.2 Use of Augmented Reality in Different Fields of Education

– Augmented reality improves learning vowel usage, the number concepts, and vocabulary learning in different languages [21].
– Augmented reality is used to improve pronunciation skills [22].
– Augmented reality is used for story reading, puzzles, and flash and match cards [21].
– It is used for dramatic play activities using a robot system [16].
– It is a mobile-based application for kindergarten children which acts as an educational toy.

14.5 Challenges of AR in Education Among Users

It has been noticed that the use of AR can impact visual aid and hampers social ability skills especially in school children [2]. Children will be busy with tablets/mobiles all the time and will be interacting less socially [3]. Another limitation being found is that younger teachers are more willing and feel confident to use this type of technology instead of experienced teachers. It has been seen that the budget for daily teaching is also limited for each school to give learning to the individual child. Students might be confused with overloaded information or fantasy environment [6]. Sometimes inflexibility of content also is challenging [6]. Sometimes screen size is also another concern for their children, or usability principles of AR need to be explored [23]. Sometimes handheld AR devices have shown challenges for smaller kids because whenever they hold these devices in their hands and get completely involved in the system, there are the chances they leave the devices from their hands.

14.6 Importance of IoT in the Education Sector

The Internet of Things has a direct and indirect effect on the education sector. IoT improves the quality of education and simplifies the overall work. The learning and teaching processes are vastly affected by it. There is a real need for the IoT to be implemented in the assessment area of education because it is well suited for real implementation. The major aspect will be upgraded after core areas such as teaching, learning, and assessment are considered [24].

14.6.1 Advantages of IoT in the Field of Education

IoT helps people to get more engaged in its applications.
It creates more interest and creativity among students.
It can also help in monitoring students' performances [24].
It helps users in learning different languages.

14.6.2 Use of IoT in Different Fields of Education

IoT solutions can be integrated into school environments in a variety of ways. Here are some applications (as shown in Fig. 14.1) where it can be used [18]:

1. Teaching foreign languages
2. Project-based learning
3. Education in physical fitness
4. Monitoring attendance automatically
5. Special education for disable students

1. **Teaching foreign languages**: Foreign immersion environments combine listening, iterating and communicating into the real-time experience. Research shows foreign language learning is improved by using IoT.

   When used in foreign language simulations, the use of connected hardware facilitates the learning process while freeing up instructors to facilitate the process themselves. Learning with IoT enhances the education process. When it comes to learning a foreign language, there are even more advantages.

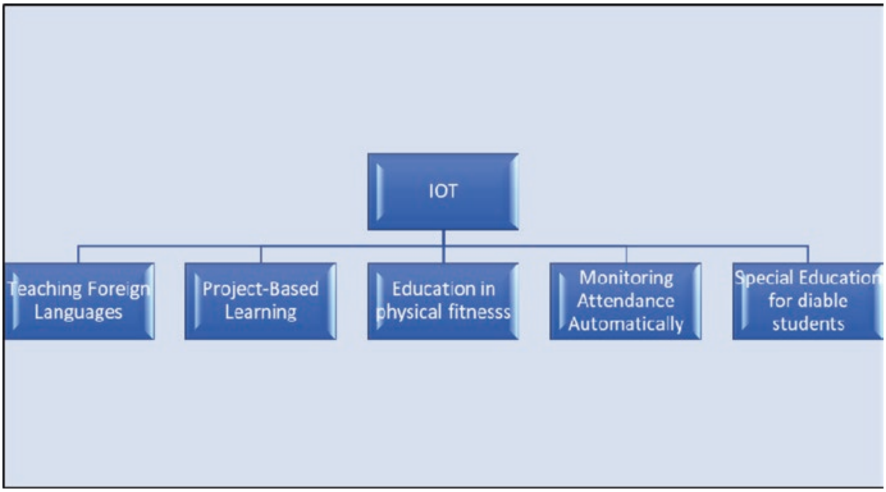

Fig. 14.1 Application of IoT in education

2. **Project-based learning:** The Internet of Things (IoT) can be utilized to design and teach a project-based IoT course, although doing so can be difficult. The IoT can have a significant impact on teaching methods, as it's associated with system free teachers from recording and tracking college students, allowing them to not only tell information but also facilitate learning.

   With a complete project-based education, college students and instructors will help each student when they need it. The IoT system automatically provides feedback, support, and tracking of classroom completion.
3. **Education in physical fitness**: Physical education strives to improve students' physical experiences and abilities, as well as their overall well-being and ability to engage in a variety of physical activities. The IoT-based physical activity and resource management collect student physical data on wearable sensing devices with accessible and secure intermediate systems. Weight, sleep, heart rate, and blood pressure can all be collected using wearable devices in a student's environment.

   The virtual connections, such as Bluetooth and wireless Internet, are commonly enabled by the virtualization network [25, 26]. Students evaluated healthy data under controlled conditions, such as improving the quality of life and replicating activity sequencing, using physical activity monitoring systems.

   The purpose of the physical activity assessment is to find out how often, for how long, and how intensely students engage in physical exercise.
4. **Monitoring attendance automatically:** In both educational institutions and enterprises, attendance is crucial for students and employees. Calling out the students' roll numbers is the most popular method of taking attendance in the classroom. The current attendance system has a flaw in that incorrect attendance can be recorded.

   Manually taking attendance is a time-consuming task. Another disadvantage is that keeping attendance records is time-consuming.

   An RFID-based IoT system [27, 28] is used to prevent all of these issues. It's a computerized attendance system that uses RFID cards. Each user, student, or employee is issued an RFID card at first, and an RFID reader is installed on the classroom, school, or company's door. The RFID card must be presented to the reader whenever a student or staff wants to enter the room. The RFID reader will read the number on the RFID card as well as the time the employee or student logged in [29–31].
5. **Special education for disable students**: The Internet of Things (IoT), a system of connected things, is steadily but transforming the way we live. Students with special needs can use connected IoT devices to help them overcome problems related to their cognitive and physical limits.

   Growing independence: Students with special needs are heavily reliant on their caregivers and teachers. As a result, the connected items created expressly to meet their needs will assist these children in becoming more independent and responsive. A visually impaired student, for example, could be handed a card that enlarges the text on his computer, decreasing the need to seek assistance from an instructor.

Aiding in the development of focus: Students with ADHD are often distracted throughout the class. A device like Muse, a headband that measures brain activity, can assist these children in improving their focus.

14.7 Challenges of IoT in Education Among Users

A few challenges faced by using IoT in the education sector are as follows:

- Privacy and security are the main concern while using IoT in the education sector [12].
- Curriculum designing and integration with IoT are again the biggest challenges faced by users [13].
- Legal and political issues are again a few challenges lying ahead [12].

14.8 Analysis of AR in the Education Sector

The following analysis in augmented reality shows the role and awareness in the education sector.

The pie chart in Fig. 14.2 shows that those in the 18–22 and 22–30 age groups, who are recent graduates or have graduated, are familiar with the term AR. Most students are familiar with the concept of augmented reality. The upcoming young generation is curious and engaged in learning with new technologies.

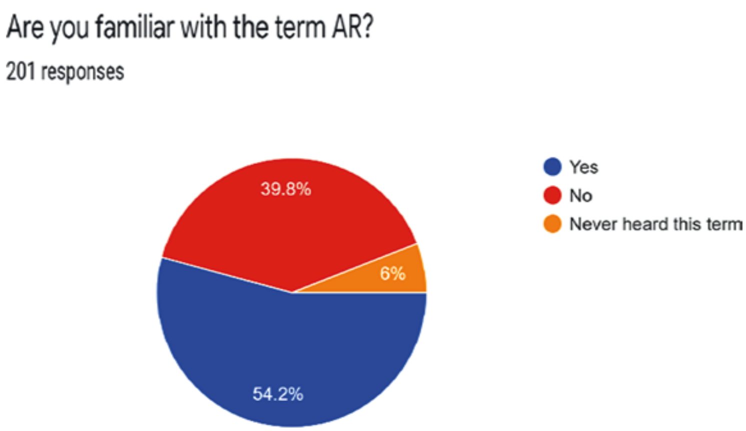

Fig. 14.2 Graph showing the familiarity of people with AR technology

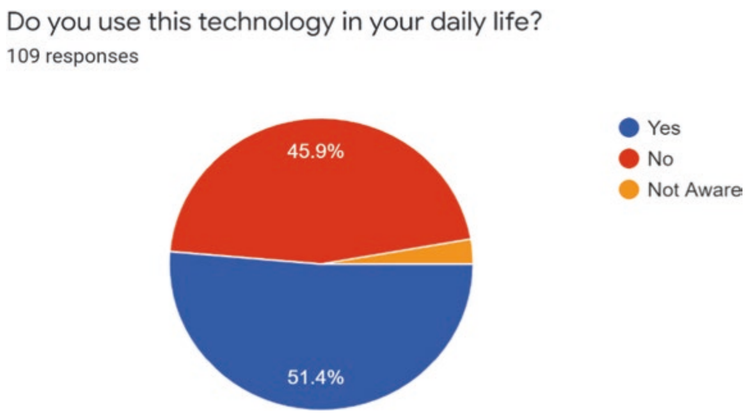

Fig. 14.3 Usage of AR technology in daily life

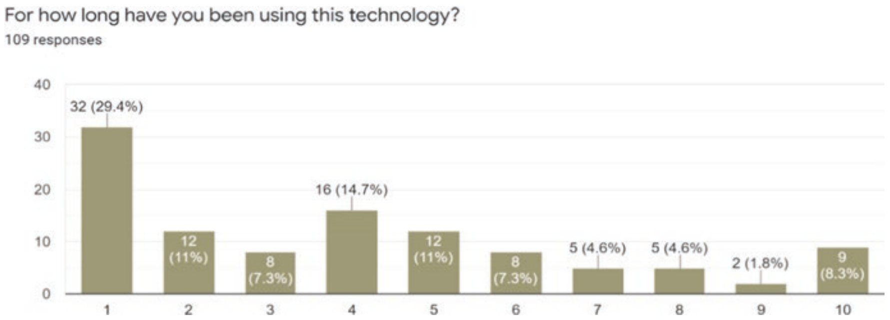

Fig. 14.4 Usage of AR in recent years

The chart in Fig. 14.3 shows that most of the users are familiar with the term augmented reality, but only 50% of the uses are using this technology. The problem here is that people only know this term; they don't know how to use it in their daily life.

Figure 14.4 shows the usage of AR in recent years.

This is an upcoming technology that has not yet been developed, so people will not use it often. We can see from Fig. 14.5 that the people who frequently use this technology are only 13% of 100%. Only around 13% of people know the actual use of AR. If compared, this is low worldwide. And the main concern is that 16.5% of people simply don't know about technology. As a result, the usability of AR is reduced. AR needs to be more expansive than it needs to be in the future.

This is a great start for all of us because more than 51% of the responses are in the favor of AR-based learning (as shown in Fig. 14.6). More than 51% of the responses said that AR-based learning is better which shows that there is a change in the mentality of the people, and they are more interested in AR learning. More than 20% of the total responses thought that AR is extremely a better learning and

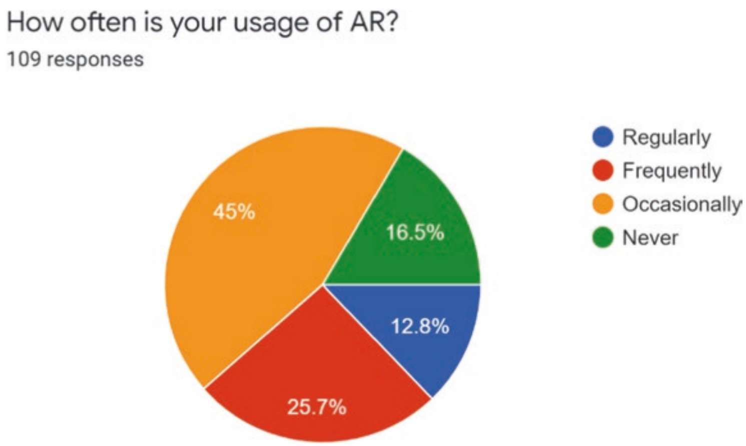

Fig. 14.5 Usage of AR among users on an often

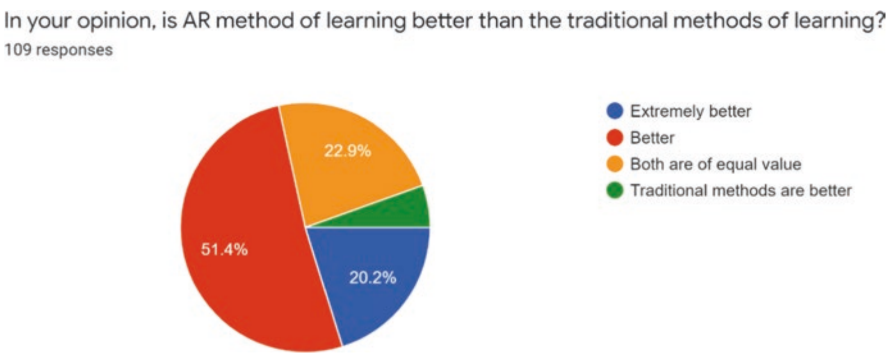

Fig. 14.6 Opinion of users in using AR as compared to the traditional approaches of learning

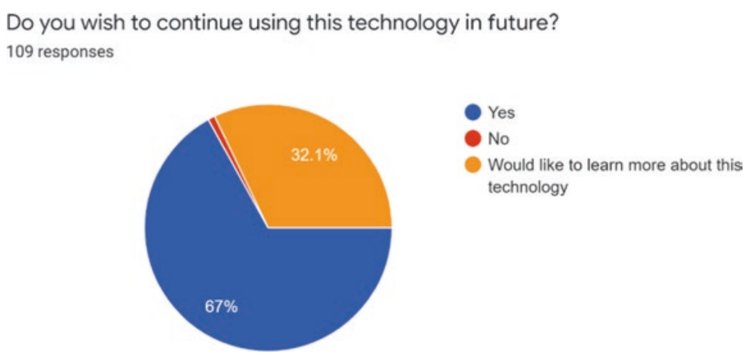

Fig. 14.7 Opinion of users to continue AR technology

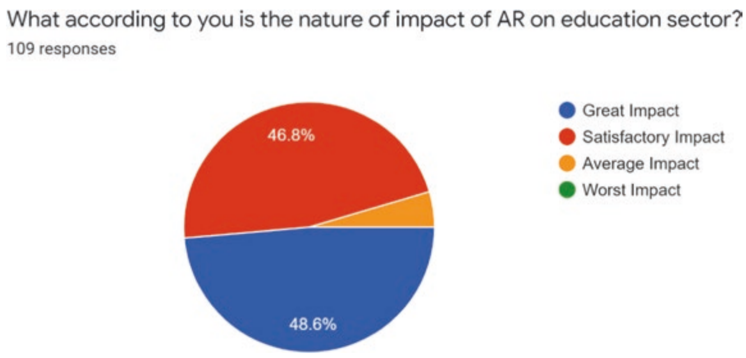

Fig. 14.8 Impact of AR in the education sector

there is no way better than this. Around 22.9% of the total responses feel that both are equal and should be given equal importance to traditional and AR approach.

The best part is that almost no one wants to discontinue this technology, and they thought it is the future. Over 65% of respondents want to continue this technology as depicted in Fig. 14.7. Out of total responses, 32.1% would like to experience more about this technology and rest less than 1% does not want to continue using this technology.

Figure 14.8 shows that 48.6% of the responses are in the preferences of AR in the educational sector and they feel that AR will have a great impact on Education. A total of 46.8% are satisfied with the AR in education, and they feel that AR will have a good impact on the development of students in education. Of the people 4.6% are still thinking about AR, and they have yet to decide which way to go. A total of 95.4% showed a positive response which shows AR has a bright future.

14.9 Analysis of IoT in the Education Sector

Out of 200 young graduates, it has been analyzed that:

From Fig. 14.9, it may be observed that:

With a 95% confidence interval, we could say that about 90–100% of educators are comfortable using technology.

With a 95% confidence interval, we could say that about 45–78% of educators know about IoT.

With a 95% confidence interval, we could say that 7–34% of educators have used IoT in learning.

Figure 14.10 shows that 97% of the young people would like to use IoT in their daily lives and 61% of users would like to continue with this technology in the future as compared to the traditional approach.

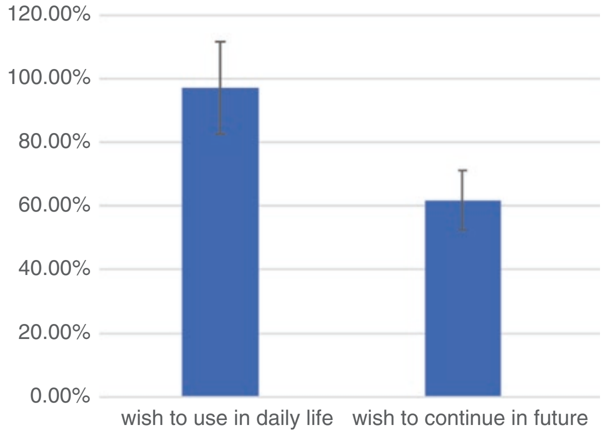

Fig. 14.9 Awareness and comfort in using this technology

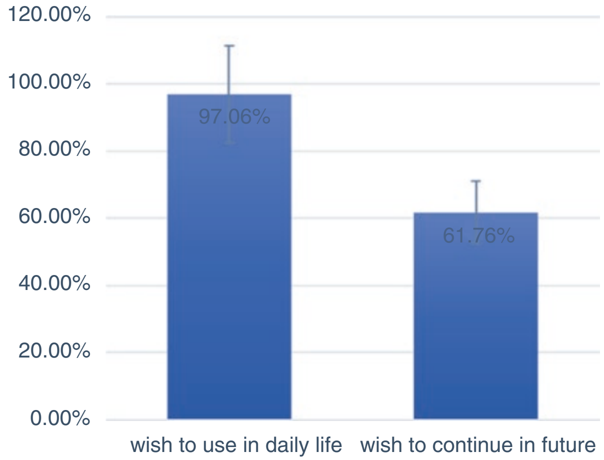

Fig. 14.10 Perception of the user to continue this in future and use in daily life

14.10 Conclusion

This review article has summarized the importance of augmented reality (AR) as well as IoT in the education system. Using both of these technologies, learning and teaching methods may be improved to a large extent. These two techniques may be collaborated with each other resulting in making educational system much better. This study has shown how AR applications yield useful information to the teachers and students [32]. The students are able to learn much easier without having a stress.

14.11 Future Scope

It has been identified by many researchers that still a lot of research is required in designing the content for preschoolers to get maximum advantage of augmented reality. If this will start from an early age group, then this will improve the overall development of the child [4]. Lots of awareness, content creation, and better curriculum designing are required in AR [19].

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Chapter 15
Raspbian Magic Mirror: A Smart Mirror System to Assist on IoT Platform

D. S. Sahana and C. Gopala Krishnan

15.1 Introduction

Every person on the planet requires a comfortable way of living. Modern man has invented several technologies to suit his needs. People in today's world need constant connectivity and access to information quickly. People must be informed about global happenings, whether through television or the Internet [1]. The Internet of Things (IoT) is a communication-capable web-based network of computing devices embedded in everyday things. As a result of its exponential expansion, the Internet of Things is increasingly being used in people's houses and apartments, transforming a home into a smart home [2–5]. Thanks to technology improvements, most of the stuff we use in our daily lives is now automated.

Temperature, power, closing and opening of doors/windows, turning on and off lights and fans, and the water tank are all things that a home automation system should focus on. Automation should be possible from anywhere using a cell phone. Multimedia and artificial intelligence essential services may personalize to manage tasks comfortably utilizing the Internet of Things (IoT) [6]. The Internet of things (IoT) is a concept that brings together wireless sensors and the Internet. Multitasking is the key to good time management about technology. According to everyone in the commercial or academic sectors, every minute counts daily. The trend of putting touch screens and Internet connectivity into commonplace appliances like stoves and refrigerators [7] exemplifies this.

Many individuals are transitioning to a smart home, and the family room and kitchen have received much attention. The current generation is encouraged by

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constant access to information and processing it quickly. The smart mirror will display the data with a voice command or hand gestures. The smart mirror is the outcome of a brainstorming session to figure out how to address all of these concerns while still producing something valuable and appealing. The smart mirror must combine the benefits of current technology with the ease with which it can be included in the daily lives of most people [8, 9]. The smart mirror should be as simple as possible to operate. The smart mirror would be utilized to incorporate technology and demand for information into everyone's everyday routine.

Weather, news updates, and local date and time are all available on the smart mirror, allowing the user to interact with it and acquire the necessary data they need in their daily activities. Security features will be added to smart mirrors in the future, allowing them to manage energy bill payments, phone bill payments, insurance policy details, and daily appointments. A Raspberry Pi and data from the Internet can be used to create a smart mirror [10]. The Raspbian Jessie pixel operating system runs on the Raspberry Pi. Web browser, JavaScript, or Python can be used to generate the user interface. On the envisaged smart mirror, the date and time, current weather conditions, remainders, and an energy meter will be displayed. It can display widgets, detect a user's presence, and navigate the user interface using the user's movements.

Parents and guardians must teach and raise their children in today's technologically advanced world, and effective parenting is becoming increasingly important. Furthermore, children require parental supervision. However, this might be challenging in today's frenetic world, where both parents frequently work or single parents are the norm. However, a breakthrough device known as the Raspbian Magic Mirror, constructed using Raspberry Pi technology and will be the subject of our IoT research, may fix this problem. Smart mirrors manufactured by IT companies serve a range of tasks and serve as a looking glass [11].

The majority of people utilize a mirror regularly in their daily lives. Aside from these mirrors, the smart mirror, which performs a range of purposes, multiplies various businesses. Various application services can be deployed by linking the Internet of Things (IoT) to the smart mirror [12]. Smart mirror is already in use in various public locations and facilities and private homes, and its capabilities are likely to grow. Smart mirrors can link and manage items and provide information channels by acting as a gateway. It is so feasible to give services to users while also fulfilling the important job of the IoT platform. Smart mirror extends to the current trend of putting contact displays and online networks into everyday devices, such as stoves and refrigerators [13]. A two-way mirror is mounted on top of a monitor to create the smart mirror. A two-way mirror is a piece of glass with a reflective side and a clear side. This allows us to see our reflection while also enabling light to pass through from the other side. The monitor is stripped of its original shell and encased in a wooden frame [14]. A monitor has already hidden away behind a gorgeous frame in the mirror. The nicest thing is that there's an opening on the back of the frame with HDMI and micro USB connectors. You will need both for the Raspberry Pi.

To avoid becoming a burden, the mirror will provide information with little to no effort on the user's side. The mirror will do the user's thinking for them. It will switch on for the first time when the user tells it with a sentence such as "hi mirror" or any other expression. Then it will search the Internet for information for the user, such as weather updates, temperature, etc. Users would be able to converse with each other through speech. The mirror displays basic information on most people's smartphones or tablets, such as Twitter and schedules [15]. People can read, reflect, and plan their day while getting dressed in the morning or at night. The mirror must be entertaining as well. It will play the music that they can control with their voice. It is also utilized by many disabled individuals and is easily accessible to everyone. It can be used in the vehicle industry and in health care to remind patients of their medicines, among other things. Smart mirror will also be used for several different purposes. Successful projects and products, such as our smart mirror, provide a diverse set of capabilities and applications. Part of the problem can be compared to the fact that the smart home is still a growing sector with high production costs that keep devices out of reach of the typical consumer [16].

The proposed architecture is adequate for any smart home's key functionality. On the other hand, according to the user's preferences, this will remind the user of a given task at a specific time. A smart mirror transforms an ordinary object into a formidable assistant. It's a very useful piece of work that makes extensive use of IoT development. It makes use of a one-way mirror that reflects information from a display beneath its surface. Voice control, face recognition, and custom services are among the tool's features. A speaker and microphone are used to provide voice control. Over a standard two-way mirror, the mirror conducts a smart activity by presenting various types of information. The system receives real-time updates because it is connected to the Internet.

15.2 Related Works

As demonstrated by Cvetkoska et al. [17], smart mirrors have a lot of potential for increasing user information access and engagement. It also works for a theft detection system and a tool for clients to get crucial data quickly. The innovation of the new smart mirror provides a beautiful interface for glancing information and may also be utilized to identify intruders in a home. The Internet of Things (IoT) circuitry was utilized to innovate a smart mirror that collects and displays data and detects a thief when no one is home. The authors' work focuses on reducing the time and crafting information more accessible. Security is fundamental in today's culture. With this in mind, the authors included a thief detecting system inside the smart mirror.

Ganesh H and Sharmila S [18] demonstrated smart mirrors with microcontrollers and computers that provide information on locations on the mirror. For retrieving data from the web, smart mirrors use microcontroller cards linked to the Internet. The suggested mirror is connected to the Internet of Things and allows home automation. A monitoring system keeps an eye on it. It makes use of a Raspberry Pi to automate and display information like weather, time, date, calendar, and news updates, among other things. A Raspberry Pi 3 microcontroller controls the sensors and the smart mirror. This will act as the intelligent framework's brain, and it will be held by reflecting programming python scripts.

The authors R.M.B.N. Siripala et al. [19] state that parenting a child is a huge responsibility. Keeping track of their children while at work is one of the most challenging tasks parents and guardians face nowadays. With the rapid pace of invention, a simple, easy, and quick framework is required to keep track of them constantly. Because the technology of Things (IoT) is still in its early stages, with a wide range of applications, this framework is based on IoT. It will be built using Raspberry Pi technology. The Raspbian mirror shown in this paper, on the other hand, is much more dynamic and intricate, and it is mainly aimed at working parents who would receive notifications from users via their smartphones. The Raspbian magic mirror will also assist parents in keeping track of their child's educational progress and managing their daily tasks.

Young Bag Moon et al. [20] proposed smart mirror as a planned assistance model for managing hazardous zones and providing health data via a smart mirror-based Internet of Things. Regularly, the client's health information is stored, assessed, and supplied to an advanced mobile phone. This study demonstrates the creation of IoT stage setup and administrations utilizing a smart mirror by employing a smart mirror connected to an IoT stage.

Muhammad Mu'izzudeen Yusri et al. [21] introduced the concept of a related item that could transport data without requiring human-to-human or human-to-computer connection. This technology can collect data and regulate the lights in users' homes. Weather, notifications, traffic, a map of the area, and the time and date are all supplied. The system makes use of Sonus technology to communicate between people and machines. As a result, in addition to getting a response from the system, users must speak orders to it.

Lakshmi N M et al.'s research [22] focuses on the design and execution of a smart mirror that concentrates on identifying thieves in the home while also functioning as a human-friendly interface for viewing information. A smart mirror displays the date, time, current temperature, and weather information in addition to the mirror itself. To create a smart mirror that could still receive and display online news and recognize a burglar when no one is home, utilizing Internet of Things (IoT) circuits. The work incorporated in the future by incorporating interactive touch screens, geo-location, Alexa, and other features.

15.3 Proposed Work

The goal of this initiative was to make homes smarter so that people could save time. By making information and other people in the digital realm more accessible, the Internet changed our way of life. At the moment, the focus of innovation is on delivering more data with less effort. The device's name is Mirror that has been researched and designed. It's a wall-mounted mirror that shows the current weather, date, temperature, humidity, news, and other relevant data [23]. The suggested Magic Mirror is a natural interface that provides a platform for more tailored access to information and data services. The goal of this project is to help with the design and implementation of a Magic Mirror-like interface, as well as the automated home environment where users can interact with the mirror interface.

The article's primary idea is to create a cutting-edge communication device. The mirror's design aims to create a user-friendly interface for accessing various information services in the house (time, date, temperature, and atmospheric pressure, for instance). The picture is sent off on the mirror as soon as we press the switch. The mirror is a tool for social conversation. This mirror displays the current location's date, time, calendar, weather, and other information. The Raspberry Pi 3 home automation system uses a voice-activated assistant system to interact with the user [24]. When linked to the Internet, a smart mirror is a Raspberry Pi (low-powered mini-computer) based display that picks up and displays the relevant information in the user's presence [25].

15.3.1 Methodology

(a) *Smart Mirror as a Mirror*

When viewing and grooming, we can use a one-way mirror with a high aluminum content to see our vision as if we were looking in a smart mirror.

(b) *Smart Mirror as a System to Hold Information*

Predefined URLs such as C.C.N., B.B.C., and others are used to retrieve time, date, and meteorological data from the Internet. A DHT11 digital sensor was used to collect humidity and temperature data.

(c) *Smart Mirror Simple Home Automation System*

Fan and light sensors can automate everyday tasks in the home. DHT11 sensor gets room temperature as input; the fan runs based on room temperature; IR sensor functions based on obstacle detection; lights are switched on if an impediment is identified; otherwise, lights are turned off [26, 27].

15.3.2 Architecture Overview

The true identity of the mirror is determined by the two-way mirror. It's a magical mirror since it has a reflective surface on one side and is transparent for good intensity light on the other. The mirror remains at the front, allowing the user to see

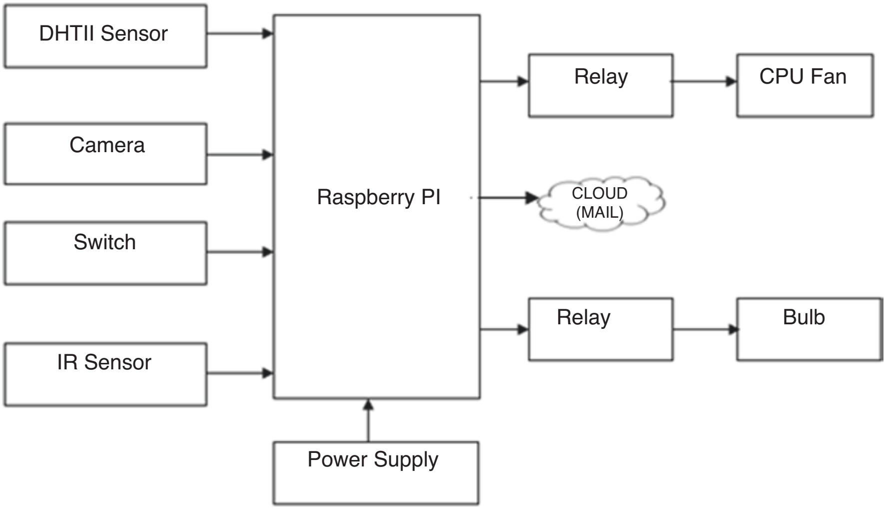

Fig. 15.1 Proposed smart mirror

Table 15.1 Hardware components used in smart mirror

Sl no.	Hardware	Specification
1	Raspberry PI 3	Broadcom BCM283764bit Quad-core
2	USB camera	Microsoft LifeCam VX-800
3	Relays	5V trigger voltage
4	CPU fan	12 volts

himself/herself in the mirror while allowing light from the display to pass through and make the UI viewable. Smart mirror looks like a regular mirror but contains a screen within. Figure 15.1 depicts the components and layouts of the suggested smart mirror. Expressed data is managed in the gathered information base. On a flat screen, the data is shown. The smart mirror contains a few pieces of data. When users look in the mirror, it offers a simple web page with software placed in it. The client is then shown data such as the date, time, and newsfeed, among other things. Second, reflect is activated in response to an instruction to operate sensors and electronic devices like fans and lights.

Proposed work focused on the weather, and if a human detects it, the bulb will immediately turn on. In this situation, the light functions as an indicator. The DHT11 sensor monitors room temperature, and the fan will switch on if the temperature rises above the set thresholds. The photograph will be sent to a specific email address if we press the button. The user's weather, date, time, temperature, and air pressure are among the services provided to the mirror via Google. The following sections go through the physical device characteristics and how they work. Table 15.1 summarizes essential hardware components and their specifications in the smart mirror.

15.3.2.1 Working of Each Module

Camera: USB wires for webcams protrude from the back. A USB cable connects the webcam to the computer, sending the digital data captured by the image sensor back to the computer, available on the Internet. Some cameras don't require a computer to function; instead, they use Wi-Fi to send photographs to your router, which can then send them to other objects that are turned on your local network or to anyone, anywhere around the globe, over the Internet.

Relay: The bare-minimum concept for a relay to work is depicted in Fig. 15.2. Because the relay has a controlled 5v trigger voltage, we used a +5V DC supply to one end of the coil and a switch to ground the other end. A button could be a single transistor, a microcontroller, or a processor with switching capabilities. The flyback diode, attached to the relay's coil, is also visible. The diode has to protect the switch from the relay coil's high supply voltages. One end of the load can be linked to the standard pin, while the other can be attached to the NO or NC pin. The load is disconnected before the trigger if it is connected to NO, and it is connected before the trigger if it is linked to NC.

IR sensor: An infrared sensor emits and detects infrared radiation to sense its surroundings. An IR sensor is employed as an object detection sensor in this method. Some of the IR transmitter's radiation reaches the item, while the rest bounces back to the IR receiver, as shown in Fig. 15.3. The intensity of the IR receiver's reception determines the sensor's output. Table 15.2 summarizes the function of infrared sensors.

