A Comprehensive Survey for Internet of Things (IoT)-Based Smart City Architecture

Rohit Sharma and Rajeev Arya

Abstract With the advent of mobile technology, the modern paradigm of "connected everyday objects" was built over the current network. The tremendous development of networked devices had increased its reach over the primitive network topologies. This significant change has launched the revolution after flat-page. The surge in the global urban population is placing new demands on people's daily lives in terms of pollution, public safety, road congestion, etc. To accommodate this rapid growth, new technologies are being developed and smarter cities are being built. Incorporating the Internet of Things (IoT) into everyday life makes it possible to develop new smart solutions such as services and applications for industries like hospitals, surveillance, forestry, etc. Research on Artificial Intelligence (AI), Deep Learning (DL), and help of Data Visualization have shown how IoT performance can be improved with some technological aids. This creates a rapid demand for addition and works in terms of Big Data with first-class technologies that we have around us, so in this paper, we will talk about such things and show a comparison on this basis with the other works that are under it, with the deep learning and artificial intelligence models. This study will help us to show how it overall contributes to the growth of the Internet of Things in society to provide a better life for future generations. Finally, we will outline the existing obstacles and problems that occur during the smart city growth facilities.

Keywords Internet of things (IoT) · Deep learning (DL) · Artificial intelligence (AI) · Technology · Services · Applications · Smart city · Innovation · Data visualization · Big data

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1 Introduction

The Internet of Things is a spider web of software, sensors, databases, and other devices superfluous web. The hardware differs in intricacy from ordinary household chattels to suave business systems. Analysts say that by 2020 there will be a shift to 10 billion connected IoT gadgets, and by 2025 there will be an upward growth of 22 billion [1]. IoT has emerged way lot over the past few decades and gaining importance day by day. This helps us in day-to-day living as we have multiple gadgets interfaced using the Internet which makes our life easier in simple terms. Digital systems are very efficient in log management and also sorting life in a better way with the aid of computing technology and analytics in providing a solution to mankind's problems. The IoT is a distributed web of connected gadgets, which are Internet-enabled entities that can receive and send information non-connection oriented without human interaction. These possibilities for reserved or business growth exceed boundaries. A networked biological device, a small electronic chip transceiver, a solar cell, a networked automated braking equipped car (gas, tire-tubes pressure, required scheduled maintenance, and much more), or other item equipped with electronics and the ability to collect and emit data wirelessly is a "thing". Industrialists are now taking inspiration from IoT and developing positive revenue, lower operating costs, and better customer service, as well as increasing efficiency in regulatory enforcement, are also driving businesses. IoT system implementations provide the bulk datasets and inner results needed to optimize workflows, visualizing user patterns, automating the processes, meeting parameters, and operating more effectively in a changing marketplace for whatever reason. The IoT is an ever-growing network capable of autonomously discovering and sharing data about distinct devices that are special. Due to the success of embedded tech and the exponential growth of embedded device technology, the IoT has become the focus of various stakeholders.

Recent developments in a variety of technologies have made it a reality. Less-cost, less-power sensor tech is there. IoT technology is now getting the door-to-door and suppliers and industries due to its less cost and varied applicability. Cloud computing platforms and cloud services are becoming more widely available, giving businesses and customers access to the technology they need to scale without having to worry about everything themselves. IoT has paved the way for big data analytics and the data collected through these sensors is turning into a mine of gold for companies and business is taking place as a result and they are selling these data for better and efficient life by analysing all the odds. Artificial intelligence (AI), conversational, and natural language processing (NLP) have made their way into IoT devices (e.g. Google, Bixby, Alexa, Cortana, IBM Watson, and Siri digital personal assistants) thanks to advances in neural networks, making them more attractive, accessible, and viable for home use. So, from the above interpretation, we can conclude that IoT means connectivity between billions of IoT-based devices. Such capabilities give power to normal gadgets that can run in real-time, adapting with conditions, and run with zero interference/control. Electronics which are now embedded in various urban centres, resulting in a huge amount of data being collected. Before it can

be viewed, the collected data needs to be stored, analysed, and processed using specialized models and visualization tools to make it useful for better insights. The recent emergence of IoT data has led IoT big data analytics, including machine learning analytics, to gain significant traction recently: ML, DL, and Computing Infrastructures, especially as conventional data processing techniques have encountered numerous limitations, especially when dealing with big data. DL algorithms have paved way to deal with similar problems. DL algorithms enable developers and enthusiasts to process real-time data with great precision and relatively much better performance. Plethora of studies have been conducted with DL. The results were ranging from various domains which led a broader sight for IoT-based cities and other baby strides towards their growth. In this report, we have chosen Smart City as the primary application because IoT-based cities have wide instances and case studies, the IoT sector instances. We then describe instances that arise in a speculative IoT-based city, including in home, in health care, in transportation, in surveillance, in agriculture, and in climate monitoring system. We further did a juxtaposition based on several parameters with challenges faced in these cities. Apart from this, we tried covering out the recent trends and issues going round the globe.

