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Image Based Computing for Food and Health Analytics: Requirements, Challenges, Solutions and Practices

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Preface

This book has a focused orientation towards *Image based Computing for Food and Health Analytics*. As during our research journey toward healthcare, there is a requirement of technology to intervein to offer the better health benefits and insights from the food intakes and physical activities. So, the thought persists in mind and meanwhile we saw that there are numerous amount of images are clicked and shared by social communities towards that food intake and fitness goals. Seldom, all these efforts were toward uninformed or unseen efforts towards a firm goal. But it will lead towards such health conditions or not was not clear. Thus, this book offers various solutions and insights that can be attained using technology mainly, data images of food, health activities etc. It offers analytics attained using images towards Nutritional intake, nutrition requirements, prevention and precautions that can be taken during healthcare. Using Machine learning, IoT, Cloud based systems many monitoring can be done towards the health of a patient. Few mentions which can change your views towards this field as per the benefits it offers can be *"Food Computing Research opportunities using AI and ML", "Estimating the Risk of Diabetes Using Association Rule Mining Based on Clustering", "Smart Healthcare Systems: An IoT with Fog Computing based Solution for Healthcare" "Secure Authentication in IoT based healthcare management environment using integrated Fog computing enabled blockchain system" "Cloud and machine learning based solutions for healthcare and prevention".*

These solutions offer the involvement of technologies like ML, Cloud, Fog, IoT, etc. for data acquisition and then analytics on various parameters for a better, informed approach toward health goals. Moreover, all chapters focus toward the main theme of attaining better health of a person using data images.

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Shuchi Upadhyay and Gaurav Goel

1 Introduction

Nowadays, Artificial intelligence and Machine learning are one of the first techniques from technology that are helping the food industry. Many processes get automated, and it also helps in saving money, reducing the chance of errors. Technology is helping the food industry to find out whether the required proportion of nutrients for humans is available in food or not. It helps humans to safe from various types of disease or if someone suffering from a disease like BP, Diabetes, or heart disease, etc. it is required for the patient to find suitable food and take intake of food in the required proportion. Packaging of foods also gets improves with the latest technologies. By estimating the size and type of foods technologies identify packaging aids required for packing. Our agriculture also gets modern, nowadays robots, drones, and automatic machines are in use for agriculture. AI and ML reduce human work and time proportion to a large extent.

Food Computing using AI and ML is in trending nowadays, identifying the objects from the set of available data (i.e., in form of images) and applying image processing to the set of images. We can do the segmentation and identification of the available data which helps the human recommendations for type and proportion of food intake and food packaging.

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2 Food Computing Research Opportunities

A Taxonomy for Food Computing using AI and ML is represented in Fig. 1, Food and Nutrition, Healthcare, Agriculture, and Packaging all parameters are interrelated with Food computing. Based on the dataset on these parameters, we can do object identification, image processing, segmentation of objects, and lastly identification of Food, disease, healthcare, and packaging can be done.

2.1 *Food and Nutrition*

Ensuring improved quality for food items is generating more interest among food business specialists. The food sector is devoting more time, expertise, and money to preserving the freshness of food ingredients. Furthermore, the availability and quality of food have a direct impact on people's health. Droughts, floods, and other utmost weather events, such as heat swings, create a need for food security. To avert the exhaustion and humiliation of natural resources, everlasting and more viable agricultural practices are being implemented [1].

The nation's principal responsibility is to upgrade the food construction and dispensation systems to protect its citizens from malnutrition and hunger-related health problems. Practically mostly developing nations are disquieted by social and economic inequities to meet their food needs and maintain agricultural growth. They want safe, nutritious food and high-quality healthcare. As the world's major producer of food grains and milk, India was given top focus in this area. But the sad truth is that India is facing several limitations like a low-grade seed, inadequate

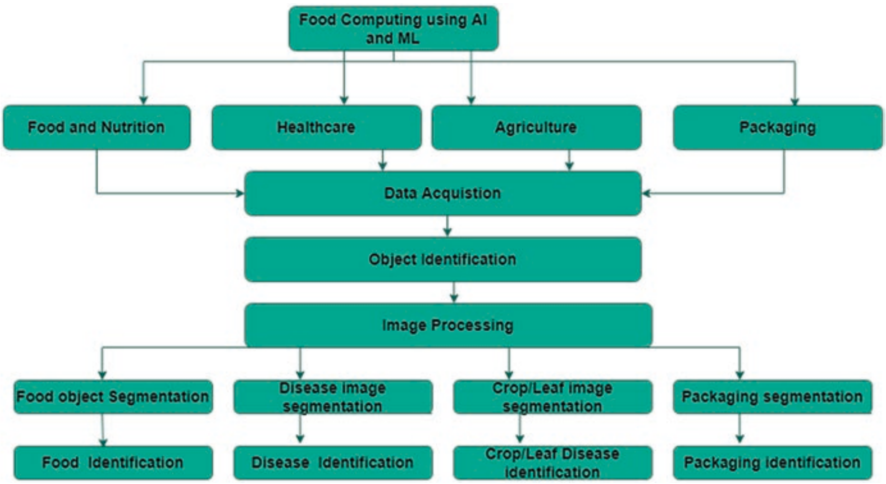

Fig. 1 Taxonomy of food computing using AI and ML

irrigation, private money lenders, etc. The knowledge discovery, data, vision, transmission, sensing, dissemination, and actuation technologies come in handy in solving the above problems.

Worldwide, People have been facing the problem of swallowing [2]. About 590 million people are suffering from this disease of Dysphagia. This is all due to malnourished diets people follow blinded and this indeed turns out as a burden on the health care centre for all countries. To overcome this disease of Dysphagia introduction to pureed food has been done. This is also done keeping in mind the Old Age people or the so-called Senior Citizens of our society. Now let's move ahead and look at some of the other aspects of healthy pureed food for this the major thing we require to assess was the current lack of tools for us humans. To fulfil this requirement of inspection International Dysphagia Diet Standardization Initiative (IDDSI) also Optical imaging System is one which also provides a powerful solution to this issue of how to investigate different aspects of the food such as thickness, thinness, concentration, dilution, temperature, texture, colour and many other aspects.

Infancy is a period of rapid physical growth and overall development. One of the most important factors that affect growth during this period of life is nutrition. As infants are dependent on others for their nutrition, it is the responsibility of the caretaker to make sure that the kid is getting an adequate amount of necessary nutrients, which are important for their physical as well as mental growth [3].

2.2 Healthcare

A nutritious diet has been demonstrated in studies to dramatically minimize the risk of disease [4]. This drives the need for people's food intake to be monitored and assessed systematically. Even dietitians must do complicated lab measurements to provide an appropriate assessment. To address these issues, the FIVR system was created to calculate the nutritional composition of a user's meal. Because cell phones have become ubiquitous devices with cameras, the FIVR system uses a calibrated cell phone as a capture device.

Nowadays in a world where more children are sent to kindergarten, a food monitoring device to help track their food intake is the need of the hour. In this research paper [3], an Automatic food analysis system with predictions to help you eat better. This sensor system includes a piezo-based sensor panel that can help determine the weight of each serving and a smartphone camera for real-time feeding of ingredients. It works with the help of the Internet of Things (IoT), which helps connect real-world sensor data with cloud-based solutions.

Healthy eating habits, including tracking calories and nutrition, are becoming increasingly important to most consumers around the world [5]. That means about six million Canadians are affected, far more than those with heart disease, diabetes, chronic lung disease or cancer, and arthritis. This affects roughly six million Canadians, far more than those who suffer from diabetes, heart disease, arthritis, chronic lung disease, or cancer. The majority of these smartphone applications automatically track daily physical activities and calorie burn. An overview of existing approaches to mobile caloric intake measurement is available, illustrating the advantages and pitfalls of related research. Mobile applications appear to be the most practical and are the focus of this study [6]. we present a mobile health app that can identify individual foods by taking a photo of the food and then calculating the total calorie content of the food. In the part feature extraction stage, we use four feature vectors: size, shape, color, and texture in the first stage.

Finally, the presence of dams around the products further complicates identification, as the same dish may be served in a bowl or covered with a paper lid. In this article, we describe a method for identifying multi-part foods and predicting calories from a given food pattern. A model like this can subsequently be translated to mobile equipment and used to automatically track calorie consumption.

2.3 Agriculture

Food Security is a topic of concern, especially for a country like India, it's important to protect the food from every kind of natural disaster and also in the fields, where farmers practice agriculture. Hence, it is the need of the hour to promote a model like the Efficient Food Quality Analysis Model (EFQAM) using IoT devices and biosensors to precisely identify the factors which damage the quality of the food. The main motivation behind this research was the importance of food for the people of India and how to maintain its quality along with the quantity, to gain knowledge regarding the same, and also to enlighten people regarding food security [1]. Through enhanced access to data, food producers can run an efficient supply chain that reduces waste, boosts productivity, and meets consumer demand in real time. The Internet of Things (IoT) adds a layer of technology to the food manufacturing process to ensure greater food safety.

As a contribution, Machine Vision System (MVS) provides high accuracy and efficiency, due to which many industries can save a lot of labour. In agriculture, when Agri-technology and MVS are combined the data-intensive methods are effectively used, higher agricultural yields are achieved and environmental impact is also reduced.

Upgrades by the changing example of IoT have driven the world towards assessment and improvements. IoT (Internet of things) has made a vision of smart applications like wireless health care and intelligent manufacturing and modern agriculture [7]. A new cloud addendum stage, Fog Computing means to give constant results dependent on information examination over the communication network. The progressive IoT innovation comprises conservative, dependable, and web-empowered remote sensors that can hand off inescapable data with the greatest effectiveness to distant areas [8].

2.4 Packaging

The latest innovations and modern food packaging methods are the results of consumers' desire for well-prepared meals with healthy and convenient products [9]. Modern business practices and lifestyle changes have led to the development of new packaging methods without compromising safety and quality. Recent changes in the packaging industry will strengthen the economy, improve food safety and quality and reduce product losses.

Consumer preferences have led to new and innovative improvements in food packaging technology for durable and convenient snack foods. Furthermore, the present trend of retail operations and changing lifestyles provide impetus to the growth of novel and Innovative packaging solutions that do not compromise on food safety and quality features. Another main cause for novel food packaging is the growing issue of foodborne microbial outbreaks, which necessitates the use of packaging with antimicrobial properties as well as food quality retention. Packaging innovations began earlier, with metallic cans, electrically powered packaging machinery, aseptic packaging, flexible packaging, aluminium foils, and flexographic printing. Furthermore, other breakthroughs in packaging technology arose in the twentieth century, such as intelligent or smart packaging. Changes happening in the packaging business will help the economy improve food safety and quality and reduce product losses [6]. Many types of packaging are available as mentioned below:

I. **Active packaging** – When it comes to food packaging technology, research, and development on active packaging are expanding. By reducing oxygen transfer, edible films and coatings in active packaging minimize oxidative damage to meals. Food antimicrobial agents can be utilized in a variety of ways, including applying them directly to the food surface for slow diffusion or using them as vapours. As part of packing materials, oxygen scavengers and moisture control agents are used.

II. **Intelligent packaging** – Intelligent packaging aims to improve food quality and safety. In addition to monitoring internal and exterior variables, intelligent packaging also records changes occurring both within and outside the package. In intelligent packaging, radio frequency identification (RFID) uses radio waves to track goods wirelessly.

III. **Bioactive packaging** – As packaging technology advances, some food components may be transformed to transfer health advantages from their container into the consumer's diet and mouth-watering nutritional intake.

IV. **Innovative packaging technologies** – Automating basic and valuable data flows allow the supply chain to increase efficiency while building fresh value-added services and environmentally friendly packaging and transport unit for the grocery supply chain, which can be used throughout the whole product cycle.

2.4.1 Packaging Technologies

I. **Functional barrier:** This means that these smart and powerful ones do not come from safety concerns, and some of them can be used behind functional barriers if they travel to functional barriers within certain limits.

II. **High chemical barrier material innovations:** Food quality can be maintained by using good packaging that prevents contamination, contamination, gas and liquid contamination, as well as the penetration of other molecules such as oxygen, liquid or gas, and water into the air.

III. **Intelligent supply chain:** This smart supply chain can identify simple ways to add value to new products**.** In order to meet large retail orders and regulatory requirements, Spain's ECOMOVISTAND has developed the MT, an innovative and environmentally safe packaging and transport unit that can be used throughout the entire production cycle in the food supply chain; That is, the MT packaging, transport unit, warehouse and supermarket displays of the manufacturer, all in one mechanical system, serve as a reversible unit of packaging and distribution.

IV. **Nanotechnology:** Nanotechnology introduces the latest developments in food packaging; providing mechanical and safety features; identifying pathogens and introducing smart and active packaging; It has proven to be the most advanced modern technology keeping food quality and safety in mind. The aluminium foil found in many snack boxes currently plays an important role in the market. Nanomaterials for food packaging are researched by solvent extraction/evaporation, crystallization, layer-by-layer self-assembly, microbial synthesis, and biomass reactions.

V. **Nanocomposites:** Nanocomposites have significantly improved strength, cellular properties, antibacterial properties, and thermal and cold stability in food packaging. On the other hand, large aspect ratios of these materials can be achieved using lateral dimensions of a few microns. For soft drinks, the same packaging material is recommended for extended shelf life.

3 Data Acquisition

Data Acquisition: under all mentioned four categories various types of the dataset available for processing

3.1 Food Dataset

Food recognition is essential to determine the types of food required for humans. By using various sets of images on food type, one can determine the food type required for humans. Some datasets available for food images like PFID, and restaurant images help in the segmentation of food and identification of the type of food. The PFID dataset is collected/made from 13 chains of restaurants in a real scenario and lab conditions. 61 types of food are categorized from various available images. **PFID** contains a single food item in a single image. Images of junk foods like burgers, pizzas, sandwiches, and French fries, also images of fruits like apples, bananas, pears, pomegranates, avocado, etc. may be collected. Unlike PFID one can also make own food datasets by the combination of various food items in one image.

3.1.1 Food101

Food101 is also one of the datasets for recognizing foods. This dataset contains 101,000 images having 101 food types.

3.1.2 Ingredient 101

Ingredient 101 is also may be used as a dataset for the recognition of ingredients available in food. Out of 101 food types of the Food101 dataset determination of ingredients is done. 446 unique ingredients found in 101 food types.

3.1.3 Fruitveg81

Fruitveg81 datasets contain 15,737 images for 81 categories of food. The dataset was found in the grocery store.

Data acquisition involved in Smart-Log System – To map the relevant nutrient values to these products, the following two approaches have been proposed along with the sensor board:

1. Optical Character Recognition (OCR) – The nutrition information can be captured with the help of a smartphone and the printed character can be identified from the image and relevant information can be stored in the database.
2. Barcode Scanning – The user can scan the barcode on the product using a smartphone, which can then be used to fetch nutrient values from an open-source API (Application Program Interface).

3.2 Healthcare Dataset

Healthcare Dataset includes data on measurement done on various parameters as per disease and regular health check-ups. An accurate and healthy dataset helps doctors, dieticians, insurers, and govt agencies to take necessary action. Various datasets are available for healthcare to provide a healthy diet to humans so that they can remain disease free to some extent.

3.2.1 UHDDS

Dataset provide by the health department in 1974 and regular update is being done on regular basis as per check-ups and disease monitoring. This data set values are used by doctors for diagnosis, insurance companies, and to follow procedures during medical treatment. Data are also being used by dieticians to suggest accurate nutrition required per health. UHDDS set some columns and principal attributes based on regular updates that are being done based on patient health.

3.2.2 UACDS

Dataset maintains for ambulatory care. This dataset is used for recommendation, this is not mandatory.

3.2.3 MDS

This dataset is maintained by the health department in collaboration with human services. The data set is used for home care patients. Dataset was introduced in 2013 and later get updated in 2016. All daily nursing care and home care data is maintained in the data set. This data set is used to generate a care plan.

3.3 Agriculture Datasets

Agriculture datasets are used in the identification of the status of leaves and crops. Three types of datasets based on biological, physical and Sensor based datasets may be available for agriculture datasets.

3.3.1 CNR Dataset

CNR dataset is a structured type of agrarian dataset. Dataset values are in the partial order, this is an incomplete manner. CNR dataset consists of data based on parameters: Date of calculation and detection, leaf area index, Etc with ETO reference value, and Evapotranspiration ratio.

3.3.2 Istat Data Sets

Istat data sets are regarding aggregated Italian crop quantity. This dataset is well maintained and contains information about agriculture creation information on the Italian state. Datasets are working on 16 parameters: crop type, crop production amount, rainfall amount, temperature, amount of potash, phosphate, organic fertilizers, and organic compounds.

3.3.3 Sensor-Based Datasets

Sensor-based datasets are required for business purposes where precision type data is required like rain gauges and thermometers. Various parameters are recognized based on the sensors like the sun's ray incidence, geo parameter, temperature, humidity, wind speed, and atmospheric pressure.

4 Object Recognition

To map the relevant nutrient values to these products, the following two approaches may be used along with the sensor board [10]:

1. Optical Character Recognition (OCR) – The nutrition information can be captured with the help of a smartphone and the printed character can be identified from the image and relevant information can be stored in the database.
2. Barcode Scanning – The user can scan the barcode on the product using a smartphone, which can then be used to fetch nutrient values from an open-source API (Application Program Interface).

The most solved part is the binary food detection problem of detecting the presence or absence of food from an image [9]. Given the applicability of the algorithm, this problem is mainly investigated as a leading method for web image indexing or automated food recognition systems. Furthermore, CNN-based models can improve the results of food recognition models with around 90% accuracy on datasets composed of around 100 different food classes.

Food Detection: – Food detection is defined as the localization and recognition of food. For this purpose, a state-of-the-art object detection algorithm – YOLOv2 is retrained to be applied in food detection. The authors propose a replacement FCN called Darknet19 composed of 19 convolutional layers and 5 max pooling layers to tackle the popularity task. Semantic Food Detection: – In object detection false positives or errors are often classified into four types: -

1. Localisation error,
2. uncertainty with the same objects,
3. uncertainty with dissimilar things,
4. uncertainty with the background.

Semantic Food detection works to cut back the commonest errors i.e., Localisation errors and Confusion with the background. For this purpose, the following procedures are introduced: -

1. **Background removal: –** The first step requires placing two borders taken from the ribbon section to remove the background check.
2. **Non-Maximum Suppression:** T The second step uses a greedy approach to reduce search inconsistencies by non-maximum suppression.

The introduction of fine-grained groups by computer vision techniques has been very popular. The problem is very complicated because some small manuscripts can be recognized by experts in the field. Contrary to popular belief, a good rendering should be able to use various native implementations, such as expert rendering, rich rendering, etc. Features [11]. The problem of better identification is divided into two parts: discrimination of regions and better study of the characteristics of regions. Researchers have made significant progress in identifying the component [12]. First, regions or zones defined by humans without supervision may not be suitable for machine classification. Second, visual differences observed in the same small classroom remain difficult to study.

To overcome these challenges, a recurrent neural network (RA-CNN) is used for better detection without grid/edge information. RA-CNN learns spatial discrimination and local representation in a robust manner. The RA-CNN is a stacked network that takes the input from full images to fine-grained local regions at multiple scales RA-CNN is a nested network that multiscale input from whole images to fine spatial regions.

5 Image Processing

The food computing process may also require digital processing of images after object identification by using an algorithm. The advantages of using image processing on food images are that many noises and distortion present in the images can be neglected. Advances in technologies are helping farmers to protect their crops from diseases. Image processing techniques like SVFT help to identify various diseases in crops.

Food analysis has traditionally been based on pen and paper, but there is a growing trend towards automated methods. Food can now be analysed using mobile phones equipped with image processing and pattern recognition technology.

Food image processing is controlled by Size Invariant Feature Transform (SIFT), and Local Binary Pattern (LBP), and the colour is used to describe food images. The Remote Food Photography (RFPM) method uses a semi-automatic food photo classification approach to focus on portion sizes of food and uses bilateral filtering to reduce noise in the captured image. Nested Object Detection – Scale-invariant feature transformation (SIFT) is used to describe spatial images of visible objects [13]. Produced with a histogram of the side orientations of the food photo. Next, is texture analysis using Local Binary Patterns (LBP) to capture the texture information of the food. Next is colour recognition. Colour plays an important role in food image classification when the size is similar. You can then construct the colour property of the image as a histogram of the colours of all points in the image.

The Point of Interest SIFT sensor takes an average of 74 s to identify objects in images captured by a smartphone camera. By reducing the size of the image, you can increase the speed of finding a point of interest and reduce the points of interest. The fastest was found to be the ezSift sensor, which takes less than 15 s. Weather also affects the computing power of smartphones. Both SIFT and colour histograms are produced by LBP. – SIFT was the worst overall. In general, the combination of all factors (SIFT, LBP, and colour) gave good results. Because many food categories can appear together in an image, recognition accuracy can be improved by separating separate food components. Accuracy is low for the cheese category. If the object "Cheese" can be registered at a closer distance and other food products besides cheese are not shown in the image, the accuracy can be increased.

In agriculture, it is important to identify leaf/crop disease. For example, our farmers daily earnings are based on crops. Sometimes the disease in the crops destroys all earnings of farmers. So, it's better to identify leaf/crop disease so that necessary action to recover from disease could be taken. Image processing by LBP technique and histogram of orientated gradients helps to detect the health of crops. Rice disease detection is also done by the latest techniques in which all key points are checked first from leaves. and all key points will be stored for further processing. These key points will be matched with disease patterns to identify the health of leave/crop.

Similarly in the healthcare system, by identifying disease patterns in humans, a diagnosis step could be taken by doctors. Artificial intelligence with the help of Digital image processing helps a lot in the medical system. Doctors are using stored data sets to diagnose patients. Cancers, heart diseases, skin diseases, etc. are treated by medical teams/hospitals.

The food packaging market is in trend nowadays because of the increase in food applications. Which type of packaging will be best or does need to fit, could be decided by the image processing method using AI and ML. Humans are free to take worry about the packaging, whether food is in liquid form or solid form and what will be the quantity available with food.

To increase recognition accuracy, machine learning techniques such as deep learning and extreme learning can be used. – Food image identification accuracy can be enhanced by training on big and diverse datasets that include various lighting conditions, complicated backgrounds, and food photographs recorded from multiple angles.

6 Segmentation

Image segmentation is used in separating the target from the background in an image. After that feature extraction is used to distinguish the characteristics of each image, like colour features, texture features, shape features, and spatial features. Then, classification is done, and in two divided parts. In the first classifier, the data objects, which are bananas, in this case, are classified into un-riped, ripened &

overripened states. Here, the YOLOv3 model detects the defected areas and further classifies them as mid-ripened or wee-ripened.

By specifying a large core in the definition section and applying a large core convolution layer between the trunk end blocks and the RoIcluster layer, predictions are preserved, reducing the size of the feature map and increasing the perceptual field. Head computing also improves drawing skills [14].

6.1 Food Segmentation

Food segmentation deals with the separation of food and food-related objects from trays and other background elements, resulting in binary images [15]. To this end, the authors used a semantic segmentation method that works in a highly focused learning process, unlike many methods for the most active aspects of the image (for example, colour or texture).

We can estimate volumes using actual depth maps or predicted depth maps and using actual segmentation masks or predicted segmentation masks. However, noticing a difference of up to 35% in calorie content between the USDA NNDB and the figures quoted by Nasco for their repeated diets.

6.2 Disease Image Segmentation

People have different ways of hearing to communicate with the outside world. When a human viewer looks at a scene, his eyes see the important parts of that scene. This process is very effective, one does not need to see a complex scene, but a group of things defined by meaning [16].

Biomedical image segmentation is usually associated with dividing the image into regions that represent the desired anatomical object [17]. Various medical image segmentation problems present serious technical difficulties, including non-uniform pixel intensity, fuzzy/unclear edges, and irregular shapes with high variation. Cancer accounts for 30% of all cancers in the United States, causing more than 160,000 deaths each year, more than the annual deaths from colon, breast, prostate, ovarian, and breast cancer combined. Lung cancer survival depends on the diagnosis. At CVIP Lab, we have developed a computer-aided design (CAD) system consisting of four main steps. The technique is to remove noise artifacts that can appear on CT images during low data analysis. The goal of the image segmentation step is to achieve accurate segmentation while preserving the details of the lung anatomy from low-resolution tomography. In particular, the pulmonary nodule must remain in the lung and its surroundings for further investigation. Colon cancer, colorectal cancer, colon cancer, and appendix cancer are the third most common cancers in the Western world. Colorectal cancer, which includes cancer of the colon, rectum, colon, and appendix, is the third most common type of cancer and the second leading cause of cancer death in Western countries. Most colon cancer starts as a polyp: a small growth that starts in the colon wall. As the polyp grows, it can become cancerous, which invades and spreads. At the University of Louisville (UofL) Laboratory for Computer Vision and Image Processing (CVIP), we have developed a fully automated system for accurate 3D colon tissue segmentation in colon CT using an adaptive method and focusing on the early detection of colon cancer. The next step involves creating a 3D model of the colon by searching for iso surfaces and finally extracting a 3D center line for 3D navigation in the colon.

For the segmentation process, an extension can be done with the global minimization/convex minimization problem of dynamic models to 3D states using Mumford and Shah's model and Chan and Vese's model for nonlinear functional lines.

6.3 Crop/Leaf Disease Image Segmentation

Segmentation separates an image into its regions or components and is an important step in image analysis. The level of migration of the partition depends on the problem to be solved. The image classification algorithm is based on neutrality and similarity, which is the main characteristics of dynamic characteristics. A feature-based classification method is used to classify this image. As it is possible to divide the area into a regular area, a good division is achieved. Image segmentation assigns a label to each pixel in the image so that pixels with the same label have specific visual properties. Image segmentation is often used to find objects and boundaries that represent segments and lines in an image. Agricultural studies on automatic spot disease are important studies because they can show results when large crops are analyzed and because these pests detect disease symptoms when they are seen on leaves [18].

The technique of Segmentation is used to divide the diseased part of the leaf. The disease can be distinguished by the layout system, considering the texture and shading of the parts. The first step in detecting and identifying infection is dissecting diseased plant leaf parts, which is an important part of agricultural research. The following is a dissection method used to separate leaves from infected plants. The system diagnoses disease based on a subject-based imaging visit (CBIR). The CBIR system was developed using a combination of color, shape, and texture of paper images, and the patient segments on the paper were classified using a K-means clustering algorithm.

The poor classification was performed in two steps and a K-means clustering method was defined to classify the diseased part of the document. To begin with, the pixels are grouped based on their shadow and objects in space, after which the grouping process is heard. At this point, the blocks are united to some extent.