Power supply: A separate power supply is required depending on the Raspberry Pi model. All models require a 5.1V supply, although the current required varies by kind. All devices up to the Raspberry Pi 3 require a micro USB power cord.

Fan: The DHT11 sensor provides the input for this automatic fan system. The DHT11 is a temperature and humidity sensor in one. The data from the sensor will be received by the microcontroller, which will convert it to fan output. Because the sensor's input is the amount of temperature in the room, we must adapt the software

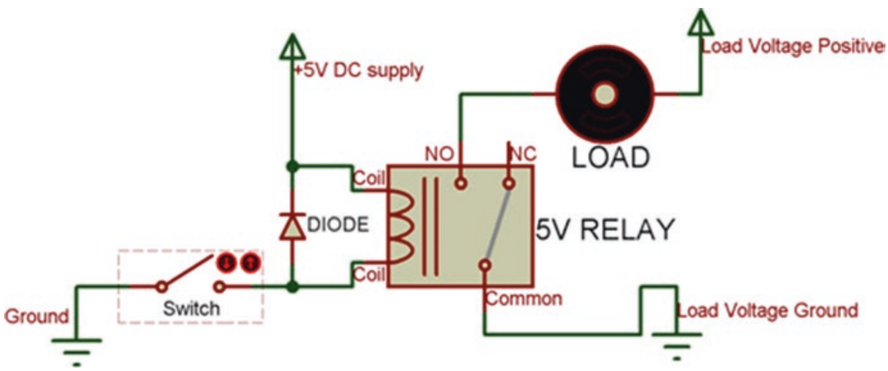

Fig. 15.2 Relay configuration

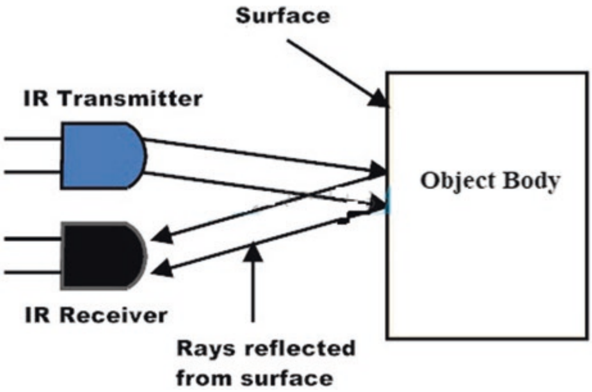

Fig. 15.3 IR module

Table 15.2 IR sensors and their purpose

Sl no	Hardware	Purpose
1	IR sensor	Obstacle detector
2	IR transmitter	Control electronic devices
3	IR receiver	Detect bursts of infrared light

to the suitable temperature and output fan speed constraints. The fan will switch off or not revolve if the temperature reported by the sensor is less than 25 °C. The fan will softly spin if the temperature sensor detects a temperature between 26 and 29 °C. If the temperature sensor detects temperatures between 30 and 34 °C, the fan will turn at a medium speed. The fan will rapidly spin if the temperature rises above 35 °C. The automatic fan detection technique is depicted in greater detail in Fig. 15.4.

Working of light: An IR sensor provides the input for this self-contained lamp system. An infrared sensor is a light-emitting electrical gadget that detects objects in the environment. An infrared detector can detect motion and measure the temperature of an object. Infrared heat radiation is emitted by almost everything. The sensor will send information to the controller, process it, and display it on the light. The black color absorbs all incident radiation, whereas the white color reflects all incident radiation. For the second time, the same approach can place the sensor couple. The photodiode and the infrared LED are placed nearby. This approach can be used to align the sensor couple for the second time. The photodiode and infrared LED are placed side by side.

The produced infrared radiation must reflect the photodiode after hitting any object because there is no direct line of contact between the transmitter and the receiver when the IR transmitter releases infrared radiation. The surface of the object can be classed as reflecting or non-reflective. The bulk of the energy that strikes the thing is remembered and reaches the photodiode if the object's surface is reflective, like white or another brilliant hue. As seen in Fig. 15.5, current flows

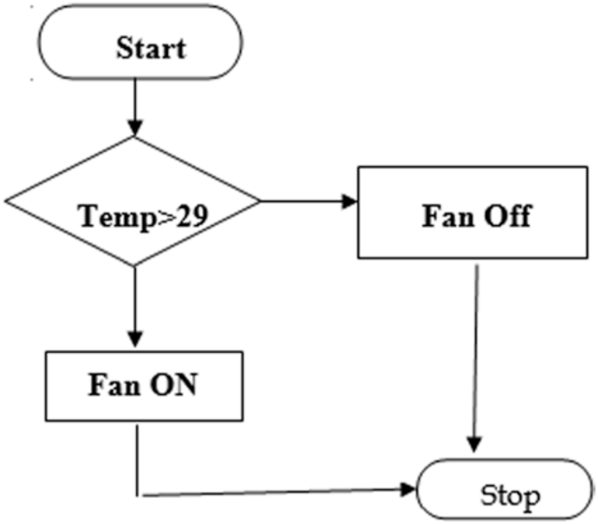

Fig. 15.4 Automatic fan detection

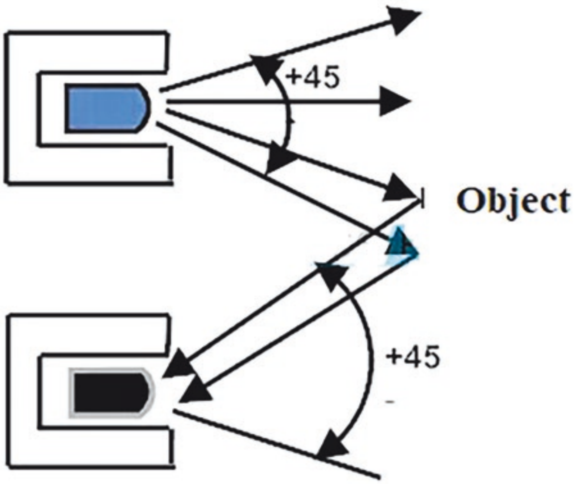

Fig. 15.5 Automatic light system

through the photodiode depending on the brightness of the reflected light. When an object has a non-reflective covering, such as black or a dark color, it absorbs practically all of the light it receives. Because there is no reflected radiation, there is no radiation incident on the photodiode. Hence, the photodiode's resistance remains greater, inhibiting current flow. It is also true if there is no object.

Raspberry Pi: The Raspberry Pi is written in Python and connected to a display with a built-in speaker to give an onscreen interface as well as voice help. Raspberry

Pi is a small computer the size of a credit card that can do everything from web browsing to scripting to gaming. Raspberry Pi is a low-cost, powerful, and developer-friendly computer that is disrupting traditional, high-energy IT installations for small and medium businesses. Raspberry Pi can act as an "Internet Gateway" for IoT devices because of its built-in quad-core processor. Pi acts as a web server for uploading and transmitting sensor data on IoT systems, and it is powered by a cloud network. To use Pi computer as a web server, you'll need custom code, an operating system, a Python library, and a cloud network. Raspberry Pi-based IoT projects have an easy design, implementation, and modification process, making them ideal for IoT applications. Raspberry Pi allows businesses to quickly deploy and control IoT applications like smart home gadgets, weather stations, agricultural projects, and more.

15.3.3 Software Specifications

15.3.3.1 Configuration of NOOBS

Stage 1: Install NOOBS (download and split NOOBS) as shown in Fig. 15.6.
Stage 2: Get an SD card ready to use.
Stage 3: Transfer the NOOBS papers to your SD card in stage 3.
Stage 4: Put your SD card in the Raspberry Pi and turn it on.

15.3.3.2 Workflow of Virtual Network Computing Viewer

Virtual Network Computing (VNC) is a graphical work area sharing solution that shows precisely the work area of a computer (running VNC Server) from another computer or a mobile device (running VNC Viewer). VNC Viewer sends console, mouse, and contact events to VNC Server, as seen in Fig. 15.7, and VNC Server responds to screen changes.

Installation of Python 3 and code execution will be carried in Python shell.

15.4 Results and Discussion

15.4.1 Home Automation

Figure 15.8 depicts the output of the circuit for home automation, which was activated by sensors. The light is monitored by an IR sensor, while a DHT11 sensor monitors the fan. If an item, such as a human, is identified by the IR sensor, the light will turn on, and the DHT11 sensor will work to determine whether the fan should be turned on or off, which is relying on the room's temperature.

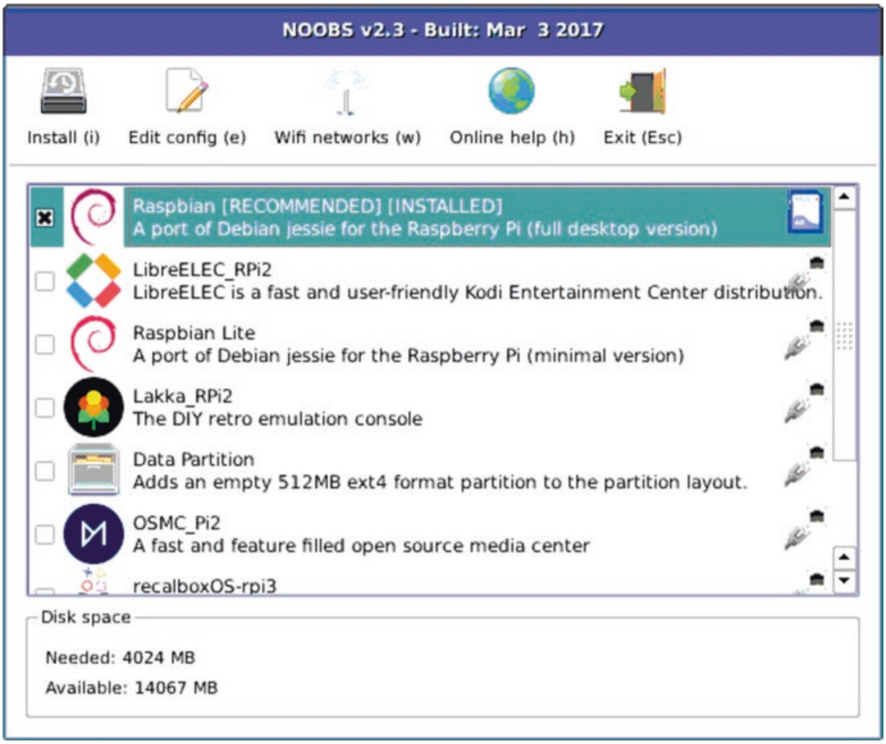

Fig. 15.6 NOOBS configuration

Stepwise workflow of VNC(Virtual Network Computing)

Stage 1: Turn on VNC.
Stage 2: Launch the VNC Viewer
Stage 3: Connect the Raspberry Pi to the PC.
Stage 4: Using the remote controller
Stage 5: Take a gander at the homes
Stage 6: Go to the web
Stage 7: Sign in to both the VNC Viewer on your PC and the VNC Server on the Raspberry Pi with a similar record.
Stage 8: IOS and Android (You may likewise utilize your cell phone to associate with the Raspberry Pi distantly.)

Fig. 15.7 VNC workflow

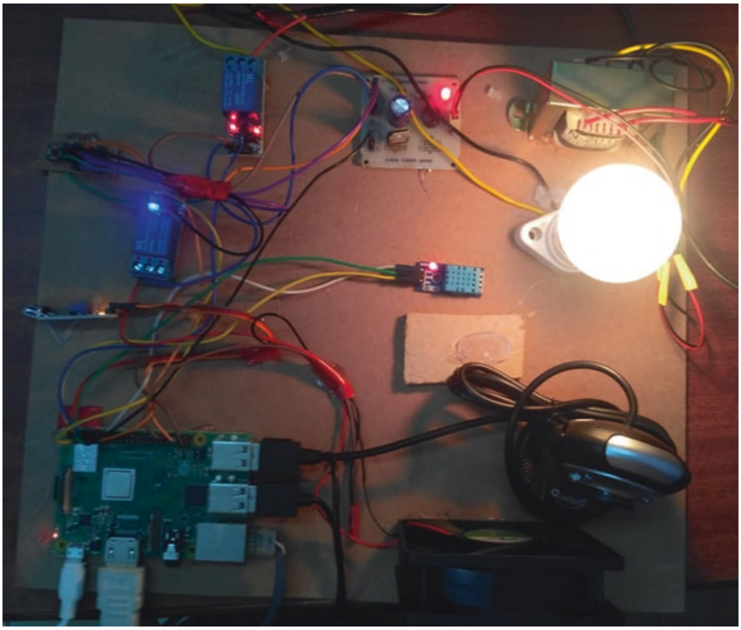

Fig. 15.8 Home automation

15.4.2 *Summary of Output*

Following the execution of the Python code, examine the output on the terminal, which will show the current date, day, month, year, time, current temperature, and air pressure, as shown in Figs. 15.9 and 15.10.

15.4.3 *PI Camera*

A switch controls the PI camera; pressing the button will take the image and communicate it to your email, as shown in Fig. 15.11.

15.4.4 *Raspbian Magic Mirror Features*

Table 15.3 displays numerous aspects supportable by the Raspbian magic mirror in the targeted model.

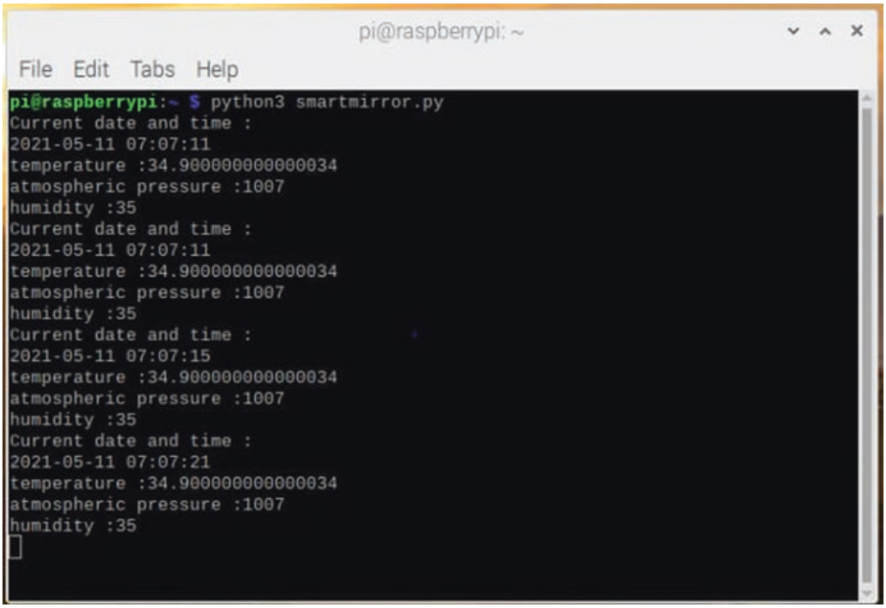

Fig. 15.9 Output displaying date, time, atmospheric pressure, and temperature

Fig. 15.10 Output displaying on smart mirror

15.5 Conclusion

With the proposed mirror, IoT-enabled home automation [28] is achievable. A surveillance system monitors it. It is controlled by a Raspberry Pi and displays weather, time, date, temperature, and humidity. Users can acquire both mirror and

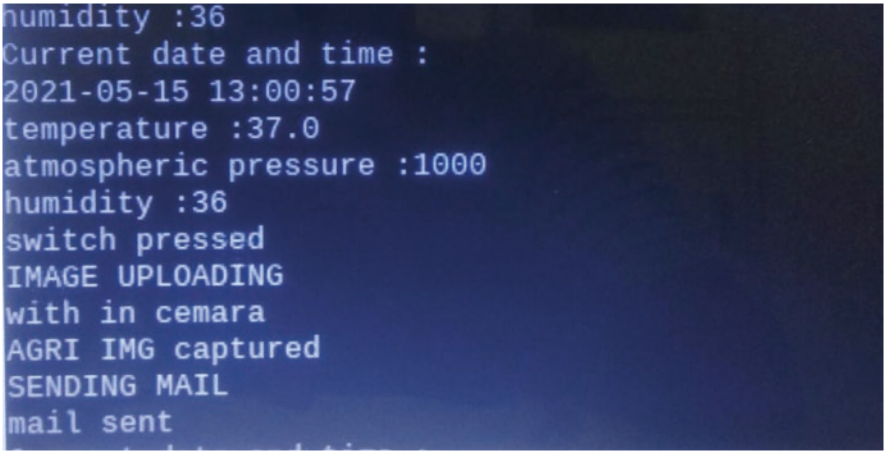

Fig. 15.11 Camera output

Table 15.3 Features supported by proposed work

Sl no	Features	Raspbian magic mirror
1	Date and time	Yes
2	Atmospheric pressure	Yes
3	Temperature	Yes
4	Gestures	Yes
5	Home automation (fan and light)	Yes

computer-assisted information from intelligent mirrors. Smart mirrors are very much in the works, but they will be important in the future. These systems can access the web and retrieve data, which may then be presented on the mirror in various positions, thanks to embedded microcontroller cards [29, 30]. According to work focused and implemented, the intelligent mirror system contains weather data, time and location data, current event data, user data, and a camera picture collected from web services using a Raspberry Pi 3 microcontroller card.

15.6 Future Scope

Every product can continually be improved because technology is continuously changing. Everything must be updated or enhanced regularly to stay up with modern technology. Apart from upgrades, smart mirror's functionality and capabilities may see a lot of significant advancements. This article has a bright future ahead of it, and it will be especially beneficial in the subject of artificial intelligence. Smart mirror-based home automation, for example, might offer a natural way to operate household equipment such as lights and fans using simple voice commands. Since this mirror will be used in a classroom, simple technology such as a barcode scanner or a fingerprint sensor can assist with tasks such as college attendance and program registration. One example is scanning ID cards to register for a program [31].

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Chapter 16
Use of Machine Learning and IoT in Agriculture

Anuj Mehla and Sukhvinder Singh Deora

16.1 Introduction

Food is one of the basic requirements of humans to survive. In the so-called technologically driven world, countries are still facing the issue of death due to hunger, malnutrition, and scarcity of food for their population. “The world is currently experiencing a pivotal moment. It is very different from what it had committed six years ago to eliminate hunger, scarcity of food, and undernutrition by 2030” (The State of Food Security and Nutrition in the World) [1]. The world recognizes that the challenges are significant and hopes to accelerate past accomplishments by adopting innovative techniques on a large scale that would enable us to achieve our targets. The report estimated (720 to 811) million hungry people worldwide in 2020, up by 161 million from 2019. The earth’s population is expected to increase to 9.8 billion people by 2050 [2]. The number of hungry people in the world is also increasing with time. Agricultural practices need to be modified for productivity at all levels to meet the global demand for food, feed, fiber, and fuel in 2050 [3].

Currently, the world faces numerous challenges such as a limited supply of resources, lack of skilled workers, and changing climates in agriculture [3]. Over most of the twentieth century, farmers have seen various improvements, including a scientific approach to produce, machines for tasks, improved genetics of seeds, and increased input of fertilizers and pesticides for increased crop production. Several issues also affect agriculture directly, such as farmers not knowing about their soil, sudden unpredicted rainstorms, crop disease, and irrigation issues. Food consumption is on the rise on one side, and agricultural practices continue to improve on the

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other [4]. In addition, the rise in income of farmers shall double what it is now, making food more expensive, especially in developing countries.

Agriculture is vital for food production and industry. Crops like cotton, rubber, and sugar cane play a crucial role in the economic future of several countries. Additionally, the bioenergy market for food crops has experienced recent growth. Food security is at risk as to the use of food crops for biofuel, bioenergy, and other commercial purposes to cater to the rising demand for energy resources [5].

With the advent of newer technologies, PA (precision agriculture) has expanded worldwide. It adopted innovative, data-driven, and disruptive techniques in PA. It used global navigation satellite services (GNSS) extensively for locating and quantifying soil quality during the first decade of PA. Tractor automation and improved crop nutrient management technologies had been the focus of concern during the second decade. As PA enters its third decade of growth, all fields of agriculture get explored for making intelligent decisions via modern sensors and other measuring devices to evolve new paradigms of evidence-based, precise farming. Indeed, future farming practices shall rely heavily on "farming the land" and "farming the data" to ensure output, efficiency, and sustainability. Researchers in agriculture explored the use of the latest technologies like multispectral sensors, remote sensing, robotics, droning, and cloud computing to monitor plant phenotyping and soil conditions (IoT). The addition to achieving a higher production level in agriculture, sensor technology leads to improved crop quality, soil quality, a safer food supply, sustainable farming, and increased profits. Farmers can analyze crops at the micro-level with these tools. The use of sensors has achieved appropriate agricultural objectives and developed multiple capabilities that would guide the future of agricultural practices [6].

Humans would like to track and count everything if computers may know and gather everything without our help, thereby significantly reducing waste, loss, and costs associated with the time and space requirements of computers. The field of the Internet of Things (IoT) arose in 1999, and now there are IoT devices everywhere constantly transmitting data and conversing with each other [7–9]. These devices can sense, track, and process the collected data to generate a large amount of well-structured, loosely structured, or unevenly structured information. However, predicting the future and finding recent information require applying analytical techniques to such data to analyze current scenarios and predict the future. It takes much effort to analyze such extensive data gathered from IoT devices. An efficient learning mechanism is needed to turn this data into actionable insights that are worthwhile. Analyzing complex IoT data using AI-based technologies is the most critical concern for handling crop-related parameters. Deep learning can only solve many complex real-life issues [4]. Recent advances in deep learning (DL) [10] can be applied to various IoT applications to produce quick results. While we have grown accustomed to IoT devices, the utilization of deep learning adds a new dimension to such connected devices when used in the domain of agriculture.

The remote sensing method collects a vast quantity of data based on images and depicts the agricultural environment in its entirety. A significant area of research in agricultural applications is remote sensing image analysis. It uses intelligent data analytics for detecting anomalies, identifying/classifying images, and identifying anomalous patterns in images. The primary purpose of this chapter is to investigate and address the applicability of various such techniques, namely, IoT, sensors, machine learning, and AI, to increase agriculture produce. It helps make precise decisions based on experimental agriculture parameters study and weather forecasts to automate all farming operations. One can develop intelligent agriculture platforms that monitor agricultural activity, including crop and plant monitoring, irrigation monitoring, water control, and others, by using sensors that measure soil moisture, water levels, and temperature [11]. Farmers can also continuously monitor agricultural fields from anywhere as compared to traditional farming. It improves all phases of farming: planting, tilling, and harvesting using IoT-based intelligent farming techniques to optimize [12] efforts and resource usage and achieve high productivity.

16.1.1 Need of IoT in Agriculture

Disease and Pest Monitoring Drones enabled with remote sensing provide the flexibility and image clarity needed to monitor pests and diseases in crops that only low-altitude systems can offer [13].

Crop Monitoring Agriculture crop monitoring becomes easy and efficient due to Internet of Things technology that enhances the management of crops and, therefore, the yield, leading to more profits for farmers [14].

Weather Monitoring The Internet of Things is a technology that makes it possible to monitor, collect, control, and connect to a worldwide network to the most advanced and efficient means of accessing weather information using weather monitoring systems [15]. It provides almost real-time data recorded through sensors and sent to the cloud servers. Farmers may access it and make decisions accordingly [16].

Storage Monitoring Agriculture products are stored in warehouses to prolong the life of storage materials [17]. Remote access monitoring for recording the temperature of grains, control fans/air conditioners, and prevent grain theft. All such systems provide real-time data that lets us know of a problem to be resolved swiftly.

Tracking Farm Products Produce from farms, including crops and livestock, is known as farm products. A crop can be any cultivable plant, mushroom, or organism cultivated to be eaten, clothed, or utilized in any other way. Using IoT sensors can easily track or monitor these farm products.

16.1.2 Working of IoT

The Internet of Things comprises devices and sensors that send data to the cloud environment through some connectivity. When the data reaches the cloud server, the software processes it and performs specific actions. It automatically sends an alert or changes the requisite sensors/devices without requiring human intervention.

A user interface provides the collected data and updates on what the system is doing to the end user. Users can perform adjustments or fine-tuning actions to the sensors/devices through the cloud.

16.1.3 Applications of IoT in Agriculture Forms

Agricultural IoT applications can transform agriculture worldwide and change humanity forever by almost real-time monitoring the extreme weather conditions, degraded soil, drier lands, crop diseases, watering, and deteriorating ecosystems to maintain or maximize productivity, plants, and livestock health at all times. Developers of IoT solutions in agriculture can help farmers monitor and optimize their operations that deliver rich insights through data analysis by using IoT, big data, and machine learning. There are many types of IoT agricultural applications used to monitor, control, and track various variables throughout the growing cycle. Precision agriculture, monitoring greenhouses, livestock, and agricultural drones constitute the main domains of IoT agriculture applications. Agricultural applications include the following subsections:

- Precision farming
- Innovating greenhouses
- Livestock monitoring
- Smart weather and climate monitoring
- Forecasting/predicting crop

In addition to helping farmers improve yields, profitability, and environmental protection, IoT solutions enable them to eliminate supply-demand imbalances. In precision agriculture, IoT technology is used to optimize resources to maximize yields and reduce operating costs. Figure 16.1 shows some of the applications of IoT in agriculture as per the latest research and application developments.

Precision Farming Precision farming is an innovative method that has been practiced since the 1980s and has become increasingly popular in the last few years. Its goal is to improve operating performance by monitoring soil properties and other factors. It involves an accurate and controlled raising of livestock or planting crops. Essentially, it uses information technology and various other technologies such as sensor technology, robotics, automated vehicles, control systems, automated hardware, and variable rate computing. The precision agriculture approach collects data electronically using computer technology and analyzes it spatially and temporally

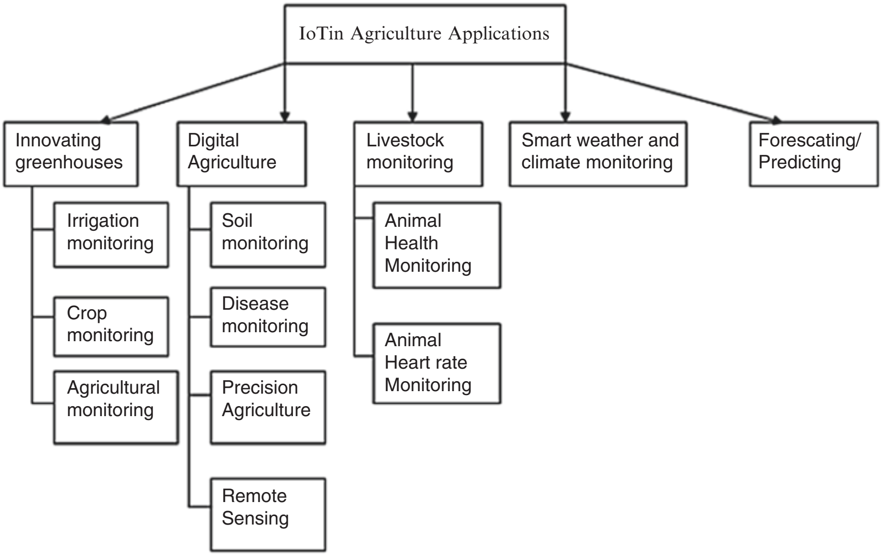

Fig. 16.1 Applications of IoT in agriculture

[6]. The real-time data level of water and nutrients of soil can be collected for better crop yield.

Innovative Greenhouses Automate climate control in greenhouses can be achieved using IoT devices for more efficient, automatic, and precise actions reducing the need for human interventions. These sensors can accurately monitor a greenhouse with sensors to collect and relay data in real time. IoT devices installed in the fields collect real-time data on water consumption and greenhouse conditions. It is provided as email or SMS alerts to control the irrigation system and temperature.

Observing Livestock Maintaining the livestock using manual processes is a highly costly affair. The use of IoT makes livestock maintenance much more accessible. Owners can track an animal's exact location, progress, illnesses it might be suffering from, the amount of food and water it needs daily, and sleep patterns and segregate healthy animals from sick ones using this technology. Poultry farming, apiculture, and pisciculture can be managed with the same technology. A lower number of labor requirements, addressing all issues at the earliest, lead to saving a huge amount of money spent for livestock management [18]. It helps the owners recognize pregnancies and take timely actions. In nutshell, sensors allow farmers to pay closer attention to what is happening in their farmlands.

Remote Sensing The satellites capture images from their geostationary and non-geostationary orbits. The images are processed to identify different segments based on the captured color codes. Real-time data related to weather, farms, crop cultivation, and water management is derived and shared with the farmers by the remote sensing stations. Farmers then manage their day-to-day affairs and make decisions accordingly using sensor-based information [19].

Monitor Weather and Climatic Conditions The climate heavily influences crop production. A crop can only grow under particular climatic conditions. The productivity and efficiency of crops depend on these conditions. Farmers can now find out the weather conditions in their fields in real time using IoT-based solutions. Farmers use the information collected by the sensors in the fields to decide about the crops that require these specific weather conditions. IoT ecosystems established shall use sensors to gather data about humidity, temperature, and rainfall, crucial for crop production. These sensors can quickly determine drastic/abrupt/sudden changes in climatic conditions to reduce the negative impact on crop production. It can help minimize the physical presence when deemed necessary and result in greater profits.

Forecasting/Predicting A key component of smart farming is predicting crop yield, storage management, market strategies, and control over risks. An artificial network uses the information collected from sensors to predict crop yield. The soil, temperature, pressure, rainfall, and humidity data are used for crop yield prediction. A dashboard or a mobile application can be customized to provide accurate soil data to the farmers for managing crops. It can predict the yield based on the relationship between previous years' data and its current year's values.

16.1.4 Sensors

Sensors play a vital role in capturing valuable data after a set time difference. The cloud services store this extensive set of data produced by these sensor devices to manage its storage. Agricultural scientists, farmers, and academicians then use this collected data for research and analysis to improve agriculture-related activities. Figure 16.2 showcases services and sensors used in agricultural innovations of the time. Farmers can access real-time crop information with IoT sensors, which help them make better harvesting decisions [20, 21]. By collecting IoT data, smart sensors can enable real-time monitoring of "what is happening on the ground." Farming can be made more efficient by knowing when to harvest, the amount of water used and whether irrigation is needed, soil health, and fertilizer requirements. A better understanding of the forecasted parameters enables farmers to plan seed sowing and manage cultivational activities, yield, and storage. The information presented here is essential since well-managed fields produce a greater (approximately 60% more) yield per acre than poorly managed ones. Agricultural sensors to enhance crop yield are required to reach the maximal efficiency of agricultural produce.

Soil Moisture Sensor Connected sensors transmitting data through Sigfox IoT can provide better insight into the soil water content. Nutrient leaching can be reduced by efficiently managing irrigation systems, water, and energy. It is one of the essen-

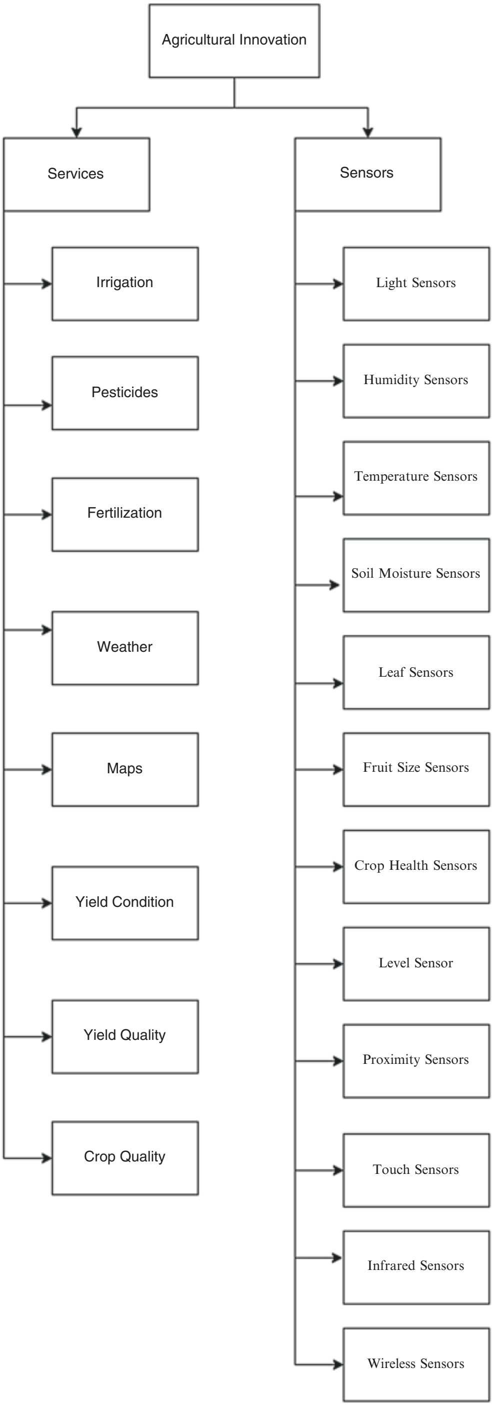

Fig. 16.2 Agricultural innovation sensors

tial sensors that measure the water content level. The moisture sensor passes a digital or analog signal comprising a soil-mounting component based on a threshold value set. There are mainly two types of soil moisture sensors: 1. a sensor for measuring the volume of water and 2. soil tension detector sensors embedded in the soil.