2 Related Work

Atitallah et al. [2] have presented a survey paper over the IoT-based cities, and they include a summary of the literature on the use of IoT and DL to build smart cities in their survey. They start by defining the Internet of Things (IoT) and describing the characteristics of IoT-generated big data. Then, they go through various computing infrastructures that are used for IoT big data analytics, such as cloud, fog, and edge computing. Following that, they review recent research that uses both IoT and DL to create smart applications and services for smart cities, and they survey common DL models. Finally, they have discussed some of the existing problems and concerns that have arisen as a result of the growth of smart city services. Silva et al. [3] worked on big data analytics for embedded smart city architecture for estimating the performance and worked for its enhancement through real-time data processing and decision-making for data collected for a year through their hardware and resources. The integration of Big Data analytics with smart city architecture is discussed in this paper to suggest a practical and feasible structure for the implementation of smart cities. Real-time intelligent decision-making, autonomous data collection, and user-centric energy customization are all possible with the proposed architecture. The most influential factor for the realization of a smart city, however, is decision and control management. As a result, the new scheme's most important aim is to achieve real-time and timely decisions. Fusion techniques also help to speed up the analysis of the massive amounts of data generated in Big Data analytics. Mohammadi et al. [4] did a comprehensive study on the different areas including in home, in the city, in energy, in healthcare, in Agriculture, in Education, in Sports, in Retail, and in IoT-based infrastructures, for IoT applications and facilities, with the most up-to-date deep

learning (DL) methods which are tested. Side by side with the analysis using Big Data Analytics Model, Mahdavine et al. [5] in this survey investigated various types of ML techniques and methodologies implemented to probe and summon IoT-based data in various IoT-based smart city use cases. The writer's defined and gave a juxtaposition of ML algorithms and reviewed the usage. Also, they discussed the vulnerabilities and challenges at last which are implemented in big data analytics. The significance of this paper's contribution. The aim is to respond to the following questions: What kind of MLA could be used on IoT smart data? What is the classification of MLA that can be used in the Internet of Things? What is the facet of IoT data in the real world? What makes the IoT-based City a standard IoT technology use case?

Zhang et al. [6] in their paper discussed the different wireless networks typically in mobiles with the implementation of DL. Also, some basics of deep learning with it for better understanding for the readers highlighting immediate problems and advantages in mobile network and a study based on the different aspects and scenarios. Zhang et al. [7] in their research studied four different ways by which DL is used in big data which are as follows: stacked auto-encoding method, deep belief networking method, CNN, and RNN. Also, they made some classifications based upon their work: bulk data group, distinct data group, the streaming data group, and finally the reduced-quality data group. Qolomany et al. [8] in their paper studied and showed how different ML is used in big data to make a qualitative analysis. They reported on and classifications made in IoT-based smart cities on various parameters which helps a city to run and depend on each other at different topologies. Chen et al. [8] conducted a brief study on how DL is used in smart IoT-based cities. He looked at the most common models and summarized the most recent researches in various IoT-based cities using cases and instances, such as vehicle management, the healthline sector, the climate, and data privacy.

3 Recent Trends and Overview

In the Figs. 1 and 2, we can see a graph which depicts the search interests of people around the globe for Internet of Things from year 2004—present; the graph has increased tremendously. This field is gaining more and more importance in today's world due to its applicability's in daily life and easing everyone's task.

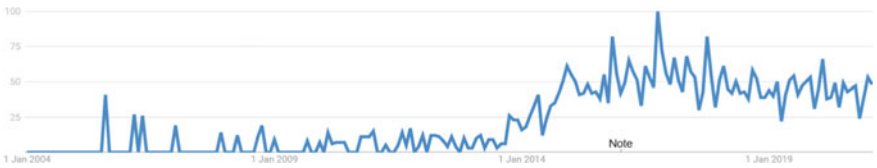

Fig. 1 Internet of Things trends search history interest on google search results