6.4 Packaging Segmentation

After doing image processing, image segmentation of food items can be done based on the by material, product type, application, and by region.

Plastic packaging products such as containers, trays, pots, bags, and lids. Widely used in the food and beverage industry to pack ready-to-eat food, frozen food, carbonated and stationary drinks, and snacks. The metal sector is expected to grow at a CAGR of 5.1% during the forecast period. Aluminium has become a famous home packaging aid due to its ability to withstand cold and heat. In addition, strict regulations on the use of plastic are expected to support the demand for metal packaging in the future.

Bread and pastries are usually packed in high-moisture packaging to extend shelf life. Flexible packaging is widely used for the above applications due to its advantages over paper cartons and cans, such as its lightweight, density, and cost-effectiveness. The attractive packaging of sweet products should also contribute to the growth of this segment.

Meat, poultry, and fish are expected to position at a CAGR of 6.0% during the forecast period. Many packaging aids such as pouches, bags, aluminium foil, bottles, and glass cups can be widely used for poultry, meat, and seafood due to their easy storage, heat resistance, moisture absorption, and flavour retention.

The Asia Pacific is assumed to account for 35.0% of revenue in 2021. The industry is assumed to increase population growth, per capita income growth, and demand in the regional economy. The Asia Pacific, such as China and Japan, and India. The country of China is the largest consumer due to its population and economic growth. The Chinese market is expected to grow significantly due to the growing middle-class population and purchasing power.

Online selling of packaged food, places extra demands on packaging with greater demands on shipping and delivery. Therefore, the increasing penetration of e-commerce in Canada is expected to drive market growth in the region.

7 Object Identification

Tracking food and snacks is a fun way to try new machine learning techniques. The main goal is embedded display computers that can perform real-time classification and classification of food products, and for many foods can push IoT devices to the boundaries of AI.

7.1 Food Identification

Because handmade items are difficult to be influenced by background material, lighting, subject placement, and class differences [19]. To reduce the amount of damage, it is necessary to optimize the environment; As a result, assumptions about the environment are not true and cannot be used in real life.

Image Classification

Image classification takes an input image, sends it to a CNN, and predicts a probability class score that describes the uncertainty of the prediction. The class with the highest probability is the predicted class. This class symbol is intended to describe the content of the entire image; does not see where the policy class appears on the diagram.

Object Detection

Object detection is based on image classification and tries to find out where each object is located in the image**.**

While doing object detection, for an input image, we desired:

1. X and Y coordinate for every object in a dataset image.
2. Label of class with every boundary of the box.
3. The score of confidence is associated with each boundary of the box and label of the class.

7.2 Disease Identification

in the past decade, the techniques of deep learning and machine learning have become popular in image quality improvement, weather forecasting, security, healthcare, military, finance, etc. Today, there is no limit to computing power and medical data, as many medical institutions or hospitals will use artificial intelligence to classify human diseases [20]. Artificial intelligence can also be used in the identification of human diseases, the detection, and localization of lung tumours, serious diseases, etc. A new study found this to be the case Disease proteins form many interconnected and ubiquitous components Protein-protein interaction network [21]. N2V-HC is an algorithm, that aims to generate the scattered disease module having basics of deep learning of biological network with integrated multi-layer.

7.3 Leaf/Crop Disease Identification

The disease is a serious threat to food security [22], but in many locations of the world, it can be detected quickly due to the lack of the necessary infrastructure [23]. The combination of using artificial intelligence to aid learning and the latest promotions in computer vision has paved the way for phone diagnostics. Object recognition and Computer vision and have made significant progress in recent years. Based on the PASCAL VOC Challenge and Image Recognition Competition (ILSVRC), the ImageNet dataset is widely used as a standard for many special problems, including object classification. Deep neural networks have currently achieved success in many areas such as complex learning. Neural networks map between inputs (such as pictures of sick plants) and outputs (such as sick plants).

To create an accurate image for diagnosing plant diseases, we need a large and valid set of pictures of healthy plants, and diseased. Until recently, no such database existed, and very little data was freely available. To solve this problem, the project plant village began collecting thousands of images of healthy and diseased wheat and making them available to the public free of charge.

Moreover, traditional machine learning methods for disease classification focus on a small number of species in one plant. An example is a collection and sequencing pipeline that uses thermal and stereo images to classify tomatoes and healthy tomato leaves. Pattern identification in an uncontrolled environment using RGB images; Apple peel detection using RGBD images.

7.4 Packaging Identification

Traditional packaging materials used in the food industry are paper, metal, glass, and plastic. Various types of metal food packaging are available in the market, such as containers, lids, tubes, bags, and films. Cans can be made of aluminium or steel and are the most common type for wet/liquid foods and beverages. Food packaging is an essential part of the food industry to help healthily store food and beverages, but food packaging can cause food safety issues. Few plastic Packaging aids such as polyethylene and polystyrene can dissipate toxins when heated and pose a risk to the consumer.

Most of the materials used in food packaging are metal, glass paper, and polymer. Common examples of composite materials are enamelled (lacquered) metals and laminates, which are made by combining elements of polymer, paper, and aluminium foil. The specific chemical and physical valuables of packaging aids regulate their ability to perform various functions intended for packaging. The utmost required structures to consider in this case are transport materials, important materials, mechanical properties, and machine operations. Various types of packaging are available like:

1. **Primary packaging:** material used in primary packaging re plastic, cardboard, and glass bottles.
2. **Secondary packaging:** Secondary packaging consists of many primary packaging and is mainly used in retail shops for display.
3. **Tertiary packaging:** is mainly used for transportation and consists of primary and secondary packaging.

Related Work

This section will describe the various work done by researchers in the field of Food computing including Disease, healthcare, leaves diseases, packaging segmentation, and identification.

Munish Bhatia et al. [15] provided the concept of food analysis in restaurants and food hubs. Using Bayesian modelling on the IoT-Fog-Cloud network researchers obtain unanimous metrics in contrast to POFG. Researchers used the concept of the IoT framework for determining food quality in restaurants. FGAS is the scale to access actual time food-oriented parameters environment of food hubs. The author also proposed 2 player game for monitoring food by food inspectors and manger. The proposed technique is checked over 42,410 instances, and the proposed technique successfully provided accuracy.

Luciano Oliveira et al. [24] have discussed the concept of a food identification system. The authors discussed the scenario of being overweight and how it is harmful to a person's health. Researchers provided the concept of food recognition based on mobile cameras. Cell phones are used for the process of segmentation and identification of food types from one image. An image has many types of food, with the help of image recognition a dietary assessment can be done like how many calories should be an intake of humans. A multi-classifier technique is used by the researcher for the experimental setup. Researchers successfully reduced the classification time by 90%.

Edward S. Sazonov et al. [25] have discussed the concept of food intake or chewing behaviour of individuals based on the sensor system. A Piezoelectric sensor was used which will detect the movement of the jaw in different situations like sitting, food consumption, and talking. A feature selection technique was used to detect the best feature for food intake out of 4–11 features. Support vector machine classifier selection was used and trained to detect the model of food intake. Sensor, signal processing, and pattern recognition methodology was used to monitor jaw movement during food intake.

Fanyu Konga et al. [26] have provided an app named Dietcam, this is a type of mobile application that can be used for food image recognition. This helps to protect humans from obesity. Because many health issues are being raised due to wrong food intake habits. Researchers claimed 84% accuracy in the proposed work. As per researchers, previously provided food recognition techniques fail to recognize food images efficiently because of poor background and combined food pictures. A probabilistic method is helpful to determine food images from each perspective that's why researchers achieved high accuracy in the proposed system.

Duc Thanh Nguyen et al. [27] discussed a food classification technique using global and local appearance structural information. Researchers worked on three folds in the proposed technique NRLBP are used to declare information of local appearance. The spatial relationship with intersecting points is used to represent food objects' structural information. Thirdly researchers proposed a description of structural information and integrated appearance, and food image classification. For experimental results, researchers used two datasets and successfully outperforms previous techniques.

Jianlong Fu et al. [28] proposed a technique (RA-CNN)Recurrent attention-convolutional neural network. Researchers said it is difficult to detect fine grained-categories due to discriminative-region-localization and fine-grained feature learning challenges. For optimization, the proposed approach is using a classification approach based on intra-scale and a ranking loss approach based on inter-scale. Both techniques mutually learn accurate region-attention and fine-grained representation. By experimental result proposed technique outperforms 3 fine-grained tasks with a gain of accuracy by some percentage on Stanford dogs, CUB birds, and Stanford cars.

Austin Myers et al. [29] used the technique CNN base multi classifier to detect food type and available nutrients such as calories in that food. This technique helps humans in taking an equivalent level of nutrients so that their health remains stable. For performing this experiment 23 restaurants dataset was used. The more complex work faced by researchers is to do the task from outside the restaurants because there is an estimation of food size and their label. For this problem, researchers used the concept of volume estimation and segmentation.

Yasmine Probst et al. [30] discussed the technique of Bag-of-words for dietary assessment. Researchers discussed mobile base food image recognition as in previous times it's difficult to maintain a record on paper and pencil. Food image is easily recognized on mobile phone through a technique of image processing and pattern recognition. SIFT, LBP, and colour of images are used to describe an image. Bag-of -words technique helps to detect food attributes or objects from an image. By mobile app, an individual can easily plan their diet, and its saves time too.

Daniele Rav'et al. [31] discussed the technique of food recognition on mobile devices with the help of an application. Researchers also discussed daily activity, and the energy expenditure of individuals can be maintained through an application. Authors have used the technique of hierarchal classification using many visualize cues. Representation of Fischer vector with linear classifier is used for categorization of food intake. Based on the Inertial motion sensor, determination of daily energy expenditure is done. The proposed technique is compared with the existing technique and successfully shows accuracy in food determination and energy expenditure.

Ishrat Majid et al. [32] discussed the food packaging market trends in today's scenario. Researchers also discussed, how food packaging helps in the healthcare system. Authors also provide discussion on novel and evolution food packaging techniques. Various types of packaging like Active, intelligent, and proactive packaging techniques discussed by researchers. Food packages help to maintain food quality and freshness of food for a long time. The latest food packaging techniques help oxidation retardation, prevention from microbial attack, hindered the respiratory process, moisture infusion prevention, and ripeness indicator during storage.

Weiqing Min et al. [33] have provided a discussion on recipes of food based on region. Researchers proposed cross region analysis of recipes with recipes ingredients, images of foods, and attributes like the course and cuisine. The authors also proposed an analysis of culinary culture and get them to visualize different applications. Researchers have provided a probabilistic model, and manifold ranking for retrieving food images. The authors also proposed topic modelling with visualize method for three applications.

E. A. Neeba et al. [34] have discussed the food quality enhancement scenario. Researchers provided the concept of the freshness of food is highly required nowadays due to the increase in medical cases. Researchers also discussed food security concepts, its highly required because of the flood, weather, and drought cases. The authors used an Efficient food quality Analysis model with biosensors and IoT devices to identify food damage factors. The data received from biosensors is further aggregation, processed, and analysed for food safety.

Ali Besharat et al. [35] described the customization technique for food products. Researchers describe whether to select or reject food based on the ingredients. Because of today's hectic schedule led to unhealthy food intake. Determination of accurate calorie intake is much required in today's scenario. This study is helpful for those who want to maintain their weight and are required to spend healthy life, and also for food companies, that want to maintain their customers.

Landu Jiang et al. [36] have discussed the technique of dietary assessment and analysis of nutrition. Researchers focussed on why food nutrition intake value and assessment of diet is necessitated. Researchers have used the concept of a deep model for food recognition on food items. Three steps recognition is done by researchers using a deep convolutional neural network. Region-based food analysis is done and then the classification of food is done base on the region. Region proposal network (RPN) is used with the R-CNN model. Based on the available dataset UEC-FOOD100, and UEC-FOOD256 image recognition is done and after that ingredient of the food is found. The amount of carbohydrates, Fat, and calories available in food is analysed and then a diet plan is generated. This helps individuals in food intake and helps body wellness and health.

As Mentioned in Table 1, various Authors worked on Food recognition technique and describing various techniques on food intake, food security, and dietary assessment. Many Authors have used CNN based model for image recognition. Food packaging is also playing vital role in keeping food healthy. Region based food detection can also be a part of dietary assessment. Dietary assessment is mainly focussed on type of ingredients available in foods. Access taken of Calories food may harm your health. That's why a healthy routine dietary plan is required for health wellness.

Table 1 Analysis of food computing techniques

References	year	Technique used	Observation
[12]	2020	POFG FGAS	1. Researchers used the concept of the IoT framework for determining food quality in restaurants. 2. FGAS is the scale to access actual time food-oriented parameters environment of food hubs.
[17]	2014	Multi Classifier Technique	1. The authors discussed the scenario of being overweight and how it is harmful to a person's health. 2. Researchers provided the concept of food recognition based on mobile cameras

(continued)

Table 1 (continued)

References	year	Technique used	Observation
[18]	2012	Piezoelectric sensor Support vector machine classifier	1. Authors have discussed the concept of food intake or chewing behaviour of individuals based on the sensor system.
[19]	2015	DietCam, probabilistic method	1. Researchers claimed 84% accuracy in the proposed work. 2. A probabilistic method is helpful to determine food images from each perspective that's why researchers achieved high accuracy in the proposed system.
[20]	2014	NRLBP	Researchers worked on three folds in the proposed technique. 1. NRLBP are used to declare information of local appearance. 2. The spatial relationship with intersecting points is used to represent food objects' structural information. 3. Thirdly researchers proposed a description of structural information and integrated appearance, and food image classification.
[21]	2017	RA-CNN	1. For optimization, the proposed approach is using a classification approach based on intra-scale and a ranking loss approach based on inter-scale.
[22]	2016	CNN	1. Authors used the technique CNN base multi classifier to detect food type and available nutrients such as calories in that food. 2. For this problem, researchers used the concept of volume estimation and segmentation.
[23]	2015	Bag-of-words, SIFT, and LBP	1. Bag-of -words technique helps to detect food attributes or objects from an image. 2. By mobile app, an individual can easily plan their diet, and its saves time too.
[24]	2015	Fischer vector with Linear classifier	1. Authors have used the technique of hierarchal classification using many visualize cues. 2. Representation of Fischer vector with linear classifier is used for categorization of food intake. 3. Based on the Inertial motion sensor, determination of daily energy expenditure is done.
[25]	2018	–	1. Authors also provide discussion on novel and evolution food packaging techniques. 2. Various types of packaging like Active, intelligent, and proactive packaging techniques discussed by researchers.

(continued)

Table 1 (continued)

References	year	Technique used	Observation
[26]	2018	Culinary culture analysis, probabilistic model, and manifold ranking	1. Researchers proposed cross region analysis of recipes with recipes ingredients, images of foods, and attributes like the course and cuisine. 2. The authors also proposed an analysis of culinary culture and get them to visualize different applications. 3. Researchers have provided a probabilistic model, and manifold ranking for retrieving food images.
[27]	2021	EFAM, biosensors	1. Researchers provided the concept of the freshness of food is highly required nowadays due to the increase in medical cases. 2. The authors used an Efficient food quality Analysis model with biosensors and IoT devices to identify food damage factors. 3. Researchers also discussed food security concepts, its highly required because of the flood, weather, and drought cases.
[28]	2020	–	1. Researchers describe whether to select or reject food based on the ingredients. Because of today's hectic schedule led to unhealthy food intake. 2. Determination of accurate calorie intake is much required in today's scenario.
[29]	2020	Region-based Food Analysis, R-CNN	1. Researchers have used the concept of a deep model for food recognition on food items. 2. Three steps recognition is done by researchers using a deep convolutional neural network. Region-based food analysis is done and then the classification of food is done based on the region.

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Estimating the Risk of Diabetes Using Association Rule Mining Based on Clustering

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1 Introduction

Diabetes has risen as a significant medical care issue in India. The International Diabetes Federation (IDF) is assessed that each fifth individual with diabetes will be an Indian. The Indian Council of Medical Research (ICMR) assessed that the nation as of late had around 65.1 million diabetes patients. There are an everyday 77.2 million people in nation who are encountering pre-diabetes. Pre-diabetes is a situation wherein the sufferers have excessive blood sugar stage but are not in the diabetes variety. These individuals are at high risk of getting diabetes. Diabetes prompts huge unexpected problems including ischemic coronary illness, stroke, nephropathy, retinopathy, and neuropathy and fringe vascular infection. Initial recognizable proof of patients in danger of creating diabetes is a significant prerequisite of medical care. Fitting administration of patients in danger with way of life changes and meds can diminish the danger of creating diabetes by 30–60%.

Type 1 diabetes used to be called adolescent beginning diabetes. It is regularly achieved by an auto-safe response where the body's security structure assaults the

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cells that produce insulin. The explanation this happens isn't completely perceived. Individuals with type 1 diabetes produce for all intents and purposes no or no insulin. The disease may affect people, things being what they are, yet by and large makes in kids or young adults. Individuals with this sort of diabetes need imbuement of insulin dependably to control the degrees of glucose in their blood. If individuals with type 1 diabetes don't move toward insulin, they will die. Type2 diabetes is referred to as non-insulin subordinate diabetes or grown-up beginning diabetes, and data for basically 90% of all times of diabetes. It is portrayed by insulin opposition and relative insulin lack, either or the two of which may be accessible at the time diabetes is broke down. The finding of type 2 diabetes can happen at whatever stage in life. Type2 diabetes might remain undetected for quite a while and the finding is regularly made when a hell shows up or an ordinary blood or pee glucose test is finished. It is routinely, however not overall, related with obese or weight, which itself can reason insulin opposition and lead to excessive blood glucose levels. Individual with type 2 diabetes can routinely at initial arrangement with their condition through exercise and diet. In any case, over the long run a great many individuals will need oral medications and insulin. Both sort 1 and type 2 diabetes are absolutely genuine. There isn't anything of the sort as delicate diabetes.

Gestational diabetes (GDM) is a form of diabetes such as excessive blood glucose tiers for the duration of being pregnant. It makes one out of 25 pregnancies round the arena and is attached with complexities to both mom and newborn child. GDM conventionally disappears after pregnancy anyhow ladies with GDM and their teenagers are at a lengthy danger of creating type2 diabetes not very some distance away. Around half of women with a foundation set apart by GDM continue to make type 2 diabetes inside five to ten years after transport. Diabetes is important for the metabolic condition, that is a set of stars of infections such as hyperlipidemia, raised fatty substance and low HDL levels, (hypertension) and focal corpulence (with weight list surpassing 30 kg/m2). These sicknesses connect with one another, with heart and vascular infections and in this manner comprehension and displaying these collaborations is significant. Alliance chooses are ideas that accomplice a ton of possibly teaming up conditions (for example high BMI and the presence of hypertension finding) with raised danger. The usage of affiliation rules is especially advantageous, considering the way that in any case assessing the diabetes risk, they in like manner expeditiously give the specialist a "support", explicitly the connected course of action of conditions. This sport-plan of situations may be used to manipulate remedy closer to a greater changed and targeted in on preventive concept or diabetes the pioneers.

Information mining procedures are the outcome of a long pattern of investigation and thing improvement. This improvement began when business data was first managed on PCs, gone before with updates in data access, and shockingly a greater amount of late, gained levels of headway that grant customers to investigate through their data intensely. Information mining takes this formative cycle past outline statistics get entry to and course to upcoming and proactive data transport. Data delving is prepared for software inside the commercial enterprise community considering that it's far saved by using 3 advances which are correct now satisfactorily skilled: gigantic data association, Powerful multiprocessor PCs, Information mining computations. Given data bases of high-quality length and quality, statistics mining headway can create new commercial enterprise openings by way of giving those limits, robotized assumption for examples and rehearses and modernized disclosure of in advance of time dark models.

Broad measures of information and information put away in clinical information bases require the advancement of specific devices for getting to the information, information examination, information disclosure, and compelling utilization of put away information and information, since the expansion in information volume causes challenges in removing valuable data for choice help. The customary manual information investigation has become lacking, and strategies for productive PC based examination irreplaceable, for example, the advancements created in the space of data mining and information disclosure in informational collections. Enormous assortments of clinical information are a significant asset from which conceivably new and helpful information can be found through Data Mining. Information Mining is progressively main stream as it is pointed toward increasing knowledge into the connections and examples covered up in the information. Patient records gathered for analysis and anticipation normally envelop upsides of an amnestic, clinical and lab boundaries, just as consequences of specific examinations, explicit to the given undertaking. Such informational collections are portrayed by their inadequacy (missing boundary esteems), inaccuracy (precise or arbitrary clamor in the information), meager condition (few and non representable patient records accessible), and estimation (unseemly choice of boundaries for the given errand). The improvement of data mining instruments for clinical determination and forecast was regularly propelled by the prerequisites for managing these attributes of clinical informational collections. The advancement of data mining apparatuses for clinical finding and forecast was regularly roused by the prerequisites for managing these attributes of clinical informational indexes.

In medication, Data Mining can be utilized for tackling spellbinding and prescient information mining assignments. Unmistakable Data Mining undertakings are worried about finding fascinating examples with regards to the information, just as intriguing groups and subgroups of information, where ordinary strategies incorporate affiliation rule learning, and (hierarchical or k-means) bunching, separately. Interestingly, prescient data mining begins from the entire enlightening assortment and focuses on a judicious model that holds tight the data and can be used for assumption or portrayal of yet subtle events.

Information mining in medication is regularly utilized for building arrangement models, these being utilized for conclusion, anticipation or treatment arranging. Prescient information mining, which is the focal point of this part, is worried about the examination of classificatory properties of information tables. Information addressed in the tables might be gathered from estimations or obtained from a clinical setting; an idea of interest can be a sickness or a clinical result.

2 State of Art

Pedro J. Caraballo, M. Regina Castro, Stephen S. Cha, Peter W. Li, and Gyorgy J. Simon [1] proposed a "Use of association rule mining to assess diabetes risk in patients with impaired fasting glucose". This paper presents three different approaches. They are survival analysis, Decision trees, and ARM. Decision Trees is to discover interaction based on a greedy approach.

In ARM, no capacity to make up for age and follow up time, specifically designed to discover interactions. Regression Analysis and Association Rule Mining is to eliminate the impact old enough, sex, FUT and find relationship between the danger factors and the DM hazard not clarified by age and FUT. The main disadvantage of this project is to produce a large number of rules.

Hye Soon Kim, A. Mi Shin, Mi Kyung Kim, and Nyun Kim [2] proposed a "Comorbidity study on type 2 diabetes mellitus using data mining". The factor of this paper is dissecting comorbidity in sufferers with type 2 diabetes mellitus by way of utilizing ARM. The technique for this undertaking is Dx Analyze Tool was created for information purging and information shop development, and to uncover relationship of comorbidity. The main disadvantage of this paper is that the Apriori calculation is restricted in deciding priority or causality of illness. Subsequently, future investigations to distinguish the transient inconveniences of illnesses thinking about sequence (e.g., the successive example of sickness event) ought to be directed.

Peter W. Wilson, James B. Meigs, Lisa Sullivan, Caroline S. Fox, David M. Nathan, and Ralph B. D'Agostino [3] proposed a "Prediction of incident diabetes mellitus in middle-aged adults: the Framingham Offspring Study". The approach for the paper is relapse models had been utilized to anticipate new T2DM, beginning with attributes acquainted to the challenge (individual version, i.e., age, intercourse, family history of diabetes, and weight report [determined as the load in kilograms partitioned by stature in square meter]), adding simple medical estimations that contained metabolic disorder traits (fundamental medical model) and lastly searching over complicated clinical fashions that contained, 2-hour put up-oral glucose power take a look at glucose, fasting insulin, and C-responsive protein stages, the Gutt insulin influence capacity list and the homeostasis model insulin resistance and the homeostasis model insulin hindrance beta-cell influence capacity records. Segregation was surveyed with region under the collector working trademark bends.

Shin AM, Lee IH, Lee GH [4] proposed a "Diagnostic analysis of patients with essential hypertension using association rule mining" The point of this is dissecting the records of patients determined to have fundamental hypertension utilizing affiliation rule mining. Technique for this paper is Patients with fundamental hypertension (ICD code, I10) were removed from an emergency clinic's information stockroom and an information shop developed for examination.

Fog computing enabled clever healthcare gadget that included with the trendy generation. Deep studying ensemble method that gives an automated prognosis of heart sickness with the making use of FETCH gadget for IoT enabled sources.

FETCH supplies hospital therapy inside the form of fog computing services and efficiently manages the data of a coronary heart patient person that come from various IoT-enabled devices. FETCH contains the deep mastering technique in part computing enabled devices and deployed these gadgets in the environment for actual-lifestyles use of heart ailment trying out [10].

A deep learning C19D-Net version is proposed for exploiting chest XR pics to hit upon and classify COVID-19 and different styles of pneumonia contamination. The dataset of 1900 Chest XR picture has been accumulated from publicly handy databases. Images are pre-processed with right scaling and regular feeding to the proposed version for accuracy attainments [11].

A new content material caching scheme is offered to improve the network performance by way of the complete utilization of available cache assets. The proposed scheme implements the caching operations primarily based at the content material reputation in a dynamically sized recognition window and the gap navigated with the aid of the Content message from the preceding router that caches its reproduction [12].

Cookies is essential for morning and night time tea time snacks. Low-cost nutritive biscuits product of natural additives wethania, somnifera powder is opportunity option to rejuvenate immunity. Cookies is wealthy in carbohydrate, strength, protein and fat boom its significance for undernourished populace. The rapid-paced existence with much less time for sparkling food training has additionally created vicinity for geared up to devour food [13].

Apriori demonstrating the ARM technique and web hub in the Clementine 12.0 program were utilized to investigate quiet information. The primary impediment of this paper is it was hard to dissect consecutive examples since patients were determined to have a few sicknesses simultaneously now and again.

3 Proposed Approach

Association rule mining [9] finds fascinating affiliations and associations among enormous arrangements of information things. This standard shows how oftentimes an item set happens in an exchange. Given a set of risk data, we can find rules that will predict the occurrence of risk data based on the occurrences of other data. This module consists of two components namely: Rules generation, Clustering the diabetes data and Risk of diabetes.