Temperature Sensor These sensors measure the greenhouse temperature periodically. Monitoring ambient conditions and mechanical assets is a critical component of such temperature sensors [22].

Humidity Sensor: Vapors in the air can be measured using humidity sensors. Humidity sensors detect and determine whether water vapor is present in the air or enclosure. The medical, agricultural, and environmental monitoring industries currently use humidity sensors. The measurement of humidity is in relative units. These comprise ceramics, polymers, and their composites for sensing in humidity sensors [23].

Light Sensor All vegetables and flowers need abundant sunlight. Different plant groups react differently and have different physiologies when dealing with light intensity. The performance of some plants improves in low light intensity and others in high light intensity. Light sensors help sense the light intensity and manage it in a certain required way to help the growth of a particular kind of vegetation.

Wireless Sensors Wireless sensors are essential tools that can assist with intelligent agriculture currently available on the market and play a crucial role in collecting crop information and other data. Almost every piece of agricultural machinery and advanced tools, such as fertilizer sprayers, has wireless sensors built into them, depending on the application needs. Some of the wireless sensors are acoustic sensors, optical sensors, electrochemical sensors, electromagnetic sensors, optoelectronic sensors, and many others.

PH Sensor With PH sensors, one can monitor a precise quantity of soil nutrients required for irrigation. Plants or crops are provided with an adequate supply of nutrients by monitoring the PH of the soil.

Ultraviolet Sensor (UV Sensor) The UV sensors monitor ultraviolet rays by converting photocurrent into voltage. A circuit converts analog signals to digital signals into its external circuit. These sensors detect light rays most effectively and are used for decision-making.

16.2 Related Work

As information and communication technologies have emerged, the agriculture sector has also evolved. Modern technology helps to increase crop production and reduce crop losses.

IoT network solutions include Bluetooth, RFID, Wi-Fi, Zigbee, Thread, NB-IoT, Sigfox, COAP, and many others. As a result of remote sensing in agriculture, multiple vegetation indices (Vis) perform reflection spectroscopy of spectral bands to provide insights into crop health. Many VIs are available, including normalized difference vegetation index (NDVI), enhanced vegetation index (EVI), soil adjusted vegetation index (SAVI), and many others that describe the difference between visible and near-infrared reflectance remotely sensed images of vegetation cover. It estimates the density of greenery, the type of cultivation, and its health.

A review on many satellites like Landsat 1, Landsat7, Landsat 8, RapidEye, GeoEye1, IKONOS, QuickBird, Worldview-3, and MODIS utilized for monitoring agriculture is provided [24]. A system that combines real-time data, machine learning, and drones to monitor crop health is beneficial for agriculture [19]. Combining multiple sensor technologies, heterogeneous data, and temporal fidelity can be used with analytical methods optimal solutions. Such practices are an essential consideration in building sensor-based systems for agriculture.

An idea to use IoT for monitoring cotton crops and acquiring the data in real time for IoT-based enterprise systems for agriculture framework [25] has become popular. It created an IoT-based enterprise system with three modules that deploy wireless sensor networks (WSN) at cotton fields. WSN monitors cotton crop conditions using the Waspmote agriculture sensor board. In addition, it also contains sensors for leaf wetness and soil moisture to monitor various parameters that affect the overall agriculture produce.

Any agricultural system relies on crop irrigation. The use of an irrigation system in agriculture is beneficial in managing the water resources and minimizes water loss. A wireless sensors and actuators network (WSANs) was designed for irrigation control in-house [26].

Researchers have suggested a solution to use multiple technology integrations to meet future agriculture expectations for intelligence and efficiency [5]. It integrates wireless sensors, crewless aerial vehicles, cloud computing, and communications to provide IoT-based platforms [27] and architectures adapted for agriculture.

In an Intelligent Agriculture study [28], new plan for developing a platform that monitors factors affecting farming operations and applying extracted knowledge to analyze farming practices for respective regions has been provided. They present a data cleaning method that uses moving averages and variances, eliminating data with more drastic variances. The inferences and knowledge extracted from the refined data are more beneficial for agricultural decisions and activities.

Another solution [29] presents a model with ICT-based integrated agricultural solution. The farmers can receive the latest information and take advantage of these informed dynamics. A remote monitoring system (RMS) uses the Internet and wireless communication technologies to provide real-time data about agricultural production. It uses alerts via a short messaging service (SMS) to provide agricultural guidance on frequent weather patterns and their impact on crops.

An information system [30] for the agricultural Internet of Things based on a distributed architecture is the need of the hour. Such a distributed information service system captures, standardizes, manages, and queries a massive amount of agriculture production data using IoT. It uses services like Information Services, Object Naming Services, and Discovery Services for tracking agricultural products and monitoring their quality in this system.

Analyzing and comparing different machine learning techniques [31] is addressed in the paper for most appropriate practical tasks. New technologies help meet the dynamic needs of agriculture as an industry that needs more sustainable and efficient solutions. Innovative farming system based on IoT [32] using architecture, layers of the networks, topologies, and protocols are useful for an in-depth analysis of agriculture variables. Cloud computing servers offer ample data storage, and analytics is carried out using big data technologies on data collected by the IoT devices.

Researchers have integrated microcontrollers, sensors, and a centralized water quality monitoring system into an IoT and AI-based platform for the agricultural sector [33]. It uses the Internet to transfer the bulk data collected by sensors to the cloud server for processing and logging. Data is collected after each fixed time interval and sent to a machine learning algorithm for calculating soil conditions.

An idea of a mobile-based agricultural control system [34] is presented with details on its components and control systems. The improvements made in this system included the throughput, energy, delay, and performance with a lesser number of operating issues.

The map-based navigation and vision-based scheme for farm management [35] use multiple edge nodes and one cloud server to disperse the computational load. A new system was proposed that provides an easy and effective way to send live notifications on real-time data related to temperature, soil moisture, humidity, UV index, and infrared parameters directly from the farmlands to farmers [36]. It helps farmers improve their crop yields and save resources like water and fertilizer. It uses IoT circuitry for live data monitoring.

A complete farming and food supply solution based on IoT and blockchain [37] is an innovative smart model for agriculture and the food supply chain for acquiring crop information. Another approach [38] uses IoT-based green agriculture for managing the operations in farming with security and integrity. Researchers developed another system to monitor soil conditions, ensuring the quality of farmland [39] that also reduces wastage of water. Additionally, it reduces water waste.

Table 16.1 provides details on some mobile applications in agriculture that help increase crop yield and transform the agricultural industry.

There are numerous significant applications of IoT in agriculture. Using IoT in agriculture, Table 16.2 discusses some previous works.

16.3 Machine Learning for Precision Agriculture: Concepts and Uses

Modern technologies such as the Internet of Things (IoT) and machine learning (ML) enhance food production, allowing farmers to spend less time on the land and pay more attention to their crops. The modern agriculture industry can benefit from

Table 16.1 Mobile applications for agriculture

Mobile application	Purpose	Performance/outcomes
Magri [40]	Diagnosis and detection of diseases	Soil characteristics like pH, soil carbon, nitrogen (N), phosphorus (P), and potassium (**K**) are identified at the specific GPS locations and shared for improvement in agriculture produce
BaiKhao [41]	Calculating fertilizers	Calculates the appropriate amount of nitrogen fertilizer to use after analyzing the rice leaf's color
BaiKhaoNK [42]	Calculating fertilizers	Provides an improved version of an application that estimates the amount of nitrogen fertilizer to be used based on rice leaf image color instead of using costly SPADs
SIFSS [43]	Soil quality	This application provides detailed information on soil, such as nitrogen, potassium, phosphorus, carbon, and many others
SOCiT [43]	Soil quality	The system provides users with accurate information about the carbon content of soil based on their geographical location
PocketLAI [44]	Leaf area index	It calculates leaf area index (LAI), a key determinant of crop water requirements of the crop
RaGPS [45]	Solar radiation from space	Application estimates crop water requirements using weather data. It also measures radiation parameters during cloudless days [46]
SafeDriving [47]	Vehicle monitoring	Track tractors to trace accidents and initiate alerts in the case of emergency
mKRISHI' [48]	Expert inspections for pests and diseases	A farmer can seek advice from an expert by sending images and videos with the query and sharing the GPS location
GeoFoto [49]	Identify land plot	The extension worker does not have to carry as many tools into the field by assisting with land plot identification
WheatCam [50]	Crop insurance	Picture-based insurance (PBI) is a solution that makes crop insurance more affordable and effective. A smartphone is used to share pre- and post-damage photographs of the insured property. It minimizes hurdles in claims verification
Crop Monitor (eLEAF's) [51]	Crop monitor	It monitors the crop and its performance to provide information about crop growth, water usage, and growth performance as per the potential
AccuWeather [52]	Weather monitor	It provides precise forecasts of rainfall for farms and fields
CITEX [53]	Citrus crop management	It is an expert system for managing citrus crops
LIMEX [54]	Lime crop management	Lime crop expert system

machine learning, which is a trending technology nowadays. ML in agriculture can create more healthy seeds. The use of machine learning and IoT in agriculture mainly reduces problems, predicts crops, predicts yield, manages livestock, detects

Table 16.2 Summary on IoT-based agriculture research application

Agricultural IoT application areas	Description of the problem	Model used	Dataset used
Monitor disease and pest of the crop [13]	Monitor diseases and pests of the crops by using IoT technology	Developed by authors	Using drones and sensors to gather data
Crop health monitoring [19]	Monitor crop health based on the integration of IoT, machine learning, and remote sensing	Developed multi-model technique by using SVM, Naive Bayes, and several deep learning models	Real-time data using drone imagery, IoT data, multi-source data integrations, VI maps, health maps, IoT data maps stored in a database
Identifying soil, diseases affecting crops and pests [29]	Predict soil conditions, weather patterns, and disease and pest	Developed by authors by integrating smart farming and ICT	Collect real-time data of agriculture in a farm field
Disease detection, plant species detection, enhance irrigation facilities [55]	Real-time observation and monitoring of farms	Developed by authors	Collect real-time data of soil, light, pH value, water, and humidity
Prediction of soil moisture [56]	Predict soil, crop type, and irrigation	Framework made by IoT and SVR, random forest algorithms, Tableau	Database of agriculture production in India [57]
Crop recommendations, fertilizer recommendations, and predict crop growth and climatic conditions [58]	Identify crops, recommend fertilizer, and predict climatic conditions	XGBoost	13 crop datasets

leaf diseases, recognizes crops, and detects disease early. Some of the uses of machine learning with IoT are shown in Fig. 16.3. In machine learning, humans instruct machines to mimic the actions they naturally perform. On the other hand, computer-supported learning is an approach in which computers automate and improve their learning processes when interacting with humans. Using IoT with artificial intelligence (AI) and machine learning can improve the efficiency and intuitiveness of these processes for developers and users.

16.4 A Generalized Model for Solving Any Kind of Agricultural Problem by Using IoT

Figure 16.4 shows a generalized model for agricultural problems. Wireless sensors combined with mobile agricultural applications and cloud platforms collect relevant data about the farmer's land's environmental parameters, such as temperature, precipitation, humidity, wind speed, pest infestations, soil quality, and nutrient levels.

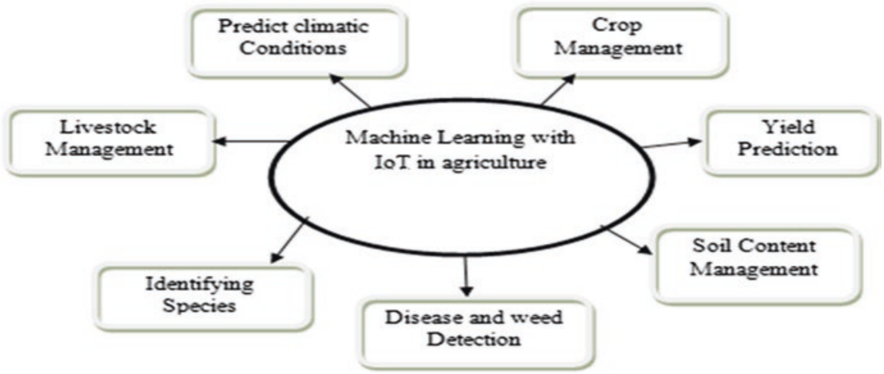

Fig. 16.3 Use of Machine Learning with IoT in Agriculture

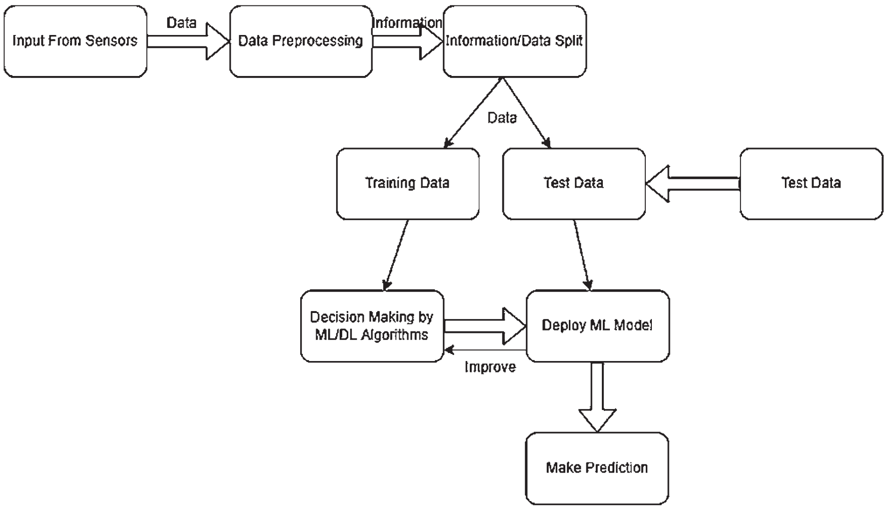

Fig. 16.4 A generalized model for agricultural problems

Farmers can use this information to make more informed decisions and improve the quality and quantity of the produce. Monitoring crops at multiple locations via a mobile app reduces the complexity of managing crops and allows farmers to estimate the impact of their farming practices and improve actions during future harvests. Mobile applications can determine *where fertilizer is required* or *amount of irrigation required in the field*.

The input from sensors is processed and analyzed in the subsystem to predict system properties that need manual or automated control. Dynamic models help in decision-making and finding their impact over time. Agricultural knowledge is studied to update agricultural practices to find the optimal procedures. The formulated models are trained and tested for optimal results based on each parameter and develop an efficient model.

16.5 Conclusion

Agricultural land is steadily decreasing due to the construction of buildings for a living, drains for waste management, factories for production, opening up of trade businesses, and natural climatic factors like hurricanes, earthquakes, and volcanoes. Thus, a proactive approach to crop sowing, cultivation, disease management, and storage is required to meet an ever-increasing global population. Using IoT devices in agriculture has many applications and sensor-based ideas to improve the overall yield from agriculture. Many remote sensing devices, temperature and soil moisture sensors, humidity sensors, water level sensors, and pH sensors, use remote sensing to provide practical solutions to agricultural challenges on the farms. Agricultural management systems can better handle farm data and help formulate more effective strategies for increasing agribusiness worldwide. Through the evolution of the IoT and ML, researchers can provide innovative ideas that put these tools to assist farmers in their daily work. Using these technologies, farmers can improve throughput, use their fields more efficiently, and monitor disease, pests, animals, and machines [59]. In no doubt, with the use of IoT, ML, and remote sensing, farmers can achieve the goal of automated cultivation and environment control in the coming days. The technologies shall revolutionize the agriculture sector by identifying best practices to reach the slogan – "food for all" a reality in years to come.

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Chapter 17
Intelligent Technology, Systems Support, and Smart Cities

Rahul Gupta

17.1 Introduction

Changed Life Style in urban cities has accelerated the need and growth of smart cities have surged in recent years; social life domains are restructuring by using advanced technological infrastructure and digital communication. To offer a secured human life with comfort in a sustainable environment has proposed the concept of the smart city. Caragliu et al. [1] conceptualized a smart city as a synthesis of physical capital or hard infrastructure with quality knowledge, social infrastructure, and fast communication. The way residents work, behave, and interact among themselves and consume public infrastructure has been redefined with the use of enhanced ICT tools and technological innovations, amalgamating the intellect of conceptual city with the physical world. The city is transforming into a "smart city," with a holistic transformation of amenities, services, and the way these services are offered and consumed [2, 3]. The surge in urbanization emphasizes environmental concerns, economic restructuring, and public sector concerns, required to be dealt with advanced and smart tactics. The pace of changes in expectations of residents poses further challenges in managing these smart cities. To supersite, these deterrent organizations need focused technological advances and communication devices. The role of fast mobile networks, high-speed Internet, IoT, and big data [4–8] plays a vital role in supporting these services. Automation of various facilities is triggered for the deployment of artificial intelligence and robotics in support of many services. Bowerman et al. [9] suggested that management of the smart city is carried by integrated technologies which include sensors, electronics networking, computerized systems for data handling, and decision-making algorithms.

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Batty et al. [10] proposed that residents in a smart city avail facility by using smartphones, supported by IoT, RFID (radiofrequency identification), smart meters, AI, ML, cloud computing, collective intelligence, software, and their smart applications. Arasteh et al. [11] said that IoT is the tangible object connected with computational devices and sensors, for data exchange among connected devices. Since smart city solely depends on their embedded technologies, the role of IoT is decisive. Komninos et al. [12] said IoT is a major research and innovation offering numerous opportunities for smart services by interconnecting virtual and physical environments, spread all over places like vehicles, homes, offices, and other commercial places.

ICT supports enhanced service delivery like retailing, communication, and transportation. Smart cities function on real-time usages and monitor data at intelligent laboratories facilitating massive exchanges among numerous spheres. Security and privacy remain a concern in the smooth functioning of smart cities. The authors in [13] pointed that smart city components include smart mobility, smart living, smart people, smart governance, etc.

Artificial intelligence an important technology for a smart city is getting popularity with reduced cost of computing and availability of big data. Technology supports learning from experience, performing complex tasks, and automating decision-making. Many services like healthcare sector (disease diagnosis, assisting patients in healthier life), transportation (automatic signal control as per traffic congestion, driver assistance), surveillance and public safety (monitoring and face recognition), production (process control and automation, robotics), retailing, etc. use artificial intelligence to support smart cities for their development and operations.

17.1.1 Application of AI in Smart Cities

17.1.1.1 Decentralization

Through a believed agency (taking an example of a bank or government) in an earlier established transaction managing system, the transaction management has taken place. The result that comes with this centralization manner includes additional cost, single-point failure (SPF), and performance bottleneck at centralized service providers. The benefit of blockchain is that transactions can be validated between two peers without the need for authentication, jurisdiction, or intervention by the central agency, which results in a lower cost of service, SPF risk, and a reduction in performance bottlenecks [14].

17.1.1.2 Immutability

Researchers have studied that a blockchain comprises an associated chain of blocks, where every link is crucially an inverse hash point of the last block, the changes of any kind made on the last block will invalidate every consequent generated block.

This approach allows for immutable recording of interactions as all interactions go through the blockchain. This approach allows you to query details on the blockchain, track all selected interactions, and add autonomy to IoT devices.

17.1.1.3 Transparency

The aid of public blockchain systems, for example, Bitcoin and Ethereum, gives the user accessibility and interaction with an identical right in the blockchain system. Also, each and every transaction performs validation and is saved in the blockchain making it available for every user. Hence, the data in blockchain maintains transparency to those users who will be able to access and perform verification of performed transactions.

17.1.1.4 Traceability

A timestamp is attached with every transaction saved inside a blockchain. It is going to be easy for users to verify and can also track the birth of traditional data items following the analysis of the data in blockchain along with communicating timestamps. It can trace one thing on the web with the guaranteed traceability for transactions, which assures clear transactions, succeeding the feature of security (Fig. 17.1).

17.1.2 Contribution to Smart Cities

Transportation: AI-controlled autonomous vehicles will enhance city transport and substantially reduce parking requirements. The space will further be used for other productive purposes. The automated traffic-controlled system using real-time sensor data will enhance city life.

Resource management: Efficient management of energy, water, and other natural resources.

Ecologically managed low carbon energy networks: Green infrastructure is developed and managed with sensors and artificial intelligence, building, and infrastructure with regulatory energy use, with comfortable air quality.

Living: Quality life, health, education, and safety.

Support for senior citizens: Support in social and healthcare with automated robotics, senior citizen-friendly urban infrastructure, and personal mobility.

Economy: E-business innovative spirit, employment.

Coherency: Social issues like the digital divide, social relations, and ICT connectivity.

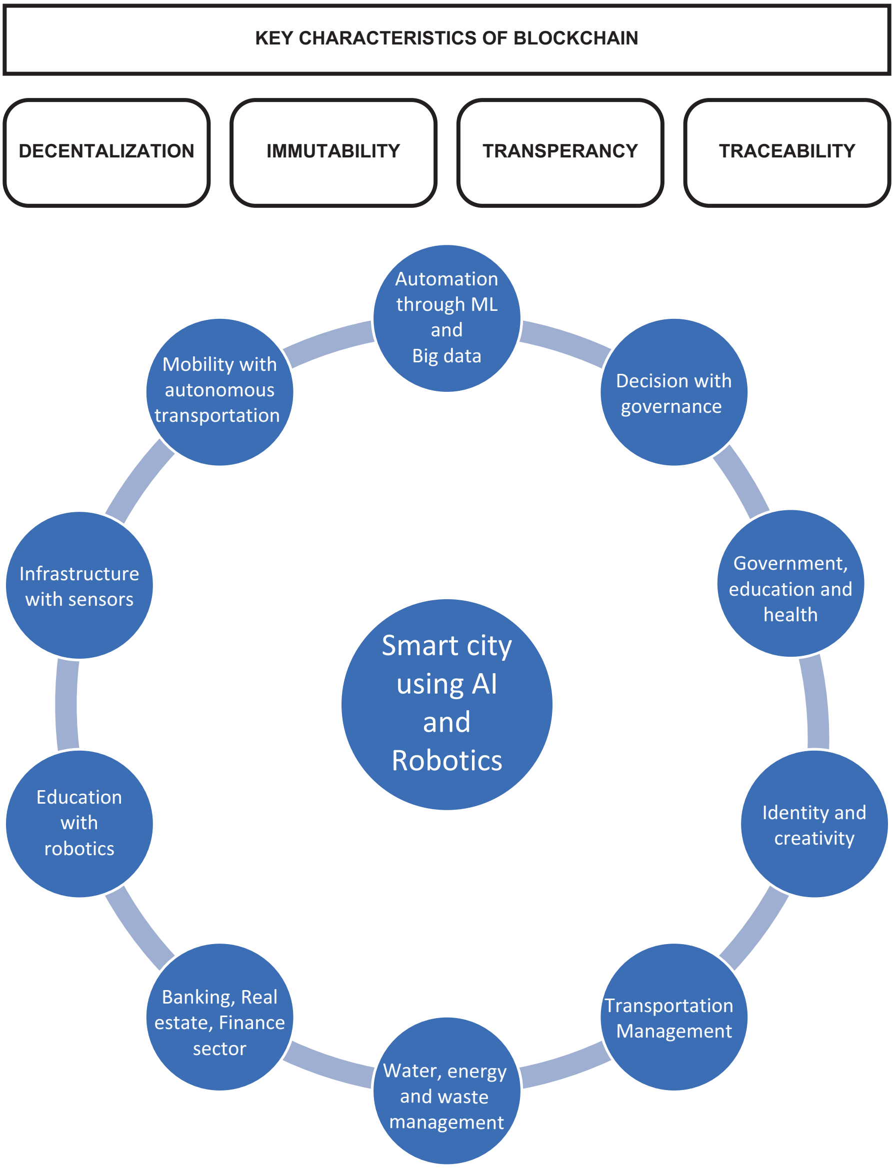

Fig 17.1 Categories used in smart cities

Maintenance of infrastructure: Efficient repair, monitoring, building management, and control with robotics where accessibility is unpleasant.

Controlled environment for food and leisure: Leisure and food growing in advanced and artificial intelligence-controlled automated environment.

Policy guidelines and security: Automated and unmanned aerial vehicles for surveillance and robotic policing.

These trends, challenges, opportunities, and robotics, artificial intelligence accompanying smart cities, unavoidably draw consideration to important players that shape the working of smart cities. Khatoun and Zeadally [15] stated that urban area with modern facilities addressing business and institutional needs is considered smart cities. Smart cities face various political and socioeconomic issues, but technical issues are a major stabling block in the development of any smart city. In technical issues, cost efficiency and interoperability, the privacy and security concerns are very important. The paper would address these challenges in the following sections. Various proposed architectures are discussed, and then a few real-life applications like energy management, transport management, and food management are discussed; key challenges and issues are explained in managing smart cities.

17.2 Smart City Architecture

17.2.1 Architecture Layers

Applications and services in smart cities are offered in layers to make them convenient for adjustments and modifications. Each layer is separated logically and physically. Layering is the feature that attracts most researchers. Various concepts have combined layers for the operation.

Kyriazopoulou [16] proposed three architectural layers for smart cities; for the first time, he compared Kyoto, Helsinki, and Amsterdam, with an information layer as the first layer consisting of data from sensors on a real-time basis, and combined them with files from the Internet using GIS. A virtual environment is created in the second layer with 2D maps and 3D spaces. Next, an interacting layer is created for the intercommunication of agent systems. Anthopoulos et al. [17] studied Trikala in Greece, with five layers. The first and last layer is for stakeholders (service designers and users) and the next as platforms with infrastructure layer, networks, and technologies for services offerings. The information layer is the next layer for required data like geospatial data for operations. The service layer is the fourth layer with applications required for interaction among an organization and its citizens.

Su et al. [18] suggested a model with three layers for a smart city, starting with the manufacturer of public infrastructure; middle layer as WSN (wireless sensor networks), network infrastructure, and cloud computing platform; and last layer as the manufacturer of basic application systems like construction of the smart home and wireless city.

Carretero [19] offered self-adaptive architecture known as ADAPCITY, for the smart city. Heterogenous devices are adopted which to react as per the requirement of the environment. An immediate recovery and updating are done for new operations. A four-layered architecture with a physical layer as the first layer comprises of behavior and state of objects and devices. The grid layer is the second layer communicating with a physical layer for data process and storage; the management layer is the third layer used for data mining, statistical analysis, and prediction, and next comes the control layer which provides services considering the desires of users and optimization measures.

A generic architecture is offered by Vilajosana et al. [20] joining features from existing platforms. The lowest layer as a capillary network layer entails actuators and sensors required for data collection, warehousing, keeping real-time, historical, and metadata. Incoming data is received at the service layer from capillary network layers. Received data is then processed, secured, and combined. Open, big, and streaming data is analyzed. The Application layer is the last layer, where analyzed data is transformed into valuable information, which is provided with predefined interfaces.

17.2.2 Architecture with Service Orientation

To have services as orientation, the objective is the collection and intercommunication among various services in the computer network. The interactions are considered as unimpeded for services that are loosely connected, self-reliant, and unrelated. Anthopoulous et al. [21] proposed a common architecture called enterprise architecture. This architecture combines data for service delivery and urban development and associates physical and logical architectures.

17.2.3 Architecture for Events

Creation, application, and reply to uncommon actions are managed with this architecture; those events relate to asynchronous and uncertain amendments. The result invokes the production of the report, for example, sensors detect alteration and are processed by the system. This type of architecture may be clubbed with service-oriented architecture as suggested by Filipponi et al. [22]; in their work researchers clubbed events and service architecture as SOFIA, for monitoring cities against security threats and identifying abnormal emergencies.

17.2.4 IoT Architecture

Diverse devices are networked through the Internet with unique Internet protocol addresses. Actuators and sensors are embedded in these devices which are remotely connected to the Internet. New and useful applications communicate among sensors and facilitate numerous applications. IoT architectures primarily support smart city operations.

Attwood et al. [23] proposed an infrastructure for a smart city to safeguard against failure or provide uninterrupted services in the case failure is inevitable. For all functions to operate properly, networking of sensor-actuator is mandatory. IoT connects with actuator network to collect data required for managing smart city operations; smart city critical infrastructure comprises of some basic amenities that researchers have offered which are CRRI (critical response reasoning instance), SANOSM (sensor-actuator network overlay state management), aggregation and annotation services, etc.

Wang et al. [24] used WGS (wind geographic software) offered by NASA for inventing smart cities. Open-source software allows interaction, visualization, and simulation, in the smart city. Visual display and data collection through network analysis, IoT, and web map services are the main components for this platform. C. Samaras et al. [25] proposed SEN2SOC as a platform for smart cities in Spain, intending to enhance interaction among social networks and sensors and using NLG (natural language generation), to enhance the living standard.

17.3 Applications

Various applications in smart cities are energy management (integrating conventional and renewable energy), food management (smart delivery of food items), transport management (traffic management and smart parking solutions), etc.

17.3.1 Food Management

Zhang et al. [26] discussed an IoT-based application for trailing the originality of the food supply in smart cities, as demand in cities has seen a tremendous surge for food items due to urbanization. Managing the food supply chain for monitoring, analyzing through smart sensors by collecting and processing data. The monitoring is essential for finding any contamination and backtracking any contaminated food offered in the market.

17.3.2 Energy Management

Management of energy is an ingenious requirement to be taken with utmost care in a smart city. In a world where all are talking about energy conservation, the objective of the devices and applications required to be used in the smart city is a must. Energy must be conserved to reduce its utilization by relying more on natural and renewable energy.

Brenna et al. [27] suggested SEM (sustainable energy microsystem) designed to join other subsystems serves independently, as a discrete production from powerhouses, combined heat, renewable sources, and recharging of electric and hybrid cars.

The researcher looks beyond the idea of smart grids and searches for resolutions to better integrate energy flow management with other subsystems as a vital part of a smart city. A flexible energy hub is installed using SEM for storing and supplying various energy haulers, aiming to propose new tools for optimizing the design. These tools are cohesive based on risk analysis and complexity science. The reliability and quality are secured by offering newer technologies for reconfigurations and service optimization, and infrastructure vulnerabilities are minimized. The controls of infrastructure and their interdependence are between infrastructure and the environment. Human factor impact and organizational problems on SEM management and control are also studied.

Klingert et al. [28] suggested the solution DC4Cities, which aim to optimize the share of renewable energy source, whereas data centers are operational in smart cities. Here data centers act as an important functionary in the smart city to perform a dual function as an energy consumer and IT service provider. The management of smart cities faces a challenge in integrating sporadic renewable energy into a local power grid with support to an IT-based low-carbon economy, a method for power management option among smart cities and data centers for internal adaptation strategies. The researcher proposed a mechanism to evaluate through a simulation.

17.3.3 Transport Management

Losilla [29] said that intelligent transport management is an essential part of a smart city and its operation would be incomplete in a case of unavailability. The management of smart transport is done with the applications for traffic control, law enforcement, safety, and finding parking smartly. Intelligent transport management should be able to sense, distribute, take decisions, and execute their task independently.

Birk et al. [30] and Qin et al. [31] discussed that intelligent transport management system deals with safety applications that screen the animal within safety perimeter, traffic congestion, intending to prevent and guard against accidents. Sensors perform their task proactively and signal the other devices in the case of any possible menace like any obstacle, bad road, and wrong directions/unsafe deriving, sense speed and communicate with other devices, and give warning signals to the drivers to avert accidents. Sensing devices perform by using a single or double approach. In the case a vehicle is detected by a static sensor, the other sensors get activated for finding further road situations. The other approach provides road conditions to other nodes without any vehicular presence, so data may be transferred to any area to pass on to other passing vehicles at a later stage. This approach is applicable for detecting non-ephemeral events.

Weingartne and Kargl [32] tried to join WSN and VANET (vehicular ad hoc network) for the implementation. The WSN monitors streets, and VANET disseminates the road situation to other vehicles in the vicinity or to the other static sensors for further warning.

Bohli et al. [33] discussed the techniques to check speed limits and help in traffic law enforcement by collaborating with other sensors. The traffic controller received pictures with registration details of speed violators for further action to be taken as per the prevailing law. Drivers can also be warned via SMS before issuing challan for a speed violation.

Bohli et al. [33] studied illegal parking with the help of sensor nodes and take pictures of their registration plates. PGIS (Parking Guidance Information System) enabled with WSN is suggested against expensive wired sensors.

Lee et al. [34] suggested WSN application detects vacant parking space with the sensor on every floor. Chang et al. [35] studied post-accident investigation, which is necessarily required to set responsibilities for the accident. Shuai et al. [36] studied that sensor nodes monitor the road network and obtain the time value for every segment for deciding the optimum route. They also propose an application for scheduling the flow of traffic at traffic light intersections. Congestion of vehicles is detected with the help of sensors at each intersection, where sensors can be placed after the traffic lights to determine vehicle queues.

Few sensors are required; hence cost is controlled, and acoustic detectors based on neural network [37] and vibration sensors in vehicles [38] are used for high accuracy.