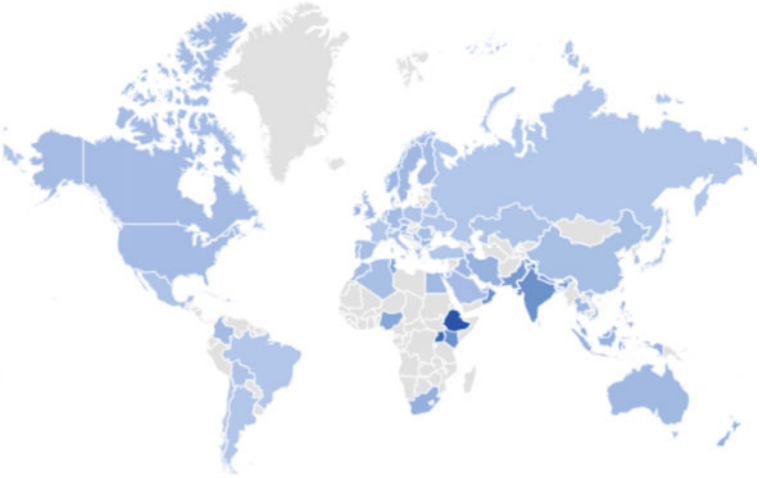

Fig. 2 Worldwide trend for Internet of Things as per search history interest on google search results

Thus, more and more people are engaging for research and finding more application of IoT. The second graph it is shown on the world map over 7 continents showing peoples interest over these many years. The darker the region, the more the search interest and people's engagement with that topic and the greyed-out areas still have not searched it on the Internet [9]. The time interval between each year is taken around 5. Out of which, if we talk about the ranking of top five countries based on their search interests then Ethiopia ranks first, Mauritius ranks second, Singapore ranks third, India ranks fourth, and Uganda ranks fifth, with having related search queries topics as the Internet of Things, cloud computing, artificial intelligence, big data and what is Internet of Things? etc [10].

In the above Figs. 3 and 4, we can see a graph which depicts the search interests of people around the globe for big data analytics from year 2004—present the graph in comparison to Fig. 1 has increased violently and much sharper and have been increasing [11]. Just because after the infrastructure have been implemented for IoT the work does not stop here the hardware generates a large amount of sensitive data year after year which needs to be stored somewhere for which we use cloud databases and people and this new field of IT is emerging at a lot faster pace and the demand for data scientists and engineers is increasing who can study this big amount of data and

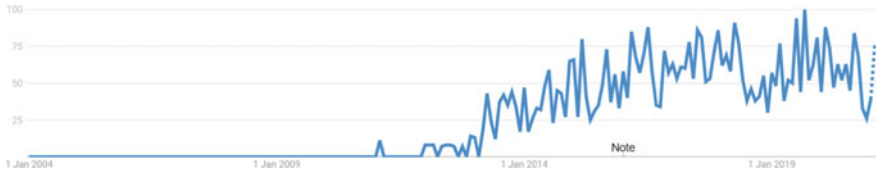

Fig. 3 Big data analytics trends search history interest on google search results

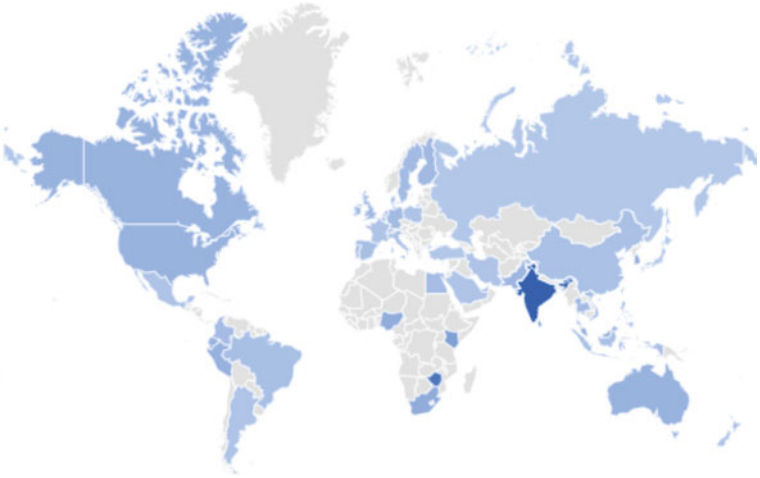

Fig. 4 Worldwide trend for big data analytics as per search history interest on google search results

can provide efficient results for the mankind to improve the quality of our lifestyles. The second graph: It is shown on the world map over 7 continents showing peoples interest over these many years. The darker the region, the more the search interest and people's engagement with that topic and the greyed-out areas still have not searched it on the Internet also can be termed as no work is possibly been done here on this topic and field. The time interval between each year is taken around 5 [12].