3.1 Rules Generation

Outline techniques depending on avaricious set inclusion share a regular trouble detailing as follows: given a misfortune degree L, build a set A comprising of k Item sets all drawn from I or a superset of I with the cease aim that A limits L. The issue is NP-hard and a rough arrangement is gotten utilizing few variations of successive inclusion. In rule set synopsis a set I of rules with a more modest set A of decides to such an extent that I can be recuperated from A with negligible lack of data. Initial a set E of thing sets is created, which shapes the assortment of thing sets from which the synopsis manages A are chosen. Regularly E is as old as, yet a few calculations add extra thing sets, making it a superset of I. At first A is unfilled and it is built repeatedly. The standard E in E that limits L is chosen and added to A for every cycle. To try not to choose a similar principle over and over, its impact is taken out. Either the actual standard is disposed of from E or the patients protected by way of the usual are taken out from the informational series. Since a standard is characterized by a solitary thing set, we will utilize 'thing set' instead of 'rule' meaning the 'thing set that characterizes the standard'. Informational collection synopsis is a somewhat unique issue. If there should be an occurrence of informational collection outline, the objective is to address an informational collection D with a more modest set A of thing sets to such an extent that the informational collection can be recuperated from A with negligible misfortune.

Algorithm for sequential coverage

Input: Set I of item sets, number k of summary rules

Output: Set $\mathcal{A}$ of item sets, s. t. $\mathcal{A}$ minimizes the criterion L

Generate an extended set ε of item set based on I

$\mathcal{A}=\phi$

While $|\mathcal{A}| < k$ do

A = $\text{argmin}_{E\in\varepsilon} L(E)$

Add A to $\mathcal{A}$

Remove the effect of A

End while

3.2 Clustering the Diabetes Data

Clustering is the task of assortment a great deal of things so that articles in a comparable get-together (labelled a bundle) are extra tantamount (in a manner) to each other than to those in various get-togethers (get-togethers). Each standard is characterized by an item set; we utilize the words rule and thing set conversely. The disclosure of distributional alliance rules includes two phases. In the initial step, an appropriate arrangement of thing sets is found and in the subsequent advance, the arrangement of thing sets is separated with the goal that line the authentically imperative ones are returned as distributional affiliation rules. For each observed thing set, we truly needed to determine whether the result portion in the impacted and the unaffected subpopulations are genuinely unique. A nonexclusive factual experiment, the Wilcox experiment, is consistently pertinent; notwithstanding, when the result variable follows familiar circulation all the more remarkable experiments can be practiced. Testing the significance for a massive number of factors units establishes synchronous hypothesis trying out techniques (Table 1).

Cluster analysis is a repetition loop of information disclosure or instinctive multi-target upgrade that includes essentials and disappointment, instead of a customized task. Changing data preprocessing and model cutoff points until the item accomplishes the ideal properties would be important consistently. K-means is a simple unsupervised learning algorithm that also serves as a clustering partitioning method. The K-implies calculation partitions a dataset of n objects into k bunches with the info k as the quantity of groups and the yield as the quantity of bunches so the subsequent objects of one group isn't like those of different bunches. In a k-means calculation, k objects are chosen at random to represent the k initial cluster center or mean. Following that, each entity is allocated to one of the clusters based on its proximity to the cluster core (Fig. 1).

Table 1 Description of risk factors

Factor	Description
bmi	sbp dbp hdl
Mass	Mass list I ≥35
Pulse	Hypertension ≥150
Heartbeat	Hypertension ≥100
High-thickness	Protein ≤40 for male and ≤48 for female
Chol	All out sterol ≥220
Trig	Triglyceride ≥160
Drugs:	
Piarb	Pro inhibitor and angiotensin receptor blocker
Ba	Beta antagonists
Ca	Calcium antagonist
Diuret	Diaphoretic
Gemfibra	Gemfibrozil
Statin	*C*lopidogrel
Aspznn	Aspirin Co-morbid ities:
Bp	Blood pressure
Tobacco	Nicotine
Ci	Cardiac infarction

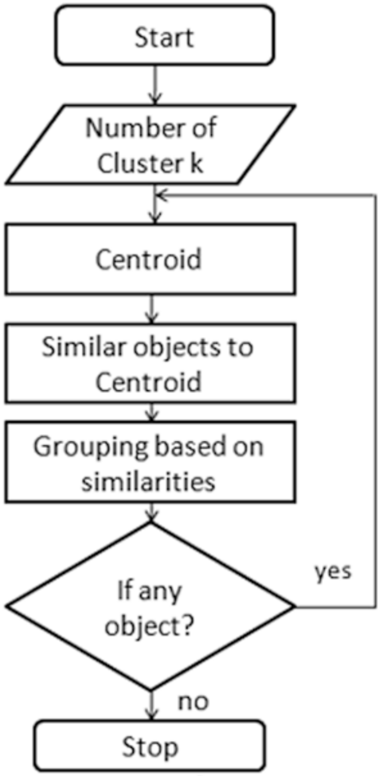

Fig. 1 Clustering based on summarized rule

3.3 Risk of Diabetes

The electronic facts delivered by using EMR‘s in routine scientific practice may conceivably paintings with the divulgence of latest records. Association rule mining paired to a synopsis method gives a basic instrument to scientific examination. It can discover stowed away clinical connections and may advocate new examples of conditions to divert anticipation, the executives, and remedy draws near. Distributional affiliation rule mining so that you can distinguish units of risk factors and the comparing patient subpopulations which are at essentially accelerated risk of advancing to diabetes. An unreasonable variety of association rules had been discovered blocking off the clinical comprehension of the effects. For this strategy to be valuable, the quantity of guidelines should have been decreased to a level where clinical understanding is attainable (Fig. 2).

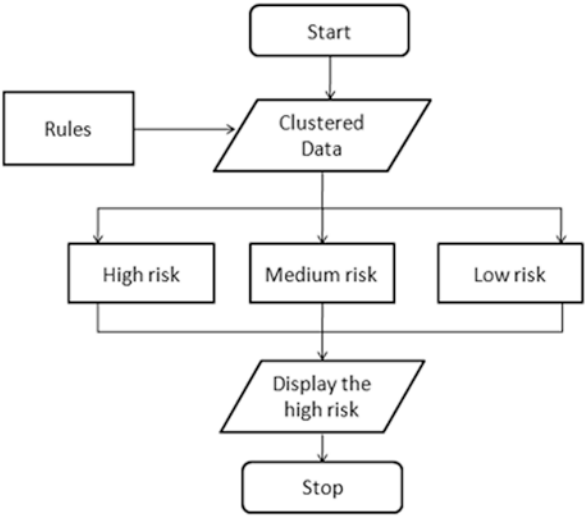

Fig. 2 Risk analysis based on the clustered data

4 Implementation and Results

Distributional association rule mining is distinguishing a group of chance regulations and the evaluating person subpopulations are at essentially elevated chance of advancing to diabetes. An inordinate quantity of affiliation rules has been located obstructing the scientific information of the outcomes. Greedy Set Coverage algorithm [7] delivered the most reasonable rundown for diabetes patients. The subpopulations are recognized by this summarization rule [5, 6] and found high-risk patients (Fig. 3; Table 2).

5 Conclusion

Distributional association rule mining is distinguishing a bunch of hazard rules and the evaluating affected person subpopulations are at basically multiplied risk of advancing to diabetes A great quantity of affiliation guidelines has been discovered hindering the medical comprehension of the effects. Greedy Set Coverage algorithm[8] delivered the most reasonable rundown for diabetes patients. The subpopulations outstanding by way of this outline covered most high-danger sufferers, had low cross-over and had been at extremely excessive hazard of diabetes. The risk rules are applied to each sort of diabetes patient's not set in stone the high danger of diabetes patients.

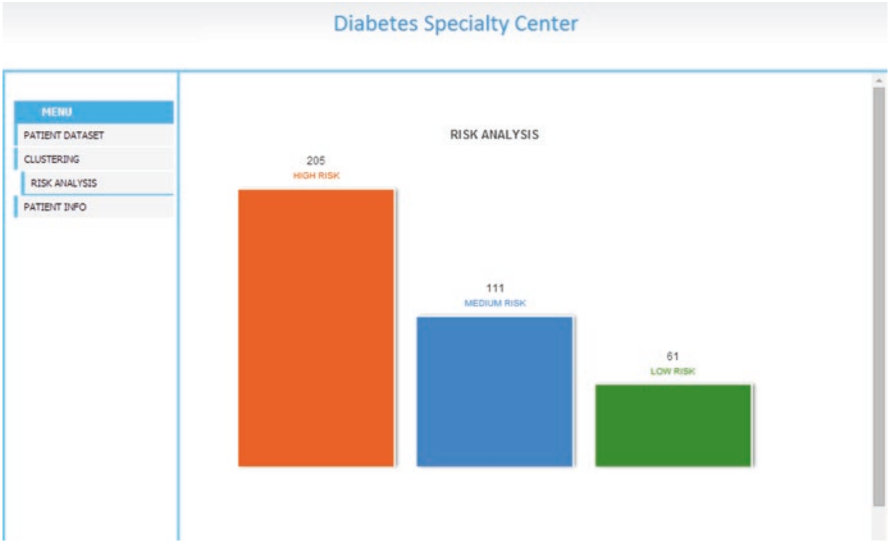

Fig. 3 Risk analysis

Table 2 Rules before summarization

Relative Risk RR	Expected ER	Observed OR	Rule
2.4	21.6	51	*gemfibra* bp
2.34	24.24	58	bmi chol *statin bp*
2.2	25.89	57	ci trig *aspznn bp*
2.19	26.22	61	bmi trig *statin*
2.18	31.03	67	bmi trig *aspznn bp*
2.08	30.02	63	bmi trig *aspznn* ci
2.09	27.04	58	bmi ba trig *statin* bp
2.2	26.10	55	ht trig *aspznn* bp
2.08	34.11	70	bmi trig *statin bp*
2.05	32.99	68	bmi *trig gemfibra*

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Conflict of Interest The author pronounces no irreconcilable situation.

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Digital Twins for Food Nutrition and Health Based on Cloud Communication

Zhihan Lv and Liang Qiao

1 Introduction

Today in the twenty-first century, people's living standards are constantly improving. Health has become a topic of concern. Health involves physical health and healthy diets. To provide proper guidance on people's diet, the relevant departments of nutrition and diet in China have formulated dietary guidelines according to the actual situation and publicized them to the masses via various publicity methods. For example, the even more popular short videos and Applets often advertise some foods' nutritional content, calorie content, and consumption methods. Still, it is unknown whether they can provide people with personalized guidance [1, 2]. With the popularization of Artificial Intelligence technology, there is also diverse nutritional diet-related software on the market recommending suitable food combinations through the user's eating habits. However, most computer-based healthy catering systems aim to cater to particular groups, such as pregnant women, infants, and diabetic patients [3]. The catering process of ordinary people is cumbersome and professional, so it is difficult to judge the rationality of the food collocation recommended by these systems. Therefore, the application of AI, Cloud Computing, and other technologies to the general public's nutrition, health, and balanced diet has become the concern of researchers in related fields.

A long-term, scientific, reasonable, and balanced diet can keep people healthy and enable them to create more value for society and improve work efficiency, promoting national economic development. With the progress of mobile communication, intelligent terminals are increasing rapidly, and the technologies related to

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Cloud Computing and Communication are even more widely used [4–6]. In the dietary nutrition field, people's increasing attention to dietary nutrition balance is in sharp contrast to the current situation of dietary nutrition imbalance. Therefore, it is urgent to apply computer technologies to food nutrition identification and health analysis. For example, apply Big Data to food nutrition management, or use Cloud Communication technology to build a cloud platform for food nutrition and diet management. In the food cloud platform, Big Data is of a large volume. It can effectively extract the relevant data in food, such as the picture and weight of food, and analyze the relevant data information with the help of the Cloud Communication platform [7]. Computer technologies face the diversification of nutrition, food types, and nutrients required by users, and the constraints of users' families, cooking menus, and regions. The convolution calculation unique to Convolution Neural Networks (CNNs) in Deep Learning (DL) can extract and classify food nutrition data features. CNN can also understand the personalized preference of users' nutritional needs and food nutrition matching through the input of many orders and autonomic learning to realize the intelligent recommendation of food nutrition matching [8, 9]. Digital Twins (DTs) technology can map the food pictures and other data collected in the physical space to the virtual space. Then, it analyzes their nutrition in the cloud platform of the virtual space to achieve the balanced food nutrition intake of users [10].

To sum up, in today's expected progress of science and technology and social economy, it is of significant practical value to make people's intake of food nutritionally balanced and healthy to promote social development. The innovation of this study lies in four aspects. Firstly, Cloud Communication technology is adopted to analyze the needs of human nutrition and health. Secondly, the improved AlexNet network extracts and classifies food images. Thirdly, DTs technology is used to map the obtained image information and human nutrition and health data. Fourth, a food DTs nutrition evaluation model is constructed based on Cloud Computing combined with AlexNet. Besides, the objective function of the Sum Throughput Maximization (STM) algorithm is built to optimize the objective function. Finally, the model algorithm is verified by experiments to provide ideas for the follow-up balanced intake and intellectual development in the dietary nutrition field.

2 Recent Related Work

2.1 Development Status of Intelligent Detection of Dietary Nutrition Intake

Regular monitoring of people's nutritional intake is essential to reduce the risk of disease-related malnutrition, especially for special groups such as pregnant women, infants, and people with diabetes. Although methods for estimating nutrient intake have been gradually developed, there is still a clear need for a more reliable, fully automated technique. Many scholars have researched the intelligent detection of nutrition and intake in food. Jia et al. (2019) employed a self-centered wearable camera to acquire pictures and developed an automatic food detection algorithm via AI from images for dietary estimation. Finally, the authors found that this algorithm could obtain images in the real world and automatically detect food with an accuracy of more than 85% [11]. Liu et al. (2020) proposed a food ingredient joint learning module based on the Attention Fusion Network for fine-grained food and ingredient recognition. The simulation proved that the module could effectively recognize fine-grained images of food [12]. Lu et al. (2020) put forward an AI-based new system to accurately estimate food nutrient exposure by simply processing Red Green Blue Depth image pairs collected before and after meals. The experimental results showed that the estimated nutrient intakes were highly correlated with the ground truth (>0.91), with a tiny average relative error (<20%), significantly better than existing nutrient intake assessment techniques [13]. Rachakonda et al. (2020) proposed a DL model for Edge Computing platforms capable of automatically detecting, classifying, and quantifying food on a user's plate. Compared with other paradigms, the model achieved an overall accuracy of 98% and an average accuracy of 85.8% [14]. Arslan et al. (2021) investigated food classification using common DL algorithms. The authors took the public food database as the object and found that the classification accuracy reached 90.02%, meeting the practical classification needs [15].

2.2 Application Status and Development Trend of DTs

The DTs technology has been extensively applied in various industries in recent years. It can map the actual data obtained in the industrial field into the virtual space, further increasing its potential. At present, DTs technology also extends to the medical and health areas. Many scholars have studied it. Laamarti et al. (2020) put forward an ISO/IEEE11073-standardized DTs framework, including acquiring information from individual health equipment, analyzing the data, and sending feedback to users in a cyclical fashion. Finally, the authors proved that this framework could be used as the foundation for promoting intelligent medical DTs [16]. Wan et al. (2021) used DTs technology to map physical brain pictures to virtual space for many un data in brain images. On this basis, the authors established a brain image integration DTs diagnosis and forecasting model based on Semi-Supervised Support Vector Machine and improved AlexNet. The experimental results showed that the constructed model had brilliant accuracy, acceleration efficiency, and segmentation and recognition performance under the premise of ensuring low error. The research supported detecting a brain image characteristics and digital diagnosis [17]. Francisco et al. (2021) used intelligent meters to adjust building energy in DTs of smart cities, making smart energy management within the geographical scope of medium and large buildings in the smart city a critical step in smart city construction [18]. Zhang et al. (2021) proposed a social-awareness-based vehicle edge caching mechanism to cope with the rapid development of intelligent transportation. This mechanism dynamically coordinated the capability of roadside units according to user preference similarity and service availability, and the caching capabilities of smart vehicles. At the same time, the edge cache system was mapped into the virtual space using DTs technology to facilitate the construction of a social relationship model. Through simulation, the authors found that the constructed edge cache scheme had significant advantages in optimizing cache utility [19].

2.3 Analysis and Summary of Existing Research

To sum up, through the analysis of the researches of scholars in the above-mentioned related fields, many scholars have carried out intelligent detection on the nutritional components of food. However, there are few studies on dietary intake and nutritional matching. Besides, with the continuous improvement of DTs technology, its application fields have also developed from the initial industrial production to medical health and many other areas. Therefore, this paper also introduced DTs technology to evaluate dietary nutrition using intelligent algorithms like DL to balance food intake.

3 Analysis of the Nutrition Evaluation Model of Food DTs Based on Cloud Computing and DL

3.1 Analysis of Demand for Intelligent Assessment of Food Nutrition

The nutritional needs of the human body all come from food. To ensure the healthy balance required by the human body and achieve reasonable nutrition, people should eat diversified types of food and supplement nutrition according to the standard level. The *Dietary Guidelines for Chinese Residents* (2019) [20] issued by the Chinese nutrition society points out that eating more green leafy vegetables and fruits, taking cereals as the staple food, and adequately supplementing dairy products, beans, and a reasonable diet with meat and vegetables every day can make the human body carry out normal metabolism. The average level of nutrition required by the human body (average demand), the amount of food recommended by the nutrition standard (recommended daily intake), the proportion of food suitable for intake (adequate intake), and the macronutrients like protein are within the acceptable range. Based on the nutritional needs ratio, macronutrients, namely protein, fat, and sugar, primary elements, trace elements, namely minerals and various vitamins, fat-soluble vitamins, and water-soluble vitamins, have been included in the *Dietary Reference Intakes of Chinese Residents* by the Ministry of Health. Productive

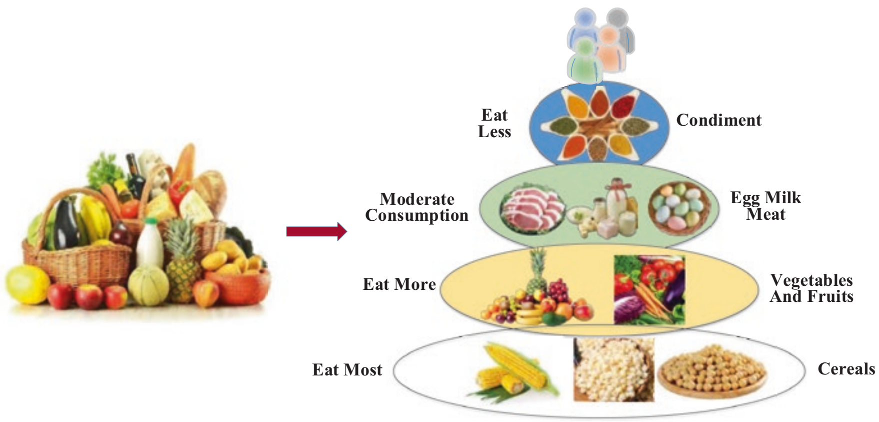

Fig. 1 Examples of food nutrition collocation

(thermal) nutrients release energy in the human body, including proteins, lipids, and carbohydrates [21]. Figure 1 displays the food nutrition collocation.

As shown in Fig. 1, human intake primarily includes five categories: spices, eggs, milk, meat, vegetables, fruits, and cereals. Due to the different nutritional content of various foods, the intake is from less to more when matching, but the demand for nutrients of different groups is different. Food recommendation is faced with the diversification of user characteristics, nutrition required by users, food types, food and nutritional components of agricultural products, and the constraints of multi-user families, cooking menus, historical menus, seasons, regions, etc. Therefore, selecting the right food from multiple agricultural products under much agricultural product classification and making intelligent recommendations to users is a practical demand. Based on the food DTs nutrition evaluation model of Cloud Computing combined with DL, this paper collects the information of relevant food data in the human body using Cloud Computing technology and transmits it to the cloud center for processing. Besides, DTs technology is used to map the data information to virtual space to design a multi-objective optimization algorithm for human nutrition demand. The methods designed here can achieve the optimal matching relationship between the nutrition required by the human body and the necessary nutrition in various foods.

3.2 Application of Cloud Computing and Communication Technology to Human Nutrition and Health Analysis

As one of the essential branches of the communication network, the Wireless Body Area Network (WBAN) takes the human body as the network information environment. It is a communication network composed of light, ultra-thin, low-power, and intelligent sensors located on the body surface or in the body. The node transmits the critical physiological parameters obtained by the WBAN in real-time to the health monitoring center and the Cloud Computing center through the wireless communication network to realize data sharing [22, 23]. Here, the WBAN is applied to human health analysis.

A WBAN is a wireless communication network constructed by multiple sensor nodes located on the surface, inside and outside the human body. The whole system adopts the operating mode of first distributed perception information, then aggregated processing and remote analysis. The specific WBAN communication architecture is divided into three-layer: communication within the WBAN, communication between the WBAN, and communication outside the WBAN, as shown in Fig. 2.

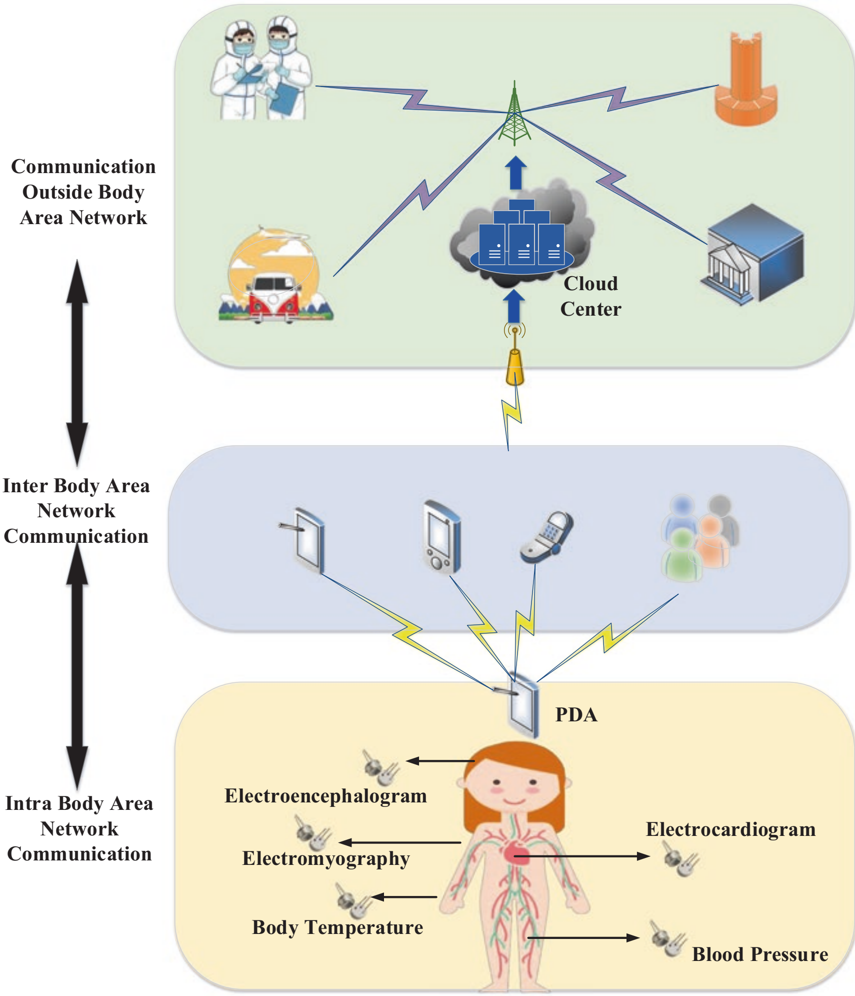

Fig. 2 WBAN communication architecture under cloud communication

As shown in Fig. 2, in the WBAN communication, various sensors (such as EEG, ECG, blood pressure sensors, etc.) distributed in the human head, limbs, and trunk communicate with the sink node in real-time. By designing a network structure suitable for the scene, they choose the corresponding communication protocol according to the receiver structure. In interbody area network communication, a Personal Digital Assistant obtains human physiological information shares information and preliminarily integrates and analyzes data with other wireless body area networks (including home data terminals) through Bluetooth or Wi-Fi communication. The communication outside the Body Area Network shares the human physiological data to hospitals, intelligent homes, smart cars, etc., through the straightforward base station and the Internet to provide people with various services. It even analyzes human data through Big Data and Cloud Computing to provide high-quality dietary balance and human health decisions.

Due to the dynamic characteristics of the human body (such as body posture, muscle movement), shadow effect, and the different environment of WBAN, the typical path loss model P_L can be described as Eq. (1).

$$P_L = PL(d) + X \tag{1}$$

In Eq. (1), according to the Fries Transfer Formula [24] in the free space, $PL(d)$ refers to the path loss corresponding to the reference distance d to the node, and X stands for the shadow factor of a normal distribution with zero mean and standard deviation. The shadow factor X is determined according to different channel environments.

In body-surface communication, the channel loss function $P_{dB}(d)$ between body-surface nodes is constructed as Eq. (2).

$$P_{dB}(d) = P_{0,dB} + 10n\log(d/d_0) \tag{2}$$

In Eq. (2), n represents the channel loss index, d_0 denotes the reference distance, and $P_{0,dB}$ corresponds to the initial path loss of the reference distance d_0.

However, the non-uniform and lossy communication transmission medium composed of human tissue layers is not uniform. Each tissue layer will absorb the electromagnetic energy of the sensor, significantly reducing the signal transmission in the body. Therefore, the channel loss model P_d between receivers and transmitters in vivo communication can be expressed:

$$P_d = \frac{P_t}{P_r} = P_0(d/d_0)^n \chi_r \tag{3}$$

$$P_d(dB) = P_0(dB) + 10n\log(d/d_0) + \chi_r(dB) \tag{4}$$

where P_t and P_r represent the transmitted signal power and received signal power in the communication link, respectively; P_0 refers to the initial path loss corresponding to the reference distance d_0; $\chi_r \sim N\left(0,\sigma_\chi^2\right)$ refers to the usual random variables with mean 0 and variance σ_χ^2, that is, the deviation caused by different tissue layers of the human body (such as skin, muscle, fat, etc.) and antenna gain in different directions.

When monitoring human health, WBAN can realize real-time monitoring of critical physiological parameters of the human body through the transmission and collection of radio frequency energy and the acquisition of information data. Among them, the energy and information transmission models of WBAN principally include a point-to-point transmission model and a cooperative transmission model with relay nodes, as presented in Fig. 3.

In Fig. 3, h and g refer to the channel coefficients of the downlink and uplink, respectively. The point-to-point energy and information transmission model is the most basic and simple transmission model in the WBAN. It is suitable for scenes with close distance and little shadow effect interference. However, in the scenario of long-distance, the point-to-point direct link will affect the system's overall performance. The relay node needs to forward energy and information to solve the problems of human dynamics and shadow effect to ensure the efficiency and reliability of system information transmission.