17.4 Smart City Challenges

Operationalizing smart city encounters many hurdles which need to be addressed. Few challenges are discussed here.

Cost of Implementation: Managing innovative technologies requires recurring costs.

Energy: Requirement of high energy for sustaining technologies is a challenge.

Security and Privacy: Use of smart devices and smartphones while availing services is connected through the internet. Their communication makes them vulnerable to cyber breaches and cyber vandalism.

Technological Integration: Information and communication technologies are used in planning and developing infrastructure for smart cities. The challenge here is to demonstrate its utilization, for the development interoperable for the function of smart cities.

Traffic Management: Reliable and fast MAC access protocol for the critical transmission of information in the case of emergency is a challenge.

Mobility: Flawless running of applications while shifting between networks is essential.

Scalability: In the case the number of user expends the storage restrictions, computational and bandwidth capabilities may hinder the functioning of a few applications.

Issues: Building technical and social intelligent systems is an issue while managing smart cities.
Public Safety: Real-time analysis of information to check crime is a quick response for the threats to the residents.
Healthcare: Improved connections and advanced analyses while interpreting huge data are required for better healthcare facilities.
Transport: Integration of all means of transportation, mitigating congestion, and finding new avenues while designing transport networks in smart cities.
Water: Efficient use of water at homes and commercially by guarding the ecosystem for ensuring the wellness of senior citizens staying alone in smart homes.

17.5 Solutions

Suryadevara et al. [39] proposed a flexible, cost-efficient, and robust intelligent system that has two models intelligent and WSN home monitoring software. Modules collect sensor data, analyses, and changes in behavior and ensure timely healthcare services. Suryadevara et al. [39] proposed a WSN-based monitoring system designed by Dasios et al. [40] which monitors environmental parameters like humidity, temperature, and the light intensity with daily activities such as moving, sleeping, and sitting. In the case of any deviation, automated alarms are raised. A real-time traffic controlling system was proposed by Semertzidis et al. [41] which uses a visual sensor network and connects with system computers for subsequent recognition and tracking. Gupta et al. [42] proposed an RFID-based system communicating between traffic signs and vehicles. Metje et al. [43] offered WSN-based intelligent pipeline monitoring system to monitor sound, pressure, and vibration to detect any leakage.

17.6 Scope

Research in the area of intelligent systems in the building is not fully explored. Further improvements can be explored. The use of cloud computing as a platform needs thorough exploration to improve life in smart cities. Services like municipal repairs, traffic details scheduling of public works with safety and security of residents. Managing big data is an immense challenge for researchers.

IoT applications: For procuring valuable real-time information. Services of IoT are essential and support extensively.

Data management: Huge data is generated in smart cities; thus handling this data is a challenge. Huge storage is required for keeping this data.

17.7 Conclusion

Services once availed in smart cities will be indispensable; residents find it difficult if these services are performing up to the mark. Various services are already in use, and many still need to be explored, with refinement in the existing structure. Services in smart cities are provided with various challenges, and issues are discussed here in this paper. The components which transform a city into a smart city include governance, infrastructure, mobility, and smart communication. The progress of smart cities is susceptible to many challenges like political, technical, and socioeconomic. The software and hardware requirements to tackle technical issues must possess system interoperability and need to be managed at a competitive cost. Data generation is huge while availing services in smart cities; this data is vulnerable for breach; hence privacy and security are of utmost importance while managing smart cities, as the connectivity of devices is susceptible to malicious attacks by spyware. The growth of smart cities is in its early stage; the requirement of information technology tools, information security systems, and other advanced technologies will certainly boost the development of smart cities [44].

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Chapter 18
Deep Learning Approach for IOT-Based Multiclass Weed Classification Using YOLOv5

K. Sandeep Kumar, Rajeswari, S. Lakshmikanth, and Himanshu Sharma

18.1 Introduction

Weed infestation has been estimated as a factor causing the decrease in crop yield, which represents economic losses [1]. These effects occur when weeds emerge within the planting line, competing with the plant for nutrients, water, and sunlight, during its growth stage. Large doses of herbicide and weed resistance constitute a serious problem in world agriculture, which causes the use of agrochemicals without control to have negative effects, among which the unnecessary use of herbicide (economic loss), the environmental damage (soil and groundwater contamination), and traces of agrochemicals in food (affect health and food safety) [2, 3].

The conventional way to control weeds is by manual screening, whenever possible, or spraying herbicides evenly across the field to keep them under control. The latter method is rather ineffective, as only 20% of the pesticides reach the crop and less than 1% of the chemical actually contributes to weed control, wastewater disposal, and pollution or overdosing of fruits exceeds the allowable limit and can have an impact on human health [4].

Since the end of the twentieth century, the collective application of new technologies has improved agricultural management practices and has given rise to the field of precision agriculture (PA) [5, 6]. These technologies are based on managing resources more efficiently, taking into account environmental conditions and the real needs of the plants. The PA links strategies for the acquisition and analysis of

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information in the field and the application of inputs according to parameters established through intelligent systems, where a main aspect is the specific management by site for an optimized and efficient production of field crops. Specific weed management with precision agriculture concepts seeks to apply the herbicide in the right place, quantity, and time, to improve productivity and reduce the waste of inputs, without affecting the environment [7]. To achieve this purpose, weed control systems are implemented, where robotic systems play a fundamental role [8]. Such frameworks must be able to detect weeds in the field and use an herbicide spray that directly affects application.

Digital image treatment techniques have been utilized to recognize phenological behavior and species of plants as one of the tools of the PA [9, 10]. Systems for determining the spatial distribution of weeds have been implemented using multispectral cameras on board aircraft [11] or at the field scale [12]. The detection of weeds in the images using the characterization of the shape and location of the crop rows allows determining the type and number of weeds per image [13]. Weed growth occurs in a non-uniform way, but they occur naturally in clusters; that is, they can grow in (or between) the rows of the crop. Weed detection can be fast and accurate if it is separated from the soil; this method can solve the technical problems for the precise application of pesticides using automated navigation land vehicles [14].

The vegetation classification has been studied in various regions of the visible and infrared spectrum, together with color indices, vegetation indices, and hyperspectral and multispectral imaging techniques [15, 16]. Most approaches to automated weed control use digital RGB (red, green, blue) cameras to detect plants [17, 18]. In the case of multispectral analysis through the acquisition of visible and infrared images, the use of bispectral cameras, composed of two camera heads, is reported in the literature.

The monochrome Images helps us to obtain two congruent pixel images of any scene in different spectral bands. There are other approaches that use hyperspectral imaging sensors [19], 3D lidars (light detection and ranging or laser imaging detection and ranging), 3D surface characterization systems for discrimination of crop weeds, and fusion concepts with multiple sensors [20].

In general, weed detection and classification are based on the main steps of digital imaging: acquisition, segmentation, feature extraction, and classification [20]. For this last procedure, images are collected, classified, and characterized as weeds or plants by a consumer, and then these characteristics are used to form classifiers based on statistics or machine learning. As a rule, the size of the training set should be on the order of hundreds or thousands of labeled reference samples in order to obtain a meaningful classifier [21]. Artificial intelligence-based cultivation techniques have been used to detect and classify weeds among soil, crops, and weeds. Examples of these techniques are artificial neural networks (ANN), decision trees, classification based on wavelets, genetic algorithms, support vector machines (SVM), and algorithms based on fuzzy logic [22–26].

The objective of proposed work is to develop a framework capable of classifying different types of weeds, through artificial vision and digital image processing, to classify the multiclass weeds. The YOLOv5 architecture has been explored, and nine classes of weeds forms are classified. This article focuses on multiclass weed classification algorithm using image processing techniques.

18.2 Literature Review

Regarding the algorithms or classification methods used, it is concluded that the SVM are still in force due to their good performance and low consumption of computational resources, being more attractive in projects that involve embedded systems [27, 28]; on the other hand, artificial neural networks follow being the most used method for the detection of weeds due to its performance and flexibility when choosing between topologies, training algorithms, or simply modifications that the author needs to carry out according to the challenge he or she is facing.

Of course, this also applies to CNNs, which are driving strong trends in image-based pattern classification and identification. In the presented article, AlexNet, ResNet, RCNN (Regional Convolutional Neural Networks), VGG, GoogleNet, FCN (Fully Convolutional Network), and YOLO (You Look Only Once architecture of [29]).

Authors of [30] ensure that convolutional neural networks (CNN) are a very powerful method, for example, Authors of [22] developed a technique for the recognition of weeds and plants with a multispectral camera in real time made by a terrestrial robot. Classification technique used is based on two convolutional neural networks: the first performs binary segmentation of the image by pixels, extracting a 3D representation of the pixels showing the green vegetation, the second is a previously trained network which performs the classification.

The main advantage of this method is to speed up the process of manually marking up files while maintaining good classification performance. Proposed technique outperforms conventional index-based ones such as NDVI with an accuracy of 98.7%, furthermore, since the input is the same image, the drawbacks mentioned in ANN and SVM with the decreased number of features. From the results, it can be concluded that deep learning and pattern recognition techniques can be extensively used in detection and classification of weeds [31].

Authors of [32] propose a weed detection system comparing various machine learning models such as KNN (k-nearest neighbors), Bayes, SVM, and ANN. Proposed mechanical prototype with help of a camera and a mechanism with locks eliminates the weeds previously detected by software. Authors of [33] use neural networks to perform weed detection in rice fields in Tolima with the help of unmanned aerial vehicles. Multispectral sensors have also started to be used in works such as those of [34] and [27], which use multispectral camera images and unmanned aerial vehicles to detect weeds.

18.3 Proposed Methodology

A framework is proposed based on the selection of a learning method of the articles reviewed in the state of the art, taking into account the method selected; the images are chosen and labeled, thus creating the dataset to be used. These images are then pre-processed, and the different spectral bands are used to generate different multispectral image combinations (see Fig. 18.1).

The base method is designed in order to select a single type of multispectral image that has the better precision as well as accuracy. Subsequently, a process is started cyclic where the base method is evaluated and its performance measures are compared, which are obtained through the confusion matrices, in order to improve the method by applying relevant changes to find a model that exceeds 80% precision for detection and provide us with a good estimation percentage of weed. Finally, a comparative analysis determines whether the final model has relevant results with respect to the evaluations obtained by experts in the weed percentage estimation task (see Fig. 18.2).

18.3.1 Image Selection and Labelling

The images of the dataset were evaluated one by one, eliminating the blurred ones, those that contained incomplete objects, and those captured in difficult-to-process angles, to achieve a noble performance in the training process. Then they were

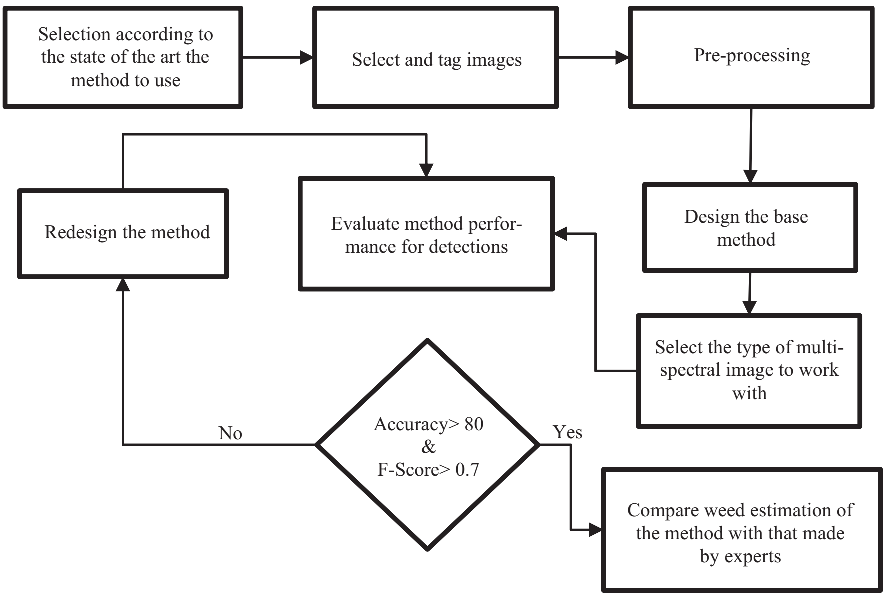

Fig. 18.1 Proposed framework

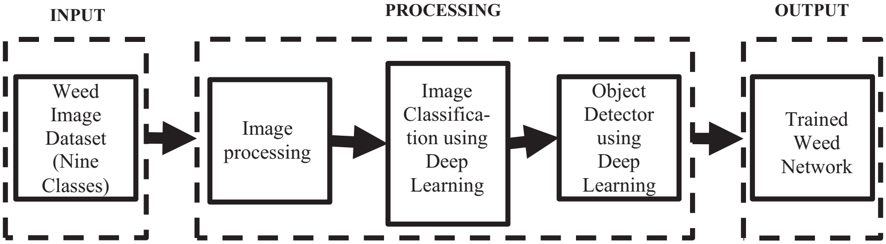

Fig. 18.2 Proposed approach

ordered in three categories according to the height of its capture: high, medium, and low with the aim of choosing 100 images that will vary in height, number of samples, and environment. The 100 selected images that correspond to approximately 600m2 were in TIFF format so a code was made in python to convert them to JPEG without losing quality. The number of images was chosen taking into account the labelling processes and CNN training which is time-consuming. Class labelling is done manually with Label Img software open source code developed in Python by [35, 40].

18.3.2 Pre-processing

Once the dataset was labelled, several types of multispectral image were generated; the first one is called NDVI-32 and is created in grayscale by calculating the index NDVI using 32 bits and performing a percentile-based contrast stretch. The second type is the False green which was raised by [27] and uses the green, red, and infrared bands and irradiance values, and the third type is the NDVI-64 in which 64 bits are used to calculate the NDVI by adding a gain of green; finally we have the filtered reds where the bands used are red, red border, and infrared and a high pass filter is applied to highlight the vegetation (see Fig. 18.3).

In 2016, the YOLO was introduced with its initial version [36], which consists of two layers fully connected that make the prediction and 24 layers with convolutions that work as feature extractors; currently works with YOLOv3 [37] version that includes significant improvements and feature extraction layers were substituted by the Darknet architecture-53. First YOLO divides the image of input into a grid of size S×S. Each grid cell forecasts at most two bounding boxes together with the probabilities of each class for each bounding box and also the degree of trust. Then, a procedure is performed that unifies the bounding boxes found in such a way that there is no double detection of the same object.

YOLOv5 results evaluated in the COCO [38] database are similar to those found by YOLOv4 (see Fig. 18.4). Figure 18.4 shows the comparison of YOLOv5 with efficient detector [39]. The advantage of using PyTorch is that the framework is more intuitive and has broader support for deep learning. In the proposed model even with the image of model input presenting resolution different from the trained

Fig. 18.3 YOLO procedure on an input image

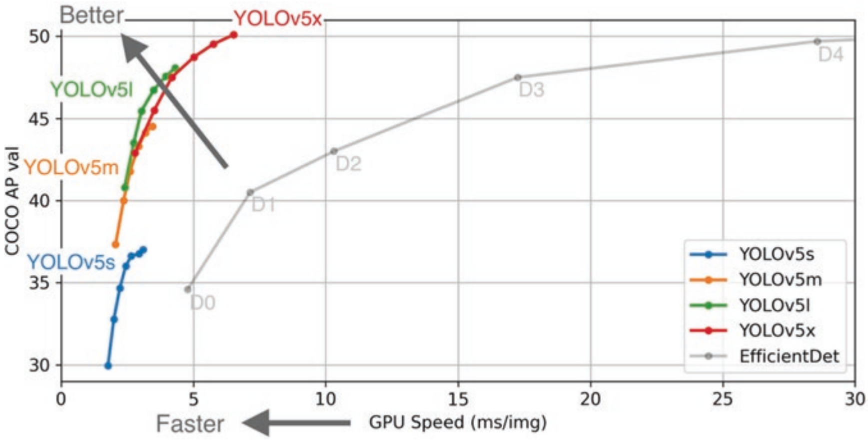

Fig. 18.4 Comparative analysis of YOLO5

images, the model was able to generalize invasive detection even to areas at the edges of the image that have small deformations due to the lens, in addition to the angle of view and distances different from the center of the image.

Base method and image type selection multispectral for the implementation of YOLOv5, the Darknet framework is used [29] which is a framework for open-source neural networks developed in C using CUDA. This includes recognized convolutional neural network architectures like ResNet, AlexNet, and YOLO.

18.3.3 Method 1 (Detection of Multiclass with YOLOv5)

This first method has four clearly identified phases (see Fig. 18.5). The first phase corresponds to pre-processing, where the images are arranged multispectral images and the false green image is generated from them. In the second stage, the convolutional neural network is fed with the green spurious image. In the third stage, the image is processed by YOLO resulting in bounding boxes for each class detected. Finally, in the fourth stage, an algorithm written in Python is used to estimate the percentage of weeds in the image from the sections detected as weeds.

To select this first method, ten models were trained in total. Then it is showing the results of the two best models taking into account two aspects: that the accuracy was equal to or greater than 0.8 since, according to the state of the art, it is a score of acceptable accuracy for models with the same objective and that the F-score was 0.7 since the total labelling for the training was 2221 samples for lettuce and 3481 for weeds, which indicates a clear class imbalance. It was also about minimizing the number of images without losing performance in the model, in order to have more images for model validation and testing. For these two models, the presented number of samples for the lettuce class was 810 (36%), and for the class weed was 1482 (42%).

18.3.4 Method 2 (Detection of Multiclass with YOLOv5+NDVI Mask)

The design is based on the development experience of Method 1. Based on the fact that the trained methods had better performance for the lettuce class, it was decided to change the third stage and train an improved model for this unique class.

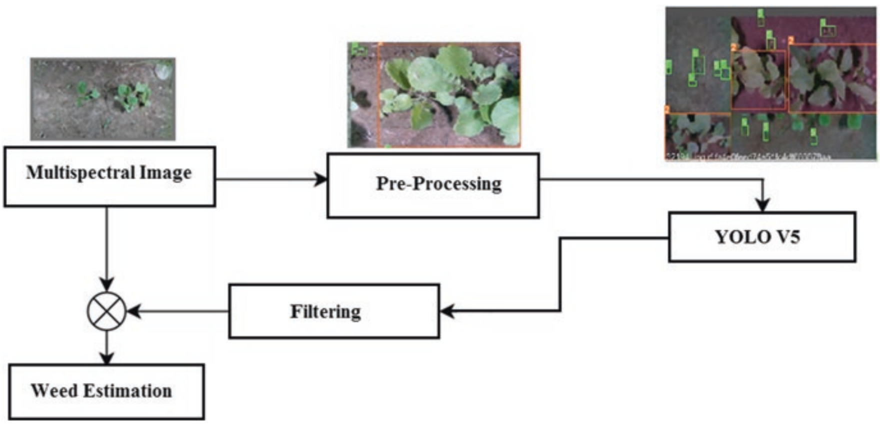

Fig. 18.5 Proposed approach for Method 1

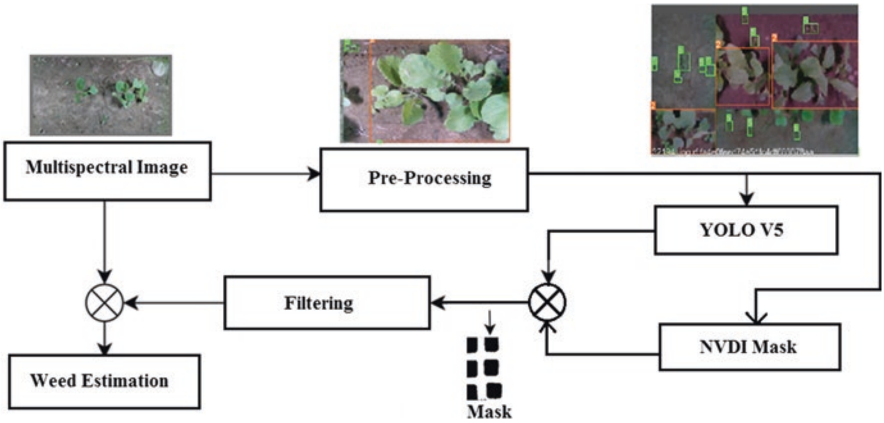

Fig. 18.6 Proposed approach for Method 2

In addition to adding one more stage (see Fig. 18.6), in this stage they take all the lettuces detected by YOLO and are removed from the image; then it is done a segmentation of the image using the normalized vegetation index (NDVI) to highlight all that is vegetation. Once the crop is removed from the image, it is highlighted the remaining vegetation and proceeds to generate a binarized image, where the vegetation is represented by the color white, which facilitates the estimation of the weed by computing the percentage of white pixels in the total image. This process was automated with a Python script that receives the coordinates of the bounding boxes as inputs thrown by the trained YOLOv5 model and the image to be evaluated.

18.3.5 Dataset

There are 1176 images in dataset out of which 8 types of weed species and 6 types of wood crops are recognized, so overall 7853 interpretations are made (see Fig. 18.7).

Three types of digital cameras were utilized to capture the images of dataset: Sony W800, Canon EOS 800D, and Intel RealSense D435. Images of cultivated food crops and weeds were taken at different stages of growth under controlled and field conditions. The folder "annotations" consists of annotated XML files related to each raw image. These images are manually annotated for labelling each class of weed.

Fig. 18.7 Sample dataset images

18.4 Simulation Results

In this paper two weed classification algorithms are implemented and simulated based on YOLOv5 on PyTorch platform. The performance of the proposed algorithm is validated using parameters such as precision, recall, and F1 score: precision vs confidence graph (see Fig.18.8), precision vs recall graph (see Fig.18.9), and F1 score vs recall graph (see Fig.18.10).

The weed classification model performance is evaluated using confusion matrix with nine classes and compared with predicated values (see Figs. 18.11) and the Plot of training and validation precision, recall values are depicted (see Fig. 18.12).

The sample simulation results of predication using YOLOv5-NDVI mask is shown below (see Fig. 18.13).

18.5 Conclusion

Taking into account the comparison with other methods that work on the same datasets, the use of CNNs is strongly recommended as their characteristic extractors help to better train the models that see their detection improved regardless of its growth stage, while methods that involve image processing such as thresholding, reflectivity among others, or fixed characteristics such as sizes tend to weaken the detection by forcing certain conditions of height and lighting. Regarding YOLOv5 as CNN and PyTorch (Python) tool as framework, ease of performing changes in

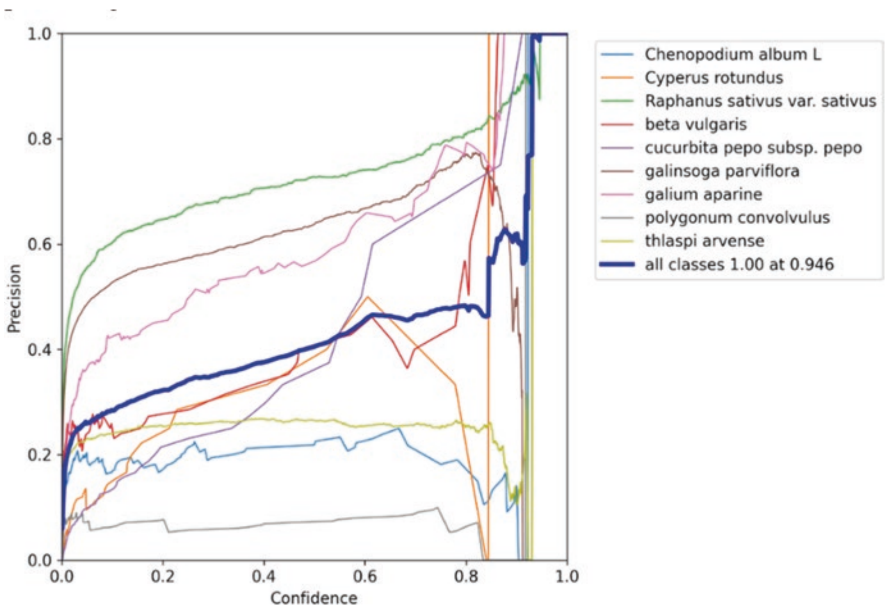

Fig. 18.8 Precision vs. confidence graph

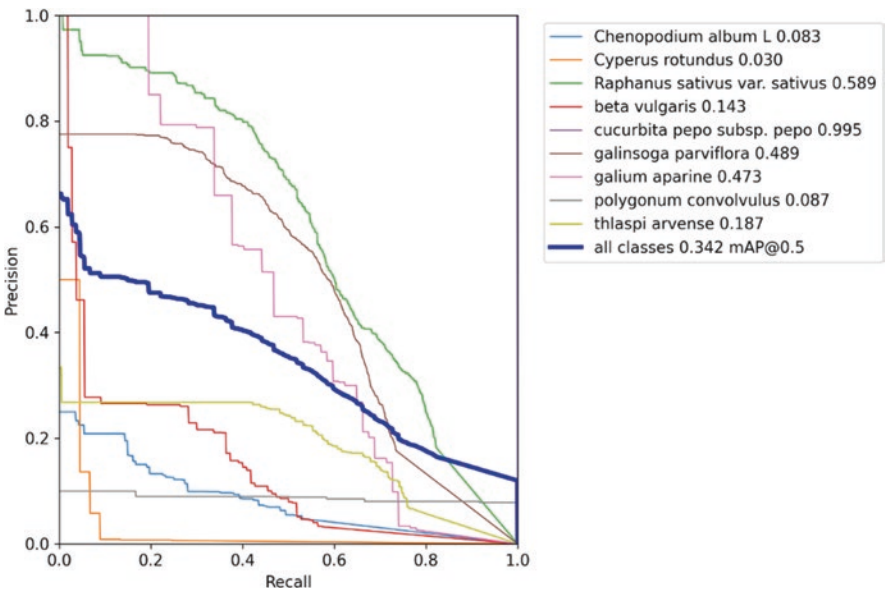

Fig. 18.9 Precision vs. recall graph

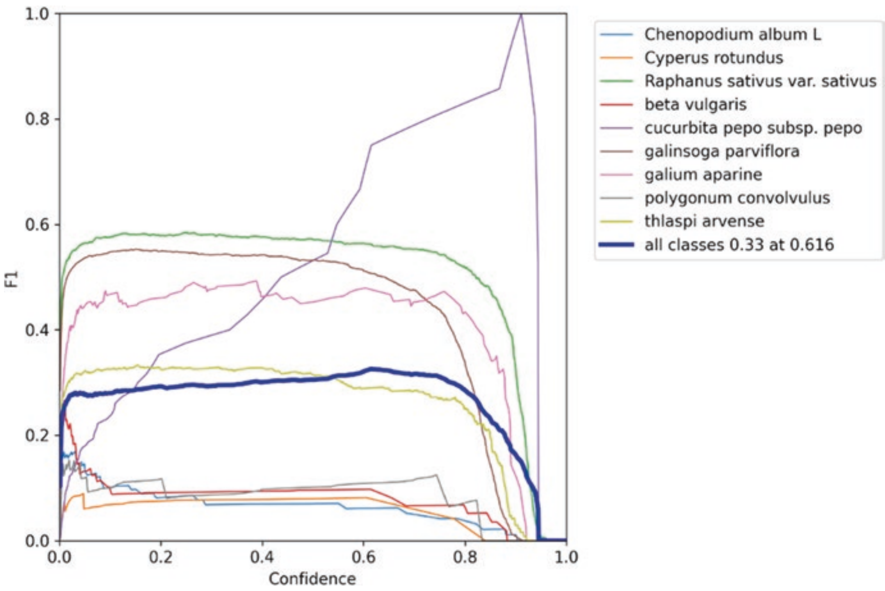

Fig. 18.10 F1 score vs. recall graph

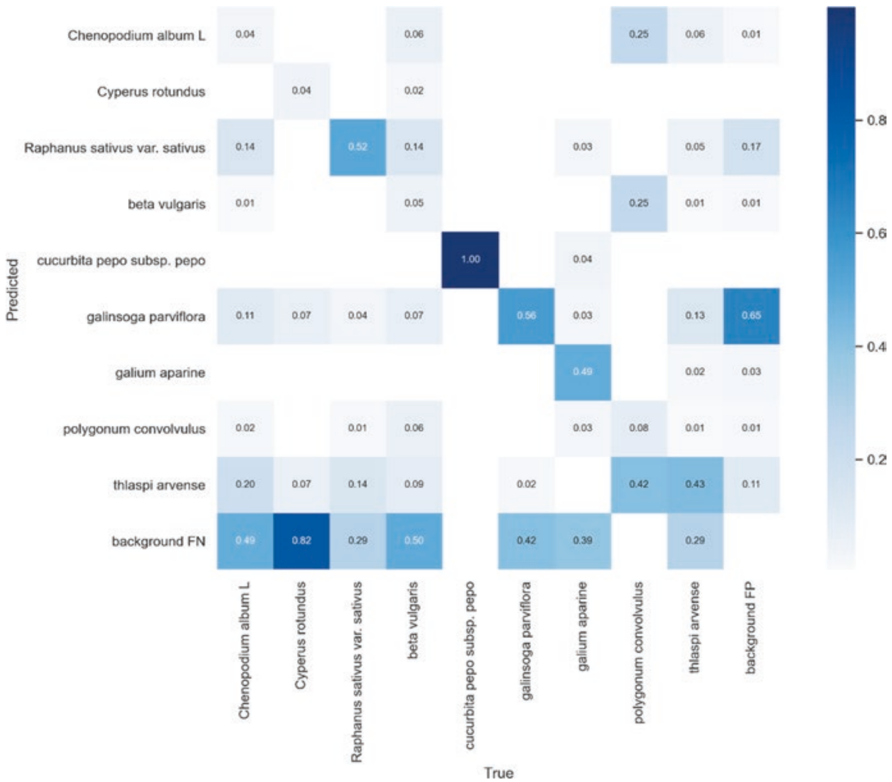

Fig. 18.11 Confusion matrix graph

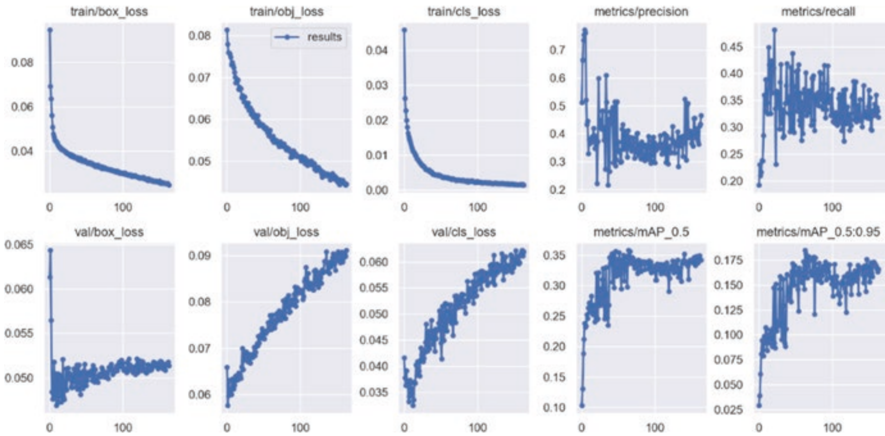

Fig. 18.12 Plot of training and validation precision, recall

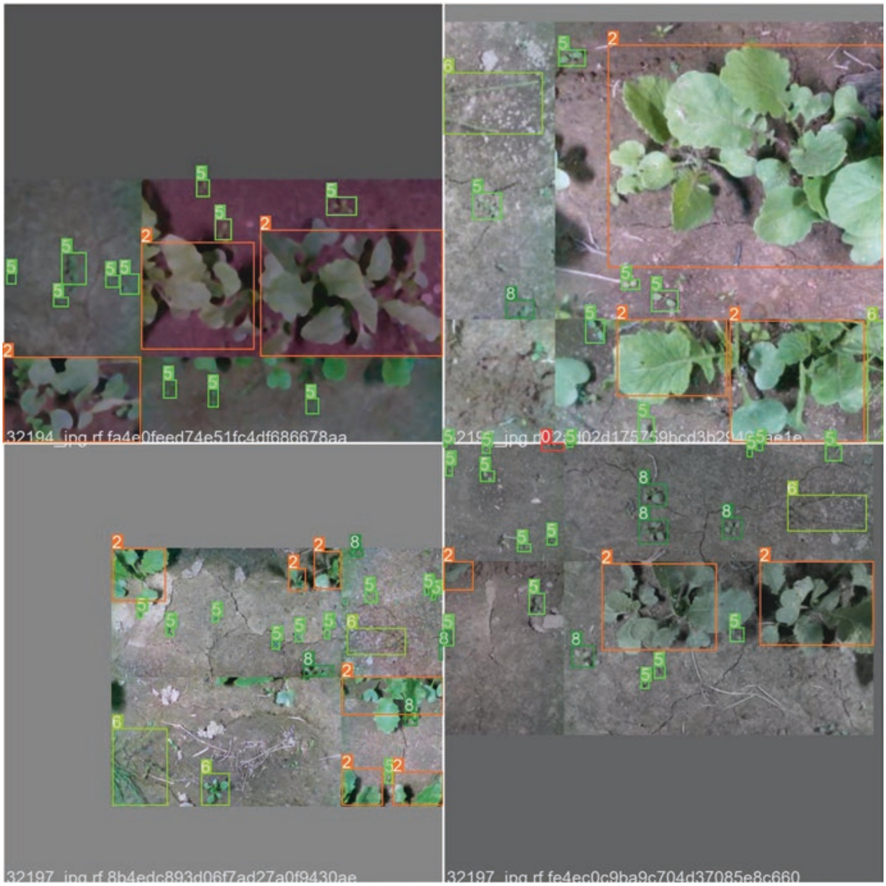

Fig. 18.13 Detection of multiclass with YOLOv5+NDVI mask

architecture, as well as its speed not only in training but also in evaluating an image with an already trained method and added to their ability to do it without a GPU, makes them very good tool for jobs involving real-time detection and automated weed control.