Out of which if we talk about the ranking of top five countries based on their search interests, then Singapore ranks first, India ranks second, Zimbabwe ranks the third, Hong Kong ranks the fourth, and Sri Lanka ranks the fifth, with having related search queries topics as big data analytics tools, big data analytics salary, tools for big data analytics, best big analytics tools, data analysis, etc [13]. Also, we can notice a difference in between Figs. 1 and 2 that Internet of Things took popularity around the year 2007, and whereas the term big data analytics gained importance at quite a later stage, i.e. around 2011 when it was felt that there was a need to secure this large data and, also, we can study this data for providing efficient solutions to the society. On the contrary, the first IoT-based device was discovered in early 1980s and the big data term was coined around 2005 [14].

In the Fig. 5, it shows an analysis of total estimated technological investments worldwide that is to be made in billion dollars which is estimated to be around 189.5 billion US dollars approx. towards it by the year 2023. By this graph, we can also conclude that the amount of money invested in this field has increased gradually since 2018 to 2023 [15]. In our paper, we will focus on some sectors of smart city to check onto the different technologies that are used in these and who these are integrated all together. Which is shown in the below flowchart Fig. 6.

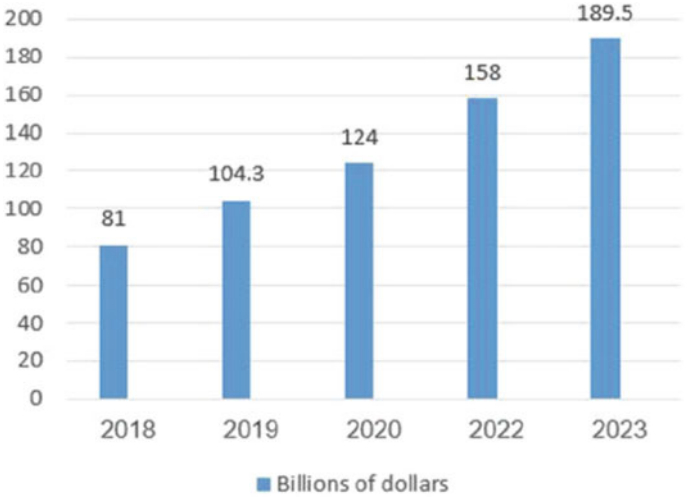

Fig. 5 Prediction made for technological investment for IoT worldwide

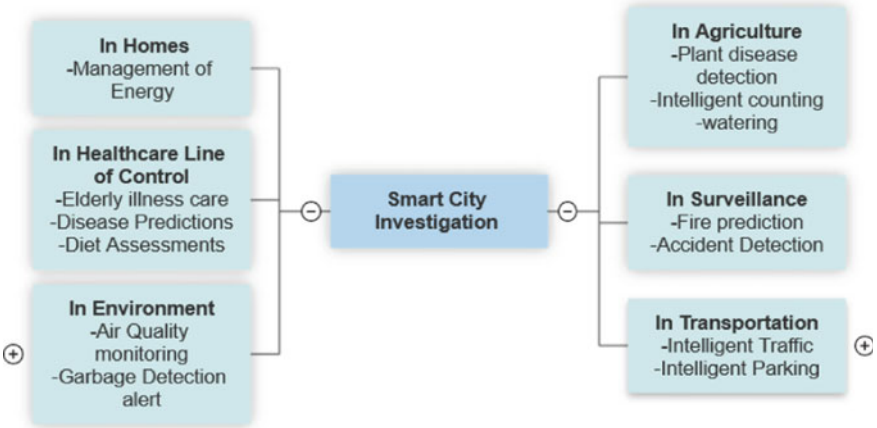

Fig. 6 Smart city investigation chart

In homes, we know that IoT is implemented for energy management; apart from this, it is also used for audio systems, security, inventory management, etc. In agriculture, IoT is used for detection of plant disease, and water regulation for watering the plants and other applications like soil Ph level and pesticide tracking. In healthcare department, it is implemented for the treatment of people above the age of 60, prediction of some hard-to-find disease using deep learning and artificial intelligence also, nowadays robotic surgery is happening which is responsible for zero human interaction, and someone can operate from far off place. In surveillance, it is used

for predicting the outbreak of fires in buildings, industry or public places, as well as accident management [16]. In environment, IoT is responsible for monitoring the air quality and it can be done both indoor or outdoor to determine the colloidal or suspended particles in air which can be an issue for asthma or breathing-related disorder patients, as well some gases in environment and weather prediction as well based on the humidity level in air and wind movement and garbage detection as well. In transportation, IoT is very much helpful easing people's life by traffic management, parking management, and also estimating time of travel and various other things which help us.