In the point-to-point transmission model, the SN P simultaneously transmits the energy flow carrying the command information to the sensor S. After passing through the power splitter at the receiving end, a part of the wireless signal is used for energy collection. The signal y_s received by the sensor node is expressed as Eq. (5).

$$y_s = \sqrt{P_a}hx + n_s \tag{5}$$

In Eq. (5), P_a and n_a refer to the transmit power and antenna noise of sensor S, respectively; x_a refers to the signal sent by the sensor node when the wireless signal is used for energy harvesting. The energy E collected by the sensor can be written as Eq. (6).

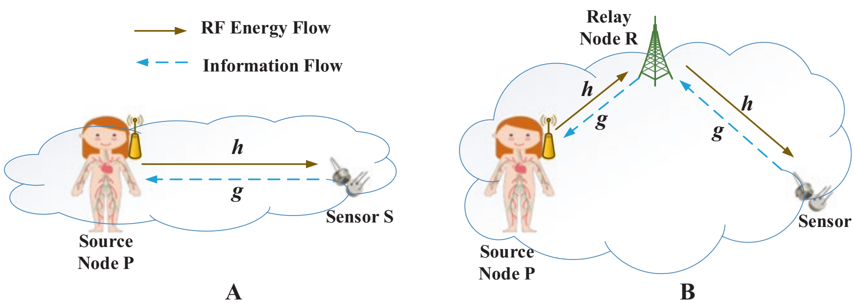

Fig. 3 Energy and information transmission model of WBAN under cloud communication (**a**. point-to-point transmission model; **b**. cooperative transmission model with relay nodes)

$$E = \eta \rho P_a |h|^2 (T/2) \tag{6}$$

In Eq. (6), $\rho(0 < \rho < 1)$ and $\eta(0 < \eta < 1)$ refer to the power split ratio and energy conversion efficiency, respectively; T stands for the time period of information transmission. Another part of the wireless signal is used for information decoding. The signal $y_s^{'}$ received by sensors and the signal x_s sent by sensors can be written as:

$$y_s^{'} = \sqrt{1-\rho}\left(\sqrt{P_a} h x_a + n_s\right) \tag{7}$$

$$x_s = \sqrt{\mu}\left(\sqrt{1-\rho}\left(\sqrt{P_a} h x_a + n_s\right) + n_s^{'}\right) \tag{8}$$

where $n_s^{'} \sim N\left(0, \sigma_n^2\right)$ stands for the additional processing noise on the sensor node. μ refers to the amplification and forwarding coefficient, as shown in Eq. (9).

$$\mu = \eta \rho P_a |h|^2 / (1-\rho) P_s |g|^2 + \sigma_n^2 \tag{9}$$

In Eq. (9), P_s refers to the received power of the sensor S.

Moreover, after the sensor S decodes the information and receives the energy, it sends the sensed information back to the SN P to complete the information transmission for some time T. After the amplification and forwarding coefficient μ is energy balanced, the signal received by the SN P is y_a expressed as Eq. (10).

$$y_a = g\sqrt{\mu}\left(\sqrt{1-\rho}\left(\sqrt{P_a} h x_a + n_s^{'}\right) + n_a\right) \tag{10}$$

In Eq. (10), n_a refers to the antenna noise of SN P following a normal distribution with mean 0 and variance σ_a^2. Finally, the throughput from sensor S to SN P is expressed as Eq. (11).

$$R = \frac{1}{2}\log_2(1+\gamma) \tag{11}$$

In Eq. (11), γ refers to the Signal to Noise Ratio (SNR) from the sensor S to the SN P in the point-to-point transmission model.

In the relay cooperative transmission model, the relay node R is used to amplify and forward the wireless energy and information from the SN P and the sensor S. Usually, there are two power splitting and time switching protocols for the transmission of energy and information.

In the power-sharing protocol, the SN P and the sensor S transmit wireless energy and information to the relay node in the $T/2$ time slot. Then, the signal received by the relay node y_r can be described as Eq. (12).

$$y_r = \sqrt{P_a} h x_a + \sqrt{P_s} g x_s + n_r \tag{12}$$

In Eq. (12), n_r refers to the noise generated by the relay node. Another part of the signal y_r' received through power splitting is expressed as Eq. (13).

$$y_r' = \sqrt{1-\rho}\left(\sqrt{P_a}hx_a + \sqrt{P_s}gx_s + n_r\right) \tag{13}$$

The relay node forwards the information and energy to the SN P and the sensor S in the remaining time slots, respectively. Equation (14) indicates the signal $y_{a,ps}$ received by the SN P.

$$y_{a,ps} = h\sqrt{\beta_{ps}}\left(\sqrt{1-\rho}\sqrt{P_s}gx_s + n_r'\right) + n_a \tag{14}$$

In Eq. (14), $n_r' \sim N\left(0,\sigma_r^2\right)$ refers to the additional processing noise of the relay, and β_{ps} represents the balance coefficient to ensure energy collection and consumption, as shown in Eq. (15).

$$\beta_{ps} = \eta\rho P_a |h|^2 / \left(\left(1-\rho\right)P_s|g|^2 + \sigma_r^2\right) \tag{15}$$

Then, the SNR generated on the SN P can be written as Eq. (16).

$$\gamma_{a,ps} = \frac{\left(1-\rho\right)P_s|h|^2|g|^2}{|h|^2\sigma_r^2 + \sigma_a^2\left(\left(\left(1-\rho\right)P_s|g|^2 + \sigma_r^2\right)/\left(\rho P_a|h|^2\right)\right)} \tag{16}$$

In the power-sharing protocol, in the first time slot τT, the SN P transmits wireless energy to the relay node. $0 \le \tau \le 1$ means the time switching ratio. Equation (17) demonstrates the total energy $E_{r,ts}$ collected by the relay node.

$$E_{r,ts} = \eta P_a |h|^2 \tau T \tag{17}$$

Furthermore, in the second time slot $(1-\tau)T/2$, the information $y_{r,ts}$ received by the relay node from the sensor is expressed as:

$$y_{r,ts} = \sqrt{P_s}gx_s + n_r' \tag{18}$$

where $n_r' \sim N\left(0,\sigma_r^2\right)$ refers to the noise on the relay node. The relay node forwards the amplified signal to the SN P; meanwhile, the sensor decodes information and energy collection. Equation (19) describes the balance coefficient β_{ts} satisfying the energy collection and consumption.

$$\beta_{ts} = 2\tau P_a|h|^2 / \left(\left(1-\tau\right)\left(P_s|g|^2 + \sigma_r^2\right)\right) \tag{19}$$

Similar to the analysis of the power shunt protocol, the SNR $\gamma_{a,ts}$ generated by the AP SN is presented as Eq. (20).

$$\gamma_{a,ts} = \frac{P_s |h|^2 |g|^2}{|h|^2 \sigma_r^2 + \sigma_a^2 \left(\left((1-\tau) \left(P_s |g|^2 + \sigma_r^2 \right) \right) / \left(2\tau\eta P_a |h|^2 \right) \right)} \tag{20}$$

The final throughput R_{ts} from the sensor to the SN P is:

$$R_{ts} = \frac{1-\tau}{2} \log_2 \left(1 + \gamma_{a,ts} \right) \tag{21}$$

3.3 Application of DL in Food Nutrition Evaluation and Analysis

DL is a typical feature extraction algorithm. CNN is a booming Feedforward Neural Network with the optimal effect. Its most significant superiority lies in local connectivity and sharing weights. A large number of neurons in the model are organized in a particular pattern and have responded to the overlapping areas in the visual field [25]. The first parameter of the CNN's operation refers to the input, the second parameter (function w) refers to the kernel function, and the output refers to the characteristic mapping [26]. Generally, CNNs conduct convolutions in multiple dimensions. Denote the input as a two-dimensional matrix I. Then, a two-dimensional kernel K is used, as shown in Eq. (22).

$$\begin{aligned} S(i,j) &= (I \cdot K)(i,j) \\ &= \sum_m \sum_n I(m,n) K(i-m, j-n) \end{aligned} \tag{22}$$

In Eq. (22), i, j, m, and n are all fixed parameters, referring to the dimension and order of the matrix. When CNN is applied to food image feature extraction and classification, the food image information in CNN intersects several convolutional and pooling layers and gathers together by one or more fully connected layers. All neurons in the layers are connected to the neurons in the previous layer. Usually, the establishment of this layer relies on two one-dimensional network layers. The local information of the convolutional layer or the pooling layer is grouped. The ReLU function is usually used as the excitation function by all neurons to improve the performance of the network.

AlexNet [27], a deep CNN model with more network layers and more vital learning ability is selected in this paper to simply the computation and enhance the generalization ability of CNN. Figure 4 reveals the process of extracting and classifying DTs data features of food images based on AlexNet.

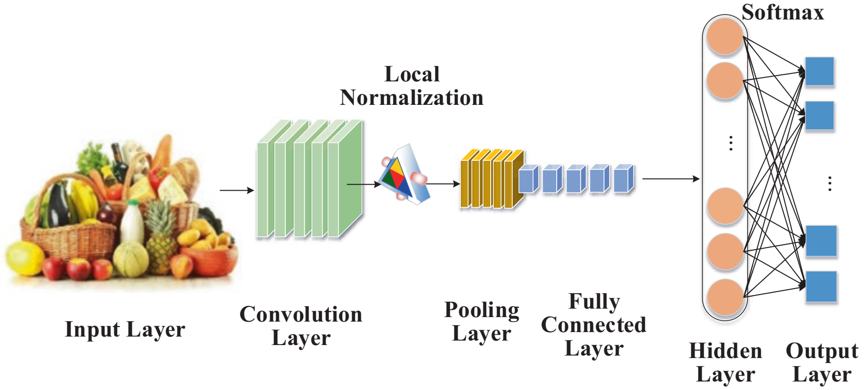

Fig. 4 Extraction and classification process of DTs data features of food images via AlexNet

In Fig. 4, the convolution operation is performed on the food image first when extracting and classifying the DTs data of food images. Then, the local normalization, pooling, and full connection operations are performed.

Moreover, the functional layer of the AlexNet model's convolutional layer is improved. Specifically, the local normalization and pooling operation operations in order are reversed. It can enhance the generalization ability of AlexNet and weaken the overfitting phenomenon, significantly reducing the training time. In addition, local normalization after Overlapping Maximum Pooling (OMP) can retain more useful information and drain redundant information in the pooling process. It also speeds up the convergence of the model training and highlights the advantages of OMP over the existing MP approaches. The calculation of each layer is as follows.

The overlapping pooling method samples the *t*-th characteristic mapping $y_t^l(i,j)$ of the *l-th* convolutional layer.

$$a_t^l(i,j) = \max\{y_t^l(i,j), i_s \le i \le i_s + w_c - 1, \quad j_s \le j \le j_s + w_c - 1\} \tag{23}$$

In Eq. (23), s stands for the pooling movement step size, w_c represents the pooling area's width, and $w_c > s$.

The AlexNet model performs the first and second pooling operations. Then, a local normalization layer is introduced to normalize the feature map according to Eq. (24).

$$c_t^l(i,j) = a_t^l(i,j) / \left(k + \alpha \sum_{\max(0,t-m/2)}^{\min(N-1,t+m/2)} \left(a_t^l(i,j) \right)^2 \right)^{\beta} \tag{24}$$

In Eq. (24), k, α, β, and m are hyperparameters, the values of which are 2, 0.78, 10^{-4}, 7, respectively. N denotes the amount of convolution kernels of the first convolutional layer. The ReLU function is used to activate the convolutional product $S_t^l(i,j)$ to avoid gradient dispersion in the network model. The activation function $y_t^l(i,j)$ can be expressed as Eq. (25).

$$y_t^l(i,j) = f\left(S_t^l(i,j)\right) = \max\left\{0, S_t^l(i,j)\right\} \tag{25}$$

The Dropout Operation's parameters are set to 0.5 to prevent overfitting in the fully connected layer. All food feature maps are integrated into a high-dimensional single-layer neuron architecture C^5. Equation (26) describes the input Z_i^6 of the i-th neuron in the sixth fully connected layer.

$$Z_i^6 = W_i^6 C^5 + b_i^6 \tag{26}$$

In Eq. (26), b_i^6 and W_i^6 represent the sixth fully connected layer's bias and weight of the i-th neuron, respectively.

The neurons C^l in the 6th and 7th fully-connected layers are abstained and output in the process of generalization capability improvement; $r_j^l \sim bernoulli(dp)$; $\tilde{C}^l = r^l C^l$. Then, the input Z_i^{l+1} of the i-th neuron in the seventh and eighth fully-connected layers is $W_i^{l+1}\tilde{C}^l + b_i^{l+1}$. The output C_i^l of the i-th neuron of the 6th and 7th fully-connected layers is $f\left(Z_i^l\right)$, i.e., $\max\left\{0, Z_i^l\right\}$. Finally, the input q^i of the first neuron of the eighth fully connected layer can be obtained according to Eq. (27).

$$q^i = soft\max\left(Z_i^8\right) = \frac{e^{Z_i^8}}{\sum_{j=1}^{12} e^{Z_i^8}} \tag{27}$$

Meanwhile, the Cross-Entropy Loss Function (CELF) for the food image classification problem is used as the model's error function, which can be written as Eq. (28).

$$Loss = \sum_{i=1}^{K} y_i \cdot \log\left(p_i\right) \tag{28}$$

$$p_i = \frac{\exp\left(\tilde{y}_i\right)}{\sum_{i=1}^{K} \exp\left(\tilde{y}_j\right)} \tag{29}$$

In Eq. (28), K stands for the quantity of types; y_i denotes the accurate class distribution of the samples; y_i refers to the CNN's output; p_i signifies the sort results after the Softmax categorizer. The Softmax function's input is an N-dimensional real vector, denoted as x, as presented in Eq. (30).

$$\xi(x)_i = \frac{e^{x_i}}{\sum_{n=1}^{N} e^{x_i}}, i = 1, 2, \ldots, N \tag{30}$$

Furthermore, the essence of the Softmax function is analyzed. This function maps an *N*-dimensional random real vector into an N-dimensional vector with the values of each element within (0, 1) to realize the normalization of the vector. The μ companding transformation reduces the output data volume to 2^8 to simplify the neural network's computation, i.e., $\mu = 255$, to improve the model's forecasting ability.

$$f\left(x_t\right) = sign\left(x_t\right)\frac{\ln\left(1+\mu\left|x_t\right|\right)}{\ln\left(1+\mu\right)}, \left|x_t\right| < 1 \tag{31}$$

3.4 Construction and Analysis of the DTs Evaluation Model of Food Nutrition and Health Based on Cloud Computing and AlexNet

Firstly, human nutrition and health needs are analyzed through cloud communication technology to realize human nutrition and health needs and multi-targeted personalized intelligent food recommendation. The improved AlexNet is used to extract and classify the features of food images. Then, DTs technology maps the obtained image information and human nutrition and health data to the virtual space to intelligently recommend methods suitable for human nutrition and health. Figure 5 illustrates the food nutrition and health DTs evaluation model based on Cloud Computing and AlexNet.

As shown in Fig. 5, this model adopts Cloud Computing, and Communication technology are to obtain human health data. Then, the improved AlexNet extracts and classifies food nutrition data. The human health and food nutrition data obtained in the real space are mapped to the virtual space via DTs technology. The obtained data results are finally evaluated through data fusion and classification transmission to determine the healthy recipes suitable for human health.

When using Cloud Communication technology to acquire and analyze human health data, the proposed time switching protocol constructs the overall throughput objective function of multipoint WBAN. It presents the objective function of STM optimization. The overall throughput of the system is:

$$\left(\mathrm{P1}\right): \max_{\tau_0,\tau_i} \sum_{i=1}^{K} R_i^{ab}\left(\tau_0,\tau_i\right) = \max_{\tau_0,\tau_i} \frac{1}{2}\sum_{i=1}^{K}\tau_i \log_2\left(1+\frac{X_i^{ab}\dfrac{\tau_0}{\tau_i}}{Y_i^{ab}\dfrac{\tau_0}{\tau_i}+Z_i^{ab}}\right) \tag{32}$$

$$s.t. \sum_{i=1}^{K}\tau_i \le 1, \tau_i \in \left[0,1\right], i = 0,1,\ldots,K \tag{33}$$

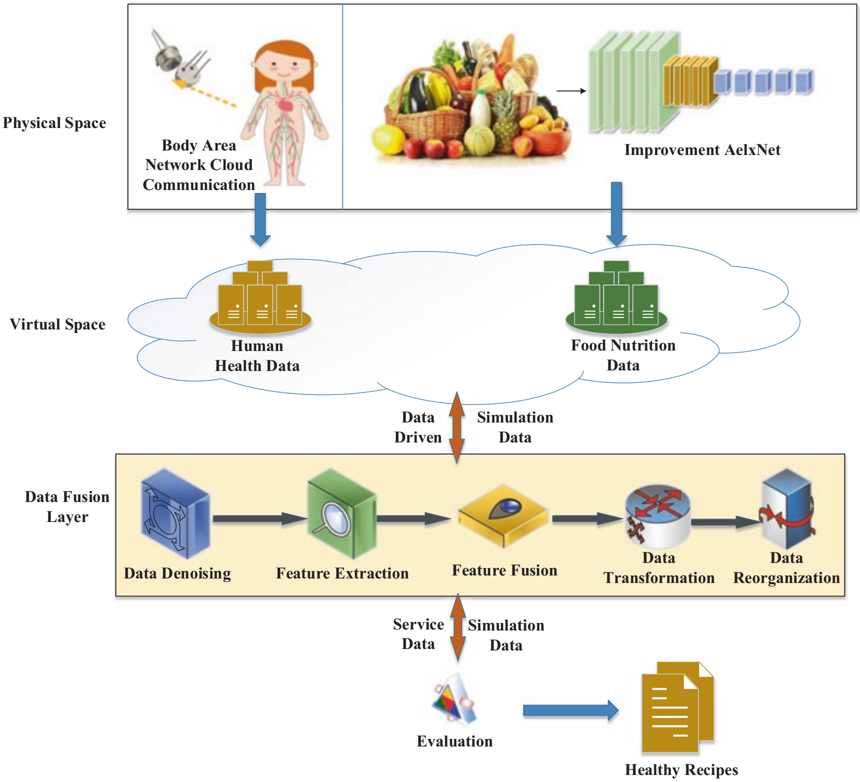

Fig. 5 Food nutrition and health DTs evaluation model based on Cloud Computing and AlexNet

where R_i^{ab} represents the throughput from the sensor S_i to the SN P under abnormal conditions; X_i^{ab}, Y_i^{ab}, and Z_i^{ab} are different parameters in the objective function, respectively; τ_0 refers to the initial energy transmission time slot; τ_i stands for the energy transmission time slot at time *i*.

In this model, a large amount of food image data is used to improve AlexNet for self-learning to accurately learn the personalized preferences matching the nutritional needs of users with the nutrition of agricultural products. When using the enhanced AlexNet for training, the Weighted Cross-Entropy is used as the cost function to optimize the model training. Denote $z_k(x, \theta)$ as the unnormalized logarithmic probability value of the pixel x of the k-th category of the food image with a specific parameter θ. The Softmax function $p_k(x, \theta)$ is decided as Eq. (34).

$$p_k(x,\theta) = \frac{\exp\{z_k(x,\theta)\}}{\sum_{k'}^{K} \exp\{z_{k'}(x,\theta)\}} \tag{34}$$

In Eq. (34), K represents the amount of food categories. In the prediction stage, when Eq. (34) takes the maximum value, the pixel x is marked as the k-th class, i.e., $k^* = \arg\max\{P_k(x,\theta)\}$. The log-normalized probability value is abbreviated as p_{ik}. Thus, the training focuses on locating the best network parameters θ^* by minimizing the weighted CELF $\ell(x,\theta)$, i.e., $\theta^* = \min_{\theta} \ell(x,\theta)$. The Weighted Loss Function for food picture integration is defined as Eq. (35).

$$\ell(x,\theta) = -\sum_{i=1}^{N}\sum_{k=1}^{K} w_{ik} q_{ik} \log p_{ik} \tag{35}$$

In Eq. (35), $q_{ik} = q(y_i = k|x_i)$ refers to the actual label distribution of the pixel x_i of the k-th category; w_{ik} represents the weighting coefficient. In the training process, the calculation strategy shown in Eq. (36) is adopted.

$$w_{ik} = \frac{1}{\ln(c + p_{ik})} \tag{36}$$

In Eq. (36), c stands an extra super parameter, empirically set to 1.11 during this experiment.

Figure 6 indicates the training process of the improved AlexNet algorithm applied to the food image DTs model

3.5 Experimental Testing and Evaluation

This section evaluates the performance of the constructed food nutrition and health DTs evaluation model based on Cloud Computing combined with AlexNet. Firstly, the analysis effect of human health data under Cloud Communication technology is evaluated. The human body path loss model is chosen to be located on the torso of the human body. The channel reciprocity between uplink and downlink makes the channel coefficients the same for uplink and downlink. The objective function optimized by the STM algorithm reported here is compared with the Equal Time Allocation (ETA) algorithm [28] and the Minimum Throughput Maximization (MTM) algorithm [29]. These algorithms are compared from the changing curve of the overall throughput of the system with the transmission power (TP) P_a of the source node (SN) P, the number of sensors S, and the energy conversion efficiency η. The changing trend of the energy transmission time slot τ_i with the number of sensors is analyzed. In addition, various algorithms are analyzed in terms of fairness index.

The improved AlexNet proposed here is also evaluated from the food nutritional characteristics data. This study collects about 1284 kinds of food nutrition components from the *Chinese Food Nutrient Composition Table* as the data of this experiment. After collecting the nutritional data of agricultural products, the data is

start

Input: Food image nutrition data matrix D

Output: Improved AlexNet food nutrition data matrix Z_i

For $D:[1,\cdots,X_i], i=1,2,...,N$ **do**

Searching for the optimal network parameter $\theta*$ by CELF $\ell(x,\theta)$;

$\theta* \leftarrow \min_{\theta} \ell(x,\theta)$

$\ell(x,\theta) \leftarrow \sum_{i=1}^{N}\sum_{k=1}^{K} w_{ik} q_{ik} \log p_{ik}$

$q_{ik} \leftarrow q(y_i = k \mid x_i)$

$w_{ik} \leftarrow \frac{1}{\ln(c+p_{ik})}$

$c \leftarrow 1.10$

$z_t \leftarrow \mathrm{Re}lu\left(W_z h_t + b_z\right)$ //Fully connected layer

$prediction \leftarrow Soft\max\left(W_{sft} z_t + b_{sft}\right)$ // Classification and prediction of food nutrition

$Z_i \leftarrow Z_i \cup z_t$

return Z_i

end

Fig. 6 Training flow of the improved AlexNet algorithm applied to the food image DTs model

processed to remove some irrelevant data and parameters. Besides, the food data is divided into five categories (staple food, vegetables, meat, aquatic products, and fruits) according to the nutritional balance guidelines. There are about 200 pieces of data for the experiment after processing. A unique Identity Document is assigned to each data to be distinguished by food category. For the neural network, the following hyperparameters need to be set: the network iterates for 120 times, the simulation time is 2000 s, and the Batch Size is 128. The Poly learning rate adjustment method is adopted as the learning rate update strategy using Polynomial Decay, expressed as $init\_lr \times \left(1-\frac{epoch}{\max\_epoch}\right)^{power}$. The initial learning rate $init\_lr$ is 0.0005 (or $5e^{-4}$), and the power is set to 0.9.

The algorithm reported here is compared with the algorithms applied by other scholars in related fields for the performance analysis, including Long Short-Term Memory (LSTM) [30], CNN [31], Recurrent Neural Network (RNN) [32], AlexNet [33], and Multilayer Perceptron (MLP) [34]. The classification accuracy is compared and analyzed from the perspectives of Accuracy, Precision, Recall, and F1 value. The time required by different models is also examined.

The specific experimental configuration primarily considers hardware and software, as summarized in Table 1.

Table 1 Experimental configuration

Software			Hardware		
Operating System	Python	Development Platform	Central Processing Unit	Memory	Graphics Processing Unit
Linux 64bit	3.6.1	PyCharm	Intel core i7–7700@4.2GHz of eight cores	Kingston ddr4 2400 MHz 16G	Nvidia GeForce 1060 8G

4 Research Results

4.1 *Comparative Analysis of Human Health Data Evaluation under Different Cloud Communication Technologies*

The objective function optimized by the STM algorithm reported here is compared with the ETA algorithm and the MTM algorithm. This experiment compares the changing curves of the overall throughput of the system with the TP P_a of the SN P, the number of sensors S, and the energy conversion efficiency η. The changing trend of the energy transmission time slot with the change of the number of sensors is also discussed. In addition, various algorithms are analyzed from the perspective of fairness. The results are shown in Figs. 7, 8, and 9. Two repeated experiments for each algorithm are conducted separately.

As shown in Fig. 7a, as the TP of the SN P increases, the overall throughput of different algorithms grows. This is because the greater the transmit power, the more broadcast energy of the SN, resulting in a smooth rise in the overall throughput. In addition, according to the international standard of WBAN, the TP cannot exceed one mW; otherwise, it will cause damage to the human body. The TP of the SN ranges from 0 mW to 1 mW. The throughput performance of the STM algorithm reported here is significantly better than that of the MTM algorithm and the ETA algorithm. The throughput performance of the STM algorithm proposed here is considerably better than that of the MTM algorithm and ETA algorithm. The overall throughput of the ETA algorithm is lower, and the difference between them is no more than 2 bps/Hz. According to Fig. 7b, the overall throughput of different algorithms increases smoothly with the growth of energy conversion efficiency η. It is possible that the higher the energy conversion efficiency, the more energy the sensor can harvest for energy harvesting, resulting in greater throughput. In addition, it can be found that the throughput performance of the STM algorithm reported here is significantly better than that of the MTM algorithm and the ETA algorithm. The ETA algorithm has the lowest overall throughput. Besides, with the increase of energy conversion efficiency η, the overall throughput gap between the STM algorithm and ETA algorithm becomes larger. When η is 1, the throughput difference between the two is about 1.5 bps/Hz.