Finally, it is highlighted that the use of convolutional neural networks is the central axis for new methods that help to improve the optimization of processes in agriculture and to the specific case of weed evaluation and generate excellent results, improving the accuracy of weed detection.

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Chapter 19
Intelligence and Cognitive Computing at the Edge for IoT: Architecture, Challenges, and Applications

S. M. Kusuma, K. N. Veena, K. S. Kavya, and B. P. Vijaya Kumar

19.1 Scope and Motivational Points

For decades cloud computing has dominated every other strategy that offers processing of data generated by the IoT devices. But, concerns over security, privacy, network connectivity, and latency among several others have sparked a paradigm shift in how the world perceives computing. Edge computing is a technology where computational processes take place at the edge device or very close to the end user. This makes it (when deployed with the right resources and in the right environment) capable of compensating for the shortcomings of cloud computing while providing the same services (to some extent).

Cognitive Computing at the Edge or Edge Intelligence involves trained intelligent models deployed at the edge or nearer to the edge of the network (close to the data source) enabling efficient resource allocation and local processing of data which in turn produces real-time results without having to ship data through the gigantic network that the Internet is, to the cloud. This essentially ensures data privacy and, if done right, reduced run-time. Edge Intelligence (edge machine learning) has a wide range of applications in domains such as business analytics, health informatics, academia, etc.

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19.2 Issues and Challenges

Edge Intelligence sounds appealing and futuristic, but it also comes with some of its own shortcomings. As applications migrate from cloud to the edge, there are a number of questions that need answering. The most important one is will it be cost-efficient? Are the smart devices and servers close to the edge capable of carrying out certain functionalities?

Cloud Computing vs Edge Computing ML and AI applications produce and require huge amounts of data (big data) which will be used both to train models and answer questions from users. The hierarchical structure of the cloud computing architecture helps streamline the three main steps of any ML application – preprocess data, train models, and answer questions. The platform performing the functionalities here is the cloud – which isn't resource constrained.

On the other hand, the performing platform in Edge Intelligence – the intelligent edge is resource constrained. The major challenge the technology faces is efficient processing of big data with minimal amounts of available resources – computing power, storage space, etc. Increasing the storage space, for example, would increase the cost of production which wouldn't benefit the developers or the users. The intelligent edge can only hold resources enough to host small applications or perform small-scale functionalities. Concurrency also takes a hit because of the restriction on computing power. The intelligent edge must be able to decide on what data should be sent to the cloud and what data can be processed locally, at the edge.

Edge Intelligence, while ensuring data privacy, is more prone to cyber-attacks compared to cloud computing. Hacking the intelligent edge to illegally access confidential data is much easier to do than hacking the cloud. In many cases, it simply makes more sense to stick to cloud computing for obvious reasons. But, the advantages Edge Intelligence has to offer cannot be overlooked either.

19.3 Problems and Functionalities

The main problem the intelligent edge solves is collecting data from local devices and analyzing it using the (machine learning) model that has been trained either locally or at the cloud server. The model is usually a machine learning model that provides direct intelligent functionalities or indirect functionalities such as resource allocation. The intelligent edge at the very least must be able to preprocess the raw data produced and analyze it. If the data produced is high dimensional, it just wouldn't be feasible to analyze it at the edge. The data will have to be sent to the cloud both for preprocessing and analysis. The intelligent edge must be designed in such a way that it is aware of its own capabilities and be able to decide whether data can be processed and analyzed locally.

Imagine an Edge Intelligence technology deployed in a storage facility that stores highly combustible materials. The intelligent edge device's main functionality in this case is to monitor and analyze heat signature data produced from the local devices. This can either be achieved using heat sensors or an image recognition methodology in conjunction with a deep learning model. In either case, the numerical data produced will be analyzed at the edge device the sensors are connected to, to predict and avoid accidents in the storage facility in real time.

Edge Intelligence has also had a major impact on the field of medicine. Motion sensors and cameras are used to monitor things like patient heart rate, glucose levels, and falls. The main functionality of the technology in this case is to analyze the data and provide real-time feedback that could help doctors make life-saving decisions.

An edge intelligent technology will prevail over all others in the above scenarios purely because of its ability to provide real-time feedback. There just wouldn't be enough time to have data sent to and analyzed at the centralized server a.k.a the cloud.

19.4 Principles of Cognitive Computing at the Edge or Edge Intelligence

The main objective of Edge Intelligence is to push cognitive computing toward the edge by exploiting the strengths and capabilities of the smart devices deployed on or nearer to the edge. By pushing computing to the edge, companies and organizations are mainly looking to achieve the following:

(a) *Data privacy*

Data in a cloud computing architecture has to be shipped all the way to the cloud server for analysis, which is considered one of the major drawbacks of the architecture simply because of accusations on companies and organizations trying to get their hands on private data of the public. On the other hand, in an edge computing architecture, the data being analyzed only travels from local devices (sensors, phones, computers, etc.) to the device located at the edge of the network. This data also helps personalize the models present at the edge to the needs of the user it belongs to.

(b) *Reduced latency*

As cited in previous sections, latency can be a decisive factor in many ML/AI applications. An edge intelligent framework is much quicker compared to a cloud computing framework owing to the local processing and analysis of data.

(c) *Improved security*

While edge computing frameworks are more prone to cyber-attacks compared to cloud computing frameworks, they offer other security advantages. An edge computing framework isn't centralized in that it distributes the processing, storage, and analysis of data across a wide range of devices, data centers, and servers at the edge; this makes it less vulnerable to DDoS or DoS attacks compared to a cloud computing framework. Devices and servers do not have to depend on the centralized server to carry out their functionalities. Because of the distributed framework, the entire data isn't present at a single location at any given point in time; this means that even if an attacker gains illegal access to data through one of the devices, the amount of data at threat is only the data produced locally.

(d) *Personalized applications*

Machine learning applications require data that the models are trained with before they carry out their functionality – predictions, classifications, etc. In some cases, an edge computing architecture can use data produced locally to train the models. This essentially means that the machine learning algorithm is trained with data related to the local environment. This personalizes the host application according to the local user's needs.

(e) *Scalability*

Edge computing allows companies to expand their computing capacity by modifying the specifications of the local devices near to the edge. This can be cost-effective in that the entire framework doesn't have to be modified/scaled as is the case with cloud computing frameworks. Expansion of processing and analysis of data only happens at the edge.

(f) *Versatility and reliability*

Companies often study the locally produced data which helps them target specific markets (personalized applications). After analyzing the local data produced, companies only have to modify the local data centers and servers to match the needs of users. This makes the framework versatile in that it quickly adapts to changes in use cases in an efficient way. The edge framework is more reliable compared to a cloud framework because of distributed processing. Any device that goes down doesn't affect the entire network. The framework can be trusted to have the edge device assign jobs to the devices that are active.

19.5 Related Works

The related works in this section highlight how the principles of Cognitive Computing at the Edge explained in Sects. 19.3 and 19.4 are used to make critical decisions at the edge of the network. Deciding between using cloud services and models deployed at the edge is one of the most important aspects of the decision-making process at the edge. Cognitive computing helps achieve it and enhances Edge Intelligence.

The convergence of deep learning technologies and edge computing has led to new opportunities in the field of Edge Intelligence, as explained in "Deep Learning for Edge Computing Applications" [1]. Recent breakthroughs in deep learning – strong ability in information perception, data management, and decision-making – have enabled the existence of state-of-the-art Edge Intelligence-based applications. The authors of [1] have mainly looked into four such applications:

(a) *Smart multimedia*: Applications such as Video Analytics and Adaptive Streaming bring a lot of latency into the network in the case of a cloud computing architecture. But, deep learning enabled edge computing frameworks process the video content close to the network edge. Amazon released the world's first deep learning-enabled camera where the locally executed deep learning function enables real-time objection without the involvement of the cloud.
(b) *Smart transportation*: Applications such as autonomous driving and traffic signal control do not perform well under high latency. The data collected by the sensors needs to be processed and decisions have to be made in real time.
(c) *Smart city*: Applications such as smart home and smart building monitor, sense, and control the surrounding environment by feeding sensor data into the deep learning model.
(d) *Smart industry*: Smart manufacturing is an application that heavily relies on edge computing. Equipment is constantly monitored, and the data produced is analyzed to decide which equipment needs replacing, upgrading, etc.

In each of the above four cases, cognitive computing is used at different phases of the application to ensure Edge Intelligence. In instances where cloud services are required, the cognitive model at the node decides to send data to the cloud for processing instead of using the services at the edge. Quick and real-time decisions as is the case with Video Analytics can be made at the edge, whereas querying, retrieving, and storing newly processed files requires cloud services.

Applications such as smart city and smart industry rely heavily on analyzing data to enhance the performance of applications and products. Although the data produced at sensor devices is processed at the edge to make real-time decisions, quarterly/monthly data is also sent to the cloud for analysis.

Because of restrictions on resources in an edge computing framework, concurrency and resource allocation become major challenges the edge has to deal with. The edge has to decide how much of the available resources is allocated to incoming tasks from nodes attached to the edge (sensors, phones, etc.) at any given time. Conventionally, this problem is solved by making use of buffers, queuing analysis (FIFO), and other resource optimization theories. But, these methods could sometimes lead to increased latencies and inefficient use of the edge's resources. The authors of "Deep Reinforcement Learning based Resource Allocation in Low Latency Edge Computing Networks" [2] have proposed a deep reinforcement learning method called Q-learning that solves the resource allocation problem at the edge. Each node attached to the edge gets to place the task it wants the edge to perform in a buffer. The edge performs these tasks and makes note of the resources required and the latency produced by them [2]. If a task does not cross the optimal performance barrier, the agent associated with said task gets a score of +1; if not, the agent gets a score of -1. In this manner, the edge "learns" about every node and adjusts its future resource allocation scheme for agents based on their current overall scores. Another machine learning approach is presented by the authors of "Cognitive edge computing through artificial intelligence" [6]. They use a deep learning model called MLPs or multilayer perceptron networks to forecast the CPU usage using historical data, which in turn solves the problem of resource allocation at the edge. The performance of Q-learning and MLP models is discussed in the future sections.

Resource allocation is another important application of cognitive computing. As mentioned in the two related works above [2, 6], cognitive computing helps ration out the minimal amounts of available resources at the edge. If an operation requires extensive memory or processing power, it will be sent to the cloud.

The choice of the machine learning algorithm deployed at the edge also becomes very critical given the constraints on the resources available at the edge. Machine learning algorithms need good storage space, computation power, and energy to produce accurate results. But, accuracy often takes a hit owing to the resource constraint edge. The authors of "Machine Learning at Resource Constraint Edge" [5] propose a string and shallow non-linear tree-based classifier called the Bonsai algorithm [5], which can be used for prediction, regression, and classification tasks. The Bonsai algorithm is specifically designed for resource-constraint environments and is designed to fit in a few KB of memory in the edge devices. Bonsai algorithm is a good fit for resource-constraint environments because of its ability to produce accurate results while supporting optimization techniques such as tree pruning, memory compression, quantization, and hyperparameter tuning. We look at the results of the Bonsai algorithm in future sections.

Cognitive computing at the edge has had a major impact on the field of healthcare. The authors of "Edge Cognitive Computing based Smart Healthcare System" [4] propose a smart model that combines the advantages of edge and cognitive computing. The Smart Healthcare System monitors and analyzes the physical health of users via the "Data Cognitive Engine" [4] which collects data based on user signals and behavior. The engine then calculates a health risk grade based on the health data [4]. This risk grade is fed to the "Resource cognitive engine" [4] which in turn uses cognitive computing to allocate resources to the edge devices – mobile phones of users. Resources allocated to devices depend on the risk grade of users. In this manner, an intelligent and optimized resource allocation scheme is realized. Suitable actions are taken based on the analysis of physical health data. If the risk grade is too high, the analysis is sent to the cloud and help will be sent to the user.

BRAINE Big Data Processing and Artificial Intelligence at the Network Edge [3]

The BRAINE project is one of the largest joint activities in Europe in the area of edge computing-enabled artificial intelligence. The project deals with how the computing edge can be integrated with AI methodologies to give rise to technological paradigms such as Healthcare Assisted Living, Advanced Robotics, Smart Cities, and Smart Factory – these four paradigms form the four main use cases of BRAINE.

BRAINE mainly focuses on hardware and software developments that help develop applications for its desired use cases. These developments can be placed in three categories:

(a) *Cognitive computing-assisted resource orchestration and allocation*: BRAINE takes advantage of the fact that edge nodes vary in their capabilities, purpose, and ownership. And moreover, these properties are dynamic and may change over time. BRAINE aims to design each edge node in a way that it responds to changes in resources and configuration in a timely fashion, thereby dealing with challenges such as resource identification and allocation. This is achieved through telemetry and instrumentations provided by BRAINE.

(b) *User-oriented utilization of the edge*: BRAINE aims to design edge nodes in a way that is beneficial to the users and developers – developers must be able to easily access data and resources in order to personalize applications. To achieve this, BRAINE provides techniques such as the following:

- Modelling of data-intensive workloads as workflows
- Developing secure, scalable, and harmonized data management frameworks
- Well-tailored AL/ML-assisted data curation and assisted mechanisms
- Providing APIs and protocols to help developers efficiently access data and resources at the computing edge
- Increasing energy efficiency by getting rid of redundant data

(c) *Hardware accelerations*: The edge micro data center or EMDC in BRAINE depends on three aspects: layout of the nodes, thickness and heat dissipation of nodes, and cooling capacity within the cooling infrastructure within a cluster of nodes. BRAINE aims to produce EMDCs that enable usage of cost-effective computing resources specifically designed for AI elaborations. BRAINE accomplishes this via several hardware modifications – making server nodes as small as possible by moving components close together, eliminating hardware by moving the functionalities into software, etc.

19.6 Basics and Fundamental Concepts

Edge Computing is a technology where most or all of the intelligent computing happens at the edge of the network (edge devices such as phones) or nearer to the edge of the network. The main goal is to push computing as close as possible to the data source. IoT devices such as phones, sensors, computers, etc. these days produce tons and tons of data that is needed by machine learning or artificial intelligence applications to solve several problems. Pushing computing to the edge of the network has a number of benefits as cited in the previous sections: improved data privacy, reduced latency, real-time results, etc.

Edge computing has two possible scenarios:

- One where all the computing happens at the edge devices. The model or algorithm responsible for processing the data produced resides in the edge devices, for example, Amazon's deep learning-enabled camera.
- One where a centralized edge is set up very close to the end devices attached to it. In this case, the data produced by the end devices gets sent to the centralized edge for processing and analysis, and the results are sent back to the end devices. The model responsible for data processing resides in the centralized edge node, for example, a Wi-Fi router (centralized edge) and all the local devices (phones and computers) connected to it.

Cognitive Computing at the Edge or Edge Intelligence is a technological paradigm that follows the edge computing architecture and is made use of by machine learning and other intelligent applications. Figure 19.1 shows the architecture of Edge Intelligence. The edge node responsible for all the computing generally hosts a machine learning or an AI model that processes and analyzes all the data produced by the end devices. The edge node, while connected to the cloud server, only utilizes it in rare circumstances such as error reporting. The cloud is generally not involved in the data processing aspect of the application. Edge Intelligence can be used to provide direct intelligent services to the users such as the smart healthcare system, or it can be used as an assisting agent to other native services – intelligent resource allocation.

19.7 Models and Methodologies Used

Machine Learning [5] Machine learning is a branch of artificial intelligence that specializes in leveraging the fact that algorithms can learn from data, identify patterns in them, and make decisions based on those patterns all the while trying to minimize human intervention. The following are the types of machine learning algorithms:

- *Supervised algorithms*: Where the algorithm is fed with features and the label for said features during the training phase. In the testing phase, the algorithm predicts the labels for given features using the feature-label relationship it learned in the training phase, for example, regression and classification algorithms.
- *Unsupervised algorithms*: Where the algorithm is only fed with features (and not labels) and tries to group the entire dataset into clusters based on the relationship drawn between the features of all data points, for example, recommender systems.
- *Reinforcement algorithms*: Where algorithms learn from mistakes. An algorithm is made aware of good behavior and bad behavior using a reward and punishment system. Overtime, the algorithm learns to choose good over bad behavior (positive reinforcement), for example, video games – AlphaGo.

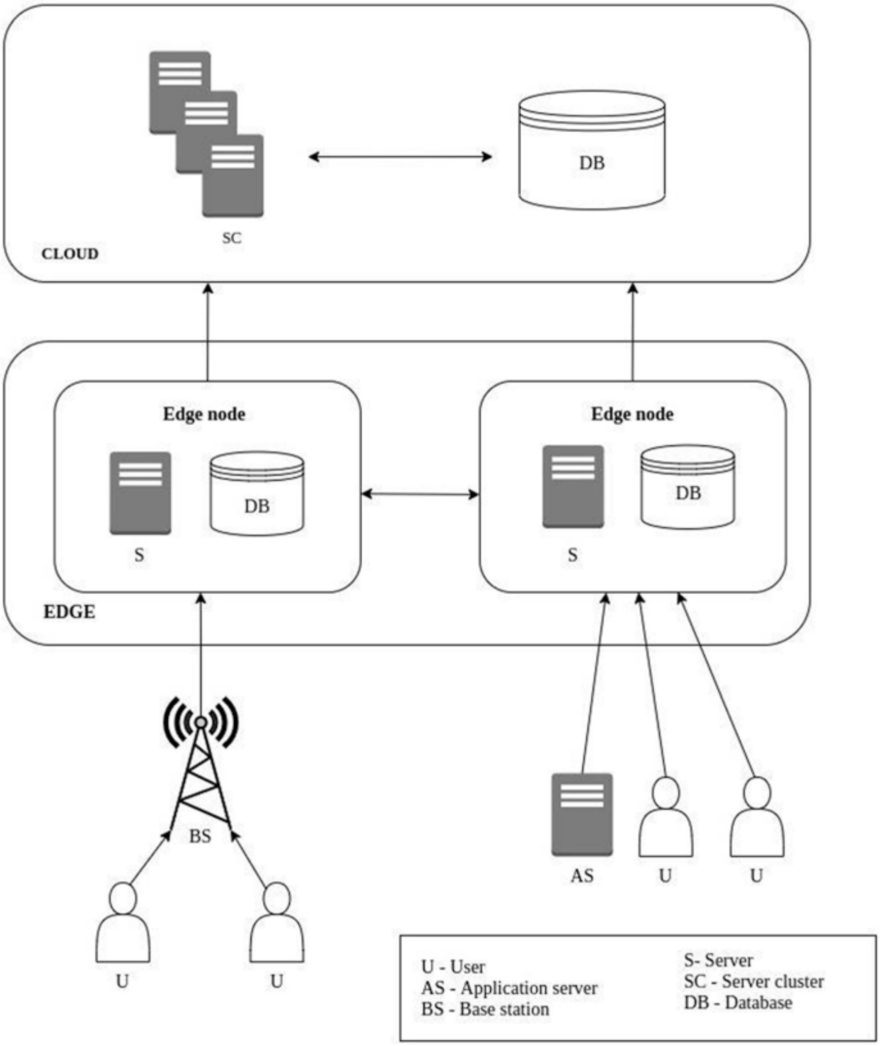


Fig. 19.1 Architecture of Edge Intelligence in IoT

Deep Learning [1] It is a machine learning method that uses artificial neural networks to learn patterns from data and make decisions based on them. Artificial neural networks are computing systems made up of several artificial neurons and layers (similar to a human brain). Data gets passed from one layer to the other while the neurons learn patterns from the data.

Deep Reinforcement Learning [2] It is a form of deep learning method where the algorithm learns to make good decisions while dynamically adjusting actions all the while trying to maximize the total reward it gets for each action.

Multilayer Perceptrons or MLPs These are artificial neural networks made up of at least three layers: an input layer, a hidden layer, and an output layer. Each hidden layer has a non-linear activation function, and the output layer often has a linear activation function because it outputs a continuous value or a class (a single value in either case).

Activation Function Every layer in an artificial neural network is made up of an arbitrary number of neurons. Each neuron hosts an activation function that is responsible for accepting inputs (features) and producing outputs (label/value prediction). The two activation functions referred to in this paper are as follows:

- *Relu* activation function**:** defined as $f(x) = x^+ = max\ (0,x)$, where x is the input to a neuron.
- *Linear* or *Identity* activation function**:** defined as $f(x) = x$**.** The function returns the input as it is. Linear functions are often used at the output layer of the neural network, where the input is the output from the previous hidden layers.

Q-learning Algorithm It is a form of deep reinforcement learning that learns from the environment and actions of agents in said environment. If S is the set of states and A is the set of actions, Q(s,a) is the reward gained by performing action a $\in$ A in state s $\in$ S. Q*(s,a) is the cumulative score after performing all available actions (training phase). The main goal of the Q-learning algorithm is to maximize Q*.

Bonsai Algorithm [5] It is a tree-based supervised classification algorithm that is developed specifically for efficient prediction on small IoT devices such as Arduino and Raspberry Pi. The model works by developing a tree model that learns a single, shallow, and sparse tree with powerful nodes followed by projection of the input data into a low-dimensional space. This is what makes the model more efficient. It aims to push the intelligence to resource-constrained IoT devices for making faster prediction, privacy preserving, and energy-efficient suitable for real-time applications.

Hyperparameter Tuning It is the tuning of parameters of algorithms in order to improve the performance. Below are some of the hyperparameters tuned in the implementations presented in this paper:

- *Normalization*: It is the process of scaling the entire dataset to a value in a specific range. Normalization is done to eliminate the negative impacts the skewness present in the dataset can have and ensure only relevant data is retained in the dataset. The Min-Max scalar scales the value of all data points between the range of 0 and 1.
- *Tree pruning***:** Tree-based classification models generate a tree after they have "learned" from a dataset. The tree has nodes that contain information that helps in the prediction of the output class for a set of input features. Pruning is an optimization technique where insignificant parts of the tree are cut off which in turn

reduces the size of the model, which could be beneficial in edge computing technologies.
- *Compression*: As machine learning models are computational and memory intensive, which makes them difficult to deploy on embedded systems, compression algorithms can be used to reduce the storage without accuracy loss.

Performance Evaluation Metrics These are the metrics used to evaluate the performance of an algorithm. Below are the metrics used in this paper:

- *MSE and RMSE*: the mean squared error and the root mean squared error are a measure of how far off the predicted values are from the actual values.
- *Quality of Service*: It is a numerical representation that evaluates the service provided by an application to users. The derivation of the QoS is up to the developers to define. Usually, the QoS derivation is defined keeping in mind the effects of different environmental parameters on the functionality of an application.

Network Softwarization Technologies These are techniques used to improve the overall performance of a network by softwarizing the network. Below are the methodologies used in this paper:

- *Network function virtualization (NFV)*: This aims to redesign the network equipment architecture. Unnecessary hardware is eliminated by virtualizing the functions of said hardware.
- *Software-defined network (SDN)*: This aims to redesign the network architecture itself. It separates the data and control layers of the network and centralizes the control. It enables the programming of network behavior using well-defined user interfaces.

19.8 Existing Implementations

(a) *Edge Cognitive Computing (ECC) -Based Smart Healthcare System [4]*

The ECC-based smart healthcare system is an application of Edge Intelligence that monitors the physical health of users while using a cognitive computing-based resource allocation system called "resource cognitive engine." The resource cognitive engine is mainly responsible for resource allocation at the edge (the authors have not disclosed the specific algorithms or models used to achieve this). The engine also offers high reliability, high flexibility, ultra-low latency, and extensibility of the system. It does so by making use of network softwarization technology such as the network function virtualization (NFV), software-defined network (SDN), and network slicing.

The application has three main layers:

- *The user side*: This is where the data collection happens. Each user is required to wear smart clothing that monitors the health factors. This smart clothing sends the collected physiological health data to the nearest edge computing node. Users also have mobile phones that receive the following from the edge computing node: the analysis of the health data, a health risk grade, and the resources required for the device – the phone.

- *Edge computing node*: The node receives the physiological health data from the smart clothing, analyzes it, and calculates a health risk grade and assigns resources to the user's mobile phone based on the risk grade. If the risk grade is high, more resources are allocated to the mobile phone.
- *The cloud*: This platform is operated and managed by the hospital. This platform comes into play when the risk grade is too high. It communicates with both the edge computing node and the end device to ensure that necessary help is sent to users.
- *Role of cognitive computing*: The two main operations that happen in the ECC-based healthcare system is the analyzing of data to produce the health risk grade and the sending of alerts to monitoring hospitals. Cognitive computing decides which stack of the architecture needs to be used in the respective situations.

The overall quality of service of the ECC-based smart healthcare system is calculated using the formula below: where *m* is the number of users, *s(i)* is the health risk grade of the i^{th} user, $\sigma(i) \in [1, n]$ is the edge node user *i* is currently connected to, and $connC(j) \in [1, n]$ shows the number of users connected to edge node *j*.

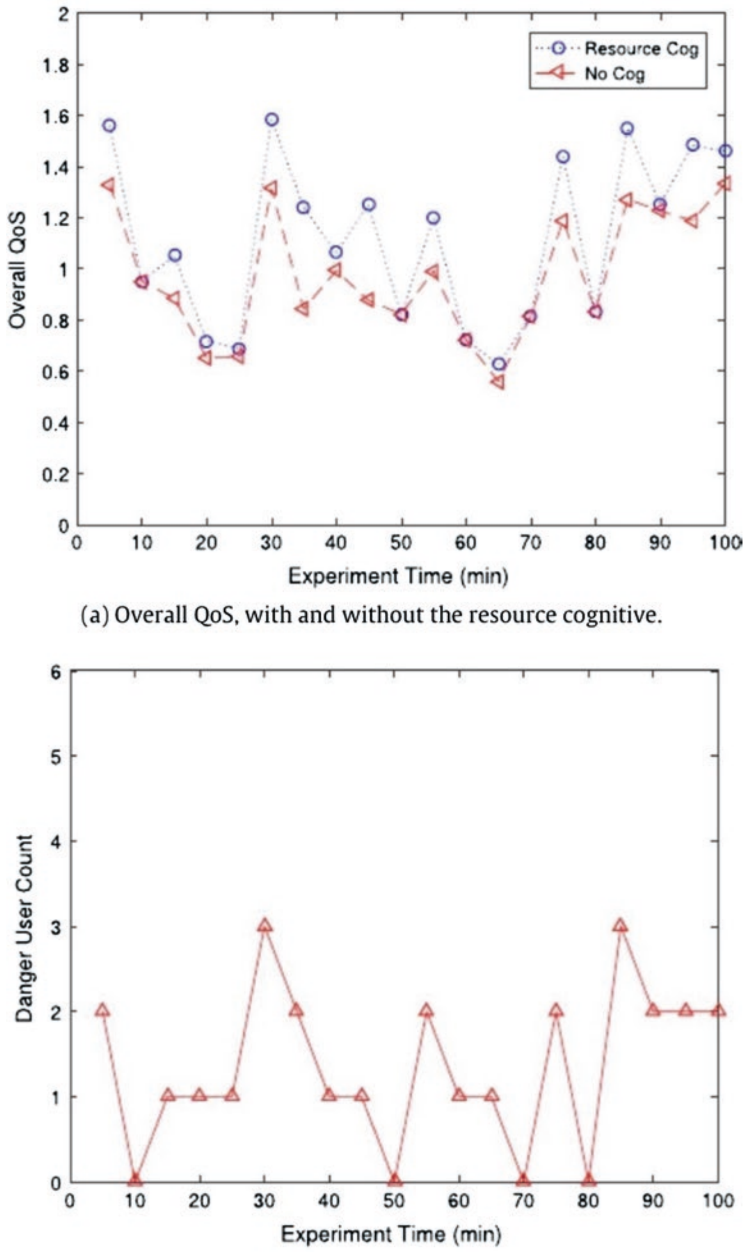
$$\text{Overall}\, QoS = \sum_{i=1}^{m} \frac{s(i)}{connC(\sigma(i))}$$

Figure 19.2a shows the results of simulations of the application with and without the resource cognitive engine. It is clear that the QoS (quality of service) shows an improvement when resources are allocated to end user devices via the resource cognitive engine. Figure 19.2b shows the number of users at high risk at the given time. The fact that the graph isn't linear and increasing shows the smart healthcare system's ability to quickly report users who are at high risk to the hospital and ensuring that the danger user count isn't cumulative. The resource cognitive edge makes sure that suitable data is processed at the edge node and other extensive operations are sent to the cloud and therefore increase the QoS.

(b) *Resource Allocation Using Multilayer Perceptrons or MLPs [6]*

In the proposed edge computing application [6], MLPs are used to forecast the CPU usage at a given time t. Cognitive computing analyzes the CPU usage forecast and helps decide if the AWS dataset is suitable for processing at the edge. The MLP model sits at the edge of the network and predicts the CPU core usage for a given task at a given time. Forecasting the CPU usage at the edge helps ensure service functionality and appropriate resource allocation to the local devices connected to the edge. Figure 19.3 shows the architecture of an MLP network.

The network is made up of two layers: linear activation layer (combination of initialization and hidden layers) and the output prediction layer.



(a) Overall QoS, with and without the resource cognitive.

(b) Danger user count.

Fig. 19.2 Simulation of the ECC-based smart healthcare system. (Courtesy: ref [4]])

The AWS CloudWatch Dataset [7] is used to test the performance of MLPs in predicting the CPU core usage. The dataset has two columns: the timestep and the CPU core usage. The configuration of the MLP network is given below with number of nodes and activation function defined accordingly.

Configuration of MLP Network

```
model.add(Dense(58, input_dim=6, activation='relu'))
model.add(Dense(24, activation='relu'))
model.add(Dense(8, activation='relu'))
model.add(Dense(1, activation='linear')
```

The network has four layers in total – one initialization layer, two hidden layers, and one output layer. The current and five previous data points are used to predict the CPU core usage at the current timestep, which is why the input dimension at the first layer (initialization layer) is 6. It is cited that this window method (size=6) produced the best results [6]. The activation function sitting on the first three layers is the "relu" activation function. The output of these layers is hence a vector. The activation function at the output layer is a "linear" activation function, and the output of this layer is a single continuous value which is the CPU core usage in percentage. The following are the hyper-parameters fed to the network:

- Train size: 66% of the AWS dataset
- Test size: 33% of the AWS dataset
- Normalization method: Min-Max scaling (0,1)

Figure 19.4 shows the visualization of the prediction results. The evaluation metric used to measure the performance is MSE (mean square error) and RMSE (root mean square error). Below are the results:

- Train score: 0.004 MSE (0.063 RMSE)
- Test score: 0.005 MSE (0.070 RMSE)

The results are calculated in terms of loss because of the fact that this is a forecasting problem. The train score is higher than the test score for obvious reasons. A test score of 0.005 MSE is pretty good considering the size of the dataset, size of the MLP network (four layers), and the fact that there's been very little hyper-parameter tuning.

(c) *Resource Allocation Using Q-Learning, a Deep Reinforcement Learning Technique [2]*

The authors of [5] propose a "reward" and "punishment" based system where each agent gets a score of +1 or -1 depending on the optimality of its tasks. A Q-learning model sits at the edge of the network and learns the probability that a particular agent will need more than optimal resources. This model is further used to predict the resources required for an agent's task based on the agent's history.