4 Technologies Involved

4.1 Architecture of IoT

Before we discuss about the technologies involved in smart cities based on IoT, let us talk first about its architecture. IoT's architecture see Fig. 7, involves hardware which usually comprises sensors, printed circuit boards, Internet connection, communication channel, Hadoop system for storing data as a data lake, and analytics based on the data collected from different data marts based upon the criterion decided by the Hadoop developer and Data analyst [17].

Here, for storing data people prefer NoSQL databases or cloud databases to store data which are large and raw data which cannot be used directly. The analysis

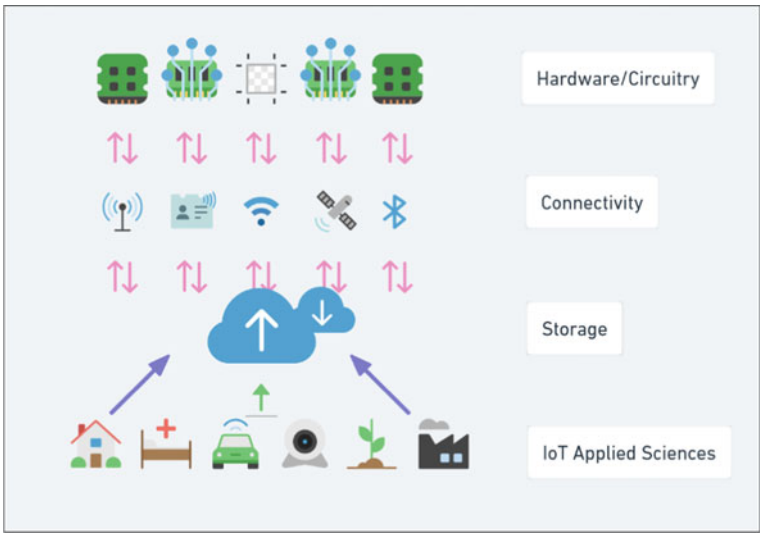

Fig. 7 IoT Architecture

performed over these data after filtering out is of three kinds: descriptive analytics, predictive analytics and prescriptive analytics (which is discussed later this section). This helps us to get an estimate or exact data for developing applications and software for them. As data analysis is performed over a history of data, thus the more accurate results. The examples shown in Sect. 3 for search trends have a data from 2004 to 2021, thus showing a variation over a long period of time [18].

4.2 Analysis

In the **descriptive analysis**, there is a historical data which actually shows a juxtaposition between different data over a period of time such type of analysis is used mainly in industries for comparing their growth, finding potential customers, etc. In the **predictive analysis**, this is used by processing data with some BI (Business Intelligence) tools and performing ETL operation (Extract, Transform, Load) or maybe an ELT (Extract, Load, Transform) thus, as a result finding us a pattern over a range or sequence of data. In the **prescriptive analytics**, this method is a successor and a much more intelligent method over the said above this method actually analyses the data and before giving any kind of decisions it gives us the exact results which helps us to take decisions much better way [19].

4.3 Cloud Computation Techniques and Concepts

Now, we will see computational techniques the different **Cloud Computing**, technologies in big data analytics; the basic definition for the same is the data which can be accessed from the Internet form anywhere at any point of time and any number of times. Some cloud computing services which are offered nowadays are based ***storing data over the Internet***; in these kinds of servers, we use TCP/IP connections for the data pipelining. Others, like ***services that are featured over the Internet*** , in these kinds of cloud computation technique all the ready-made options are already there and we are supposed to perform our operations on them and get the result. The last one is the ***apps that run on the Internet***, and these are the files or software that run on Internet which are installed and often come up with some GUI.

Whatever data is collected from the systems installed, goes to processing which is based on deep learning algorithms designated specifically to find the results. Like, in our project we used one such model for end-to-end deep learning over the data for analysing. But these include some limitations such as like **cost of infrastructure** is too high for running such model and frameworks, signal strength is too important else **latency** can be a disaster while data analysis, redundant infrastructure should be there and some disaster management is required and data replications should be stored in racks and no more than two replicas should be stored in a single rack. Also, **data privacy** is one of the essential factors in this case as we have huge amount of sensitive

data which can be used by people who have malicious intent [19]. Other Computing techniques are Fog and Edge Computing. In *Fog Computing,* Fog is a component of something like a distributed network environment which is correlated to cloud computing and the Internet of Things (IoT). Computing resources that provide public infrastructure as a service could be thought of as a large, global destination for data; data from IoT nodes is formed at the network's edge. Fog connectivity is a portion of the Internet of Things (IoT) idea, which anticipates most of the device's individual use on a daily basis being linked to one another. Smart phones, wireless health tracking technology, connected vehicles, and VR technology using devices like Smart Glasses are only a few instances. *Edge computing* is an emerging virtualization technology that pushes business processes closer to datasets like IoT systems and local edge servers [20]. This relative vicinity to data at its source does provide large financial advantages, such as better perspectives, faster response times, and also more spectrum accessibility.