Figure 8**a** suggests that the overall throughput of each algorithm increases significantly as the number of sensors grows. In addition, the overall throughput

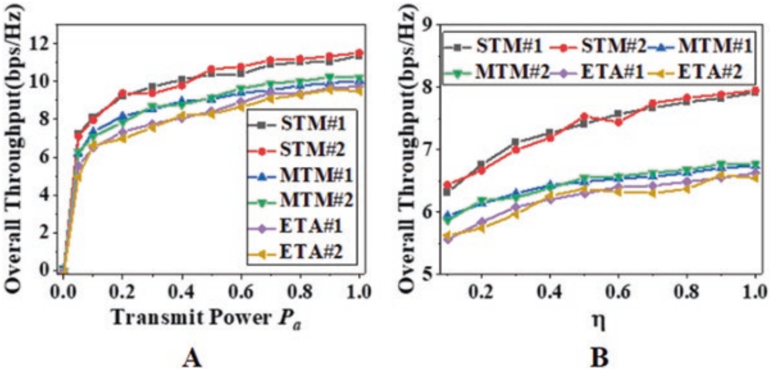

Fig. 7 Variation curves of the overall throughput varying with the TP (mW) of the SN and energy conversion efficiency η (**a**. the overall throughput varying with the TP of the SN; **b**. the overall throughput varying with the energy conversion efficiency η)

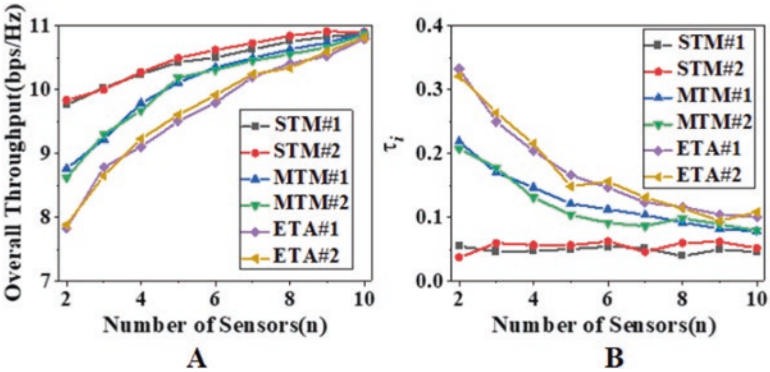

Fig. 8 Variation curves of overall throughput and energy transmission time slot with the number of sensors (**a**. The overall throughput changing with the number of sensors; **b**. the energy transmission time slot changing with the number of sensors)

performance of the STM algorithm reported here is substantially better than that of the MTM algorithm and the ETA algorithm. The overall throughput of the ETA algorithm is the lowest. With the increase of sensors, the overall throughput gap between STM algorithm, MTM algorithm, and ETA algorithm become smaller. When the number of sensors is 7, the throughput gap between the two does not exceed 0.5 bps/Hz. According to Fig. 8b, as the number of sensors increases, the energy transmission time slots τ_i of the MTM algorithm and the ETA algorithm show a downward trend, sharply affected by the number of sensors. However, the energy transmission time slot τ_i of the STM algorithm proposed reported here does not decrease significantly, almost stable within a specific range. The increase in the number of sensors implies that more information transmission time slots are required, reducing the energy transmission time slots within the normalized time

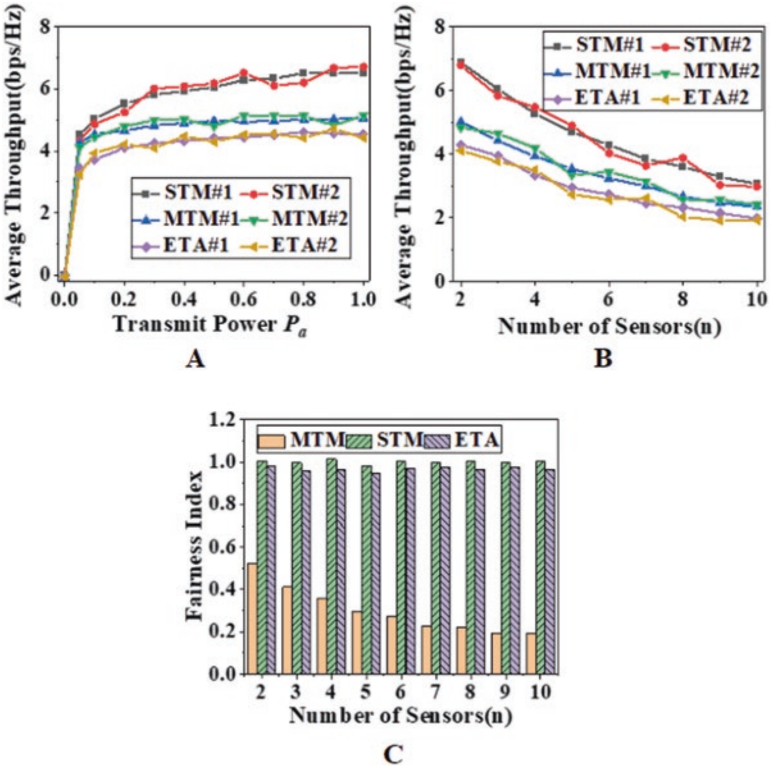

Fig. 9 Results of the average throughput varying with different factors (**a**. Average throughput varying with the TP of the SN; **b**. average throughput varying with the number of sensors; **c**. the fairness index varying with the number of sensors)

slot T. This explains why the energy transmission time slots τ_i for each algorithm are reduced. Therefore, the STM algorithm can be kept within a certain range (τ_i is around 0.05) to ensure the stability of energy transmission

As shown in Fig. 9a, with the increase of the TP of the SN, the average throughput of the system under different algorithms increases smoothly. This is consistent with the reason that overall throughput increases with transmit power. In addition, the STM algorithm reported here produces significantly better throughput than the MTM algorithm and the ETA algorithm. With the increase of the TP of the SN, the difference between the MTM and ETA algorithms gradually reduces. According to Fig. 9b, as the number of sensors increases, the average throughput decreases, which just verifies the phenomenon presented in Fig. 8b. The throughput of each sensor decreases due to the decrease of energy transmission time slots due to the increase of the number of sensors. In addition, the STM algorithm has a significantly higher average throughput than the MTM algorithm and ETA algorithm. The change of fairness index with the number of sensors is shown in Fig. 9c. It can be found that the fairness index of the MTM algorithm decreases gradually with the uneven resource allocation caused by the addition of new sensors to the network. The fairness index of the STM algorithm is one and remains unchanged, making the resource allocation fair to obtain the same throughput to maximize the average throughput. The Equal Time Distribution Protocol assigns the same information and energy transmission time slot to all sensors. Therefore, the fairness index of the ETA algorithm decreases slightly with the increase of sensors, which is lower than that of the MTM algorithm. Thus, in terms of resource fairness, the STM algorithm is better than the ETA algorithm and MTM algorithm, which has better stability and better effect in analyzing human health data.

4.2 Prediction Performance Analysis of Food Nutrition Classification Under Different Algorithms

This test analyzes the food nutrition recognition accuracy of the food nutrition and health DTs evaluation model based on Cloud Computing combined with AlexNet constructed here. The recognition and prediction accuracy of the algorithm reported here is compared with LSTM, CNN, RNN, AlexNet, and MLP from Accuracy, Precision, Recall, and F1 value, respectively. The results are shown in Fig. 10. Figure 11 further compares the training and test time required by each algorithm.

Figure 10 shows the comparison results of the model constructed here and the models proposed by scholars in other related fields from the perspectives of Accuracy, Precision, Recall, and F1 value. It can be found that the Accuracy of this algorithm reaches 93.17%. Compared with other neural network algorithms, the Accuracy is increased by at least 2.01%. Meanwhile, it is evident that the algorithm reported here has the highest values of Precision, Recall, and F1. Compared with other algorithms, the difference is at least 3.24%. In conclusion, compared with other neural network algorithms, the algorithm used here to build a food nutrition and health DTs evaluation model based on Cloud Computing combined with AlexNet has excellent food nutrition recognition and prediction accuracy.

Figure 11 provides the results of the time needed by each algorithm in the test set and training set under different food image data amounts. It can be found that the optimized AlexNet algorithm is better than the algorithms used by other scholars. Under different food image data amounts, the time required for the food image data increases gradually. At the same time, the time required by various algorithms in the test set is slightly lower than the time needed for the training set. This phenomenon is since the model has not yet formed a nutritional identification and analysis path corresponding to the food image during the training process. Besides, the neural network learns autonomously through the training process. Afterward, it can precisely analyze the nutritional classification of many food images, significantly improving the efficiency. Therefore, in the comparative analysis of the experimental results of all methods, the food nutrition and health DTs evaluation model based on Cloud Computing combined with AlexNet performs the best and achieves the better food nutrition classification and identification effects.

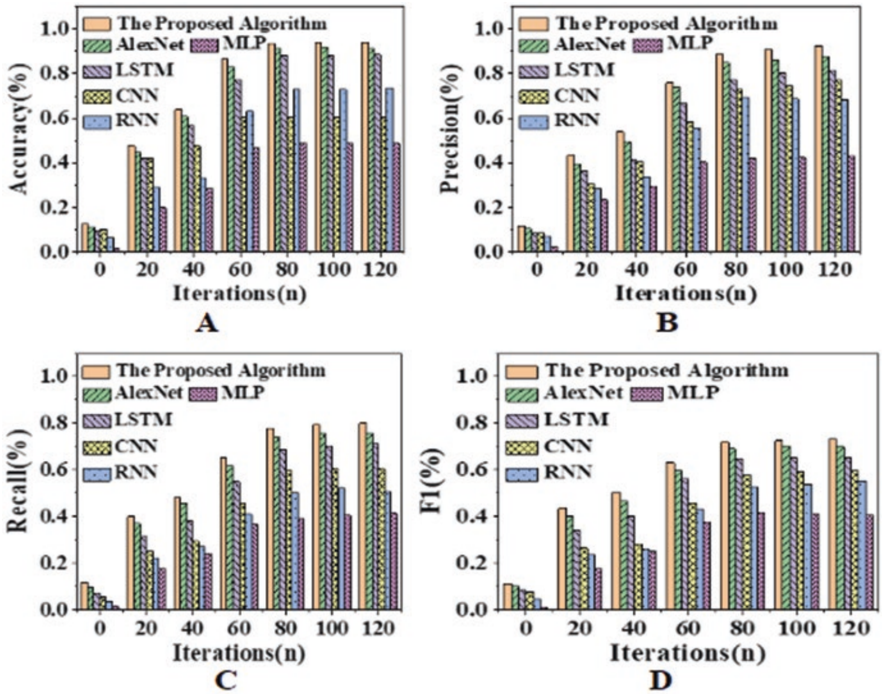

Fig. 10 Recognition results of different algorithms as the number of iterations increases (**a**. Accuracy; **b**. Precision; **c**. Recall; **d**. F1 value)

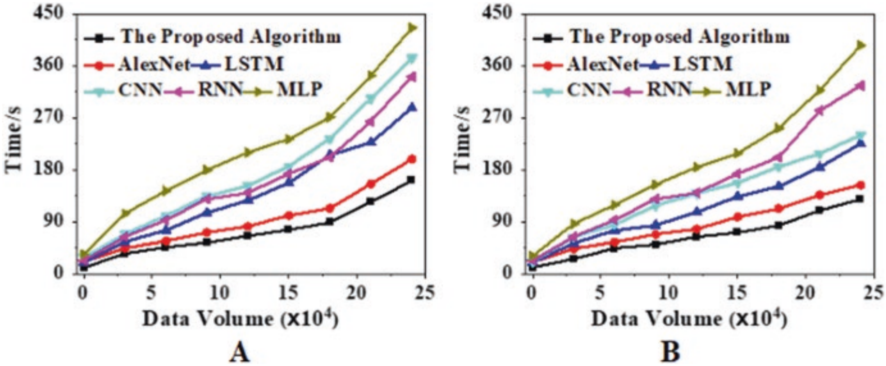

Fig. 11 Comparison of the running time of different algorithms under the training set and test set under different food image data amounts (**a**. training set; **b**. testing set)

5 Conclusion

Today, people pay increasing attention to balanced nutrition. Here, Cloud Communication technology, AlexNet, and DTs technology build a food DTs nutrition evaluation model. Through experiments, it is found that the throughput of the STM optimization algorithm proposed here is optimal, which can ensure the stability of the identification and processing of human nutrition and health data. At the same time, the improved AlexNet algorithm has a classification and recognition accuracy of 93.17% for food images, providing a direction fr the balanced intake and intellectual development of the follow-up dietary nutrition field. Still, the present work has some shortcomings. For example, the Body Area Network is cannot acquire all types of data on human nutrition and health. Therefore, future work will optimize the nutritional structure of users and study the impact of human social attributes on the correlation between food nutrition.

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Smart Healthcare Systems: An IoT with Fog Computing based Solution for Healthcared

Maher Thakkar, Jaineet Shah, Jai Prakash Verma, and Rajeev Tiwari

1 Introduction

1.1 Problem Formation with Background

Wearable sensors are becoming integral components of the healthcare industry. These devices collect data about a person's health and transmit it to a network or through their mobile devices [1]. The explosion of wearable sensors has created a massive amount of data that needs to be stored and analyzed in the Cloud. This makes it hard to gain a full understanding of the health of our patients. Unfortunately, real-time big data analytics from medical devices can be quite challenging to implement and manage. Aside from the data quality issues, it can also consume a huge amount of storage space and require a high amount of power consumption [2]. The ability to act in real time and work within a set of bandwidth constraints are two key factors that concern us when it comes to handling big data.

E-health has gained widespread acceptance in many countries. Its concept is still in its infancy, but the rapid emergence of information technology has greatly impacted the way medical data is managed. The data collected by healthcare systems must be collected, integrated, and analyzed in order to make informed decisions [3]. This process can help improve the accuracy and efficiency of the data used in healthcare.

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Smart cities could benefit from the use of machine learning technology to monitor the activities of their residents and provide them with helpful advice and support. There are generally four main types of analytic techniques used in healthcare data: descriptive, diagnostic, prescriptive, and predictive [4]. Descriptive analytics help identify the current status of a patient and generate reports and charts. Predictive analytics is a process that uses machine learning algorithms to identify unknown events that can trigger the reappearance of certain diseases. Descriptive analytics aims to make informed decisions about the treatment of patients. It uses big data to identify the most effective treatments for each patient [5]. This paper introduces a new approach called e-health, which combines cloud computing, big data mining, and fog computing to analyses big healthcare data. Instead of focusing on centralized data processing, we use distributed fog computing to perform fast and secure processing.

1.2 Motivation

The COVID-19 pandemic affected the world's economy and human health. It caused considerable morbidity and mortality [6]. COVID-19 declared as a pandemic that has a faster rate of infection and has impacted the lives and the country's economy due to forced lockdowns. Its detection using RT-PCR is required long time and due to which its infection has grown exponentially. This creates havoc for the shortage of testing kits in many countries. This work has proposed a new image processing-based technique for the health care systems named "C19D-Net", to detect "COVID-19" infection from "Chest X-Ray" (XR) images, which can help radiologists to improve their accuracy of detection COVID-19 [7].

It's also been proven that persons with chronic ailments including diabetes, cardiovascular disease, and chronic respiratory infections are more vulnerable to the virus. Elderly adults have been shown to be more susceptible to infection, and a higher number of deaths have been reported among those over 60 years old. Home hospitalization is one of the options that the government must consider in order to keep the virus from spreading further. Indeed, the most common cause of COVID-19 propagation is people meeting [4]. With the rise and advancement of technology, early detection and involvement in health-associated monitoring through home control are growing with population aging. The expansion of healthy life expectations is progressively significant due to the speedy aging of the world population. The patient requires early and home-based treatment to detect and prevent disease on time and with less effort [8]. In this circumstance, one of the greatest techniques that individuals and governments should implement is to treat patients remotely at their homes. It has been shown that the approach of home hospitalization is very efficient for both patients and healthcare workers since it allows them to reduce illness burden in two ways. To begin with, home hospitalization permits medical treatment to take place in the comfort of one's own home [9]. This type of treatment in a family setting has a significant impact on human health, resulting in patients' quick recovery and increased pleasure. Second, home hospitalization is cost-effective since it reduces the amount of time spent in the hospital. Environmental elements, on the other hand, must be maintained and managed by healthcare workers for the effectiveness of home hospitalization because they can affect patients' health and recovery [10]. Advanced technologies, such as the Internet of Things (IoT), have made it possible to monitor the environment around patients with the help of smart items and gadgets in recent years. It gives you the opportunity to collect and share data. In the sphere of healthcare, IoT applications were used, and more extended benefits were associated with remote assessment of the patient's state and environment. The usage of this technology improves the quality of healthcare services as well as the health and well-being of patients [11]. Cloud Computing is a technique that can be used for processing, calculation, storage, and resource sharing in a convenient manner [12]. In addition, a cutting-edge method known as fog computing puts processing and storage resources closer to users. Cloud computing and fog computing are two approaches to get access to IoT- based healthcare applications [13].

1.3 Contribution

In this paper, we have proposed a deep neural network model based on fog computing for the prediction of types of stress, diabetes and hypertension attacks. The proposed model is explained first through the system architecture followed by the technology and mathematical concepts which can be applied to make the system viable and finally the implementation details including the dataset characteristics as well as the hardware and software details. The results presented are obtained using a fine tuned version of the proposed model by Rojalina Priyadrashini, Rabindra Kumar Barik and Harischandra Dubey in their paper [14].

2 Related Work

2.1 Work Done by Different Researchers

The related work has been trifurcated. Firstly, the progress done in the domain of fog computing in healthcare is reviewed. Secondly, the current research in deep neural networks for the classification problems is discussed. Lastly, the development and expansion in fog computing based tele healthcare monitoring systems is emphasized upon.

Fog computing can be described as an emerging technology for efficient processing of big data obtained from IoT devices. It has been utilized in several domains such as the geospatial data analysis [15–17], creation of reality-based augmented gaming applications [18], smart city applications like network management of vehicles for smart parking [19, 20], and sensor data analysis [21–23].

The interest in artificial neural networks has rejuvenated in the past few years, especially in deep learning because of successful results obtained in the field of classification of images, regression issues in time series data and natural language processing [24, 25]. Some of the many problems include fraud detection, brain tumor classification, classification of ultrasound images, and image recognition, and object localization, inspection of various other medical imaging techniques and examination of time series data. Deep learning is a methodology that possesses the capability to extract fundamental features from the input data and use the derived features to train a model to become more efficient [26].

This paragraph discusses the works focused only on the healthcare domain. Gia [27] has proposed a low cost health monitoring model (LCHM) which obtains some features from ECG (Electrocardiography) data based on a wireless body area network (WBAN). The purpose of the model is to detect the heart rate from the ECG signals. The model utilizes fog computing as a gateway for the mining and storage of data in a distributed manner in order to communicate notifications at the network edge. The LCHM model collects and pre-processes the signals from the sensors and transforms them with a wavelet function. The main objective was for the model to achieve superior network bandwidth utilization and communication of low-latency real-time notifications. Next, a fog-based architecture is proposed by Dubey for the creation of a tele-healthcare monitoring system to monitor patients suffering from Parkinson disease. The proposed architecture utilizes the ECG signals / speech data captured from the sensors deployed in the patient's body. In order to extract loudness and frequency, filters are applied on the speech data. Additionally, the processed data is compressed using a GNU zip program to enhance the bandwidth utilization to obtain better network latency. Also, the optimization of battery power consumption is emphasized in the architecture. Next, a fog-based solution to obtain disorder in clinical speech data of Parkinson disease has been provided by Monteiro [28].

2.2 Comparative Study (Table 1)

A wearable watch supplies the raw data for the system. The system attempts to process the speech data to derive features such as loudness, short time energy, the zero-crossing rate of speech data. In contrast to the previous author, the system has not used any specific algorithm, instead a customized python coding for data extraction is implemented. Next, Rahmani [42] has presented a smart e-health monitoring system which timely notifies a patient before any emergency arises. Noisy data is accumulated followed by the application of some filters in order to remove the noisy patterns and finally, the data is compressed using both lossy and lossless compression techniques to deal with communication latency. The system also makes use of a public key encryption scheme to protect the locally stored data in the edge devices. Ahmad [43] employed fog computing for creating a customer-centric healthcare application that can play the role of a personal caretaker by giving alerts according

Table 1 Comparison of different models proposed by different researchers

Work	FC	IoT	DL	Power Consumption	Latency	Execution Time	Training Accuracy	Testing Accuracy
LCHM [27]	✓					✓		
Fog- Cep-	✓					✓		
ECGH [29]	✓	✓					✓	
AMS [30]		✓		✓				
GRAM [31]			✓					✓
SFG [32]	✓	✓		✓		✓		
HEDL [33]	✓	✓	✓			✓		✓
FEMI [34]	✓		✓				✓	
FIH [35]	✓	✓		✓	✓			
Fog- Learn [36]			✓					
SADL [37]			✓				✓	
CoSHE [38]		✓						
EOTC [39]	✓	✓				✓		
SLA-HBDA [40]	✓				✓			
CFBA [41]	✓				✓			

to a customer's request. The capturing of health data is done by a smartphone with integrated sensors. The data is acquired from various sources and a transitional fog layer between the end user and the cloud is implemented to secure the data to a higher degree.

3 Proposed Research Work

3.1 Problem Definition

The globe is becoming more industrialized, and the death rate is rising. However, the number of lifestyle diseases has risen during the same period. Obesity, type 2 diabetes, heart attack, and hypertension attack are among these disorders. The kind of nutrition, degree of stress, a lack of physical activity, and environmental factors are to be considered [44], are all key contributing factors in various disorders. The adverse effects of these medications can include life-threatening symptoms which are in need of medical emergency assistance like heart-attack, heartbeat that is irregular and pain in the chest. Diabetes regulance is said to grow twice in India to 366 million by the year 2030. Number of diabetes patients increased to 422 million in

2014. A report made by WHO states that diabetes mellitus is the main issue that causes kidney failure, becoming blind, cardiac arrest and strokes. In the United States in 2014, hypertension claimed the lives of more than 410,000 people. Therefore, to have a system that helps monitor fast and help detect early along with latency that is low, large accuracy level and quick response time is very important. The government spends lot of money on health- related IT frameworks and support services [45].

With increased computational power, analysis, health data collection and processing can be over more quickly, and the information that is educed can be given as needed. The performance of web caching policy might be measured using many metrics. In this simulation, two main performance metrics are used which are the HR and the BHR because they are the most widely used metrics for evaluating the performance of Web proxy caching policies [46]. Data transfer handling, latency, and processing huge amounts of data, and the rightness of the working solution are some of the underlying issues with these types of systems. Numerous health-care systems make use of cloud related technologies to analyses and store massive volumes of data gathered from a variety of sources. Scalability is the ability to store huge amounts of data, as well as service costs, deployment and low maintenance, are just a few of the benefits. The transmission of huge amounts of data via a network may cause a delay, affecting the overall performance of the system [47]. The system stops running properly as it avoids network latency and delays communication which is imposed by the enormous amounts of data generated by IoT devices, especially in applications such as health monitoring, where real-time data transfer is very important. As a result, communication and network delays caused by big data transfers across cloud servers must be reduced.

3.2 Proposed Solution

As a result, researchers and industry experts are turning to Fog computing, a new computer paradigm (FC). "Fog computing," defined by Salvatore Stolfo as "an enlarged computing version of the cloud," was coined by him. It supports networking, compute, framework and support of storage as the foundation for end-user computation. It also brings up the issue of latency [48]. According to CISCO, fog computing is a distributed paradigm that offers cloud-like services to the network's edge. In all of the fog related systems, a mediator fog layer is formed in between the physical layer, where the edge devices collect row data, such as sensors implanted in smart health- care equipment, smart devices and the upper layers, where cloud servers are situated. The fog computing framework is partitioned into three different tiers. First is the Physical Level: Some examples of physical equipment are switches, setup boxes, smart devices like phones and refrigerators. These are domain specialized, which depend on the field application. Some of these devices like smart watches or phones can be used in customized healthcare monitoring systems [49]. Or, smart refrigerators or air conditioners in a smart home application can be used for this purpose. These can be either in the category of resource-conserving or of the category resource-intensive, all depending upon the application type. A Virtual Cluster (VC) is formed by the devices that are networked geospatially. Whenever a new fog instance has reached this level it can go to any cluster that is in existence on the basis of its geographic proximity. In the same way, a fog instance can be unplugged from any cluster [50]. These devices oversee sensing and sending all current events to the immediate top layer. The FC paradigm is applied here, in which a fraction of the real-time that is required and latency specific analysis which has to be managed in this particular layer before being sent to the fog layer for additional processing, instead of transferring all the data packets from the physical device to the cloud.

1. Fog Level: The fog computing elements, referred to as fog nodes, as well as holding up hardware and software elements, which include all network's core parts accountable for giving all network support, make up the middle level. Routers, switches, and wireless access points are all part of the edge device category. Incoming data of all sorts are generated at the lower level which can be handled and processed by these devices. Data may be collected for a brief period of time before being sent to the layer for long-term storage which is above [51, 52].
2. Cloud Level: cloud layer is the highest level, consisting of data centers and a cloud server. They are intended for large-scale processing of data and bulk storage of expensive data applications. With a traditional cloud computing design, the cloud server will always be overburdened with requests of users and its applications; however, in an architecture that is FC, access of the cloud server is more controlled and properly utilized, and performance is improved. The fog layer, which sits in between the physical-cloud layers, adds value by allowing edge devices to perform tasks such as mining, processing and local storage. As a result, it can be used as a smart gateway.

3.3 Proposed System Architecture

DeepFog is a three-layer framework that includes a client layer, an intelligent gateway fog layer and a cloud layer. The client layer consists of a variety of smart devices that help capture data and collect data that is health related which helps detect diabetic and panic attacks, as well as signals to predict levels of stress. Following that, data is transferred to the fog layer that is in the middle, which does diagnosis, prediction and real-time processing [53]. The cloud layer receives the processed data, analyzed health- related outcomes, and diagnosis reports without delay. This data is then given to specialists, doctors, health-care professionals along with family members so that they can take preventative measures and respond rapidly in the event of an emergency. The primary function is to gather data related to health which is required to categorize stress types, determine whether a client is diabetic, and estimate the chance of a hypertension attack. The health-related features are: (1) SBP; (2) DBP; (3) HDL; (4) LDL; (5) PGC; (6) HR; (7) 2-h serum insulin; (8) BMI; (9) diabetes pedigree function; (10) age in years; (11) EDA; (12) SpO2 [54]. Data from the surroundings, physical activity that is ongoing, and the GPS are examples of the data that can influence a linked attack. Smartphones, which can be hand worn smart devices that are connected to the body of the user, collect all this data. The data can be obtained using the sensors built into these devices [55]. Figure 1 shows the overall framework of the proposed model, while Fig. 2 shows a sequence diagram that shows the workflow of various functions over the entire framework.