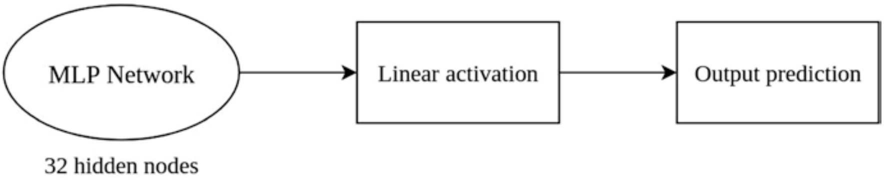


Fig. 19.3 A multilayer perceptron network. (Courtesy: ref [6])

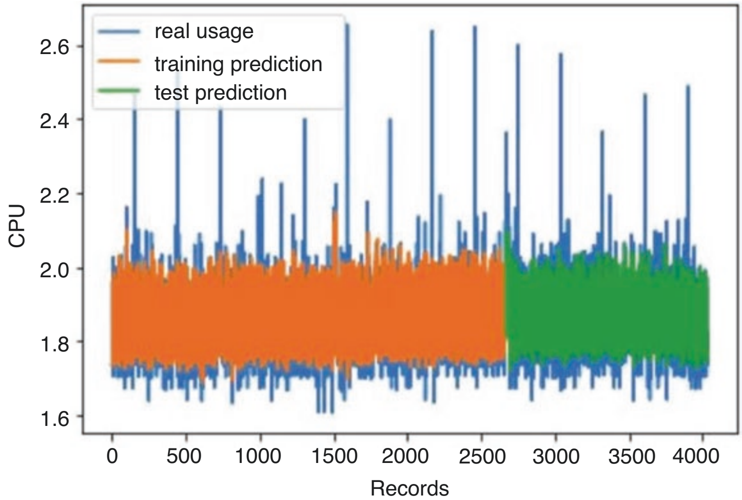


Fig. 19.4 Actual vs predicted CPU core usage. (Courtesy: ref [6])

Table below shows the hyperparameters the Q-learning model is trained with *hyper-parameter tuning for Q-learning* [2].

Parameter	Value	Parameter	Value
t_s	4.5 μsec	γ	0.95
T_f	600 symbols	ε	1 to 0.1
m_{UL}	200 symbols	W	3
L	2640 cycles/bit	ρ_{DL}	0.7
f_0	3×10^9 cycles	ε^*_{DL}	10^{-4}
η_{DL}	25 dB	α	3
$D_{UL,n}^{(k)}$	{0.5, 1, 1.5, 2} . 10^3 bit	β	0.5

where f_0 is the cycle frequency of each CPU core, T_f is the frame length and t_s the length of each frame, m_{UL} is the blocklength of uplinks, D_{UL} is the packet size of uplinks, L is the required CPU cycles per bit, n_{DL} is the average SNR of downlink, ρ_{DL} is the channel correlation coefficient, ε_{DL} is the decoding error probability. Figure 19.5 shows the simulation results for a mobile edge computing or MEC node equipped with a three-core CPU and two users connected to the node.

The Q-learning method is compared to two benchmarks: equal and random. The equal allocation strategy allocates CPU cores equally to all incoming tasks, while the random allocation strategy does it randomly. It is clear from Fig. 19.5 that the random method is the least performing method because of the randomness in the relationship between task requirements and resources allocated. The equal method performs decently at first, but the task success rate gradually decreases as more and more tasks arrive. The Q-learning method is the best performing method owing to the allocation of resources based on historical task requirements of agents.

(d) *Bonsai Algorithm at the Resource-Constraint Edge [5]*

The authors of [5] stress on the importance of choosing the right machine learning model to deploy at the edge. Oftentimes, the edge will be resource constrained, and hence the machine learning model that sits on it becomes significantly important. The Bonsai classification model is a tree-based algorithm that doesn't require a lot of resources because of its ability to retain accuracy even after optimization techniques such as tree pruning, memory compression, etc.

The USPS Handwritten Digits dataset [8] is used to test the Bonsai algorithm. The dataset consists of 9298 rows. Each row has 257 columns: the first 256 columns are the values formed by flattening the 16×16 pixel value matrix for a specific digit, and the last row is the digit the 16×16 pixel value matrix represents, i.e., a number

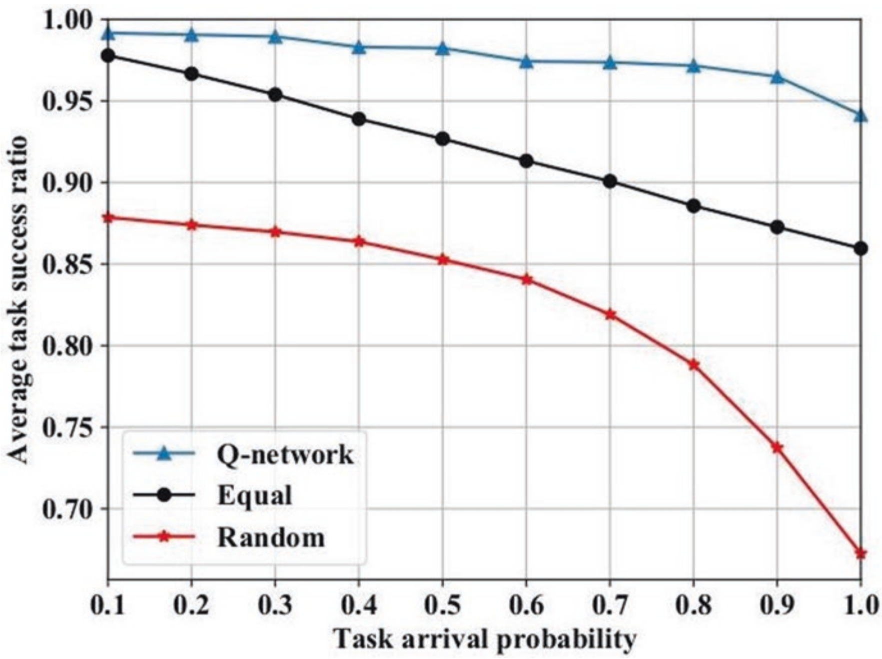


Fig. 19.5 Simulation results of the Q-learning algorithm. (Courtesy: ref [2])

between 0 and 9. The following are the hyperparameters under which the Bonsai algorithm is trained:

- Depth of Bonsai = 2
- Projection dimension = 10
- Number of epochs (iterations) = 80
- Train size = 78% of the USPS dataset
- Test size = 22% of the USPS dataset

Figure 19.6 shows the results of the Bonsai algorithm. This is essentially a classification problem where each prediction is classified into one of the ten classes (0 to 9). The final accuracy achieved is 92% which is a pretty decent result considering the size of the dataset. Moreover, the model after 80 epochs takes up only 6.25 KB of memory, which is significant from the resource-constraint edge's point of view.

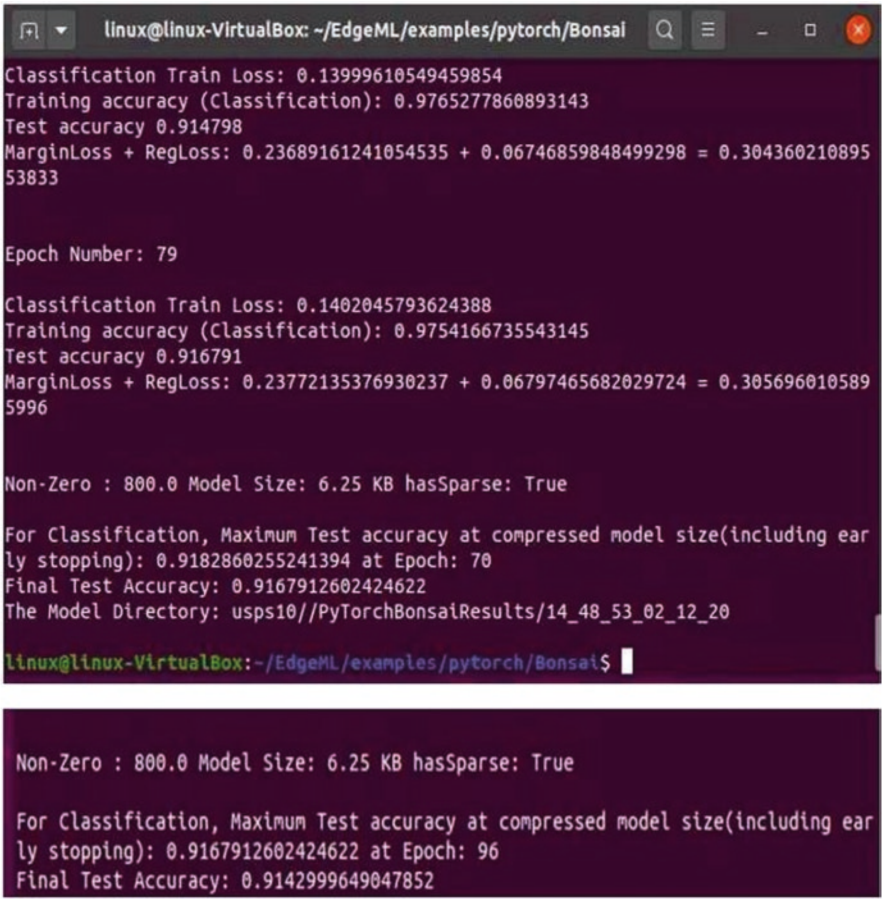


Fig. 19.6 Results of the Bonsai algorithms. (Courtesy: ref [5])

Less memory for the native machine learning model means more room for other computational processes. The work which is discussed in this research is verified and validated through various test processes [9, 10] and test techniques [11 12].

19.9 Conclusion

This chapter examines the fundamental concepts, architecture, challenges, implementations, and applications of Cognitive Computing at the Edge. It's clear how much of an impact cognitive intelligence along with edge computing can have on today's computing use cases. Users are always keen on more secure, real-time-result-producing applications. Companies and organizations have started leveraging edge computing and Edge Intelligence over the last decade or so to meet user demands and develop applications that have had a major impact in the field of medicine, healthcare, business analytics, etc. Edge Intelligence has a number of direct intelligent applications such as smart city, smart healthcare, smart factory, etc. These applications are often monitoring critical environments that need real analysis of data and results based on the analysis in order to take necessary actions. Therefore, it is very important and necessary that such applications are hosted using an edge computing-based architecture. Intelligent resource allocation is another application of cognitive computing at the edge presented in this paper. The MLPs, the Resource Cognitive Engine, and the Q-learning model produced good results in allocation of resources to devices (or tasks) connected to the edge. Efficient resource allocation is important in edge computing technologies because of the restrictions on resources available at the edge. Cognitive computing, as shown in the mentioned implementations, can help achieve efficient resource allocation [13, 14]. Although Edge Intelligence comes with a lot of challenges and issues, there is always a way around them to leverage the advantages the technology has to offer. The Bonsai algorithm, for instance, proved to be an optimal algorithm that can be deployed at the edge. The designing of the edge becomes a major factor in how well the application performs. Aspects of the edge such as hardware, software, models hosted, data transmission bandwidth, etc. have to be optimized in order to allow the edge to perform to its full potential.

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Chapter 20
IOT Sensor-Based Smart Agriculture Using Agro-robot

Dinesh Dattatray Patil, Ashutosh Kumar Singh, Anurag Shrivastava, and Devendra Bairagi

20.1 Introduction

The use of pesticides has grown significantly due to two factors: the first, to fight pests such as fungi, insects, weeds, mites, bacteria, nematodes, and rodents, among other forms of animal or plant life, undesirable or that may harm to agriculture and diseases that affect the countryside and the second to make the “end product” more attractive, since it had no pest and disease problems in its development.

However, these pesticides can trigger serious problems when they are applied incorrectly and can cause the producer financial loss and lethal damage where its manifestation is “long term” and also harm the environment [1, 2]. The pesticide is more present in agriculture. However, this product is also used in homes and public gardens, among others. Despite offering pest control and plant diseases, pesticide overuse can trigger various problems environmental and health problems. Environmental problems triggered by the use of incorrect dosage results in environmental contamination around the applied site harming both fauna and flora [2]. Health problems are linked to the applicator of the pesticide and to other people who reside or are close to the applied location; it can also affect the final consumers of the culture that was exposed to the product. Like growth of the “Smart Farms” concept, it became clear how technology can contribute for the development of agriculture and the need, thinking of how to produce more with less effort, and one

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of the solutions is the possible integration of current technology with the conventional methods of agriculture [3]. The Smart Farms concept involves several challenges; some of them are as follows [3]:

- Sustainable decision-making: Productively linking effectiveness any decision-making that was previously related to the user.
- Farmer education and knowledge: One of the most important reasons because it is not related to the technology itself but to the quality and qualification of field schooling which is often a big limiter when it comes to technological application.
- Limitations of digital infrastructure: As it is a rural area, one of the main obstacles that exist is the lack of digital infrastructure such as the lack of coverage of network or mobile phone; linking robotics with agriculture, areas such as automation and the Internet of Things (IoT) offer several services, including pesticide spraying, which is still a service that is growing a lot in the market having a bigger prominence in aerial robots [4]. Robotics is a multidisciplinary field on the rise, involving all segments of engineering [5]. Due to the rapid growth in this field, the use of robotics in agriculture, industry, entertainment, education and other diverse areas is increasing [6].

In the context of agriculture, the use of robots and other new technologies gave rise to the so-called smart agriculture; this means that over time it will be possible to carry out highly integrated communication in agriculture and visualize and predict real-time weather conditions, improving crop management, automation, utilization of monitoring system, traceability, and greater applicability of sensors in order to obtain more accurate data [7]. Robotics in agriculture, in particular, was a sector that made several advances. These advances are due to the advantages that the robot presents when compared to human beings like higher speed, minimum maintenance time (in this regard any type of unplanned stop of man as too much heat and physical wear and tear are considered a maintenance time), staying active for more hours, and working properly and consistently [8].

So, in a way, the development of technology and the adoption of robotics in the field are providing good efficiency in production management, stimulating in a way the management of agronomic knowledge and long-term profit of rural properties referring to a significant decrease in undesirable impacts on the environment [9].

The robotization of agriculture must consider all the factors that are involved in production, so that this robot-human relationship enables the intensification of production with the smallest possible impact [8]. The use of robots in agriculture is seen in several parts that compose the whole as harvest [10], at planting [11], robots that supply the plant inputs in the necessary quantity and perform irrigation [12] and spraying robots [13]. To achieve high productivity with the least possible impact, the field is following a tendency to replace heavy and large machines with more subtle technologies that are based on information and which also provide the user with viable autonomous operations and reliable [9]. The machines and methods currently used to assist the process of spraying are falling into disuse due to its very low efficiency; it has greater soil compaction, and these impacts are driving a trend toward development of mobile robots to carry out specific tasks but aiming at increased efficiency consequently resulting in less soil compaction and self-employed work [9].

We can classify robots into three categories: robotic manipulators or robotic arms, mobile robots, and humanoid robots, which are those whose structure mimics the human form. Mobile robotics needs a very wide field of knowledge to reaching a level of perfection that makes it a multidisciplinary area. To solve problems involving displacement, one must apply knowledge of kinematics, dynamics, and control in the development of a robust system that performs the sensing with the use of artificial intelligence to perform location and mapping activities [14].

Increasing productivity through sustainability requires the use and mastery of techniques, methods, and tools that in most cases do not match real needs. In this sense, agriculture should focus on developing methods, processes, systems, sensors, and devices that integrate sustainable and productive systems [15]. This paper aims to show a new direction in agriculture and discuss the basics of robotics, the development of intelligent machines in an agricultural production environment, examples of the use of agricultural robots, as well as the main problems in the implementation of robotic systems in an agricultural environment associated social problems and expectations generated by robotization.

20.2 Literature Review

Robots for open or unprotected areas are primarily concerned with navigation, route planning, and obstacle avoidance. Over the past decade, this area of research has evolved from autonomous tractor control to coordinating multiple autonomous tractors. For example, the current system can harvest 100 peat fields in one season using three autonomous tractors. Each tractor can approach the field, collect peat, drive up to a certain place, and unload it independently [16]. The selective fumigation developed by the authors [17] made it possible to identify 88% of weeds in cotton fields and adequately spray them.

The authors propose an SUV for robotic automation of the garden, and the creation of a system that detects the stress of plants, diseases, and insects measures the diameter of the tree and the number and size of fruits before harvesting [16].

Other irrigation and nutrient management projects through distributed harvesting aim to conserve water, increase efficiency, and reduce the environmental impact of agricultural production methods using data from sensor networks with plant physiology models for automated irrigation and nutrient management of ornamental plants used [18].

With regard to robots and autonomous vehicles designed specifically for working in greenhouses, the authors of [18] recall several studies: the authors of [19] and [20] developed the Agrobot project, a mobile platform with stereoscopic vision and a tweezers/hand arm manipulator. The author [21] describes an autonomous vehicle (Aurora) for spraying crops. Authors [22] and [23] describe a mini-robot for spraying, the navigation of which is controlled by an algorithm based on fuzzy logic. The authors [24] describe an independent platform for assessing plant health. The author [25] has developed a robot for harvesting peppers in a greenhouse. The author has developed another robot for picking cucumbers.

In Japan, studies were carried out on a robotic vehicle system with RTK-GPS (real-time and kinematic global positioning) and GIS (geographic information system) with the aim of fully automating the production line, marketing, and delivery of products to end users [26].

Rice planting robot developed in NARO (Japan) was converted to fully automatic mode, equipped with a DC servo motor to control the pressure regulator, gearbox (CVT) with tool clutch, hydraulic control valve, hydraulic solenoid valve and steering, left and right brakes, and clutch and lift control. It also uses RTK-GPS and navigation sensors.

The robot control system, developed on the basis of an integrated agricultural GIS [27], can process various types of data, for example, this system has the function of exchanging data with robotic vehicles about working conditions, for example, work efficiency, fuel level, fertilizer, and chemicals in each reservoir. The robot control system can also receive data on the collection of information from robotic vehicles using intelligent vision sensors.

A technology designed for remote monitoring of environmental variables is the data acquisition system in agricultural environment, which allows the reading of up to 250 sensors, and is also suitable for automatic irrigation control. The system allows remote monitoring of sensors in the agricultural area, enabling the reading of numerous variables of interest for the automation of processes on a farm, including irrigation controlled by soil moisture sensors (tensiometers) and by climatological environmental sensors. These are made up of "intelligent" sensors with automatic monitoring of environmental data and also on the ground, whose transmission is carried out via radio-modem [28].

Sprayer robots in agriculture play a crucial role in the economic and social sectors around the world. The system provides accurate spraying, collects real-time information about the location and the presence of diseases and pests, and transmits it to a sprinkler or sprinkler, which more or less regulates the need for pesticides. In addition to reducing waste, this improves the working conditions of the farmer, as he does not come into contact with highly toxic products that can cause health problems and, in the worst case, death [29].

Robotic systems have not been fully implemented in agriculture for various reasons such as the fragility of machines, expensive mechanical technology, and operational efficiency, where machines have to work and improve within their capabilities and adapt to different situations. In addition, outdoors, it is difficult to spread the investment cost across multiple operations, since most robots are designed for a single application and the requirements are usually available at a single station [28].

The challenge to come back to this point is to design these complex systems in low-power mobile configurations while maintaining the required high computing power. Good design depends on a balance of factors such as cost, size, performance, performance, and complexity, as well as the functionality required.

Currently, the cost of agricultural robotics is still very high, but as the demand for technology increases, its total cost decreases, which reduces investment in technology development or significantly reduces production costs.

Another issue to consider is the natural resilience of farmers in the industry to changing farming practices while realizing that automation is part of the management process and not an instant solution or problem.

20.3 Material and Method

This study was carried out through an exploratory, descriptive, and bibliographic methodological process. These methods were suitable because the objective was to describe and point out the state of the art of robotization in agriculture. Through bibliographical research, it is possible to explain, describe, and analyze its evolution, the types that are available in the market, and others that are in development and the technological and social context of its implantation in the field.

- Sensors and methodologies for monitoring that assess chemical, biological, and physical features related to the quality of the environment, agro-industrial processes, and agricultural business chains
- Precision agriculture, with emphasis on instrument development, immediate reading sensors, remote sensing techniques, aerial images, crop forecast, management zone recognition technique
- Non-invasive techniques applied to agriculture and environmental monitoring, such as spectroscopic and imaging techniques, associated with statistical and computational methods of analysis

In this context, trends in agriculture should focus on the development of methods, processes, systems, sensors, and devices in terms of the integration and sustainability of production systems.

Robotics is a discipline related to the use and programming of robots. Robotics refers to the creation of robots and robotic devices. A robot, as ISO (International Organization for Standardization) calls it, is a reprogrammable, automatically controlled, multifunctional manipulation machine with varying degrees of freedom, which can have a stationary or mobile basis for industrial automation applications and applications.

Robots can be classified according to their construction application, into two distinct types: industrial robots and non-industrial robots. The applications, limitations, models, and forms make them be divided into two basic types.

- Fixed Robot: Also known as robotic arm. It consists of a fixed base and a set of links and joints that allow movement in various directions. Because it is widely used in industrial applications, it has become the most common type of robot.
- Mobile Robot: Commonly called a robotic vehicle, it can come in many different shapes and models. They usually have a certain degree of intelligent assistance

for locomotion or for controlling the system, including AGV (automatically guided vehicle), which usually land on wheels, legs, or tracks; UAV (unmanned aerial vehicles) which are generally pilotless aircraft and helicopters; AUV (autonomous underwater vehicles) which are intelligent and unmanned; and ROV (remotely operated vehicle) which are in general robot submarines with an umbilical cable control transmission.

Industrial robots have a limited space for manipulator movement, called work space or volume, where the robotic system can position itself and use the tool (end-effector). Robotics was developed with different goals, often all of these at the same time. These include the creation of useful controllers for real-world robot work, exploration of details, and psychological phenomena, among others.

The use of robots as autonomous agricultural tools has interesting potential as a valuable technology tool for precision farming, the advantage of which is to leverage some of the established and recognized robot control theories for applications in many other industries.

The recent trend toward the development of mobile robots and autonomous vehicles for specific tasks is driven by the realization of greater efficiency and operational benefits (less unmanned soil compaction) from larger machines.

Robotics in agriculture is not a new concept; it has more than 20 years of history in a controlled environment (greenhouse). Work was carried out to create machines for harvesting cherry tomatoes, cucumbers, mushrooms, and other fruits. In gardening, robots are used to pick citrus fruits and apples. Robotic milking is widely used in milk production in the Netherlands. But the greatest development of the automatic agricultural production system undoubtedly took place among the Japanese. An example of such a development is the NTA Vegetable Plant, which grows vegetables in a hydroponic system under artificial lighting. Computers and robots control the planting, fertilization, disinfection, root trimming, packaging, and weighing processes, resulting in a flawless product and a flawless result. The level of automation in factories is so high that over time they can become fully autonomous production units.

The use of robotics in this area is relatively recent, but in 1984 Hollywood made a movie called Escape, in which agricultural robots were created as researchers to extract insects from corn husks.

Farmers need to collect information about crops and soil conditions before and during the growing season, which is injected into the soil to measure compaction and supplied with an electric probe to measure pH. During the development phase, it is important to measure the water and nitrogen stress of plants using optical sensors, as well as measure insect and weed infestation using cameras. The author states that the new generation of agricultural robots is giving satisfactory results. Although much smaller than conventional agricultural machines, they can work together and perform tasks such as spraying people with harmful pesticides. Lasers are used in a variety of applications, from harvesting to weeding.

The new generation of lightweight robots with low-pressure tires will process a minimum amount of soil to collect seeds. It is planted exactly according to the moisture content of the soil. Your movements are controlled by special software – SAFAR (architectural software for agricultural robots) – and routes are planned using Google Earth. Robots can continue to selectively harvest crops, allowing farmers to cut better, while crops that still need time to grow remain in the field.

Robots are still too small for memory-intensive tasks such as loading fertilizer and lifting harvested grain, but they can be used where relatively little energy is required. Weed control is a good example where weeds can be treated with small amounts of chemical weeds, highly concentrated or mechanically controlled [28, 32].

The limiting factor for field robots is energy consumption, which affects their range. While robots can run on fossil fuels, it makes sense to use locally available resources such as sunlight, renewable energy, or biofuels to reduce their environmental impact. If robots are used for harvesting, they can even use part of the harvest for their own operations. This is comparable to the use of homologous biological preparations, for example, haymaking in horses [28].

Agricultural robots range from large and versatile mechanical machines to small, autonomous vehicles designed for specific applications. The design of a robot is often determined by the environment in which it operates. The outdoor environment often allows the use of large robots such as autonomous tractors. However, outdoor robots require advanced navigation systems to explore unstructured environments. But robots used in stores, warehouses, factories, etc. can take advantage of infrastructure in their environment, for example, controlled lighting conditions can improve the reliability of imaging systems, allowing more sophisticated robots to be developed for growth.

A sensor is a term that describes an element that is sensitive to some type of environmental energy and lacks the necessary functionality to implement it in control systems that typically require an interface that generates a readable signal to the controller.

Sensors are devices that can convert physical events into electrical signals. Hence, sensors are part of the interface between the physical world and the world of electrical devices such as computers. Another part of this interface consists of actuators that convert electrical signals into physical events. Figure 20.1 represents the role of a sensor.

Sensors can have two types of outputs, analogue or digital. For the analog type, they assume any voltage value between two extreme values, and when they assume only two values, these logical levels can be high or low. In mobile robotics, sensors are used to measure parts of the robot, among them the internal temperature and the rotation speed of the engines. Another class of sensors more sophisticated is used to acquire data from the environment where it is inserted. Because of environment dynamics this detection activity can become very critical.

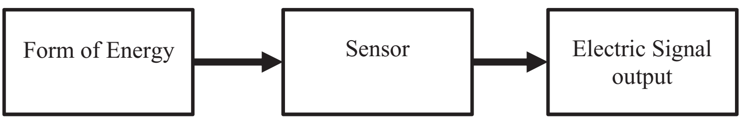

Fig. 20.1 Function of the sensor

Sensors are used for quantitative measurements, not qualitative assessments. The characteristics of the quantity to be measured will determine the sensor, considering the quantity to be measured and the sensor environment.

Wireless sensor technology and mobile robotics in agriculture have become one of the most popular technologies for monitoring agricultural systems.

20.4 Proposed Model

20.4.1 Block Diagram

The complete system uses the Arduino Uno (based on ATMEGA 328). The practical block diagram of the arrangement is presented in Fig. 20.2. Temperature sensors, moisture sensor, LCD display, buzzer, and relay are handled by Arduino Uno. All the modules are interfaced and programmed in a way to wok the entire module in synchronization. The panel can be linked to the personal computer, and the programming of the microcontroller can be done for sensor to work and can sense breathe. The reading will be demonstrated on the LCD board which is interfaced with the Arduino Uno board (Fig. 20.3).

20.4.2 Arduino Board

Figure 20.4 shows the main part of the system which is Arduino board, a microcontroller section based on ATmega328 [30]. Because of the use of ATmega328, this board has different features from previous board that it does not use the FTDI USB to serial driver. This is a very cheap device and has available source, and it has a

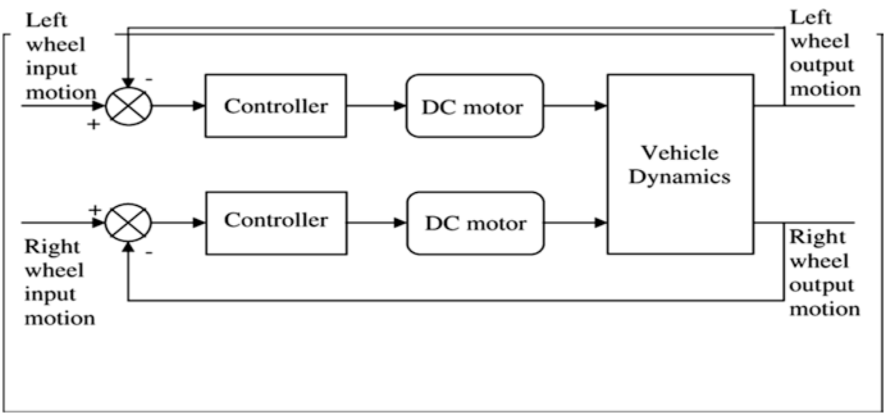

Fig. 20.2 Working of Arduino Uno board

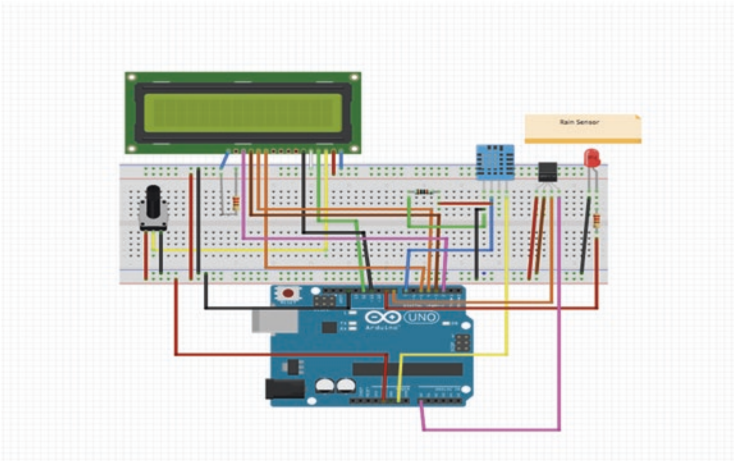

Fig. 20.3 Arduino temp. interface block diagram

very much comfortable to use hardware and software. This can be powered by USB connection and DC batteries.

20.4.3 Liquid Crystal Display

Figure 20.5 shows the diagram of the very basic module of liquid crystal display used in different device and circuits with numerous applications. The LCD can replace seven-segment display LEDs and other multi-segment LEDs. It has low cost, is convenient to program, and has no constraint to display special and custom characters. It uses 5 × 7 pixel matrix to display each character. The command registers stores the command instructions given to the LCD. The files are the ASCII value of the character to be displayed on the LCD.

20.4.4 Moisture Sensor

In Fig. 20.6, a moisture sensor is used to measure the water (moisture) content in the soil. This sensor reminds users to water the plants and also monitors soil moisture. It is widely used in agriculture, irrigation, and terrestrial botanical gardens. The working voltage of soil moisture is 5V, the required current is less than 20 mA, and the interface consists of an analog sensor and operates from 10 °C to 20 °C. The soil moisture sensor uses a capacitance to measure the dielectric constant of the surrounding soil. In soil, the dielectric constant depends on the moisture content. The sensor generates a voltage proportional to the dielectric constant and therefore to the

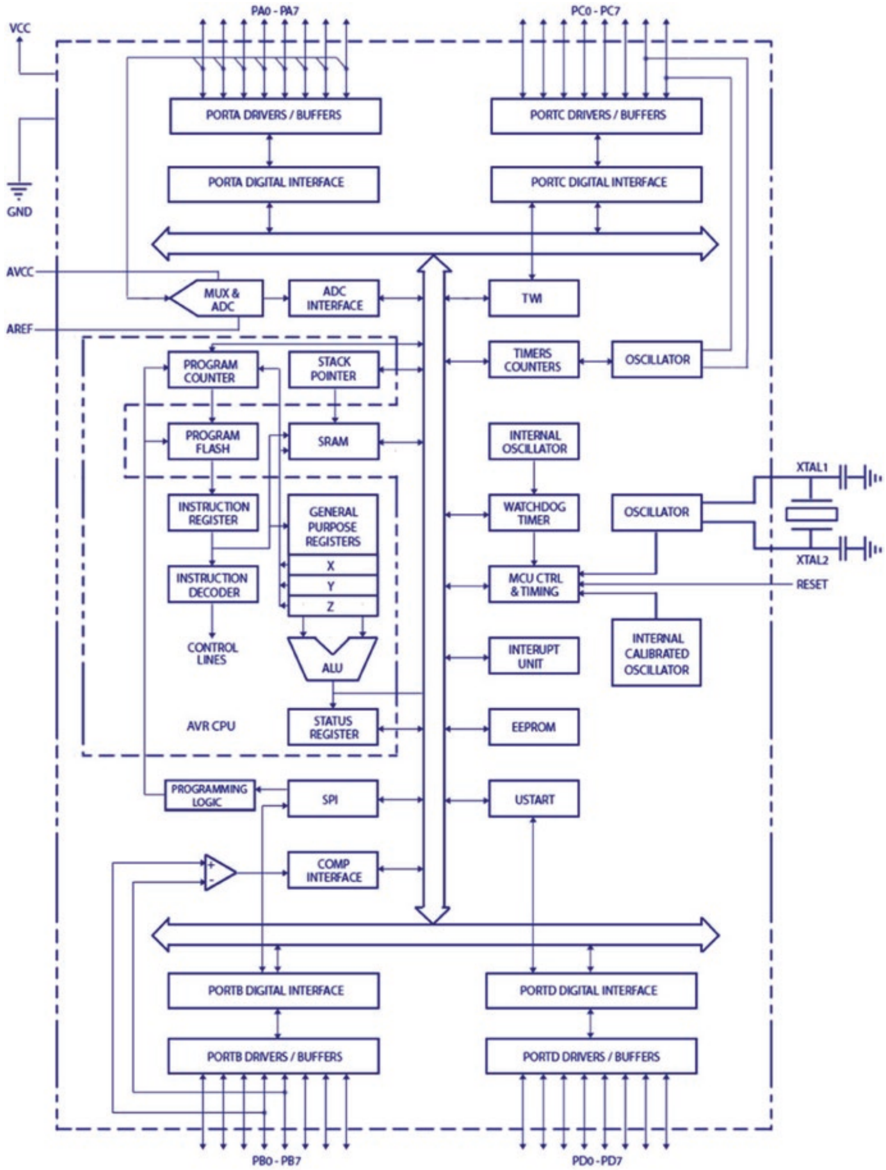

Fig. 20.4 Architecture of the Arduino UNO [30]

water table. The sensor calculates the average moisture content over the entire length of the sensor. Soil moisture sensors are used to measure the evaporation and moisture loss of plants over time. Monitor soil moisture levels to control greenhouse irrigation and improve bottle biological experiments. The hardware and software required for a soil moisture sensor are the Arduino IDE Moisture Sensor software

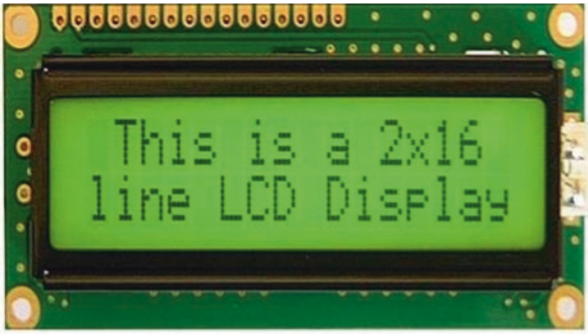

Fig. 20.5 LCD 16/2 display module

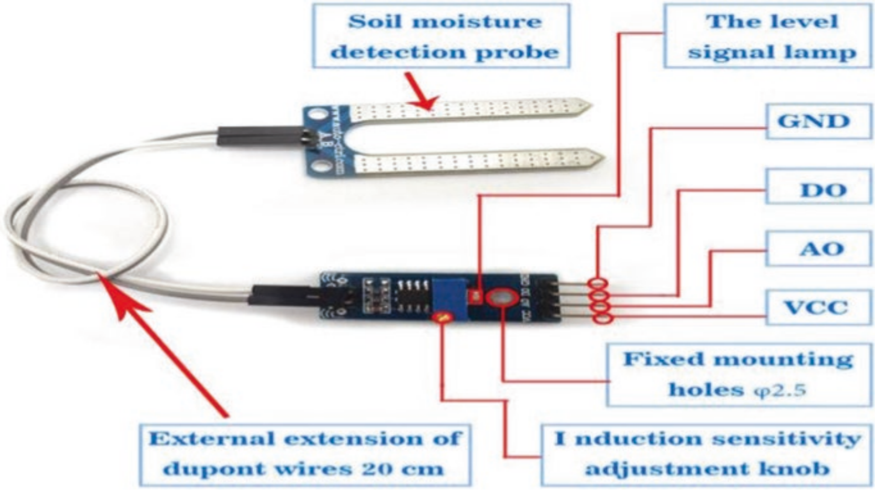

Fig. 20.6 Moisture sensor overview [31]

and the Arduino Uno board. Soil moisture VCC% v Arduino UNO connects to GND Soil moisture sensor, and Arduino UNO and end sensor A0 port connect to Arduino 0 analog board.