4.4 Models and Tools Used

Artificial Intelligence as term itself says that it is a kind of intelligence which is artificial not god's creation it is manmade creation which is able to compute and process data and provide us solution to daily life issues or business problems. This comes under Deep Learning; due to this feature, we are able to teach machines and learn new tricks from their errors using machine learning algorithms. There are many Deep learning Algorithms which are used in smart cities; for data analysis, we will discuss Deep learning models below:

- Yolo v3
- CNN and Mask R-CNN (Convolutional neural network.)
- RNN (Recurrent neural network)
- DBN (Deep belief Network)
- SAE (Stacked auto encoder)
- GAN (Generative Adversial network)
- DRL (Deep reinforcement learning).

These models can be further categorized into four types of techniques: supervised deep learning model, unsupervised deep learning, semi supervised deep learning and reinforcement deep learning.

Some tools which are used in deep learning (DL) are as follows:

- TensorFlow—it is a kind of framework for dl models interfacing and can be done by python, C++, Java, and Go language.
- Torch (if in python use pytorch lib)—it is also a framework for running dl models; it is interfaced via C, C++, Lua, OpenCL
- Theano—it is python-based library used in low level apis, and this is used mainly for RNN

- Caffe—it is a framework used using C++ via python, C++, MATLAB.
- Keras—it is library in python used in high level apis
- MatConvNet—it is MATLAB-based toolbox which is written in Cpp language
- MXNet—it is a library written in Cpp and often used using python, R, Scala, Cpp, Perl
- Google Colab—it is written in python and its best suited for machine learning, data analysis work.

5 Methodologies of Dl in IoT-Based Smart Cities

Now we will focus on how these deep learning methodologies are used in smart cities.

In Homes: Nowadays, most of the urban and modern homes are connected with Internet at every corner of house, thus with the advancement, people want everything at their palms to control things around which is possible through IoT they control all these using smartphones. Appliances like lights and bulbs, air conditioners, cameras, fridge, kitchens, or personal assistant robots and many other such things here, we can see how these things are connected together to give the optimal experience to the user and live life in a luxurious way. In smart IoT-based homes, the use of LSTM and CNN can help us in regulating the energy and managing the load-based AI. The data collected from various sensors are collected and stored in a db which acts as a data lake from here the deep learning algorithms designed takes the data and show the result and predictions; such results are used by companies for designing better and improved sensors and applications for future generations [21].

In Health care: In this sector, IoT is like a boon to mankind and helps in saving lives of many, and these are available in the form of some gadgets which can be wearable or not wearable, some trackers, or some transducer in bio medical which checks for some ailment and reports it into a db or AI-based system. This many a times helps us in estimating the future diseases and many other things which can be inhibited at a very early stage. One such example recently is neuralink which is developed by a neuro tech-based company which is founded by Elon Musk, this chip is implanted in human brain and brain can be connected through a connectionless medium to a smart phone which helps us to track many activities till now it has been experimented in pigs and have given successful results. Also in health care, OPEN CV, YOLOv3, LSTM, CNN, and GRU models are used for different applications such as treatment of people above the age of 60, prediction of chronic and acute diseases in people and kids. It is helpful in predicting some genetical disorder which is nowadays, a part of research in biomedical engineering. Also, this is helpful in creating reports collected from blood samples, or predicting intolerance charts in diet planning. Also, in estimating if a person is COVID positive based upon the symptoms ensuring social distancing and create a huge database and record and predictive analysis to control the wide spread of disease and create a vaccine [22].

In Environment: These sensors implemented at different institutions and buildings can also be used for applications where there is need to monitor environment such as air quality index and humidity. Weather conditions and wind speed, also, can be used for garbage management. RNN, ANN, CNN, R-CNN, and LSTM are used for estimating and prediction; this is also beneficial for prediction of pressure prone areas and forest fires as well. Thus, we can find a solution beforehand before any major loss.