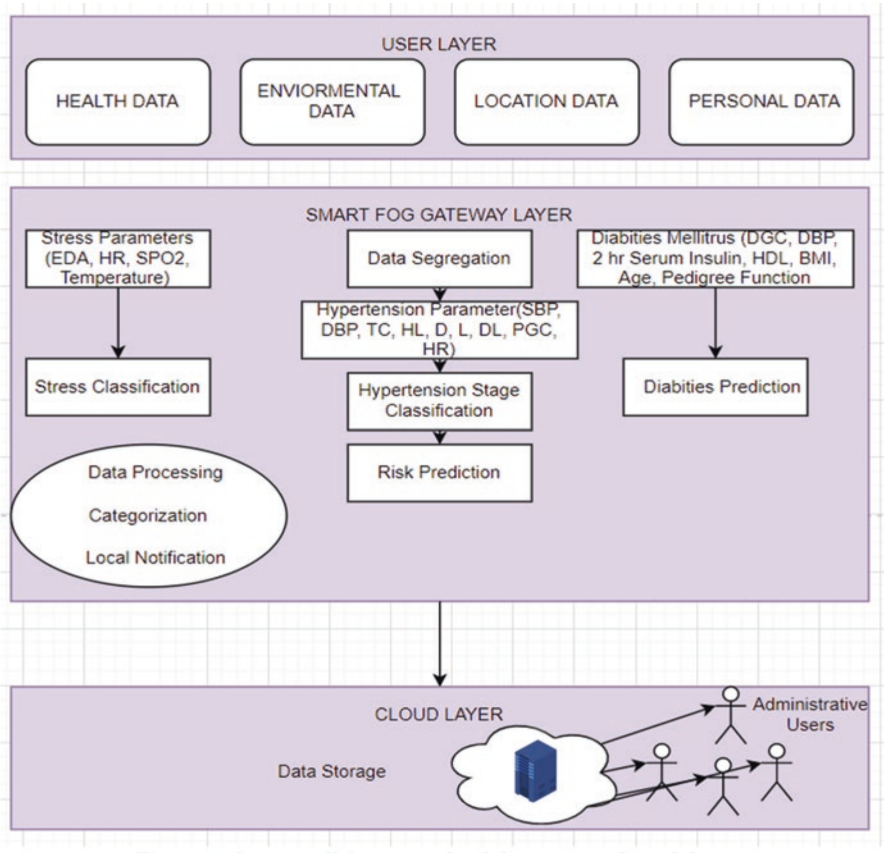

Fig. 1 The overall framework of the proposed model
Between the user and the cloud layer, the proposed DeepFog framework features an intermediate layer that acts as a smart gateway. The user layer is a collection of smart data capturing devices that capture health-related feature data to identify diabetes and hypertension attacks, as well as biosignals to anticipate stress levels. Administrative users can manage a range of datasets that are kept in the cloud layer

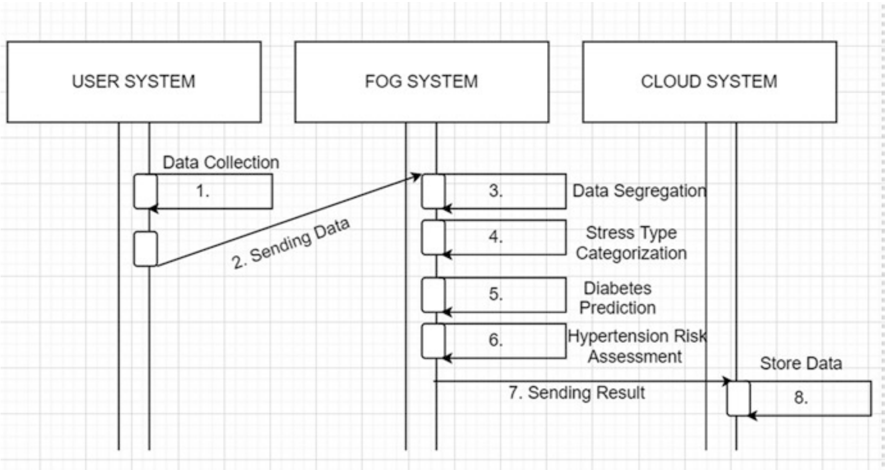

Fig. 2 The proposed System model of the DeepFog

4 Methodology and Concepts

4.1 Technology and Concept

In accordance with the suggested model discussed in Fig. 2, the highest layer i.e. cloud layer can be configured with multiple open source software's. Servers like 'Owncloud', 'Dropbox', further connected to the Apache web-server can be used to initialize the cloud storage [56]. For configuration purposes, PHP and MySQL can be utilized in the background. The fog layer comprises three virtual machines (VM) that are considered as individual fog nodes. In order to maintain diversity among the fog nodes, the three virtual machines can be made to run on different operating systems— two on Linux and one on Windows. A Mininet emulator can be used to implement this. A single virtual machine can be made responsible for data storage. The code for separating the high and low probable victim groups (Algorithm-1) is mentioned in the below sections. The algorithm can be executed with the Deep learning Dl4j (deep learning for Java) which can carry out the data analysis. Furthermore, data captured from sensors or any IoT devices can be utilized through a suitable user interface which is difficult to develop. Related and similar data can be utilized for experimental purposes. The above discussed architecture is illustrated in the below Figure 3.

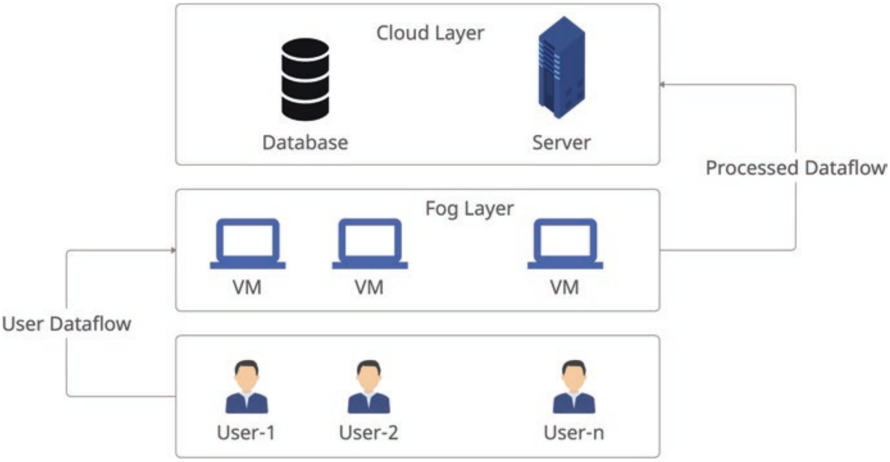

Fig. 3 System Architecture Technology

4.2 Mathematical Equations and Derivations

The prediction model can be built by adapting deep learning. In this paper's context, it should automatically explore the features of the raw inputs. The proposed model can be described as follows: Given a training set composed of n features represented by

$$T = \{(Ii, Oi)\} \tag{1}$$

$i = 1, 2, ..., $ n, where $Ii \in RT$, where I is a feature vector of dimension T, $Oi \in [1,C]$ is the corresponding class label of Ii. The neural network specifies a nonlinear relationship between the two components hi and $hi + 1$ through a network function, which has a form.

$$h_i + 1 = \alpha\left(Wh_i + \delta\right) \tag{2}$$

where α is an activation function and the matrix W and δ are the model components or parameters that need to be tuned. $hi + 1$ and hi can be represented as layers. Here, α is either a ReLU or SoftMax function. In the case of a single layer neural network, there is only one layer. If they are augmented with multiple layers and adapted to advanced learning strategies, they form a deep neural network (DNN). For a prediction model indulged with a prediction function, $O = f\,(I)$ can be built by stacking multiple network functions like $h1$, $h2$,, O given in Eqs. (3, 4, and 5).

$$h_1 = \alpha_l\left(W_1 l + \delta_1\right) \tag{3}$$

$$h_2 = \alpha_l\left(W_2 h_1 + \delta_2\right) \tag{4}$$

$$O = \alpha_l \left(W_l h_l + \delta_{l-1} \right). \tag{5}$$

In the above equation, ‘l’ is the number of layers. In a given training data set, $T = \{(In, On), i = 1, 2,. .., N$ contains inputs and targets and an error function $E = (Yn, On)$, that computes the difference between output Yn and target On. The model parameters $P = \{W1, W2,........, Wl, \delta1, \delta2,, \delta l\}$ have to be adjusted to minimise the net error. This error function is depicted in Eq. (6).

$$\min\left(P\right)\left\{\sum_{i=1}^{n} E = \left(Y_n, O_n\right)\right\} \tag{6}$$

4.3 Pseudocode

Algorithm 1: Separation of high probable victim group and low probable victim group

Input: S = {**S1, S2**, ..., **Sn**} where *S* is the set of total testing sample data

1. Obtain the DBP and SDP value of *Si;* where Si represents the data of ‘*i*th’ instance out of Total sample set *S*
2. If (DBP of *Si* >= 90 && SDP of *Si* >= 140)
   a. If (Detect_Diabetes() is true for *Si*)
   b. If (Predict_Stress() does not return Relax)
3. Return *Si;*
4. Assign *Si* to high probable victim group
   (End of if)
5. Else
6. Assign *Si* to low probable victim group.

Output: High probable victim group

Detect_Diabetes() is the method to check diabetes mellitus. It returns true or false. The *Predict_Stress*() method returns the mental state of a person. The values returned are the type of stress (cognitive, physical or emotional) or it may be a relaxed state [14].

5 Implementation and Execution Flow

5.1 Dataset Selection (Table 2)

For stress classification and diabetes detection, the above mentioned datasets are easily accessible and can be readily used, whereas for hypertension risk assessment, a dataset can be created by extracting the parameters of the given three datasets in the table.

Table 2 Datasets Information Table

Topic	Data Attributes Used	Source of Data
Stress Classification	EDA (Electrodermal Activity), Heart rate, temperature	www.utdallas.edu/~nourani/Bioinformatics/Biosensor_Data
Type-2 Diabetes Detection	Age, Body Mass Index, DBP, diabetes pedigree function	https://archive.ics.uci.edu/ml/datasets/Diabetes
Hypertension risk assessment	SBP, DBP, total cholesterol, heart rate	http://archive.ics.uci.edu/ml https://archive.ics.uci.edu/ml/datasets/Diabetes https://archi https://archive.ics.uci.edu/ml/datasets/Diabetes https://archi www.utdallas.edu/~nourani/Bioinformatics/Biosensor_Data

5.2 *Dataset Pre-processing*

The 'stress' dataset can be pre-processed to segregate the equal state data in order to merge them together. Then, a total sample space can be obtained by fusing all samples of the 20 subjects. Hence, the data can be levelled. CS can be levelled as '0', ES can be levelled as '0.5' and PS can be levelled as '1'. After assigning the levels to the corresponding data fragments, the data sample can be divided into two sets-Training set(80% of the total sample) and Test set(20% of the total sample). Atlas, the data can be normalized through a Min-Max normalization technique to bring the values in the range of 0 to 1.

The 'diabetes' dataset can be normalized through Min-Max normalization technique which displays the isolation of the features according to their classes.

The 'hypertension' data derived from 3 datasets mentioned in the above table can be grouped into two clusters corresponding to the yes or no value for the hypertension field using a *K*-means clustering algorithm. The data clusters can then be analyzed to find the distribution of the contributing features in the formed cluster. If the data of a certain attribute was found to belong to the incorrect cluster, then that attribute can be omitted from training.

5.3 *Characteristics of Dataset*

'Stress' is a major parameter and plays an important role in analyzing a patient's condition, as well as for making a decision about his/her medication. The Biosensor Data dataset available at www.utdallas.edu/~nourani/Bioinformatics/Biosensor_Data can be used for the categorization of stress types. This dataset contains the bio-signals of 20 students. The bio-signals comprise readings of EDA, 3-dimensional accelerometer, temperature, HR, SpO2. Each fragment of the data is assigned to one of the 4 neurological states namely, (1) physically stressed (PS); (2) cognitively stressed (CS); (3) emotionally stressed (ES); (4) relaxed state. In this paper, all four states are considered.

Knowledge about being or not being diabetic is a very crucial piece of information. Diabetes can be predicted in the basis of factors such as (1) the plasma glucose concentration, (2) diastolic blood pressure, (3) 2-h serum insulin (mu U/mL), (4) body mass index, (5) the diabetes pedigree function, (6) age in years. This type of data can be collected by utilizing health sensors installed in smart phones. However for experimental purposes, the diabetes dataset available at https://archive.ics.uci.edu/ml/datasets/Diabetes can be selected and used.

Hypertension is a type of frailty that can lead to a life-threatening event like cardiac failure, thickening of the heart muscle or renal failure. It can be diagnosed through diastolic blood pressure (DBP) or systolic blood pressure (SBP) of more than 90 mm Hg or 120 Hg respectively for at least two measuring instances. However, these values are greatly governed by the occurrence of dangerous situations. The elements which impact these situations can be clustered into five types of data, which are depicted in the table below. The blood pressure measurements also can be categorized into five stages according to the values of DBP and SBP parameters such as normal, the prehypertension stage, hypertension stage-1, hypertension stage-2 and the hypertensive crisis stage, which are depicted in the table below. In order to assess the risk of hypertension with reduced communication delay after training the deep neural network, during real time prediction of hypertension attack, user requests can be divided into two groups: (1) the high probable victim group and (2) the low probable victim group. A priority can be enforced for user requests which belong to the high probable group and these users can be attended first. Algorithm 1 serves the above mentioned purpose by taking into consideration the information provided in the table given below (Tables 3 and 4).

Table 3 Types of data used, their features and their effect

Type of Data	Attribute	Description and Effect	Effect of factor
Clinical information of health data	SBP, DBP, heart rate, cholesterol	This type of data can be collected by body sensors and possess a major influence on hypertension attacks.	5
Personal information	Height, weight, age, gender, family history, smoking habits	Body mass index can be measured, obesity can be detected, the attacks are also dependent on the specifics of the family history.	4
Behavioural data	Stress level, type of stress, anxiety level, level of discomfort	Stress increases the probability of hypertension attacks.	3
Surrounding data	Temperature, humidity, air quality	Higher temperature and humidity as well as poor air quality increases the chances of the attacks.	2
GPS data	Location, time	BP will be high in colder and higher altitude places.	1

Table 4 Stages of Hypertension

Stage of Hypertension	SBP	DBP
Normal	< 120	< 80
Pre-hypertension	120 < = SBP < = 139	80 < = DBP < = 89
Hypertension Stage-1	140 < = SBP < = 159	90 < = DBP < = 99
Hypertension Stage-2	> = 160	> = 100
Hypertensive Crisis	> = 180	> = 110

5.4 Execution Environment

DL4*j (Deep Learning for Java)* is one of the many available frameworks that can be used for building a deep neural network in order to validate the proposed model. DL4*j* can be described as a distributed deep learning framework primarily utilized for building, training and deploying a deep neural network model. Since it is based on 'Java', it is platform independent. It can handle huge amounts of data in a reasonable amount of time and hence it can provide a feasible big data environment. Integration with other parallel and distributed programming environments like 'Hadoop', 'Apache Spark' along with GPU computing is supported. Also, in order to produce deep models and to handle different sorts of data, this framework issues multiple built-in classes and methods like CSVRecordReader, ImageRecordReader, JacksonRecordReader, VideoRecordReader classes to handle input data such as csv files, image data, JSON data and video data respectively.

5.5 Execution Flow Explanation

CSVRecordReader can be used to work with csv data. 'Transform' class can be used to normalize the data. 'MultiLayerConfiguration' can be used to configure the network. One of the possible viable networks can be described as follows. The number of the inputs as 7, 5 and 8 and the outputs as 2, 4 and 2 respectively for diabetes, stress and hypertension prediction. The configuration details are shown in the below table. The number of instances can be expanded by randomly combining the current instances and the already available 5000 instances in the instance of diabetes and hypertension samples for training the deep neural network effectively. The stress dataset is large enough, hence can be utilized as it is. The 'pretrain ()' value must be set to be '0', since this network utilizes a supervised learning method. Three inputs each for the dense layers. The learning rate parameters can be optimized by using a hit and trial method. The input layer activation function can be taken as Tanh() for diabetes and hypertension whereas for the stress data samples, it can be taken as Relu(). SoftMax() should be the activation function for the output layer which means that the number of output nodes must be equal to the number of classes. The 'iteration' parameter must be fine tuned just like the learning rate. In this proposed model, the 'iteration' parameter is considered as one update of the neural network model parameter (Table 5).

Table 5 Deep Neural Network Configuration

Datasets	Inputs	Outputs	Input and Hidden Layer Activation Function	Output Layer Activation Function
Diabetes	7	2	TanH	SoftMax
Stress	5	4	ReLU	SoftMax
Hypertension	8	2	TanH	SoftMax

Table 6 Comparative Analysis of Stress Classification

Author	Tools Used for Application Development	Purpose	Accuracy	Data Used	Whether Used in Fog Environment
M.M. Sani et al. (2014) [57]	Support vector machine	Stress classification model	83.33%	EEG Signals	No
Q. Xu et al. (2015) [58]	K-Means clustering algorithm	To provide personalized recommended products for sstress management	85.2%	EEG, ECG, EMG, GSR signals	No
S. H. Song et al. (2017) [59]	Deep belief network	To design stress monitoring system	66%	KNHANES VI	Yes
Proposed Work	Deep neural network	To obtain the stress level of patients to assist doctors	91.63%	EDA, HR, SpO2, Temperature	No

6 Results and Discussion

The findings were compared to those of other academics who did comparable studies in recent years. Some existing models were compared to the current stress classification study. Use of fog environment, usage of different tools, objective of the work, accuracy percentage of forecast and the data that is imputed where considered when the work was being analyzed. The data can be found Table 6. The task diagnosing type-2 diabetes mellitus was contrasted based on the approaches used, accuracy %, and whether cloud or fog was used in the work reported. This is seen in Table 7. The hypertension attack which was detected early is compared to state-of-the-art research done in the past, as indicated in Table 8, based on the domain application, the study objective, cloud storage (CS) usage, fog environment (FE), and prediction model (PM).

Table 7 Comparative analysis of diabetes prediction

Method	Accuracy (%)	Use Cloud for storage	Used in Fog Environment	Author
Hybrid model	84.5%	No	No	HumarKehra-manili (2008) [60]
Multilayer perceptron	81.90%	No	No	Aliza Ahmed et al. (2011) [61, 62]
Decision tree	89.30%	No	No	Aliza Ahmed et al. (2011) [61]
Extreme learning machine	75.72%	No	No	R. Priyadarshini et al. (2014) [63]
Improved K-means andlogistic regression	95.42%	No	No	Han Wu et al. (2017) [64]
Proposed approach	84.11%	Yes	Yes	

Table 8 Comparative analysis of Hypertension risk detection

Author	Application	Purpose	Us	Us	Use of PM
Fernandez et al. (2017)	A web-based hypertension monitoring	To identify weakness in the clinical process of hypertension detection, to	No	No	No
Zhou et al. (2018) [65]	Cloud and mobile internet	Cloud and mobile internet- based hypertension management system	Yes	No	No
S.Sood and Isha Mahajan (2018) [66]	IoT-fog based system R	Real time monitoring and decision making	Yes	Yes	Back propagation neural network with precision 92.10%
Proposed Work-Deep	Deep learning-based	Real time Assessment of hypertension in patients	Yes	Yes	Deep neural network with preci-

7 Conclusion

In terms of science and technology, the entire world has advanced substantially. At the same time, people's lifestyles are changing. Exercise and physical work has drastically dropped and stress levels have rapidly risen. This is a concerning situation since it encourages the spread of lifestyle disorders like diabetes and hypertension. Everyone including doctors and elderly are concerned. Thanks to considerable evolutions in processing along with current communication technology and effective solutions to this problem can be found. This study aims to help demonstrate DeepFog, a fog computing based deep learning model helps recognize a person's mental health and detect early type-2 diabetes utilizing part of the data that is collected. It develops a model which helps to predict the occurrence of panic attacks. The strategy that is proposed splits the high-probability hypertensive attack sufferer group even further, giving priority to crucial instances. A deep neural network based in Python was used to create the hypertension dataset. DL4j, a Java-based software, was used to tool the model which is proposed. The data and comments back up the effectiveness of the proposed approach in monitoring of wellness. We examined the findings of a variety of existing state-of-the-art research procedures and discovered that the proposed method was superior to or comparable to current state- of-the-art technology. In the upcoming years we want to set the neural models for a variety of user-based research. This will increase the number of research and development opportunities in the field of wellness monitoring systems.

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An Intelligent and Secure Real-Time Environment Monitoring System for Healthcare Using IoT and Cloud Computing with the Mobile Application Support

Shashank Shetty

1 Introduction

In recent times, real-time environment monitoring has become significant for many applications and maintenance of specific devices at a particular environmental condition. In relation to this, temperature and humidity are two crucial constraints on such systems, and hence monitoring these, in particular, becomes significant. Such monitoring is used in devices such as heating, ventilation, air conditioning systems, equipment management to maintain the machines at specific environmental conditions etc. On the other hand, these data are also used in weather stations and smart power grids [9] for predicting weather and generating renewable energy, respectively.

Technology has helped a lot to ease the complexity of monitoring the environment in real-time. One such technology is cloud computing. Cloud Computing is playing a significant role in relation to IoT systems [17, 27–29]. It is an easy and convenient way to store data, access the data remotely and even analyze it. Cloud resources consist of servers and storage that can be quickly released with no or less management and service provider interaction [1].

Here, for practical implementations, we have used IoT devices, i.e. NodeMCU and DHT11 sensor. We have used the ThingSpeak cloud services [13] for data storage and analysis purposes. ThingSpeak is an IoT analytic cloud platform service for live stream aggregation, visualization and analysis in the cloud. ThingSpeak[1] can be interconnected to any user interface for easier access to data and data visualization. The implementation of IoT solutions using ThingSpeak is depicted in Fig. 1. Privacy and security [11] of the data gathered from these connected IoT devices play a vital

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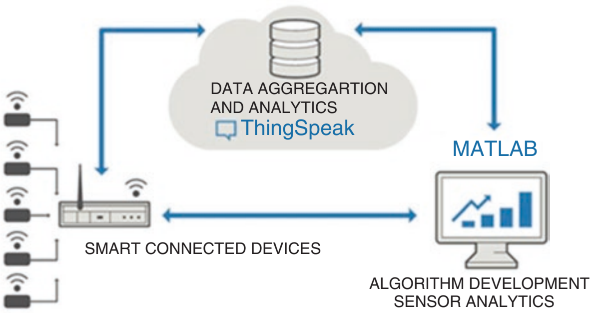


Fig. 1 IoT solution using cloud (https:www.thingspeak.com/pages/ learn more)

role with no margin for errors, as most of the task involved here will be mission-critical. Henceforth, we use symmetric-key block cipher Advanced Encryption Standard algorithm for data security in the IoT sensor data collected.

This paper consists of details of practical implementation of IoT solutions for detecting temperature and humidity using the ThingSpeak cloud platform. Furthermore, we will be discussing the related work, proposed system, implementations and results. The final section will consist of concluding remarks.

2 Motivation and Contribution

Real-time environment monitoring systems are beneficial in industrial applications where constraints like temperature and humidity significantly impact product quality and lifespan. The real problem of these environmental constraints arrives during shipping and warehousing. With the current situation of the pandemic and the need to keep the vaccine at a specific temperature and monitoring the temperature is essential. The implementation of the project is applicable in:

- Humidity and Temperature monitoring Laboratories.
- Food Safety.
- Warehouse and Inventory Management.
- Shipping vehicle temperature during the transport of goods.
- Special equipment management where certain devices must be in certain environmental conditions.
- Accessible from remote locations.

The main contribution of this research paper are as follows:

- We design and develop an intelligent and secure real-time environment monitoring system for collecting real-time data from sensors to the ThingSpeak cloud platform and notify the same through a mobile application.
- We also integrate AES encryption and decryption technique for data security in the cloud platform

3 Related Work

Cloud computing has been widely used in various aspects, and domains like Fog computing [4] Artificial Intelligence in different big data fields like health, sports and web services [7, 15, 18, 19, 20], etc. Likewise, IoT with cloud computing strategy has its benefits in Industry 4.0 applications [21]. In this section, we discuss some related works with respect to the usage of IoT and cloud computing in real-time environment monitoring systems.

Armbrust et al. [9] in their research paper explained about the assimilation of the future technology called Smart grid. The main requirement of smart grid is an efficient and robust hardware i.e. resources and storage. The technology used is cloud computing to integrate resources and provide storage. Chen et al. [3] have put forward their research on smart grids using cloud computing technology for security, storage and faster computations with a design idea on achieving such systems. The idea is a cloud computing intelligent data device with cloud service, security, data integrity checks and high storage. The main focus is the data collection using the device. S Thilaga et al. [25] investigated the increasing complexity of the power meter, which is made of many sensors, and its service requirements of security, reliability and efficiency. It briefs about using a trustworthy cloud, i.e. (Tclouds), to reduce hardware issues and improve protection.

R Sonawane et al. [21] in their research work, have conducted testing of the developed temperature and humidity monitoring system at various locations of their college campus to monitor plant growth and cope with the agricultural changes. Here, the monitoring system was developed at a low cost, and the system showed a percentage variation of 0 to 8\% for temperature and 0 to 5.97\% for humidity. Also, accuracy for the same was measured. Utomo et al. [26] proposed a cost-effective system to monitor the two parameters, i.e. temperature and humidity for server rooms. It is an IoT system that is capable of providing details regarding the changing temperature and humidity continuously. The system is connected to the cloud, and data is sent whenever the temperature is read. The proposed idea uses Microsoft Azure as the cloud service provider for storage, computations and security. The authentication of users is performed, and the telegram application is used to send notifications to the users.

Sumarudin et al. [24] proposed a system to monitor the soil status. The system prominently collected data collection and monitored the data to help increase the soil quality. The data is contained in the form of tables and stored in the cloud. Rathod et al. [12] implemented a real-time environmental monitoring method to achieve optimal efficiency and accuracy of collecting real-time data of temperature, humidity and moisture of the soil. A mobile app was developed with farmers as the end-users to help them in increasing yield by providing the correct environmental conditions information.