20.4.5 Relay

The relay is a mains voltage switch (Fig. 20.7). This means that it can be turned on or off to enable or disable the flow of current. Controlling a relay with an Arduino is as easy as controlling an output such as a motor. There are many types of modules such as single-channel, dual-channel, four-channel, and eight-channel. A type of relay that can handle the high power required to directly drive an electric motor or

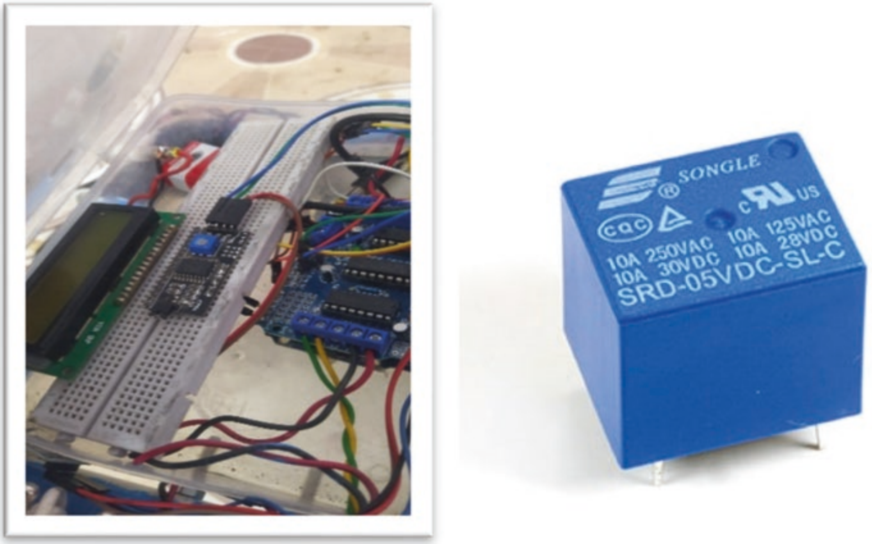

Fig. 20.7 Relay module

other load is called a contractor. Calibrated performance relays and sometimes more than one working coil are used to protect the circuit from overload or interference. The relay has three connection options depending on the mains voltage. There are common contacts (COM), normally contacts (NO), and normally closed contacts (NC). There is no contact between the common contact and the normally open (NO) contact. We activate the relay to connect the COM pin and power is supplied to the load. There is a contact between the COM contact and the NC contact. A connection between the COM and NC pins is always required, even when the relay is de-energized. When we activate the relay, the circuit is open and there is no current to the load. All shipping pins. The communication between the relay module and the Arduino is very simple. The GND relay is shorted to ground. The IN1 relay port is connected to a digital pin on the Arduino. Check the first channel of the relay (Fig. 20.8).

20.5 Simulation Results

The collected data regarding the variable stem height of plants irrigated by the robot are presented through descriptive analysis, in Table 20.1, in which the average found was 22.99 mm, standard deviation was 0.895, and the coefficient of variation was 3.89%. The data collected can be considered normal because the values of symmetry and kurtosis are in the range of 3 to −3; thus the analysis of variance proves to be efficient.

Fig. 20.8 Agrobot prototype

Table 20.1 Descriptive statistics of stem height (robot)

	Robot stem height
Number of samples	50
Average	22.990
Standard deviation	0.895
Variance	0.801
Variation coefficient (%)	3.89
Maximum	25.00
Minimum	21.00
Symmetry	0.03
Kurtosis	−0.74

Stem height samples of manually irrigated plants are shown by descriptive analysis, in Table 20.2; the mean value of the samples is 22.67 mm, with a deviation standard of 1.02 and coefficient of variation of 4.54%.

Table 20.3 shows the analysis of variance of the stem height of sample plants irrigated by the robot and manually. The *P* value, level of observed significance, is the lowest significance value where the null hypothesis H0, hypothesis considered to be true initially, would be rejected or that there is no difference between the irrigation performed by the robot and the manual for the variable stem height; for this the *P* value found is compared with the adopted α significance, in this case a value of 0.05 or 5%, and if the *P* value is less than or equal to α, it implies the rejection of hypothesis H0, and if the value *P* is greater than α, the hypothesis H0 at level α should be considered. From Table 20.3, it is possible to compare the *P* value of 0.100, with the value of α, and conclude the hypothesis, with no significant difference between treatments.

Table 20.2 Descriptive statistics of stem height (robot)

	Manual stem height
Number of samples	50
Average	22.670
Standard deviation	1.028
Variance	1.507
Variation coefficient (%)	4.54
Maximum	25.00
Minimum	20.00
Symmetry	−0.01
Kurtosis	0.06

Table 20.3 Stem height analysis of variance

	GL	SQ	QM	*F*	*P*
Factor	1	2.499	2.75	2.75	0.100
Error	98	90.029	0.9291		
Total	99	92.528			

Comparing the stem height frequency histograms, Figs. 20.9 and 20.10, it is possible to see that the measurements of the samples treated by the robot present a predictability of data by the normal curve, and it is also visible that there is less variation in the robot samples.

Among the advantages of using robots when applied to a work environment is that they can replace manual work in dangerous tasks, thus reducing contact with the activity; robots are often used on production lines as a fundamental element of the assembly process of the most diverse products, for the ability to perform repetitive activities and for the precision and speed of execution. As a good example, automobile assemblers that employ robotic manipulators in the assembly of their vehicles are available, as this removes operators from repetitive activities, such as the assembly process.

20.6 Conclusion and Future Scope

In this study, a microcontroller-based intelligent agricultural robot was developed, and the main areas of machine learning and artificial intelligence were applied. The microcontroller circuit consists of several components, and this circuit is quite reliable. This circuit consists of an Arduino UNO, a relay, a soil moisture sensor, a motor (12V), a temperature sensor, self-made custom PCB prototype circuit to make a control processing board, motor controller, image recognizing signal processing program and code for each of sensors merged to perform and execute

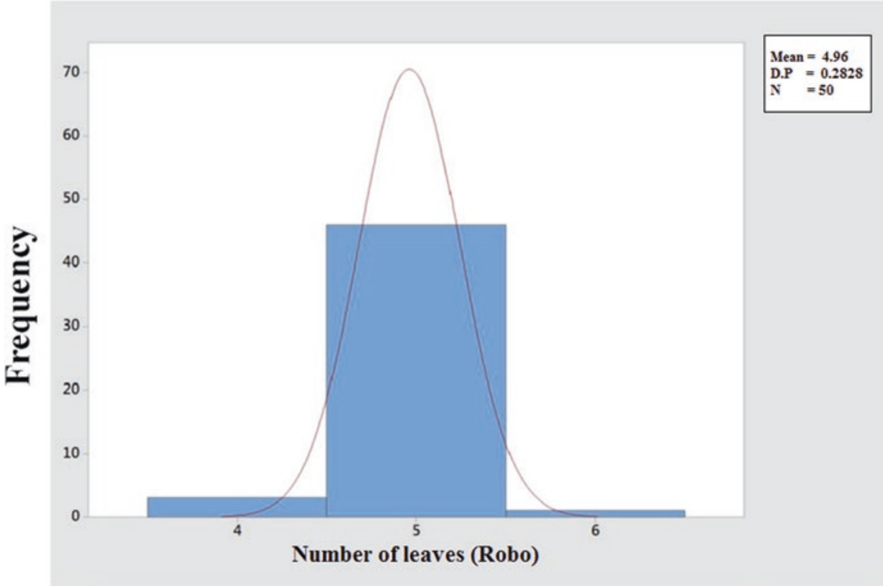

Fig. 20.9 Leaf number frequency histogram (robot)

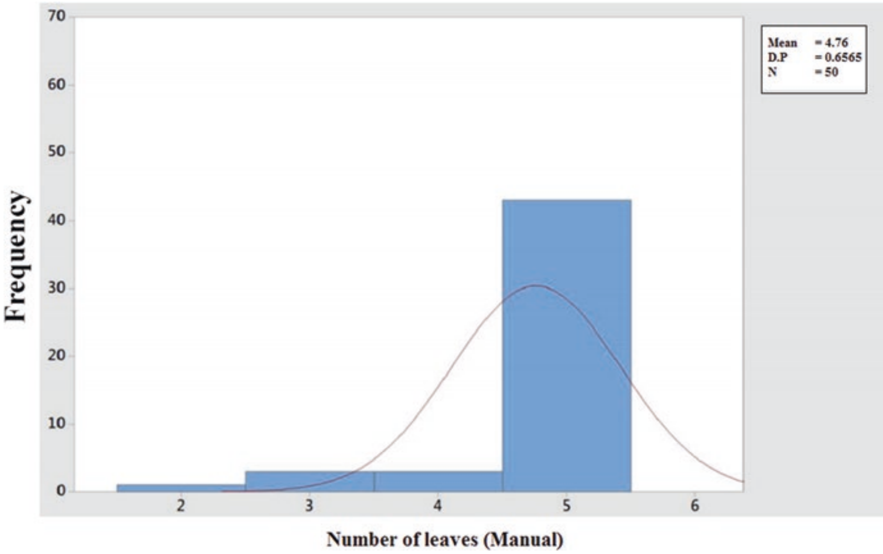

Fig. 20.10 Leaf number frequency histogram (manual)

various tasks, BT module, and ESP8266 Module for starting and linking communication between mobile devices (operator/controller) to connect with agriculture farming robot and battery.

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Chapter 21
Role of the Internet of Things (IoT) in Digital Financial Inclusion

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21.1 Introduction

Digital finance can provide vulnerable communities in developed nations with accessible, easy, and safe banking services [1]. Almost 50% of people in the developing world already own mobile phones. “Digital finance can contribute to financial inclusion, the extension of banking services to the non-banking sectors and the expansion of basic services to individuals” [2]. Customers use a variety of smart gadgets to access a variety of services and data all over the world. Banks and other financial service providers have also employed technology to provide users with real-time access to and views of their accounts. The confluence of technology and information has enabled the development of IoT [3–8] in the financial sector. Payments are initiated and processed over IoT objects on the Internet of the payments system [9]. IoT is being used by a huge number of fintech companies to collect data and conduct big-scale financial services. Smart features are used by users all around the world for safety, security, and convenience.

The Internet of Things has the potential to dramatically transform the financial products and services sectors [10]. The banking business deals with large amounts of data transfer, collection, and analysis; the Internet of Things has a significant impact on it, benefiting both financial services and customers. The Internet of Things (IoT) is the most significant technological advancement, heralding the second great digital revolution [10, 11]. IoT technology is employed in the financial services industry to help users save time, work smarter, and live a more active lifestyle. IoT in the banking and financial industry is still in the planning stages, but it has a lot of room for innovation. The objective of this chapter is to examine the factors that affect the role of IoT in digital financial inclusion.

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The remainder of the chapter structures is as follows: Sect. 21.2 represents the literature review. Section 21.3 describes the research methodology. Section 21.4 explains the results and findings. Section 21.5 defines the conclusions of the study.

21.2 Review of Literature

There are numerous national and international review literature in IoT, digital finance, and financial inclusion. Information communication technology has been recognized as a key factor in promoting economic success [12–16]. Previous literature study explained the effect of smartphones on economic growth from 1998 to 2007 in African countries. To determine the effect of smartphones on expansion, the authors examined mobile penetration rates as well as the cost of mobile local calls. The conventional growth model and generalized methods of moments (GMM) estimator method were applied to evaluate the outcomes. The results suggested that smartphone production is leading to economic development in Africa [17]. Digital finance refers to the modern business model of the use of IoT to carry out a wide variety of financial operations, for example, payment by third parties, online lending, and direct sales of money, crowdfunding, online insurance, and banking. The Internet has the potential to reduce transaction costs and asymmetry of information, improve the efficacy of risk-based pricing and risk management, and expand the number of transactions that are possible [18]. The authors studied the moderating effect of social systems in the connection between IoT payments and inclusion in Africa. The study showed that perceived networks had a favorable moderating effect on the link between the use of IoT payments and financial inclusion. The authors suggested that the existence of strong and weak social networks among users of digital money promotes financial inclusion in Africa [19]. The study found a causal relationship between the Internet, digital payments, and financial inclusion in Africa. Data were collected from 2000 to 2016. The facts showed that the IoT has a favorable impact on financial inclusion, which means that increased financial inclusion is linked with increasing levels of IoT [20]. An exploratory study on 200 individuals in India measures the relationship between telecommunications and financial inclusion. The two dimensions, i.e., financial Inclusion and telecom, were taken into account. Structural equation modelling was used with Smart PLS to test and develop the model. The study demonstrated the positive effect of telecommunications on financial inclusion [21]. The study pointed out the effects of digital finance on financial inclusion and its stability**.** The convenience of digital finance for low- and variable-income individuals is often more valuable than the higher cost they would also pay to obtain such services from conventionally regulated banks. Fintech-based digital finance has a significant positive impact on developed and emerging economies' financial inclusion [22]. Similarly, the literature highlighted the effects of digital product growth on financial inclusion in countries of the South Asian Association of Regional Cooperation. Data were collected from 2004 to 2014 to create a financial inclusion index using primary component analysis. The study found a positive connection between digital product growth and financial inclusion [23]. The study emphasized the impact of ICT diffusion on financial inclusion. The study was related to 9 years from 2007 to 2015 (across 16 states). Dynamic panel data analysis has shown a positive significant effect of the ICT on the financial inclusion index [24]. Additionally, the authors conducted a study on digital payments and their contribution to promoting financial inclusion and development. The authors analyzed how mobile technology could contribute to the practice and theory of economic development and financial inclusion. The study also proposed the future scope of work for IoT and financial inclusion, the sustainability of digital payments and conventional finance, and the regulatory frameworks for institutions to provide digital payment services [25]. Contextually, the authors explained the role of IoT for improvised digital financial inclusion. The study found that fintech enhances digital financial inclusion. The authors concluded that financial inclusion would help to promote digital services and IoT service providers. The study highlighted the positive, negative, and dual dimensions that exist between IoT and digital financial inclusion [26]. Internet of Things is a promising disruptive technology with enormous growth, impact, and promise. The parametric analysis is used to explain the IoT security issues and solutions [27]. Indeed, the authors described the five technical and managerial challenges of IoT. The study used the net present value and real options method for IoT investment and concluded that IoT is one of the most important areas of future technology [28]. Additionally, various previous literatures are available on the introduction of IoT [29–33] and digital financial inclusion [34–38].

21.3 Research Methodology

To identify factors affecting IoT in digital financial inclusion, a descriptive study was conducted. The data was gathered from both primary and secondary sources as shown in Table 21.1.

The convenience sampling techniques method is used to collect the data for exploratory study. These are non-probability techniques of sampling [39–41]. This method was employed with a sample size of 120 customers from diverse segments to ensure valid and accurate results. The information gathered from the respondents was coded and collated in MS Excel, and conclusions were derived. To compress the data and find major elements affecting the role of IoT in digital financial inclusion, principal component analysis was employed.

Table 21.1 Data collection method

Primary data collection method	Secondary data collection method
Self-designed questionnaire	Journals, newspapers, web, and other relevant manuals/ publications

21.4 Results and Findings

21.4.1 Demographic Analysis of Respondents

Let the analysis of the respondents as follows. The age of respondents is shown in Table 21.2 and Fig. 21.1. The genderwise respondents are shown in Table 21.3 and Fig. 21.2. The marital status of the respondents is shown in Table 21.4 and Fig. 21.3. The education of the respondents is shown in Table 21.5 and Fig. 21.4. The occupation of the respondents is shown in Table 21.6 and Fig. 21.5. The monthly income of the respondents is shown in Table 21.7 and Fig. 21.6.

Table 21.2 Age of respondents

Age	N = 120	% percentage
18–25	23	19.2
26–35	31	25.8
35–45	22	18.3
45–55	24	20
55–65	12	10
65 above	8	6.67

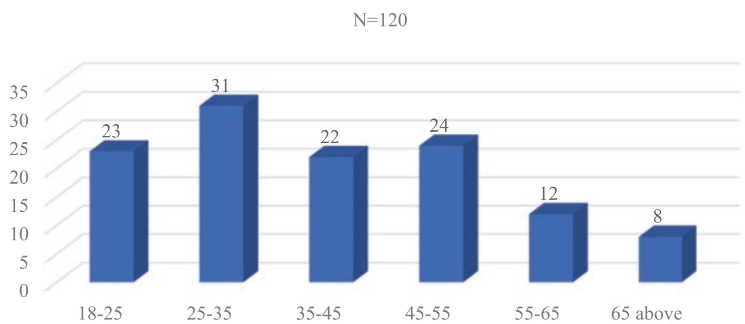

Fig. 21.1 Age of respondents

Table 21.3 Gender of respondents

Gender	N = 120	% percentage
Male	77	60.5
Female	43	39.5

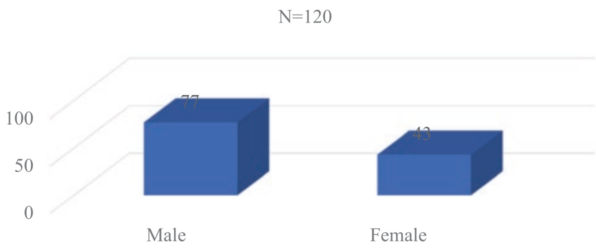

Fig. 21.2 Gender of respondents

Table 21.4 Marital status of respondents

Marital status	N = 120	% percentage
Married	53	44.2
Unmarried	46	38.3
Others	21	17.5

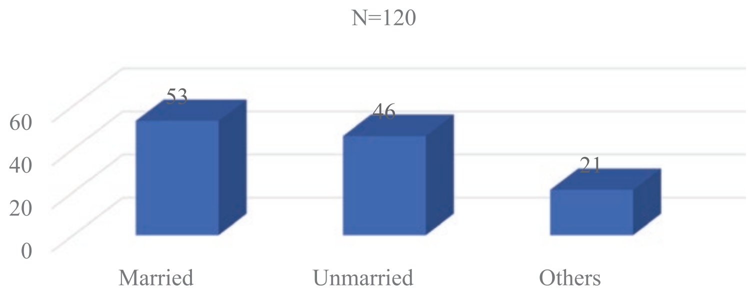

Fig. 21.3 Marital status of respondents

Table 21.5 Education of respondents

Education	N = 120	% percentage
Up to 12th	22	18.3
Graduation	54	45
Post-graduation	36	30
Doctorate	8	6.67

21.4.2 Reliability Analysis

The major objective of this chapter is to examine the factors that influence the role of IoT in digital financial inclusion. Cronbach's alpha for 20 items is 0.795, as shown in Table 21.8. Cronbach's alpha is greater than 0.70, indicating that the scales

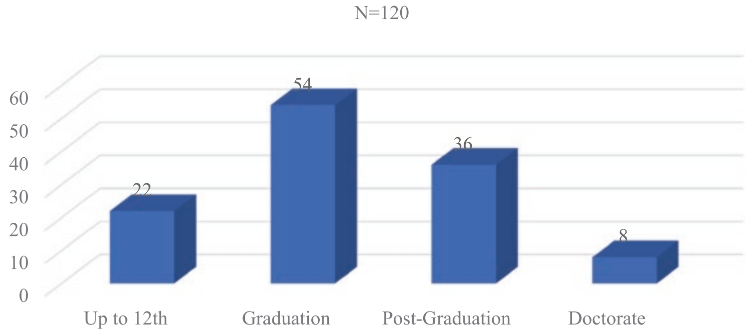

Fig. 21.4 Education of respondents

Table 21.6 Occupation of respondents

Occupation	N = 120	% percentage
Self-employed/business	46	38.3
Govt. sector employees	23	15.7
Private sector employees	19	19.3
Homemaker	20	16.7
Any other	12	10

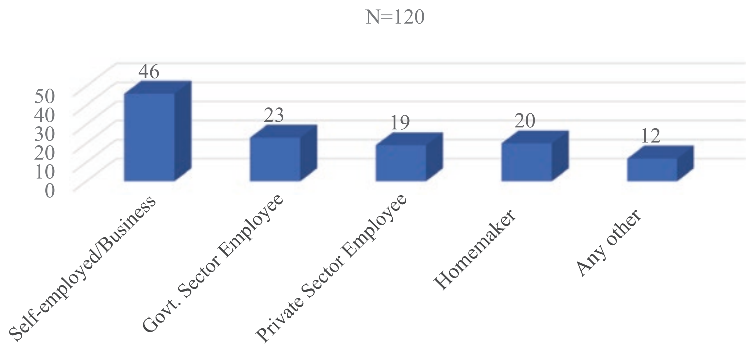

Fig. 21.5 Occupations of respondents

Table 21.7 Monthly income of respondents

Monthly income	N = 120	% percentage
Below 10,000	8	6.67
10001–30000	17	14.2
30001–60000	52	43.3
60000 above	67	55.8

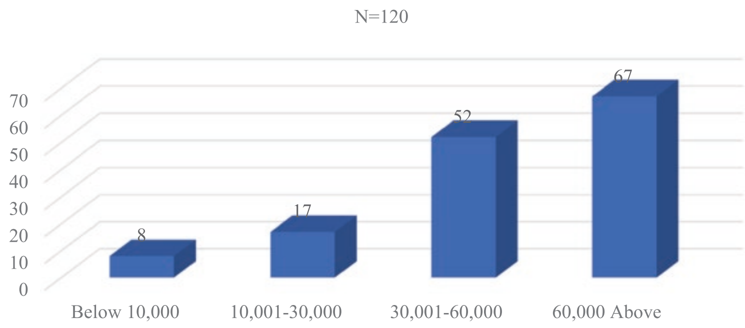

Fig. 21.6 Monthly income of respondents

Table 21.8 Reliability statistics

Cronbach's alpha	N of items
.795	20

are internally consistent. As a result, the instrument used in this study has a high level of reliability.

21.4.3 Factor Analysis

The new elements determining the role of IoT in digital financial inclusion were constructed using principal component analysis. Both the KMO index of sampling adequacy and Bartlett's test of sphericity can be used to establish the factorability of the matrix as a whole.

Table 21.9 represents the significance of Bartlett's sphericity test ($p<0.001$, $p = 0.000$). Furthermore, the KMO index is 0.642, which is higher than 0.6. As a result, the principal component analysis should be used to examine factors that can affect the role of IoT in digital financial inclusion.

Table 21.10 shows the total variance explained for factors affecting the role of IoT in digital financial inclusion at seven phases. Eigenvalues were greater than one; seven variables were identified, representing 77.00% of the variance.

The rotated factor matrix for the questionnaire is shown in Table 21.11. Factor 1 consisted of four elements with factor loadings ranging from 0.826 to 0.596 after varimax rotation with Kaiser normalization. Factor 2 is composed of four elements, each with a factor loading of 0.829 to 0.550. Factor 3 is composed of three elements, each with a factor loading of 0.933 to 0.561. Factor 4 is composed of three elements, each with a factor loading of 0.949 to 0.592. Factor 5 is composed of two elements, each with a factor loading of 0.833 to 0.803. Factor 6 has two elements that range from 0.902 to 0.887, whereas factor 7 has two elements that range from 0.885 to 0.827.

Table 21.9 KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sampling adequacy		.642
Bartlett's test of sphericity	Approx. chi-square	1513.56
	Df	190
	P-value	.000

Table 21.10 Total variance explained (rotation sum of squared loadings)

Components	Total	% of variance	Cumulative %
1	2.507	12.535	12.535
2	2.479	12.394	24.929
3	2.311	11.555	36.485
4	2.288	11.438	47.923
5	2.164	10.821	58.744
6	1.983	9.913	68.657
7	1.669	8.343	77.000

Table 21.11 Rotated component matrix

	Component						
Statements	1	2	3	4	5	6	7
IoT awareness							
Aware of the functionality of IoT	.826						
Aware about online banking	.796						
Aware about OTP	.724						
Aware about SMS	.596						
Financial service awareness							
Knowledge of different types of accounts		.829					
Knowledge of online, mobile banking services		.819					
Knowledge of debit card and credit card		.649					
Knowledge of insurance and loans		.550					
Usability							
I use the Internet for all money transactions			.933				
I carry little cash because I use Internet banking			.869				
I always use Internet banking because of its reliability			.561				
Benefits							
Online services are simple to use				.949			
Comfortable to use services 24/7 everywhere				.949			
Complaints can be easily resolved				.592			
Trust							
Online services are trustworthy					.833		
I have no fear about IoT service provider					.803		
Security and privacy							
Online transactions are secured						.902	
Satisfied with privacy provided						.887	
Accessibility							
Ease access to digital banking services							.885
Access to online banking speeds my transactions							.827

Table 21.12 Factors affecting the role of IoT in digital financial inclusion

Factors	Name	% of variance
1	IoT awareness	12.537
2	Financial service awareness	12.394
3	Usability	11.555
4	Benefits	11.438
5	Trust	10.821
6	Security and privacy	9.913
7	Accessibility	8.343

Using factor analysis, seven new factors were effectively developed and designated as factors affecting the role of IoT in digital financial inclusion. The names of the new factors are listed in Table 21.12, along with the percentage of variance explained for each component. When the first factor was extracted, it showed the largest percentage of variation explained. The variables are IoT awareness, financial service awareness, usability, benefits, trust, security, and privacy, as well as accessibility.

21.5 Conclusion

The Internet of Things (IoT) is a new technology paradigm that envisions a global network of interconnected equipment and objects. It is also known as the Internet of Everything or the Industrial Internet [42]. The Internet of Things (IoT) is largely regarded as one of the most important areas of future technology, and financial institutions are showing a lot of interest in it. According to the survey, 25.8% of respondents are between the ages of 26 and 35, 60.5% are men, 44.8% are married, 45% are graduates, 38.3% are self-employed, and 55.8% have an annual salary of more than Rs 60000. The sample size for this study is 120 respondents, and we identified seven major factors that affect the function of IoT in digital financial inclusion. IoT awareness, financial service awareness, usability, benefits, trust, security, and privacy, as well as accessibility, are all on the list. As a result, we can conclude that the Internet of Things(IoT) plays an essential role in digital financial inclusion.

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Chapter 22
Diagnosis of COVID-19 Using Low-Energy IoT-Enabled System

Yogini Dilip Borole, Anurag Shrivastava, and M. Niranjanamurthy

22.1 Overview

The Internet of Things (IoT) is a comprehensive feature of connected logging strategies and advanced and mechanical tools capable of transmitting information through a token organization without human intervention at any stage. All of these examined tools are associated with exceptionally identifiable statistics or software. The Internet of Things is now stable and has shown innovative innovation that transcends endless strategies, quick research, artificial intelligence theory, haptic elements, and more. Furthermore, in the day-to-day operation of the mill, IoT is considered to be the utility of goods or machines that serve the real-life needs of individuals in a variety of ways, for example, setting up home security, strobe lighting game plans, and many other things that can be effectively controlled in our day using many speakers, cell phones, etc. [1, 2]. In the current epidemiological situation, all countries, including India, are struggling with COVID-19 and are looking for a practical answer to tackle the problems that are emerging in many ways. Scientists in physics and design try to deal with such difficulties, to develop new hypotheses, to illustrate new test problems, to create client-centric illustrations, and to enlighten ourselves and the general public in general. Basic, but better, protective measures against the novel coronavirus, for example, social division and regular

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hand washing, are also gradually changing our methods of protecting ourselves from spreading. Some people try to sever contact with exposed objects/surfaces that everyone has moved to keep a strategic distance from strangers or the possibility of contamination. This small survey aims to focus on this creative innovation as well as its recognizable applications to the COVID-19 epidemic.

22.2 Internet of Things for COVID-19 Epidemic

In plain English, the Internet of Things (IoT) is a set of interconnected tools/tasks that are accepted for all parts of the setup, for example, equipment, programming, network setup, and any other electronic/computer requirement. And it ultimately provides feedback from over-the-counter help data and assortment. If we talk about the Internet of Things (IoT), we are talking about a concept that establishes a broad synthetic framework that will ultimately allow for the strong integration and exchange of data between individuals and expert collaborators. In the current situation, there are a lot of concerns as a result of non-mandatory access to patients, which is the second most important issue after concern about antibody development [3, 4]. The use of the concept of the Internet of Things increases the accessibility of patients, allowing them to care more in the hope of overcoming their illness.

22.3 Necessity for the Education of Internet of Things

In the current severe pandemic situation, the number of infected patients is steadily increasing everywhere, and there is a need to recruit well-functioning and well-organized offices provided by the IoT method. In addition, IoT has already been used to address unmet needs in a variety of areas related to IoT's current challenges to health and medicine. The number of cases resolved can be increased and improved by following the rules and visiting health and medical offices.

22.4 Key Merits of Internet of Things for COVID-19 Pandemic

The Internet of Things is a creative idea that seeks to isolate all those infected with the disease. It is important to have a proper screening mechanism during isolation. A web-based solution is used to accurately track all high-risk patients. This invention is used to calculate biometrics such as blood pressure, heart rate, and glucose level [5, 6]. Figure 22.1 shows the main advantages of the Internet of Things for the COVID-19 pandemic. If this innovation is successfully implemented, we can expect

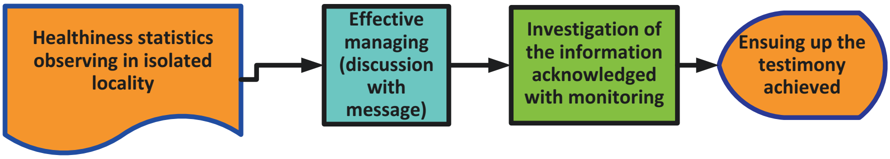

Fig. 22.1 The critical procedures utilized by IoT for COVID-19

an increase in the capacity of clinical staff as well as a reduced residual burden. As costs and confusion are reduced, a comparator may be appropriate for the COVID-19 pandemic.

22.5 Processes Involved in IoT for COVID-19

The Internet of Things is an innovative creative phase to combat the COVID-19 pandemic and may face critical issues in lockdown situations. This discovery can be used to obtain continuous information and other important data about the affected patient [7–9]. Figure 22.1 shows the critical actions used by the Internet of Things for COVID-19. Initially, the IoT is used to capture wellness information from different areas of the affected patient and to manage all information using the default management framework [10, 11]. This innovation helps to control the information and track the achievement report.