In Agriculture: The use of IoT in agriculture specially for country such as India is very much beneficent and will ensure us in maximum production and less losses for a country where agriculture comprises of the maximum part in the GDP. The farmers can use techniques which checks for soil Ph level, level of water in soil, thus regulating the water supply, level of pesticides, keeping a regulatory check for throughout process form sowing to harvesting a crop. For prediction analysis, we generally use CNN model for analysis; YOLO and OPEN CV can also be used. Using contrast identifying methods or Scada system.

In Surveillance: Nowadays, most of the public areas and buildings are equipped with cameras which are connected with Internet for security purpose for theft, or some misfortunes. All these can be controlled using a mobile or systems also; AI-based motion alert systems or some other things can help us in identifying some issue before hand and thus helping in getting a quicker solution. For this mainly CNN and GPS, GSM-based detection technology is used which predicts such as fire breakouts, and sending an automated message on mobile with location.

In Transportation: The inclusion of IoT in traffic management system especially for centralized traffic monitoring system can be very useful; this can help us in predicting the traffic beforehand and help us to alert the passengers before about the traffic flow and civic authorities to take action based upon the real-time data they are getting through sensors and cameras for easy flow of traffic and vehicles. Also, segregating lanes based on IoT and predictive analysis can help a lot in regulating traffic. Apart from this, we can also use for parking lots for automated parking systems, thus ensuring less traffic on roads and payment systems based on RFID or NFC technology especially, in countries in India where traffic is worst on roads and management is poor also in the times of COVID-19.

These wireless transactions will ensure social distancing. Also, YOLOv3, LSTM, RNN and Mask R-CNN can be used in solving such issues.

6 Comparative Analysis

In the above, Table 1 we can see a complete descriptive point wise analysis on various aspects of the papers that have taken into consideration for this study with their limitations mentioned.

Table 1 Comparison of various paper in this study

Author	Journal name	Procedure	Field	Use cases	Main Purpose	Limitation
Atitallah et al. [23]	ELSEVIER	Detailed study	IoT and smart city	(1) Intelligent applications in home, health care, agriculture, vehicle, surveillance (2) Dl models and applications	Brief study to show an interrelation of smart cities with DL and tech stack used in it	The paper does not involve some new methods such as YOLO, image AI, open cv for smart city analysis adapted in DL
Silva et al. [2]	WILEY | HINDAWI	Detailed study	Big data and smart city	1. Car, 2. Waste, 3. Electricity, 4. Water, 5. Gas, 6. Society	Data which is being processed and was analysed the data was streamlined used for making decisions	Did not included the wide aspects of IoT and their applications with technology used
Mohammadi et al. [3]	IEEE journals	Detailed study	IoT	(a) In home (b) In megalopolis (c) In energy management (d) In Healthline (e) In agriculture (f) In education (g) In sports (h) In retail (i) In IoT-based buildings	For IoT applications and facilities, the most up-to-date deep learning (DL) methods are tested	(1) Does not go into great detail about smart IoT-based city facilities their wide aspects (2) Does not discuss various technical/business problems and concerns which are associated with the growth of IoT-based cities

(continued)

Table 1 (continued)

Author	Journal name	Procedure	Field	Use cases	Main Purpose	Limitation
Mahdavine et al. [4]	DCN	Detailed study	IoT-based megalopolis	(a) In energy (b) In mobility (c) In between citizens (d) In Urban city plan and modernization	Analyses machine learning methods and implementations in IoT-based cities city scenarios	(1) Four cases for IoT-based city implementations are considered: energy, mobility/movement, residents, and urban city planning (2) Does not look at the usage of dl methods for analysing IoT-based city data (3) Does not address the open problems surrounding IoT-based city growth
Zhang et al. [5]	IEEE journals	Detailed study	Cell phone communication networks	–	He studied deep learning methodologies and varied usage over cell phone networks	Does not look into the use of deep learning in various IoT applicability, particularly in the growth of IoT-based cities

(continued)

Table 1 (continued)

Author	Journal name	Procedure	Field	Use cases	Main Purpose	Limitation
Zhang et al. [6]	Information fusion	Detailed survey	Big data analytics	1. Massive quantities of information 2. Data that is heterogeneous 3. Data in real time 4. Data of poor quality	Several studies that use deep learning techniques for big data feature learning is discussed	(1) Just looks at research that use deep learning models for big data function learning.—Does not look into the use of deep learning in various IoT aspects and applicability (2) Does not examine IoT frameworks for smart cities that uses Deep Learning models
Qolomany et al. [7]	IEEE journals	Detailed survey	IoT-based infrastructure	1. Home treatment for the elderly 2. Efficient energy use 3. Convenience and amusement 4. Protection and safety 5. Programmes that are not related to the others	Review the usage of ML and BDA for the growth of smart infrastructure	(1) Does not concentrate in IoT-based city applications (2) Does not go over DL methods (3) Does not examine the use of machine learning models in fog/edge computing