P Avula [2] says that the countries in the Tropical regions reflected significantly less death percentage due to covid-19. In the same way, the recovery rate is high in the countries of Tropical areas ranging from 88 to 99\%. It is observed that the subtropical countries' death rate is relatively high compared to the Tropical regions. It can be predicted that the low temperature has facilitated the survival and the spread of Covid-19 in the Subtropical region when compared to that of the Tropical region. Mecenas et al. [8] in their research work, have discussed how the change in the climatic condition affects the spread of the coronavirus. It was observed that in extreme temperature, the spread was minimal. This was supported by statistics and its analysis.

The above literature review provided us with the significance of IoT and Cloud computing in the various real-time environmental monitoring system. This implied us to design and develop a cost-effective intelligent and secure real-time monitoring application using IoT and cloud computing. Our proposed system can be used for a wide variety of applications like health, food safety, smart grid, goods transportation, etc.

3.1 Summary of the Literature

We have summarized the overall literature survey in the Table 1.

4 Proposed Methodology

The proposed system is an IoT device, a real-time environment monitoring system primarily focusing on temperature and humidity constraints. The system setup is connected to the ThingSpeak cloud, and in turn, the cloud is connected to the user interface. The IoT device consists of sensors that will collect data and send it to the ThingSpeak cloud for storage in real-time. This real-time data sent to ThingSpeak is then read by the mobile App created using MIT-App inventor [6].

Figure 2 shows the architecture of the proposed system. It consists of three main modules. The first module is the IoT sensor Layer consisting of a DHT11 sensor, a temperature and humidity sensor; the sensor is connected to the NodeMCU, which has an inbuilt WiFi module connected to the next module (i.e., Cloud Computing Platform). The NodeMCU has a flash memory where AES encryption takes place, which is a security technique. The encryption takes place in flash memory, and decryption occurs when the data reaches the WiFi module from the second module, i.e., a Cloud computing platform using ThingSpeak cloud. A detailed explanation of AES working is given further in the section. At the top layer, the mobile application then reads the data from the ThingSpeak cloud and displays it for the user's view.

Table 1 Summary of the Literature Review

Author & year	Contribution	Merits	Remarks & future Directions
Patricia Morreal, Feng Qi [10] – 2010	Distributed sensors have been used to detect environmental condition changes like a volcano with respect to place and time and are notified to users.	Less costly and parameters can be customized easily.	User can be given better interfaces and provide alert scripts instead of mails for notifying users.
Pawan Singh [9] – 2018	Detailed discussion on the new and different kinds of IoT technology in the field of healthcare and data monitoring of the same.	Reduced medical expenses, time and human error. Early and quick detection, improved management of drug usage.	Improve healthcare system's and overcome barriers, challenges and issues.
Tinu Anand Singh et al. [22] – 2018.	The solution to make low power consumption MQTT protocol greenhouse adaptation.	Don't have to consider changes to the network during attachment time.	Can be extended to Monitor data in a larger Agricultural areas.
Sudha Senthilkumar et al. [14] – 2019.	Proposed a patient monitoring system, which takes in details about temperature, heartbeat, humidity and body positioning.	Capable of adopting into any new changes and avoids further modifications. The results provided good performance and accuracy.	Quick alerting of the user when health deteriorates.
RN Sonawane et al. [21] – 2019	Achieved monitoring and control of a greenhouse environment using sensor.	For better agricultural output.	Help in making better agricultural produce.
Kasham Jummai Shamang et al. [5] – 2020.	The system mentioned here sends notification about the temperature on a telegram app.	Easy and user friendly.	More efficient applications with better systems/ hardware.
Paulo Macenes et al. [8] – 2020.	Temperature and humidity are not alone enough for the spread of covid-19. Population density, immunity, migration patterns, etc., are the other matters that affect the Covid-19 spread.	Weather conditions and health policies are valued knowledge.	A system should be developed to take in account all the parameters and evaluate with respect to all the attributes.
Nirav Rathod [12] – 2020	IOT-based Agriculture stick which helps in providing accurate data of environmental constraints.	Application: farming, aids farmers in maximizing the yield.	Increase the number of sensors for more data and greater efficiency.
S Shetty et al. [16] – 2020	Remote monitoring of garbage level using cloud. it separated waste based on its type. Web and mobile application for user interaction.	Less expensive and remotely accessible.	Addition of more sensors and an automatic truck can be designed which works automatically.

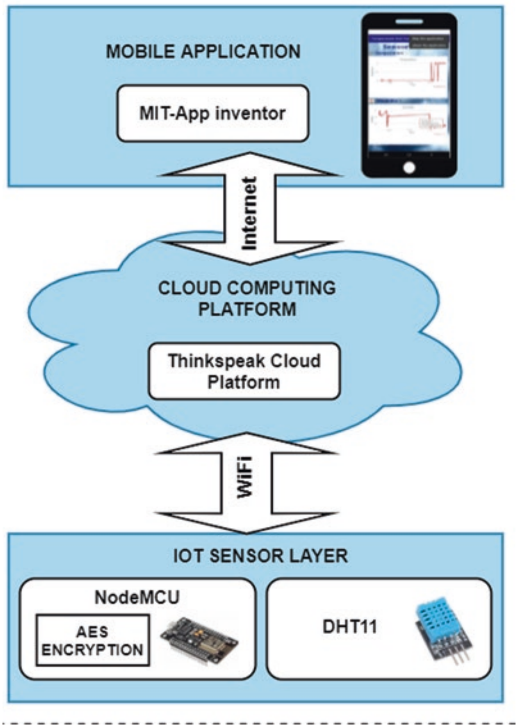


Fig. 2 Proposed Architecture of an intelligent and secure real-time environment monitoring system

4.1 Advanced Encryption Standard for Data Security

The Security of the data is provided in the device's flash memory using the Advanced Encryption Standard (AES) algorithm. AES algorithm is a symmetrical key cipher block algorithm. Here, AES128 has been used, which means that it can convert data into 128 bits cipher blocks.

Algorithm 1: Advanced Encryption Standard Algorithm

START
Step 1: Byte substitution
There are predefined substitution boxes which are rules for the block text bytes.
Step 2: Row shift
Exclude the first row and shift every other row by one.
*Step*3: Column mixing
the cipher data is jumbled by mixing the columns.
Step 4:Addition of round key
XOR of data with the key.
STOP

AES is proposed in various modes. Here, we have used AES Cipher Block Chaining (CBC) which uses the following formula where Eq. (1) is for encryption, where E_K represents the block encryption using the symmetrical key, and C_{i-1} is the cipher for $B_{i-1.}$ Eq. (2) is for decryption where D_K is the block description using symmetrical key k

$$C_i = E_K(B_i) \oplus (C_{i-1}) \tag{1}$$

$$B_i = D_K(C_i) \oplus (C_{i-1}) \tag{2}$$

5 Experimental Setup and Results

The implementation setup architecture of the proposed intelligent and secure real-time environment system using IoT and cloud computing is shown in Fig. 3.

5.1 Hardware Implementation

The major components are NodeMCU and DHT11 sensor (see Fig. 4.). The V_{cc} and GND of DHT11 is connected to the V_{cc} and GND of NodeMCU respectively. The data of DHT11 is connected to D3 of NodeMCU (See Table. 2. for components). The USB cable is connected from NodeMCU to the COM port-3 of the system with WiFi connectivity. NodeMCU consists of WiFi module ESP8266 which connects the hardware to the ThingSpeak cloud using WiFi. (See Fig. 3.). The hardware is programmed in Arduino IDE. The board used is NodeMCU-ESP (see Fig. 4).

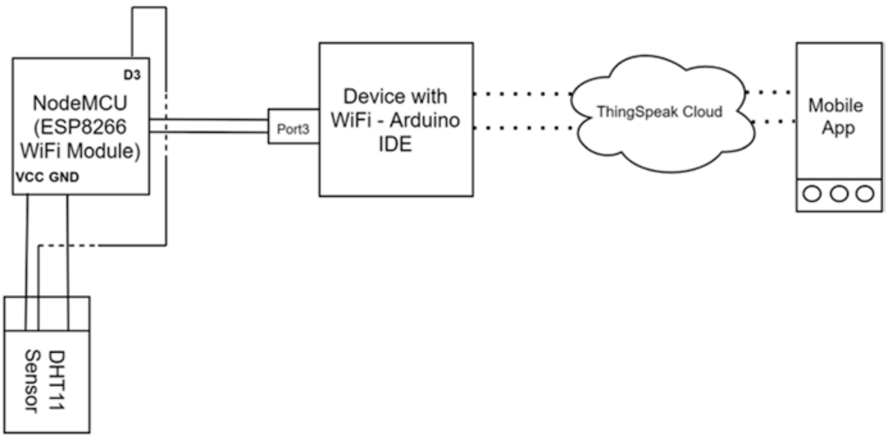


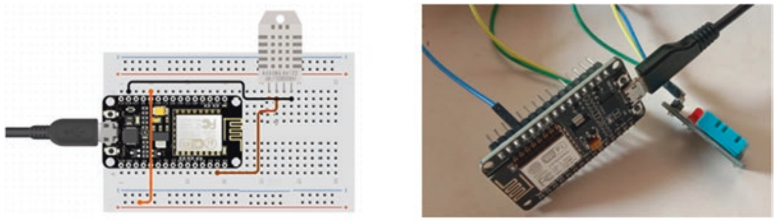
Fig. 3 Implementation setup flowchart of the proposed Real-time environment monitoring system

(a) NodeMCU (b) DHT11 Sensor

Fig. 4 Hardware Components requirement. (**a**) NodeMCU, (**b**) DHT11 Sensor

Table 2 Component requirements

Components	Quantity
NodeMCU	1
DHT11 Sensor	1
Male-Male jumper wires	3
Micro USB cable	1



(a) Detailed Circuit Connection (b) Proposed experimental setup

Fig. 5 Detailed Circuit connection and the experimental setup of the proposed system. (**a**) Detailed Circuit Connection, (**b**) Proposed experimental setup

Detailed circuit connections and the experimental setup of the proposed real-time environment system is depicted in Fig. 5. The header files like AES.h, DHT.h, ESP8266WiFi.h and ThingSpeak.h needs to be installed and included. The SSID and password of the WiFi must be specified. ESP8266 module should be programmed in the setup function for accessing the WiFi connectivity. The sensor should read the temperature and humidity values, encrypt the data and decrypt it as soon as the data reaches the cloud in the loop function. ThingSpeak is connected using the Write API key and channel ID.

5.2 ThingSpeak Cloud Platform and Mobile Application

The sensor data is stored in the ThingSpeak database. Two parameters are considered and are collected in every iteration: Temperature in Celsius and Humidity in %. The data is stored in the public channel of ThingSpeak for everyone to view the data on a daily basis. The data can be retrieved in .CSV, .XML and .JSON formats. The data can be accessed altogether, or just the recent data or just temperature data and so on. The write API key allows the hardware to store the data, and the read API key allows the user interface (Mobile App) to read the data (See Fig.3.). Using the widgets, we can see the real-time data for checking the correctness of the sensor reading. For analysis and visualization purposes, various graphs can be plotted.

The ThingSpeak is then connected to the mobile app. The mobile app is made using MIT App inventor. The code uses the channel ID and Read API key of ThingSpeak to read the data and visualize the same through the graphs. Thus, the mobile application provides a detailed analysis of the humidity and temperature data collected in real-time and provides a visualization of the same through the graph-based representation. (See Fig. 6).

5.3 Result Analysis and Discussion

The final implementation of the setup leads to hardware connecting to ThingSpeak cloud, and in turn, it is connected to the mobile app. In total, 641 temperature and humidity data have been collected over a week. A sample of the result is shown in Table. 3. The table consists of four fields, namely created_at, entry_id, field1 and field2. The field 'created_at' gives the date and time in Indian Standard Time, 'entry_id' is the id assigned to every value stored in the cloud. field1 represents the temperature value in degree Celsius, and field2 is the humidity value in percentage.

In our proposed work, we designed and implemented a cost-effective real-time environment monitoring system to collect the temperature and humidity. This system is secure as it uses one of the best encryption scheme (i.e., AES) for encryption and decryption of the data collected and stored in the Thinkspeak cloud platform. The data collected can be analyzed and visualized through a mobile application designed by us. This overall proposed system can be utilized in various industry 4.0 application to recommend and provide automatic notification about the machines or devices used in the industry.

6 Conclusion and Future Work

Intelligent and secure Real-time environment monitoring IoT system is a critical IoT solution for various fields of the power industry, heating, air conditioning, smart power grids etc., based applications. We have considered temperature and humidity as parameters for the implementation. Cloud computing is an essential aspect for the above applications in terms of storage, security, integrity and access to the data anywhere. We have done a practical implementation of storing the real-time environmental constraints' data with security using one IoT DHT11 sensor. If we were to use millions of such IoT systems together connected to the cloud, there would be

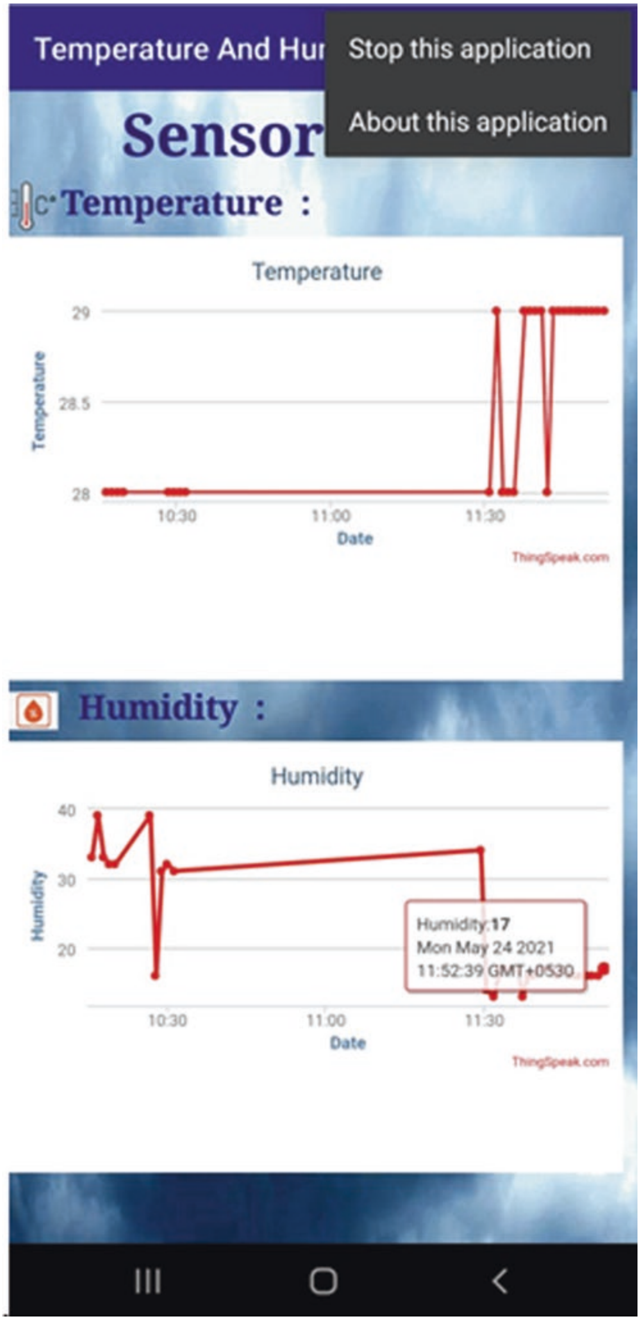


Fig. 6 Mobile application providing the detailed analysis of the humidity and temperature data

Table 3 Sample Results

created_at	entry_id	field1	Field2
2021-05-06 07:09:05 UTC	1	–	75
2021-05-06 07:09:38 UTC	2	32	–
2021-05-06 07:10:10 UTC	3	–	72
2021-05-06 07:10:42 UTC	4	31	–
2021-05-06 07:11:14 UTC	5	–	72
2021-05-06 07:11:46 UTC	6	32	–
2021-05-06 07:12:18 UTC	7	–	73
2021-05-06 07:12:50 UTC	8	30	–
2021-05-06 07:13:22 UTC	9	–	72
2021-05-06 07:13:54 UTC	10	32	–
2021-05-08 09:49:22 UTC	11	–	38
2021-05-08 09:49:55 UTC	12	30	–
2021-05-08 09:50:30 UTC	13	–	39
2021-05-08 09:51:03 UTC	14	30	–
2021-05-08 09:51:35 UTC	15	–	41
2021-05-08 09:52:09 UTC	16	30	–
2021-05-08 09:52:41 UTC	17	–	40
2021-05-08 09:53:13 UTC	18	30	–
2021-05-08 09:53:45 UTC	19	–	41
2021-05-08 09:54:18 UTC	20	30	–
2021-05-08 09:54:49 UTC	21	–	40
2021-05-08 09:55:23 UTC	22	31	–
2021-05-08 09:55:54 UTC	23	–	39
2021-05-08 09:56:26 UTC	24	30	–
2021-05-08 09:56:58 UTC	25	–	39

more significant improvements and innovations in the field of renewable energy production, smart power grid, environmental monitoring, equipment management, etc. These innovations would be beneficial economically and environmentally.

In future works, the system can be upgraded to a web-based application using the GPRS technique and MQTT protocol for security. This will not only help in a remote place but also boost the system for monitoring larger area. Along with temperature and humidity, other parameters like pressure using the barometric sensor, different components of air to check air quality etc., could be integrated into a single system and stored in the cloud for better analysis. Further, the Artificial Intelligence-based techniques can be applied to the data collected and can provide the recommendation system to various industry 4.0 applications by predictive analysis.

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Efficient BREV Ensemble Framework: A Case Study of Breast Cancer Prediction

Akriti Sharma, Nishtha Hooda, Nidhi Rani Gupta, and Renu Sharma

1 Introduction

Cancer is now accountable for every one out of three premature mortalities due to non-communicable diseases worldwide and the number of cancer diagnoses is expected to increase annually [1]. Cancer is estimated to be a hurdle in boosting life expectancy in general. In a large number of countries (140/184), lung cancer is the most prevalent cancer diagnosed in males, whereas breast cancer is the most common disease diagnosed in women. Male lung cancer and female breast cancer are the major causes of cancer death [2–4].

Breast cancer is considered to be caused by a variety of factors including lifestyle, reproduction, genetics, and environmental factors. In these, environmental factors serve a significant role [5] to the level that multiple environmental factors are believed to be accountable for the development of the disease [5]. Laboratory research shows that environmental pollutants can add to the risk of breast cancer by promoting tumor growth or enhancing susceptibility by altering the development of mammary glands; DNA damage [6]. Continual exposure to environmental contaminants, especially those with an estrogenic effect, can exacerbate the situation, particularly in hormone-related tumours including breast tumours, which ultimately cause cancer [7]. Exposure to environmental estrogens for example organochlorines in industrial chemicals and pesticides has been reported as a reason for increasing rates of breast cancer [8]. The majority of research reveals that susceptibility to

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dichlorodiphenyltrichloroethane during fetal life is highly correlated to the elevated risk of malignancy [9]. Additionally, because of the estrogenic activity of DDT, it has been conjectured that exposure to the organochlorinated pesticide may prompt an expanded danger of developing breast cancer [10]. DDT and its metabolite DDE have received a lot of concern as they are remarkably lasting EDCs in nature and can accumulate in the food chain, permitting them to appear in adipose tissues and breast milk [11].

Cancer is a major health issue that has a high fatality rate around the world. Progress has been made in cancer prediction as a result of technological advancements and the deployment of various machine learning algorithms that have emerged in recent years, providing insight into accurate and effective decision-making in the treatment of this disease [12]. Therefore, it is of great current importance to develop ML approaches, which can effectively identify people with cancer from healthy persons. However, no single approach performs better than all other classification methods implemented to predict cancer so far [12].

Timely identification of breast cancer can assist medical professionals in delivering suitable treatments or post-surgery relapse monitoring [13]. Breast cancer has several risk factors. There are various forms of breast cancer having varying spread or stages, genetic makeup, and aggressiveness. Therefore, having a mechanism that allows for early detection and prevention would be extremely beneficial in terms of increasing breast cancer survival rates. Multiple kinds of literature have addressed a variety of machine learning and statistical approaches used to build predictive models for breast cancer, such as artificial neural networks, logistic regression, naïve Bayes, vector machine support tools, decision trees, k-nearest neighbor, and linear discriminate analysis [14, 15].

It is recognized that classifier ensembles or the integration of multiple classifiers usually provide better output than individual classifiers [16]. The basic idea behind ensemble learning is that no single method can claim to be better than another and that the output of final classifiers can be improved by combining various single classifiers (e.g., reliability, comprehensibility, accuracy). Thus, an ensemble classifier outperforms the single base classifiers [17]. Rathore, et al., compared Naïve Bayes, Association-based classification, and Decision tree which are the supervised learning algorithms, and subsequently indicated that the ensemble approach is one of the best approaches to breast cancer prediction. The proposed approach aimed to acquire better accuracy by combining these three classification techniques [18]. West et al., explores the ability of different selection approaches to form ensembles out of 24 population classification models to improve the accurateness of the decision support system for diagnosing and detecting breast cancer. Outcomes suggest that ensembles build from varied models generally have more accuracy than either the selection of a "single best model" or pure-bagging ensembles [19].

Varied forms of cancer, like breast cancer, could be treated whenever they are identified at the starting stage. Early and credible diagnosis of this type of cancer can ensure patients' prolonged survival [20]. It would therefore be very valuable to form a framework that permits early identification and counteractive action to enhance the rate of breast cancer survival. There are multiple cancerous cell traits that can be examined to determine the likelihood of the illness. Machine learning can be incorporated for breast cancer prediction on an early basis, considering patients' characteristics and lifestyle factors [20].

In this study, the research intends to apply machine learning to build a diagnostic model for breast cancer. Machine learning is a sub-division of AI that incorporates a range of optimization, probabilistic, and statistical tools that allow machines to pick from prior cases and notice sequences that are difficult to discern from complex and large data sets [20]. This paper discusses the design and implementation of BREV framework, which is a new ensembling technique and this combines classifiers that improve the accuracy in identifying risk of breast cancer in patients. Voting and stacking are among one of the ensemble approaches combining multiple classification models for better classification and breast cancer prediction. The machine learning model is trained in the current work with the available dataset comprising varied characteristics of the patients and predicting breast cancer possibilities. A feature selection approach is utilized to choose the relevant characteristics and examine the generalization efficacy of the number of algorithms.

The remaining segment of the work is streamlined as follows: Section 2 presented similar work on the prediction of breast cancer. Section 3 discusses the experimental investigation. Section 4 covers the methodology incorporated in the work. Section 5 outlines the outcomes of the study and concluding observation is mentioned in sect. 6 while addressing further research issues.

2 Related Work

Breast cancer is among the most prevalent malignant tumors in females, necessitating the need for breast cancer diagnosis. Huang et al., introduced an open-source software framework to predict the result of gene expression profiles by employing an extremely versatile SVM algorithm integrated with standard recursive function elimination [21]. The models are intensely efficacious while the prediction of the drug response of a wide range of cancer celllines [21]. Kourou et al. explore the principles of machine learning while describing its applications in cancer identification and prognosis [22]. The majority of recent studies have centered on the adoption of predictive models that use supervised machine learning methodologies and classification algorithms to determine valid illness results [22]. Owing to their observations, combining heterogeneous multidimensional data with a range of categorization and selection strategies can result in useful inference tools in the cancer domain [22]. In order to classify cancer, Agrawal et al. study several neural network techniques [23]. Most of the neural network reveals great outcomes in the accurate classification of tumor cells [23].

Ahmad et al. examined the use of data mining methods to build predictive models for breast cancer recurrence in 2 year-monitored patients [24]. The accuracy of SVM, DT, and ANN has been reported to be 0.957, 0.936, and 0.947 respectively [24]. The model of SVM classification estimates the recurrence of breast cancer with both the highest precision and lowest error rate [24]. Jerez et al. assess the efficiency of several machine learning and statistical methods of imputation applied for breast cancer recurrence prediction in patients in a diverse set of actual breast cancer datasets [25]. Methods based on ML techniques are found as the most suitable methods for imputing missing values and resulted in a substantial boost in the accuracy of the prognosis, especially in comparison to statistical procedures of imputation methods [25]. Liu et al. use the SVM classification technique for the diagnosis of breast cancer [26]. Simultaneously, the SVM gets contrasted to several contemporary techniques of machine learning [29]. SVM has outperformed two neural artificial networks and a cluster of k-means [26]. Polat et al. conduct a breast cancer diagnosis utilizing the least square SVM classification algorithm [27]. The accuracy of the proposed classification obtained is 98.53% and comes out to be very promising compared to the existing classification techniques [27].

Bazazeh et al. compare three among the most popular breast cancer diagnosis and detection ML techniques commonly used, namely Bayesian Networks (BN), Random Forest (RF), and Support Vector Machine (SVM) [28]. Results have shown that SVMs have the highest specificity, precision, and accuracy in terms of performance. However, RFs are most likely to correctly categorize the tumor [28]. In a study by Montazeri et al. the Random Forest model, a rule-based classification model, has shown to be the best model with the highest degree of precision [29]. Kharya et al. designed an effective and intelligent system for breast cancer prediction utilizing Naive Bayesian classifiers [30]. Findings indicate that NBC is an effective approach for extracting significant breast cancer patterns from the dataset. The maximum accuracy was achieved by 93 percent [30]. Hwang et al. used 3 machine learning approaches to classify cancer problems: radial basis function networks, neural trees, and Bayesian networks [31]. Then their characteristics and performance is analyzed in three different aspects. It is concluded that RBF networks and neural trees are very good classifiers [31]. Considering the data constraint underlying cancer categorization with levels of gene expression, they reveal outstanding prediction accuracy. Bayesian network learning is a powerful technique for analyzing gene expression data because it can show probabilistic correlations between levels of gene expression [31]. Thongkam et al. suggested a survivorship prediction model for breast cancer using a combination of random forests and AdaBoost algorithms. The presented approach outperforms a combination of classifiers in predicting breast cancer survivorship compared to a single classifier, according to experimental findings [32].

Abreu et al. investigated the efficiency of machine learning techniques in predicting breast cancer recurrence. Despite the use of various techniques, the prediction of recurrence of breast cancer remains a major concern [33]. Combining multiple machine learning techniques and defining standard predictors for breast cancer recurrence seems to be the primary future dimensions for improving outcomes [33]. Asri et al. examined several machine learning algorithms on the Wisconsin Breast Cancer datasets, including Decision Tree, Naive Bayes, k Nearest Neighbors, and Support Vector Machine. The major intent is to analyze the accuracy, sensitivity, specificity, and precision of the classification of data in order to ensure the efficiency and effectiveness of each algorithm [34]. SVM gives the highest accuracy with the minimum error rate, as per experimental findings (97.13%).