22.5.1 The General Effect of IoT in Setting to COVID-19 Concerns (E.g., Contact Following, Group Distinguishing Proof, and Consistence of Isolate)

As mentioned earlier, the concept of the content network uses an interconnected network to facilitate the flow and exchange of information. It allows social workers, patients, lay people, and others to communicate with management sponsors on any topic, as well as collaborate with them. Using the IoT technology proposed in the COVID-19 pandemic, identifying patients, as well as suspected cases, can be fully guaranteed. Most of them, the general public, are already aware of the symptoms associated with coronavirus. By assembling a well-informed group around a relevant schema, a diverse directory of the whole group can be built. Some specific mobile-based applications can also be developed so that the poor can benefit [12–15]. The controller, for example, professionals, physicians, supervisors, etc., should be aware of the side effects and recover quickly so that significant movement can be stopped and total isolation time reduced.

22.6 Worldwide Mechanical Progressions to Determine COVID-19 Cases Quickly

As a result, to further educate the general public about the survival of the COVID-19 pandemic, the Government of India has launched a cell phone app called eArogya-Setu, which aims to establish a link between key potential social insurance segments and the public of India. In addition, the Chinese government is promoting the mobile application eClose Contact (English translation) to its residents. This application indicates the applicant's proximity to the Crown Builder's person, aiming to be able to think more while outdoors. At the end of April 2020, the US government will launch a similar mobile application for its citizens. After China, the highest number of COVID-19 cases was reported in Taiwan, which is predictable. Taiwan, on the other hand, quickly assembled and established precise principles for each potential coronavirus case, setting up assets for identifying, concealing, and monitoring network wellness. Taiwan provided and coordinated its National Medical Coverage database with the Movement Department, as well as a list to promote big data generation for research and generated continuous alerts during the clinical visit in the light of the kinematic device and clinical indications to assist in the identifiable evidence of the case; continuous alerts were issued during the clinical visit in the light of movement effects and clinical indications to assist in establishing a detectable condition. They also used the latest invention, which includes QR code scanning, transport history statements, etc., to obtain potential evidence of contamination [16].

22.7 Huge Uses of Internet of Things for COVID-19 Pandemic

The Internet of Things (IoT) utilizes an extensive network of connected devices to create an intelligent system to manage the integrity of the board. It warns and records all types of diseases to improve patient safety and accurately records patient information and data without the need for any human interaction. This knowledge is also useful for good dynamic processing [17–21]. The main application is discussed in Table 22.1. Figure 22.2 shows the key benefits of using IoT to combat the COVID-19 epidemic.

The Internet of Things is being used for a variety of purposes to meet the urgent need to mitigate the effects of the COVID-19 pandemic. It has the ability to predict future events by analyzing previously collected data. Its apps are used to find the right CEOs to fight the epidemic. The patient can use IoT units to track their pulse, blood pressure, glucose meter, and other exercises for more personalized care. IoT units help to monitor the health of the elderly. The most important application of this innovation in social insurance is the continuous field tracking of healthcare equipment and tools for rapid and painless treatment. This invention can be used by human service insurance companies to identify misrepresented insurance and to provide transparency throughout the system. It helps the patient to have treatment work procedures and productive execution and furthermore for accommodating dynamic process during complex cases. There are hardly any things, for example, switches and remote controls that everybody wind up contacting on numerous occasions in a day, even in the midst of the well-being alarm we are right now seeing.

Table 22.1 Applications and its explanation

Sl. No	Application	Explanation
1	unwired-attached clinic	Emergency clinic sites require a full coordination system to use the Internet of Things to help pandemics such as COVID-19
2	Notify to concern medicinal team At the time of crisis	This integrated system allows patients and staff to respond more quickly and efficiently at any time when needed.
3	See-throughCOVID-19 action	This integrated system allows patients and staff to respond more quickly and efficiently at any time when needed.
4	Automatic therapy method	The choice of treatment methods becomes profitable and helps in the proper treatment of cases
5	Telemedicine discussion	This will make treatment more accessible to the poor in remote areas, especially through the use of frequently linked remote services.
6	Unwired wellness program to recognizeCOVID-19 sufferer	Various original software can be installed on mobile phones, which makes the detected proof method work more smoothly and efficiently.
7	Clever finding of diseased sufferer	Various original software can be installed on the phones, which makes the selectable proof method smoother and more efficient.
8	Actual in float the time of extent of this contagion	Because devices, regions, channels, and other components are all highly educated and connected, real-time data exchange should be possible and manage situations precisely.
9	Speedy COVID-19 showing	Since the case originated / found from the initial example, one can try to identify as best as possible using the most relevant processing hardware. As a result, the wider screening system is becoming more and more popular.
10	Recognize inventive clarification	The most serious goal is the general feature of management. This can be done easily by bringing beneficial innovations to the grassroots.
11	Link all medicinal apparatus esplus procedures concluded through inter web	During COVID-19 treatment, the Internet of Things (IoT) connected every clinical device and device to the Web, transmitting continuous data during operation.
12	Truthful predicting of disease	Based on the available data, the use of a measurable approach may also help in predicting the situation in the future. It also helps prepare management, professionals, educators and others for a superior office.

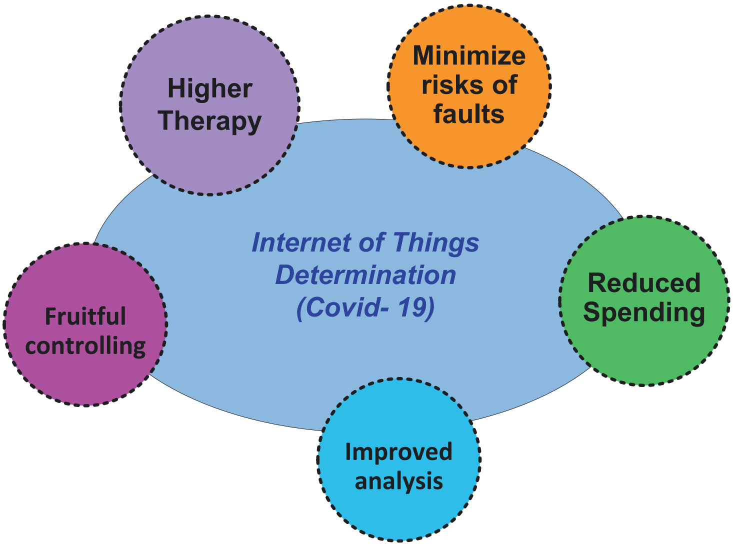

Fig. 22.2 Significant key benefits of utilizing IoT for battling the COVID-19 pandemic

A knowledge that is able to support reduce the necessity of emotive such things is the Internet of Things. IoT provides benefit to avoid infections similar to COVID-19 by removing the necessity to sense things to function them in several situations, be it at household, a lodging house, and workplaces.

22.7.1 Savvy Household Devices

Flexible GPS tracking aside, there are a lot of extra innovative utility cases and cases that show the bright side of the story. Smart video input phones, smart and discreet cameras, cool locks, smart lighting, smart TVs, and smart force air systems are just some of the smart home IoT devices available. In addition to improving the comfort of mortgage holders and residents, each of these devices can prevent delivery personnel from having direct physical contact with the milkmaid, Internet delivery operator etc. All of these devices are provided by contactless voice assistants. There are countless examples of how these innovative home appliances can help prevent physical contact and thus prevent disease. Take, for example, the video entrance telephone, which allows users to check in without having to contact visitors directly at their homes or appear at the front door.

22.7.2 Canny Household

There is a plenty of IoT gadgets, for example, keen video entryway telephones, brilliant locker, shrewd illuminations, savvy Television, and savvy climate control systems, among others, that can include a great deal of accommodation for shrewd home-use cases. These gadgets can be controlled without contact by utilization of voice partners, for example, Google Assistant, Alexa, and Siri, or through your cell phone. For instance, video entryway telephones can assist clients with checking guests at their home. With two-path sound of the video entryway telephone, clients can associate with guests through portable applications and can thoroughly take out undesired and less-significant guests. Especially, it tends to be exceptionally helpful when you are managing food and web-based business conveyances. Moreover, monitoring illuminations, blower, air conditioner, and other home machines is effectively conceivable without contacting the switches or utilizing remotes. Clients can likewise plan on and off occasions of these apparatuses, further diminishing the physical get in touch with one needs to do to turn on and off the machine.

22.7.3 Savvy Office

Major use instances of IoT in an office domain are smart water and refreshment distributors, keen access controls, and brilliant office of the executives that incorporates control of illumination and air conditioner utilizing IoT. Brilliant allocators can be controlled through motions, versatile application, and voice orders, ruling out any physical contact with normal assets, for example, water containers and espresso machines. Keen access controls that are non-biometric and depend on mix of radiofrequency identification tokens or arbitrarily tokens on portable applications additionally empower representatives at the working environment to gain admittance to explicit territories without having any need to contact any entrance control framework, which are in any case utilized by various representatives every day. Brilliant office of the executive decreases vitality utilization, yet in addition wipes out the need to control lighting and high voltage and air conditioning (warming, ventilation, and cooling) at work environments through switches. Utilizing a concentrated cloud open dashboard, office directors can set calendars, situations, and rules for controlling and setting proper modes for assets, for example, lights and heating ventilation and air conditioning.

22.8 Brilliant Workstation Devices

As isolation is gradually being lifted far and wide and individuals are gradually beginning to come out in the city, and numerous workplaces are opening with a bit of their worker quality, there is a dread that the infectious cases out of nowhere detonate if the individuals begin getting rid of the social removing standards. All things considered, working environments continuing their work in the post isolation period can be generally powerless against the episode. Utilizing savvy contactless IoT arrangements in the workplace situations, for example, the smart water and drink gadgets, brilliant registration frameworks, shrewd access controls, and keen office, the executives can limit the individual presentation to physical contact in working environments. For example, keen distributors that can be controlled through signals or versatile application controls or voice orders can decrease the chance of physical contact to a base. The equivalent can be said about keen espresso machines. Internet of Things for lever Patients Precaution Controlling Web of Things isn't simply constrained to shrewd homes or savvy working environments; however they as of now assume a significant job in current clinical and medicinal services foundations around the globe. During this pandemic, the clinical Internet of Things biological system is viewed as the correct innovation to meet the enormous scope persistent consideration needs. The versatility of Internet of Things frameworks is significant now for observing an enormous number of high-hazard patients. Regardless of whether in isolate or seclusion offices or in medicinal services offices or independent COVID-19 emergency clinics, the Internet of Things-empowered checking frameworks can truly ponder by delivering constant patient following information to guarantee quicker dynamic which is critical for containing an infection episode of such length and gravity. Such brilliant frameworks can really get rid of the need of the human services suppliers to go entryway to entryway for doing tests and for following the cases in thickly populated urban settlements. Internet of Things can likewise assist numerous patients with checking their internal heat levels and transfer the data on the cloud bolstered application for the specialists to complete investigation and take proper measures as appropriate. Such mechanized and keen frameworks help human services suppliers accumulate colossal information in substantially less time and use the information to follow the contacts and contain the infection as quickly as time permits. Above all, such robotization and smoothed out procedure of following and assembling information can truly diminish the outstanding task at hand of the clinical staff so they can work with less pressure and focus better on persistent consideration and treatment.

22.9 Pathway to Trace Isolator

A basic advance to check the spread of COVID-19 is the successful isolate of contaminated or seen to be tainted individuals. Yet, in a worldwide world, this is actually quite difficult. Thus, nations all through the world went to Internet of Things- and

Global Positioning System-empowered applications to follow and, when vital, limit such individuals' developments. Many countries are a couple of nations that are going this course. These countries began its isolate endeavors from the air terminal. Showing up travelers were given wrist-groups alongside an exceptional Quick Response Code to follow their developments. Travelers downloaded an application called "Stay at Home Safe" on their cell phones and examined the Quick Response. On arriving at home, the individual needed to stroll around the loft to adjust the gadget. The fundamental innovation is Geofencing, where a virtual border is made utilizing Global Positioning System, radio frequency identification, wireless networking, Bluetooth signal, and cell arrange.

22.10 Pre-screening or Analysis

While emergency clinics and clinical focuses rushed to begin telemedicine administrations to analyze and respond to inquiries concerning COVID-19, the quantity of calls was overpowering. As per healthcare, the normal hold-up time on their hotline topped to 30 minutes, and numerous guests even dropped out inside this time. To counter this issue, programming organizations teamed up with clinics and clinical focuses to set up talkbots on their site and versatile applications. These talkbots pose a progression of inquiries to screen guests as indicated by the seriousness of their conditions. Along these lines, the specialists and clinical staff don't need to address similar inquiries again and again. They can rather utilize this opportunity to treat patients.

22.10.1 Dusting and Sanitizing

Dusting, disinfecting, and sanitizing of clinical offices are crucial, and the irresistible idea of COVID-19 further underlines this progression. Because of organizations' disinfection services, self-driving robots are utilized for this undertaking. They purify the surfaces by transmitting high-force bright light, which wrecks the infection by destroying their deoxyribonucleic acid. They are wireless networking based and can be controlled through applications.

22.10.2 Imaginative Usages of Drones

With social-separating turning into the new typical, drones have discovered some inventive employments:

1. To screen and implement the stay-at-home requests
2. To sanitize the exceptionally tainted hotspot

3. To fly clinical examples and isolate materials
4. To check temperatures of those in isolate through infrared thermometers mounted on drones while the patients remain on their overhang

22.10.3 Keen Hotel

COVID-19 has had the most impact on the hospitality industry. IoT can help the company with zero contact registration, which is consistent and reduces the time guests spend in the inn's hall. IoT technology is also suitable for incorporating personalized interaction with visiting environments. They may interact with room administrators and the front desk using voice partners installed in rooms. Flipping through channels or film collections on your voice-controlled smart TV, manipulating window decorations in the room with voice commands, regulating room lighting, and setting appealing temperature/mode on ACs all contribute to the visitor's comprehension and provide a no-contact experience.

22.10.4 Diminishing In-Household Contaminations

There is an expanding mindfulness among individuals to abstain from contacting powerless surfaces like door handles, light switches, and so on especially in the wake of contacting sends or bundles. Rather, they use IoT-empowered shrewd speakers, lights, security frameworks, and so forth to open entryways and switch on lights. Truth be told, this individual as of late utilized his shrewd security framework to demand the conveyance fellow to go out while he opened the entryway from his telephone.

22.10.5 Versatile Tracking Applications to Prevent COVID-19

As a rule, the principal bunch of cases tainted by the coronavirus has some movement history. This is the reason it is critical to follow the areas and developments of individuals and test their well-being in time. Such following endeavors frequently face mishaps; the same number of individuals disregarding sharpening about the genuine effect of the infection simply decreases to coordinate and even attempt to get away from the tests. While following these individuals can be troublesome by utilizing a customary carefulness and reconnaissance framework, versatile following applications can assume an extremely helpful job in this. Versatile applications can undoubtedly follow the enlisted people by utilizing the GPS trackers permitting specialists to tell about individual areas IoT is getting even more a need than extravagance for homes, workplaces, and lodgings. In view of social removing and to stay away from numerous touch focuses, versatile applications and voice control are the best approach forward. Then again, with the stay at home requests set up, Internet of Things gives us the adaptability of video conferencing and furthermore for all intents and purposes meeting our friends and family with a basic voice order.

22.11 Simulated Intelligence with IOT Initiatives Is Already Emerging

A few governments and emergency clinic frameworks around the globe have utilized artificial intelligence-fueled sensors to help triage in complex manners. Innovation organization designs a no-contact infrared sensor framework to rapidly single out people with a fever, even in swarms. Railroad station is furnished with this framework to distinguish possibly infectious people, supplanting an awkward manual screening process. So also, hospital sent an artificial intelligence framework in a joint effort with care at its passageways to capture people with potential COVID-19 manifestations from visiting patients. Through cameras situated at passageways, the innovation leads a facial warm sweep and gets on different side effects, including sweat and staining, to avoid guests with fever. Past screening, artificial intelligence is being utilized to screen COVID-19 side effects, give choice help to computed tomography examines, and mechanize emergency clinic tasks. The Hospital utilizes an Artificial Intelligence driven Computed Tomography check translator that distinguishes Covid-19 when radiologists aren't accessible. Some hospital built up a brilliant field medical clinic staffed to a great extent by robots. Essential signs were checked utilizing associated thermometers and wristband-like gadgets. Canny robots conveyed medication and food to patients, lightening doctor introduction to the infection and facilitating the remaining task at hand of social insurance laborers encountering depletion. Furthermore, in South Korea, the legislature discharged an application permitting clients to self-report manifestations, alarming them on the off chance that they leave an "isolate zone" so as to check the effect of "super-spreaders" who might somehow proceed to contaminate enormous populaces. Also Internet of Things and simulated intelligence tools and innovations help strategists, the clinical network, and the community's efforts to combat each stage of an emergency and its consequences everywhere: identifying, anticipating, responding, recovering, and expediting research as shown in Fig. 22.3.

22.12 Utilizing AI with Internet of Things to Help Identify, Analyze, and Forestall the Spread of the Coronavirus

Computer-assisted intelligence may also be used to identify, diagnose, and prevent disease transmission. Algorithms that detect instances and symptoms are now identifying and evaluating COVID-19, while image recognition frameworks are

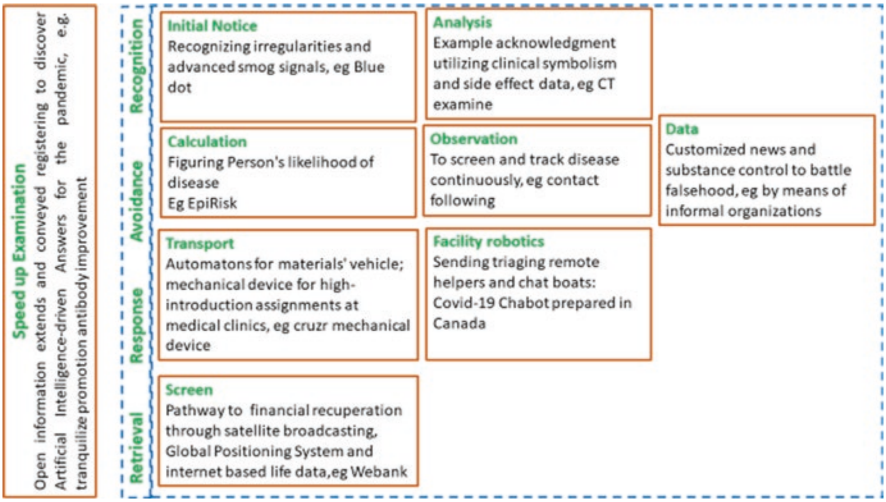

Fig. 22.3 Instances of AI applications at various phases of the COVID-19 emergency

speeding up clinical analysis. Computer-controlled early warning frameworks, for example, aid in the detection of infectious conditions by standardized mining news, online content, and other data sources in a variety of dialects to provide early warnings that can complement syndromic surveillance, other human service systems, and information streams (e.g., the WHO Early Warning System and Blue Dot.) AI devises aid in the identification of illness transmission networks as well as the elucidation of larger economic ramifications. Advances in artificial intelligence have shown the capacity to analyze epidemiological data quicker than conventional ways of capturing health data in certain circumstances. Organizations like Johns Hopkins University and the Organization for Economic Cooperation and Development (oecd.ai) have also developed user-friendly dashboards that follow the progression of infection through live news and confirmed coronavirus cases, recoveries, and continuing statistics on mortality. Rapid diagnosis is critical for controlling the infection and understanding how the illness spreads. COVID-19, when applied to AI, pictures, and display data, may aid in the speedy analysis of situations. To guarantee uniformity and accuracy, data from the whole population must be gathered. Disease control is critical in all nations, and artificial intelligence technologies may help limit the spread of illness. Population monitoring is used in several nations to identify COVID-19 instances (e.g., accounts in Korea use geolocation information, survey camera film, and visa records to track coronavirus patients). By configuring the phone in China, each individual at risk of infection is given a risk level (shading symbol, red, yellow, or green). While AI algorithms anticipate the location of the next episode and propose border checks based on travel, payment, and correspondence data, online and web-based life indicators are also valuable for continuous illness monitoring. Many nations, including Austria, China, Israel, Poland, Singapore, and Korea, have implemented contact monitoring systems to identify illness development. Geolocation data, for example, has been utilized in Israel to identify persons who are closely affiliated with known disease vectors and to send instant messages to them requesting quick departure. Robots and semi-autonomous mechanisms are sent to emergency clinics to answer to urgent needs such as food and medication delivery, cleaning and sterilization, supporting doctors and midwives, and moving equipment.

22.13 How Artificial Intelligence with IoT Can Help the Reaction to the Emergency and the Recuperation to Follow

Conversational and intuitive AI frameworks assist in responding to a wellness emergency by providing tailored data. Guidance, therapy, and education are all accessible. To fight phishing, the "source of information" for COVID-19, commercial organizations and web crawlers use artificial intelligence algorithms devoted to detecting and eliminating accounts, data, and problematic items based on them. Small help and chatbots have been provided to human service groups in Canada, France, Finland, Italy, the United States, and the American Red Cross. These tools aid in the classification of persons based on the closeness of attributes. The Centers for Disease Control and Prevention in the United States and Microsoft have collaborated to create a coronavirus self-testing unit to assist consumers in self-assessing COVID-19 and recommending a strategy. Individuals that are vulnerable or at high risk should be identified, identified, and contacted. For example, the Medical Home Network, a Chicago-based non-profit, has used AI to identify Medicaid patients who are at high risk of COVID-19 infection based on their respiratory difficulties and risk of community isolation. In the long term, artificial intelligence will help to accelerate medical professional preparation and training. Finally, AI devices can assist in monitoring and recovering from a financial crisis, such as the use of satellites, unlawful long-distance communications, and other data (such as Google Community Mobility Reports), as well as learning from occurrences and generating early warnings.

22.14 Key Proposals with Internet of Things and Artificial Intelligence

Governments and different partners are urged to the following:

AI group of individuals, designers and issue identifiers, differentiators of important information, strategists for open data sets, and tool sharing, promoting and training models for big and worldwide interdisciplinary, multi-partnership joint ventures and communications trading. It should be noted that AI does not always have a silver lining. Man-made and AI-based intelligence frameworks function by breaking down designs into information, and a large amount of data is required to uncover these instances. The results are only compared to the prep information and, at times, cast doubt on the analytical instances, and some chatbots have responded differently to inquiries regarding adverse effects. Ensure that AI frameworks are effectively disseminated and that the OECD artificial intelligence principles are followed. This is particularly true for permanent population monitoring and control ratios, where some AI frameworks raise issues about causal details and the danger of misusing personal information in ways that violate numerous safeguards and rights. Action is meant to study AI breakthroughs that may benefit from controlled data, such as that provided by patients with certain diseases. The Data Science Group and Artificial Intelligence (ML) are working to develop metrics for epidemiological models, reconstruct data flow via Twitter to promote system executives, and review the success of strategies to prevent its spread. As a result, various data sets are instantly posted to the public population. However, as COVID-19 becomes more widely used [15, 16], more data must be retrieved, created, and analyzed. The epic coronavirus is having an economic effect. Because of the ease of transmission, which occurs mostly by saliva capsules or discharges from the nose when an infected individual inhales or inhales, populous nations must be especially cautious [17]. We present a machine learning model that can apply non-NU to determine how COVID-19 impacts the global population and to predict the number of COVID-19 cases and epidemic end dates in various nations. Stop for a correct evaluation of the spread by legislators and citizens, as well as proactive optimization of the main response (cloud data centers).

22.14.1 Cloud System

The ML models with IoT are worked to make a decent propelled expectation of the quantity. New cases and epidemic end dates. To provide a quick poll of advance calculations and information, we propose a system for transferring these models to cloud data centers as shown in Fig. 22.4. In a cloud-based situation, administrative emergency clinics and non-private welfare places send out. Stop their positive patient tally. Populace thickness, normal and middle age, climate conditions, well-being offices, and so on are additionally to be incorporated for improving the precision of the forecasts.

22.14.2 Different Issues and Future Extent of the Examination

The main reason for concern when using the Internet of Things in the current COVID-19 epidemic situation is the privacy and preservation of the data obtained, which is unique and crucial from a long-term health perspective. The next thing to check is the precautions to be taken when integrating the information organization

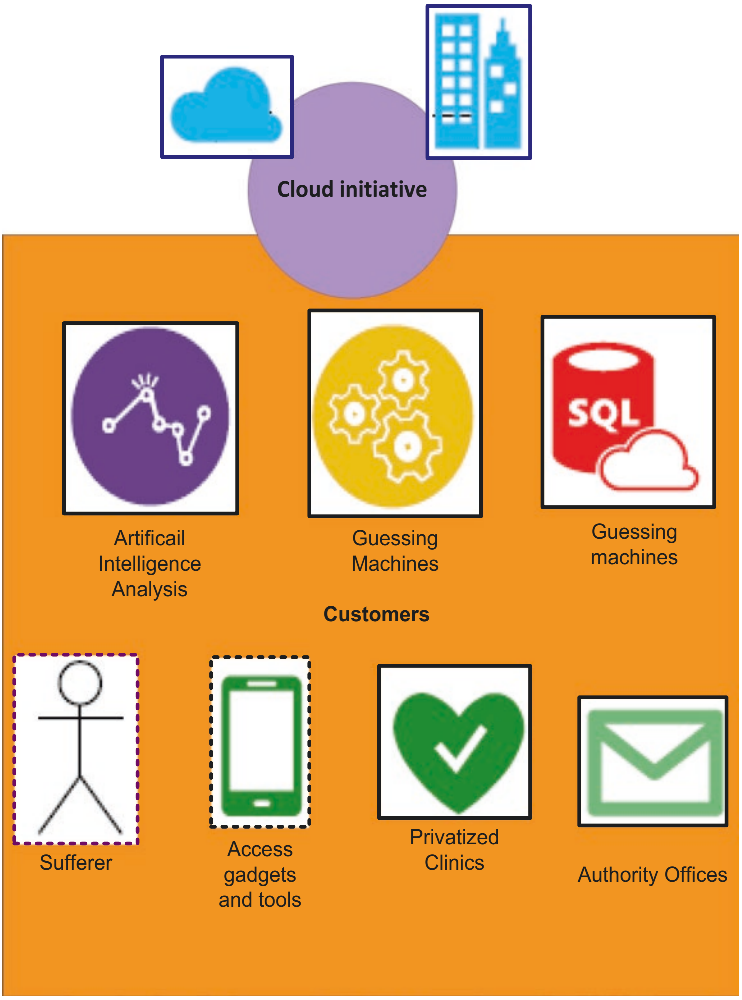

Fig. 22.4 A system to convey models on cloud datacenters

between the relevant tools and conferences. Figure 22.3 illustrates the synthesis of concerns and challenges in using IoT for the COVID-19 pandemic. Furthermore, future efforts should focus on database and executives. Additional research will also look at how to submit financially reasonable selection applications. The COVID-19 pandemic has prompted researchers to explore some new areas for current and future infections. In Fig. 22.5, the most prominent research fields are shown.

1. Consolidating different pointers: Important boundaries like populace thickness, conveyance old enough, individual and community developments, level of social insurance offices accessible, strain type and harmfulness of the infection, and so forth should be remembered for the relapse model to additionally improve the expectation exactness.

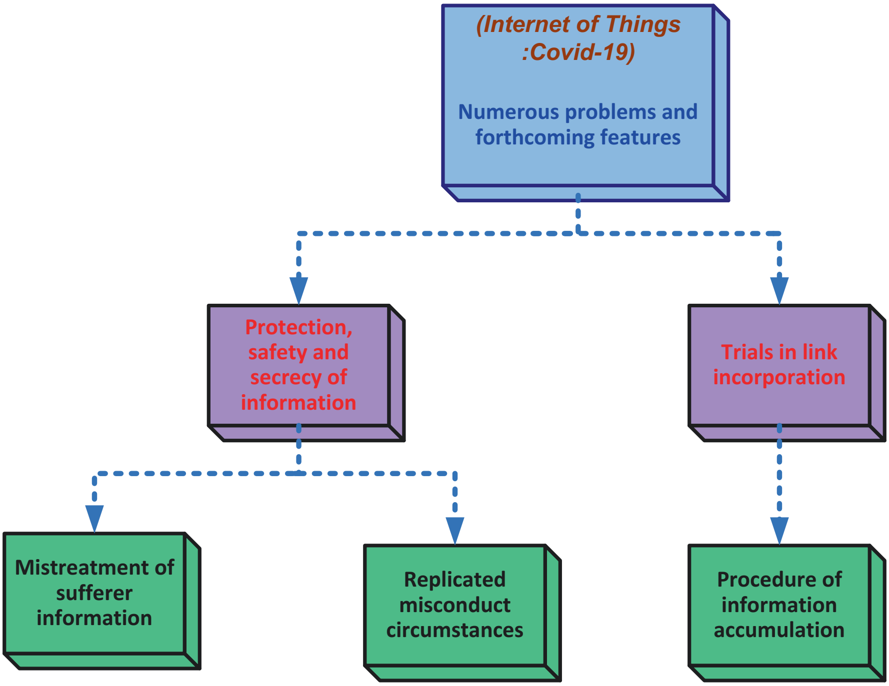

Fig. 22.5 The overall view on concerns and challenges in using IoT for the COVID-19 pandemic

2. Coordinating with other time arrangement models:
   Models like autoregressive integrated moving average can be incorporated with Weibull work for additional time arrangement investigation and expectations.
3. Anticipating protein structure of CoV-2:
   Artificial intelligence can be used to foresee the structure and capacity of different proteins associated with CoV-2 and their association with the host human proteins and cell condition. The commitment of different financial factors that decide the powerlessness, spread, and movement of the scourge can be predicted by creating reasonable calculations. This can help productively choose asset portion in enormous nations with constrained medicinal service assets.
4. Dissecting online networking information utilizing artificial intelligence:
   We can likewise investigate and examine Internet-based life information for continuous assortment of epidemiological information identified with COVID-19 [15].
5. Contactless therapy and robotic drug transfer:
   AI-based robots can be used to remotely treat patients to make contactless deliveries and reduce the involvement of medical personnel in contaminated individuals. Furthermore, there have been significant improvements in air quality worldwide due to the implementation of COVID-19 lockdowns.

6. Climate change: There have been significant improvements in air quality worldwide due to the COVID-19 positive lockdowns. In any case, there is a general speculation about retaliatory pollution after this closure. Large-scale research that considers age allocations and the socioeconomics of different traits is focused as part of future work.
7. Risk assessment: The risk of serious infection associated with COVID-19 in people of different ages can be estimated using artificial intelligence. Using these accounts, precautions can be taken to prevent the spread of infection to sensitive public meetings.
8. Sensors and continuous visual imaging: Sensitive meetings in the general public can take precautionary measures based on artificial intelligence to prevent the spread of infection. Continuous sensors can be used, for example, during rush hour or on a surveillance camera, to track COVID-19 indicators based on visual imaging and the following applications, illuminating administrative professionals for specific clinics and correctional activities. The following requirements cover all stages, from departmental outlets to open spots and emergency clinics.

The examination information with experiments exist which are brief in Fig. 22.6.

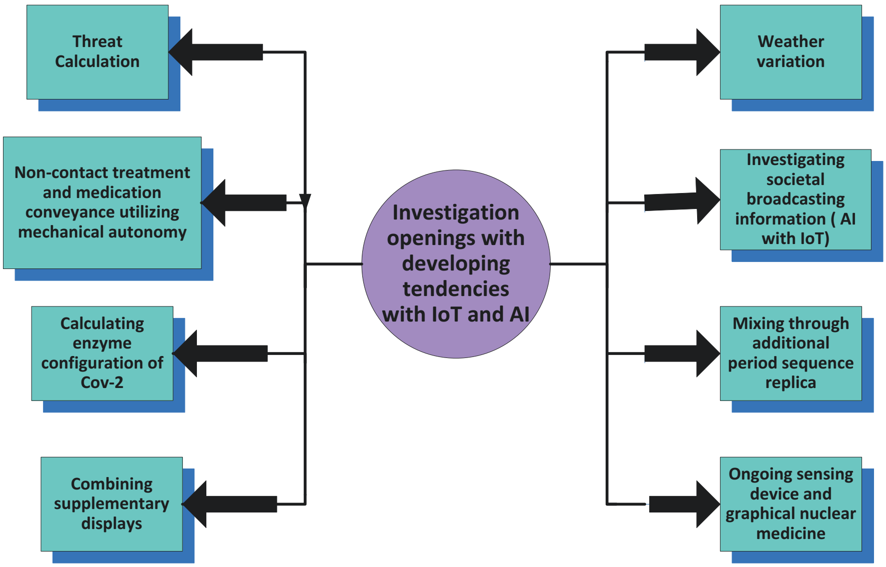

Fig. 22.6 The examination information with experiments exist

22.15 Conclusion

To combat the COVID-19 epidemic, the Internet of Things provides a comprehensive and coordinated mechanism for social insurance. Each clinical device is connected to the Internet and sends a message to the medical staff in case of an emergency. Contaminated cases can be adequately handled in a remote location with all the necessary remote equipment. He carefully examines all cases to provide better services to human services and patients in the long run. The Internet of Things seems to be an excellent way to test an infected patient. This innovation is important in human services to maintain quality control using real-time data. The Internet of Things is convenient for predicting the future and future status of this disease using a measurable strategy. Properly covered, it will withstand a great deal of adverse conditions.

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