(continued)

Table 1 (continued)

Author	Journal name	Procedure	Field	Use cases	Main Purpose	Limitation
Chen et al. [8]	IEEE journals	Detailed survey	IoT-based city	1. Getting around 2. Medical treatment 3. Public safety 4. Environment	It looks for a detailed study on DL in IoT-based cities, summarizes the most common models, the most recent work on DL-based smart city applications	(1) Excludes IoT-based home and agriculture applications (2) Does not look at how cloud, fog, and edge computing can be used for DL-based applications (3) Does not address the issue of IoT big data

7 Challenges

The biggest challenge or issue that the smart cities nowadays are facing is security and privacy issue. The people who are having malicious intent exploit the databases and get all this raw data and sell this into the dark web or ask for huge ransoms from the company to keep their data private. In the past year, there have been many such incidents such as in New York; a hacker hacked around 200 homes security camera and leaking that data in deep webs; the deep web comprises the 90% or more part than what we access in daily life. It was developed by US for top secret and confidential activities to take place. Later it became something which was completely opposite of it. Recently, in March hackers breached a company Verkada Inc., all surveillance cameras getting an access to 150 k cameras thus ruining up the reputation of company for their own profit.

Previous year, there was an attack of Ransomware which actually affected many organizations and their data, causing them huge losses. Some notable companies are which were affected by it:

- Cognizant
- Magellan Health
- CPI—Communication and Power Industries
- University of California San Francisco
- Baltimore County Public Schools
- Advantech
- Carnival Corporations
- Canon.

All these companies since then have implemented two factor authentications for account safety and protecting their databases. Also, many incidents happened with companies like dominos all the user base data got leaked with all credit card details of customers being exposed in dark web. Apart from this, there have been many such cases reported all such activities which have taken place in the past are the limitations of IoT and security they have.

The attacks usually used by the hackers to gain access to these IoT-based systems are:

- Botnets Attack
- Denial of Service Attack
- Man in the Middle Attack
- Identify and Data Theft
- Social Engineering
- Advanced persistent threats
- Ransomwares
- Remote Recording.

Also, apart from the security issues there are some other issues which are related to the Hadoop and Big data which is the management of nodes and high-end infrastructure everywhere is not possible specially country like India which is still developing where advancement is supposed to go step by step not in haste. Not everyone can buy the required devices and build the infrastructure. As, if there is some disaster it requires racks and mostly companies in India rely on single racks which is very wrong as there is no disaster management for databases. In India, not large datasets are available; thus, we are not able to get the very accurate data to make predictions as the foreign countries they use it for analysis and making decisions. Cost of production and implementation for IoT-based systems is too high apart from this if we implement, we need someone to monitor and make it function thus, mostly companies do not want to put that much effort until the work gets done. Also, the quality of service in India is not up to the mark as no production plants are there who manufacture on a large base; thus, we need to import everything from outside country which is increasing the inflation rate and cost of the good.

Through the above study, we saw there are numerous challenges consolidated altogether here in a summarized manner which is: some papers do not focus on the newer research topics and technology and some are defined to a particular technology whether it is a smart home, infrastructure, or big data processing data in real time. Also, some papers are based on DL models. The comparison made on different areas of the smart city is confined to only some areas not covering the wider spectrum. As IoT is a wide field and has expanded a lot in the recent trends since 2007 and still its demand is growing day by day and so is the concern for the data privacy.

8 Conclusion

We can conclude that our paper was segregated into the basic introduction which lets us know about basic IoT and how it is useful to us. Then, we showed some related works done on these smart IoT-based cities, after that we showed a visual analysis of different recent trends that took place and the variation between them creating demand for big data with the planned estimated investment for the same for providing better applications and life experience. After this, we talked about various other technologies which help it to function properly. Thereafter, we talked about the methodologies used in these cities and how the recent trends are happening on this area with the advent of pandemic. This led us to the observation with the related surveys we did and we were successfully able to show the survey and detailed analysis basically a juxtaposition on different aspects of the research work done based on the parameters in the direction of "Technologies Involved in IoT-based Smart Cities". Followed by, the challenges faced in such cities which covered all recent happenings around the world along with some technological and financial crisis which will help us to understand this on a better scale.

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