All of the experiments are carried out in a simulation environment using WEKA, a data mining tool [34]. Ayer et al. assessed if a large prospectively trained artificial neural network (ANN) of consecutive mammography observations can make distinctions between malignant and benign diseases and reliably assess the risk of breast cancer in individual patients [35]. The authors' ANN successfully classifies between malignant benign anomalies and appropriately predicts the risk of breast cancer for individual anomalies [35]. Bellaachia et al. reported a study that used data mining techniques to predict survival rates for breast cancer patients [36]. The research examined three data mining techniques: back-propagated neural network, Naïve Bayes, and C4.5 decision tree algorithms, and observed that the C4.5 approach outperforms the others [36]. The objective of Huang et al. was to adequately assess the predictive efficiency of SVM and SVM ensembles over different size datasets of breast cancer [16]. As per the conclusions, the linear kernel-based SVM framework based on the bagging approach and the RBF kernel-based SVM framework based on the boosting approach are the best solutions for a small-scale dataset. RBF-based SVM ensembles built on boosting outperform large-scale dataset classifiers when compared to them [16].

3 Experimental Investigation

This section covers the experimental setup, the data set which includes sample evaluation, and the tool incorporated in the postulated prediction framework.

3.1 Dataset

This study is conducted in the Malwa belt of Punjab (India) which is well-known for its food grain production, cotton growing, and a high number of cancer cases. To investigate the likelihood of breast cancer as a result of chemical exposure, 100 distinct samples of blood and adipose tissue are taken from the females of Malwa region of Punjab (consisting of Patiala, Fazilka, Moga, Shri Muktsar Sahib, Bathinda, Barnala, Mansa, Faridkot, Firozpur, Ludhiana, Sangrur) afflicted from benign and malignant breast cancer growth. This analysis covers 50 patients with malignant and benign breast cancer growth, each having 51 features. These 51 features include Isomers of hexachlorocyclohexane (HCH); dichlorodiphenyltrichloroethane (DDT) and its metabolites; aldrin; configurational isomers of enddosulfan; endosulfan sulfate; endrin; endrin aldehyde; dieldrin; heptachlor; heptachlor endo epoxide, and methoxychlor. Organochlorines (OCs) are important environmental contaminants that have been associated with cancer. This research intends to evaluate the role of organochlorine pesticides as a breast cancer risk factor.

3.2 Experiment Setting

The data mining tool Weka 3.6.9 is used to empirically assess the results over the dataset in order to categorize the data using numerous algorithms. WEKA is an innovative tool in the history of research communities in machine learning and data mining. It is an open-source and platform-independent software [37]. Weka comprises tools to develop new schemes for ML that could be employed for classification, clustering, preprocessing, association, and visualization [38]. The tool is used to implement, evaluate, and analyze various model-building strategies with the goal of improving the predictive accuracy of classifiers.

4 Methods

Machine learning is applied in the presented framework to predict breast cancer. Machine learning is built on innovative methods for cost-effectively processing large amounts of massive and intricate data. The fundamental goal of conducting machine learning operations is to create a computing machine that is capable of predicting objects based on a particular data collection and sample size. Figure 1 displays the schematic view of the recommended framework.

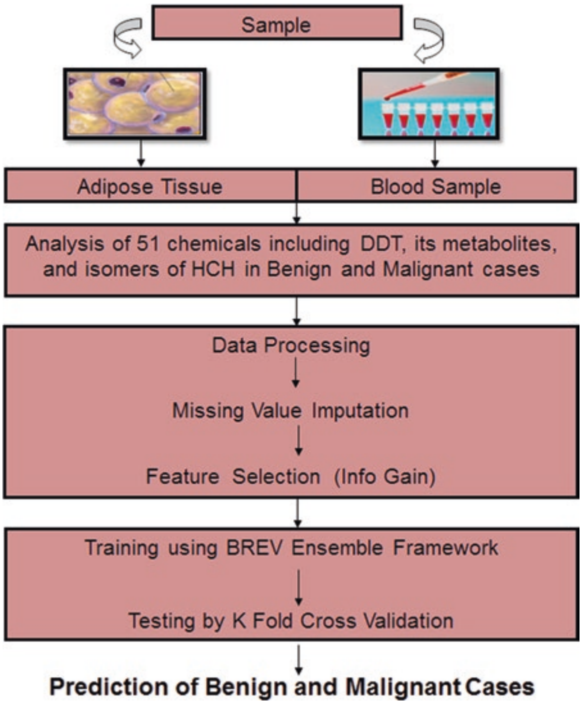

Fig. 1 Proposed Framework

The output of the presented framework aids in the accurate prediction of breast cancer risk. The data obtained from the biopsy samples is processed into the suggested framework so as the receive information on various risk factors. The prediction framework is then trained with several machine learning classifiers to provide an effective output that supports in risk prediction of the disease in consideration.

4.1 Machine Learning Models

Below are some machine learning models with their unique set of advantages and disadvantages. The suggested framework is an effort to create an ensemble approach that takes advantage of the benefits of existing models.

(i) Random Forest (RF): The Random Forest classification approach is applied in order to train and evaluate the framework [39]. Due to the existence of important features such as out-of-bag error, variable importance measure, proximities, etc., this is by far the most used classification method [40]. This is an ensemble approach that provides accurate outcomes, but it is also a time-consuming process compared to other techniques [40].

(ii) Neural Network (NN): ANN is a connected node group similar to a huge brain neuron network [41]. Because NN is best suited for distinguishing patterns or examples in information, they are ideal for the estimation of needs or expectations [42]. Even with limited information, the data can generate a response after ANN training. The significance of the missing information determines the performance loss in this case [43]. Artificial neural networks, due to their structure, require parallel processing processors. The realization of the equipment is therefore dependent. There is no specific rule for artificial neural network structure determination. By trial and error and experience, adequate network structure is achieved [43].

(iii) The SVM approach divides the obtained data into multiple classes using the hyperplane and identifies the largest margin among classes to provide reliable findings [44]. Support Vector Machine (SVM) is a supervised learning approach used in regression and classification analysis [45]. Multiple new studies have shown that the SVM (support vector machines) can typically offer higher classification accuracy performance than the other data classification algorithms [46]. There are also some drawbacks of SVMs. The lack of transparency in results is a common problem [47].

(iv) AdaBoost (A Boost): At every level of the AdaBoost algorithm, each training data is fed into the tree and an efficient ensemble classifier is built [48]. AdaBoost has the advantages of being easy to use, fast, and easy to program. Except for a number of iterations, there is no requirement to change parameters. In order to look for a weak hypothesis, it can be combined flexibly with any method without the requirement for any previous knowledge of WeakLearn [49]. However, there are several drawbacks to AdaBoost. Its real success on a specific issue, for example, is clearly dependent on data and WeakLearn; it performs poorly when the data set is insufficient, and it looks to be noise sensitive [49].

(v) Bayes Net (BN): The DAG (Directed Acyclic Graphs) represents the Bayesian network, with nodes denoting the Bayes Net perception variables. Every node represents a probability function that takes the node as an input and passes the probability distribution of the variable [50]. Bayesian network is one of the efficient methods of artificial intelligence to describe the system's probability reasoning and uncertainty analysis [51]. Bayesian networks still have some drawbacks. It is still not easy to build a Bayesian network for a large complex system. Furthermore, the nodes are not discrete for some hybrid Bayesian networks, nor do they adhere to a particular continuous distribution like the Gauss distribution [52].

(vi) Decision Tree (DT): A decision tree utilizes a tree-like framework of decisions and their potential results [53]. Decision trees are among the most powerful techniques for data mining. This has been extensively used in a number of disciplines because they are ambiguous, easy to use, and robust even when missing values are present [54]. Even though DT is a comprehensive technique, it has a number of flaws. The following are the major disadvantages: making changes to a decision tree is difficult; if the target or output variable is not adequately stated, unacceptable results can be detected; decision tree with several branches can lead to processes that are time-consuming and more complex; large trees are hard to interpret, resulting in high costs as well and this cannot yield adequate results for continuous values [55].

(vii) Naive Bayes (NB): To a given example, Bayesian classifiers relegate class which is most likely described by its feature vector [56]. By presuming that attributes are independent of class, this classifier considerably facilitates learning. Even though independence is a dubious assumption, in practice, naïve Bayes routinely outperforms more advanced classifiers [56]. It also has some issues like the Zero Conditional Probability problem and how to solve this. A class conditional probability calculation is the key issue in the naive Bayes method and kernel density estimation is a popular way to do that [57].

(viii) Logistic Regression (LR): In comparison to various machine learning techniques, the retrieved attributes are classified with the shortest classification time and maximum classification accuracy using the Simple logistic regression approach [58]. This is one of the varieties of prevalent multivariate tools utilized in biomedical informatics. Logistic regression is among the most famous prediction models and has been applied to the prediction of cancer [59, 60]. The complexity of the model is already low in logistic regression, especially when few or no variable transformations and interaction terms are used [61].

(ix) J48: The J48 classifier is used to improve the accuracy of data mining procedures. The features of J48 are a derivation of rules, continuous attribute value ranges, pruning of decision trees, accounting for missing values [41]. J48 algorithm is one of the finest ML algorithms for categorical and continuous analysis of the data. But, when used for instance purposes, it takes up more memory space and reduces the performance and accuracy of medical data classification [62].

(x) Decision stump (DS): A DS is commonly a one-level decision tree wherein the root level split depends on a particular value pair/attribute. Decision Stump is the nest in view of speed alone [63]. This depends on the value of a single attribute only. Based on the type of attribute selected, many variations are possible. They are most often used as components in ML techniques, such as boosting [64]. Decision Stump is better for speed only, but other classifiers such as J48 are the right choice considering speed as well as accuracy [63].

(xi) Adabag (ABag): Bagging is a ML technique based on the combination of aggregation and bootstrapping [65]. Both sets will provide better behavior for the classifiers compared to the original set. As a result, in the condition of noisy observations in the training set, the bagging strategy becomes a useful tool for developing a superior classifier [66]. Findings indicate that when applied to the actual dataset, SVM-RBF, KNN, and AdaBoost are over-fitting [67].

4.2 Ensemble Techniques

The idea of the ensemble technique is to integrate multiple models to build a predictive model with an end goal to enhance the quality and measure of the prediction outcome. Ensemble methods are well known to be used to improve predictive performance [68]. Due to their strong experimental results and theoretical performance guarantees, bagging and boosting are two of the best-known ensemble learning methods [69].

i. Stacking is an ensemble learning strategy that uses a meta-regressor or meta-classifier to integrate various regression or classification models [68]. This technique attempts to induce reliable and non-reliable classifiers by utilizing a meta-learner [68].

ii. Voting is one of the ensemble approaches where multiple models for better classification can be combined [70]. There are three different forms of voting namely; majority, plurality, and unanimous voting. The larger part of voting considers over 50% vote for end decision, the majority of the votes in the plurality vote decide the final prediction and all the classifiers adhere to the final decision by unanimous voting [71].

4.3 Proposed Framework

The study examines the levels of many chemicals in benign and malignant breast cancer cases in Punjab’s Malwa region. The hypothesis is that the novel ensemble machine learning classifier will effectively distinguish benign and malignant cases in breast cancer data. In the proposed framework, biopsy samples are collected and information is recovered in the form of fifty-one distinct chemicals, as illustrated in Fig. 1. These 51 attributes are fed into the suggested framework, and the sample is trained. While processing data, missing values in the dataset are identified and replaced with appropriate values using the simulation tool's Replace Missing Values filter. A pool of eleven classifiers namely Naive Bayes, Random Forest, Support Vector Machine, AdaBoost, Neural Network, Bayes Net, Logistic Regression, J48, Decision stump, Decision Tree, and Adabag are explored and their performances are tested using k fold cross-validation technique. The suggested system's input is a collection of all the selected features, and its output is a value of 1 or 0 indicating whether patients have breast cancer or not. During the experimental work, the K-fold cross-validation approach is implemented, with K set to 10. To begin, the dataset is separated into ten equal-sized sub-samples. As a base classifier, the nine sub-samples are trained and the remaining are assessed using some of the top machine learning techniques. The procedure is performed multiple times in order to determine the robustness of the built framework. To optimize the performance of the single classifier, a combination of classifiers has been experimented. After several iterations, an efficient ensemble of Random Forest and BayesNet is generated using the voting approach. Using ensemble approaches enables better predictions than a single model being used. In order to enable an efficient combination of basic classifiers, numerous techniques have been built. Voting is the simplest approach, in which each entry token is assigned to the class predicted by the most basic classifiers. ROC Area, FP Rate, F-measure, Precision, TP Rate, and Recall are some of the discrete parameters used to assess the efficiency of the mentioned framework. For the classifier, a confusion matrix is also computed. The best attributes are considered to train the algorithm after the pre-processing phase, which includes removing the missing value and the data cleaning. As shown in Table 1, the proposed framework's performance is evaluated employing several confusion matrix performance criteria such as sensitivity, F-score, and accuracy, and it is found to be efficacious with 90% accuracy.

5 Results and Discussion

This segment displays the performance analysis and the outcomes of the models utilizing K fold cross-validation.

5.1 Performance Evaluation

The suggested model utilizes the feature selection technique to obtain relevant features in order to improve the model's accuracy. The feature selection is aimed at eliminating the redundant and irrelevant features and making the later classifier

Table 1 The Performance of Various Algorithms with Top 20 Features

Classifier	TP Rate	FP Rate	Precision	Recall	F-Measure	AUC	Acc (%)
RF	0.87	0.144	0.872	0.872	0.872	0.915	87
NB	0.89	0.138	0.901	0.894	0.891	0.91	89
BN	0.89	0.138	0.901	0.894	0.891	0.914	89
NN	0.85	0.169	0.851	0.851	0.85	0.853	85
ABoost	0.82	0.199	0.822	0.823	0.821	0.869	82
ABag	0.83	0.222	0.847	0.83	0.823	**0.938**	83
SVM	0.89	0.139	0.89	0.887	0.885	0.874	89
J48	0.85	0.178	0.854	0.851	0.849	0.833	85
DS	0.79	**0.262**	0.795	0.787	0.78	0.737	79
DT	0.83	0.199	0.831	0.83	0.828	0.828	83
BREV	**0.9**	0.128	**0.907**	**0.901**	**0.899**	0.919	**90**

obtain better performance. Table 1 displays the performance of different algorithms with top 20 features.

Combinations of machine learning classifiers are explored and implemented using different ensemble techniques like Stacking and Voting in order to boost the prediction rate. The effectiveness of various combinations is tested and compared to state-of-the-art approaches after a number of iterations. In the end, the ensemble technique with a high accuracy rate is concluded.

The best performance is shown by the combination of Random Forest and BayesNet using voting approach having ROC Area, Recall, TP Rate, F-measure, FP rate, and Precision with the value of 0.919, 0.901, 0.901, 0.899, 0.128, and 0.907 respectively. The performance is highlighted in Table 1. With a 10% error rate, 90 percent accuracy is attained. In terms of high prediction, the proposed model outperforms other well-known classifiers.

The K-fold validation method is applied for 10 iterations to validate and assess the performance stability, and the quality of the suggested framework is found to be robust. The performance matrix stability like AUC and accuracy are shown in Fig. 2, (a) and (b) respectively. K from 0 to 10 is selected to explore the influence of the k value on the accuracy of prediction. Figure 2 (a) demonstrates the accuracy with K Fold validation whereas Fig. 2 (b) displays the area under the curve with the K-fold cross validation technique.

5.2 Experimental Results

The empirical results of this work using various classifiers over the WEKA tool are presented in this section. The research described in this study is being undertaken in the Malwa region of India’s Punjab state. To assess the risk of breast cancer owing to chemical exposure, hundred distinct samples of blood and adipose tissue are

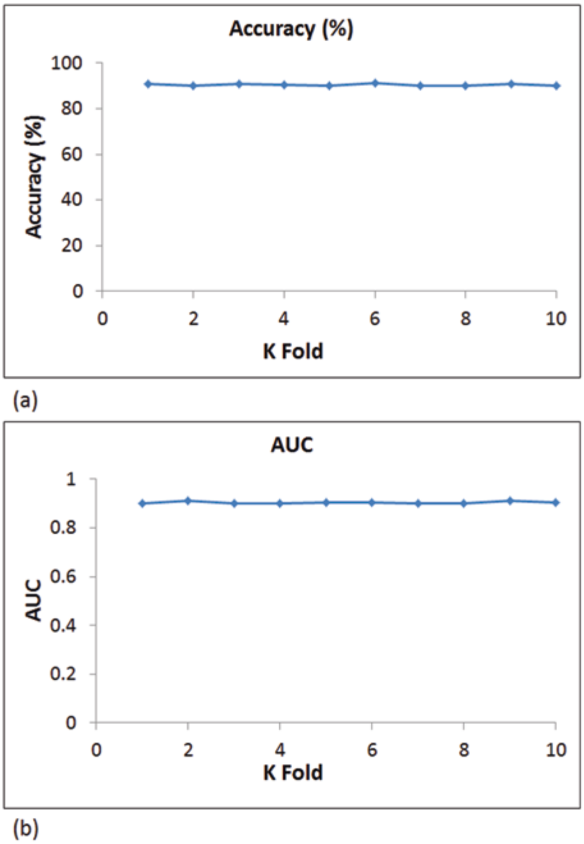

Fig. 2 K Fold Cross Validation Results of Accuracy

taken from female patients experiencing benign and malignant breast cancer in the Malwa belt of Punjab. In the study, fifty cases of breast cancer with both malignant and benign growth are considered, each with 51 features. Weka 3.6.9, a data mining tool, is used to empirically examine the outcomes over the dataset in order to classify the data using several algorithms.

The empirical evaluation is being conducted using a variety of machine learning approaches, including Neural Network, Bayes Net, AdaBoost, Decision Tree, and SVM. Multiple single classifiers are integrated to boost the final classifier's performance as no single classifier can claim to be better than the others. The performance of single classifiers and various combinations of machine learning classifiers are explored and compared. Random Forest and BayesNet ensembles applying the voting approach outperform other classifiers. The proposed approach employs stacking and voting classifiers that are among the ensemble approach where defects of one classifier algorithm advantage for another one. In the proposed model, first, there is a collection of data set from Malwa region of Punjab. Then, with the assistance of the ranker algorithm, low-ranked attributes are excluded as the low-rank attributes contribute less to predict tumor. Subsequently, all missing values are found and replaced at the time of pre-processing. After training the filtered dataset, it is then assessed with ten-fold cross-validation. Initially, single classifiers are tested then various combinations of machine learning classifiers are explored and implemented using different ensemble techniques like Stacking and Voting in order to boost the prediction rate. The performance of various combinations is tested and compared to state-of-the-art approaches after several iterations. In the end, the ensemble technique with a high accuracy rate is concluded.

The best performance is shown by the combination of Random Forest and BayesNet having ROC Area, Recall, TP Rate, F-measure, FP rate, and Precision with the value of 0.919, 0.901, 0.901, 0.899, 0.128, and 0.907 respectively. The performance is highlighted in Table 1. A 90% accuracy by an error rate of 10% is achieved. When compared to other known classifiers, the proposed model provides significantly better results in terms of high predictability. The K-fold validation method is applied for 10 iterations to validate and assess the performance stability, and the quality of the suggested framework is found to be robust. The performance matrix stability like AUC and accuracy are shown in Fig. 2, (a) and (b) respectively. K from 0 to 10 is selected to explore the influence of the k value on the accuracy of prediction. Figure 2 (a) demonstrates the accuracy with K Fold validation whereas Fig. 2 (b) displays the area under the curve with the K-fold validation technique.

6 Conclusion

In this work, the effectiveness of individual classifiers is evaluated and compared with various combinations of machine learning classifiers in terms of FP rate, ROC Area, Recall, TP Rate, F-measure, and Precision. The research presented in the paper proposes a novel method for accurately predicting breast cancer disease from patients' medical records. This paper showcases an interesting case study of breast cancer prediction by investigating the levels of 51 chemicals in female patients with both benign and malignant breast cancer growth. Data from the patient's biopsy sample is used to train the model. To classify malignant and benign tumors, numerous data mining techniques are applied and experimented. Various supervised learning classification algorithms are employed in the study to predict breast cancer and compare them on diverse parameters. AdaBoost, Bayes Net, SVM, Decision Tree, and Neural Network are among the machine learning algorithms used in the empirical evaluation. This study mainly focused on finding the classifier with better prediction accuracy and applying the ensemble approach by combining algorithms for attaining optimal accuracy. The proposed approach employs stacking and voting classifiers that are among the ensemble approach where defects of one classifier algorithm advantage for another one. Initially, single classifiers are tested then various combinations of machine learning classifiers are explored and implemented using different ensemble techniques like Stacking and Voting in order to boost the prediction rate. The performance of various combinations is tested and compared to state-of-the-art approaches after a number of iterations. Amongst all the research observations, the optimal solution to breast cancer prediction has been found by combining the Bayes Net and Random Forest algorithms using the voting approach. The proposed system achieved a prediction accuracy of 90% by combining an optimized ensemble version with feature selection. The prediction model proposed attempts to predict breast cancer risk with an efficacious performance of different parameters namely; F-measure, FP rate, ROC Area, Precision, Recall, and TP Rate with the measure of 0.899, 0.128, 0.919, 0.907, 0.901, and 0.901 respectively. The method proposed is faster, accurate, efficient, and exhibits a wide range of medical assistance, resulting in the early identification of disease, which saves many lives. The Hadoop framework provides a possible possibility as future work of the case study described in the paper for detailed data collection and processing in greater depth using big data.

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Current and Future Trends of Cloud-based Solutions for Healthcare

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1 Introduction

The adoption of cloud-based computing and accompanying business models has had quite a significant impact on not only the computer economy but also a multitude of other areas. Around 80% of today's industries are estimated to switch to the cloud in the subsequent years, according to [20]. Organizations' that have resource constraints to invest in and stick up in platforms to implement their applications can even use the cloud approach to satisfy their stringent guidelines. IT resources are constantly being applied in various areas of the healthcare industry in today's modern environment [17]. They aid in the improvement of service quality, medical education, and data analysis.

We are entering the era of next-generation healthcare, which encompasses networked, intelligent, and content- aware smart devices, smart homes, and also smart hospitals, among other things [30]. For example, IBM has launched the Smarter Planet initiative, in which companies and ubiquitous, pervasive technology are urged to work across industries to address technological challenges. Personalized management techniques that suit patients' requirements by allowing them to take

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responsibility for their own advanced health informatics and enable collaborative treatment via the innovative use of technologies must also be established to transition to smart healthcare [37]. The cloud compatible system can promote smart healthcare in a variety of ways, including improved emergency response, because cloud interoperable systems enable instant access to patients' lab test data, allowing clinicians to review them right away. Cloud computing in the context of public health enables smart healthcare systems to track e-records that supports medical practices and research such as bio-surveillance, rapid response to medical issues, biological or chemical assaults, and enhanced monitoring of adverse medication effects [19].

The healthcare industry is distinct from other industries in several ways, which can be categorized as discussed here. To begin with, these industries are heavily controlled by government law, which includes patient safety laws. Second, compared to any other industry, the cost of high-risk errors in healthcare is exceptionally expensive, and finally, this manufacturing contributes to the formation of different units, such as hospital administration, labs, and patients. The exceptional privacy of healthcare and the integrity of patients' data makes the data itself sensitive, and any deceptive criteria will have had a big impact, which could result in life or death in some situations. As little more than a result, the implementation of technology can result in this sensitivity of information storage being unhurried [22] [14]. Healthcare is still being structured across the boards, and reform is enabling healthcare information innovation (HIT) to be globalized, and cloud computing, without certain, is a key element of this transformation, [27].

Infrastructure in order to improve quality healthcare and even the innovative impact it will have on other industries, [22]. Cloud businesses usually make every effort to make sure that they are extremely available and scalable. Organizations like those in the healthcare field can also benefit. Further sections of this work are providing a glimpse of the current and future trends of cloud-based solutions for the Healthcare sector. The followed section is focusing upon the research trends based upon the detailed survey of documents published during the last ten year i.e. 2011-2020 on cloud healthcare solutions from the Scopus database. The very next section is focusing on the future trends in this area and the last section is describing the conclusion.

2 Methodology

The data for this study has been collected from the Scopus database. Types of documents, the significance of publishing, subject categories of documents, popular journals, country contributions, most cited papers, title analysis, keyword analysis, and abstract analysis are all part of the study. The AGR (Annual Growth Rate), CAGR (Compound Annual Growth Rate) for documents published over the last ten year i.e., 2011-2020 has also been computed. To illustrate the more common and significant terms, word clouds were generated for the top 100 words in the title, keyword, and abstract from the 4294 published documents during the last ten years. The magnitude of the terms in this word cloud is related to how frequently they appear. The larger the word in the cloud, the higher the frequency of the term. In last, the future trends of cloud computing for healthcare sector are also covered.

3 Results and Trends Analysis

3.1 Year Wise Documents' Publishing Trends

Table 1 depicts the trend in document publishing, addressing the ideas and applications of cloud computing in healthcare over the last ten years, from 2011 to 2020. It can be shown that the number of documents on cloud-based healthcare solutions has steadily increased over the years, rising from 90 documents in 2011 to 801 documents in 2020. There has been an 88.7% growth in the number of documents' publications during this span of years. The average annual number of papers was discovered to be 429.4. This exponential growth of publications' trends in the field of cloud-based solutions for healthcare has a trend line that may be mathematically described as a graph as shown in Fig. 1. The black line in the graph with markers is representing the number of published documents for a specific year. The increasing order of this trend line is representing continuous increase of interest among researchers for e-cloud solutions in medical field.

The number of published documents in this field is represented here, along with the year of release, AGR as annual growth rate, and CAGR as compound annual growth rate. The computed average AGR and CAGR are 18.51 and 27.02, respectively. All of these indicators point to an increasing interest among researchers in using cloud-based solutions for healthcare

3.2 Types of Published Documents

According to the Scopus database, 4294 documents on cloud for healthcare have been published in the previous ten years, from 2011 to July 2020, as shown in Fig. 2. The majority of the articles published in 2011 (46.83 percent) were exclusively published at conferences. Articles type have been submitted to the remaining 37.09 percent of papers. With 5.82 percent of publications, conference-based

Table 1 Year wise publications' trend

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NOP	90	158	212	305	381	394	489	665	799	801
AGR	–	43%	25%	30%	20%	3%	19%	26%	17%	0%
CAGR	–	32%	33%	36%	33%	28%	27%	28%	27%	24%

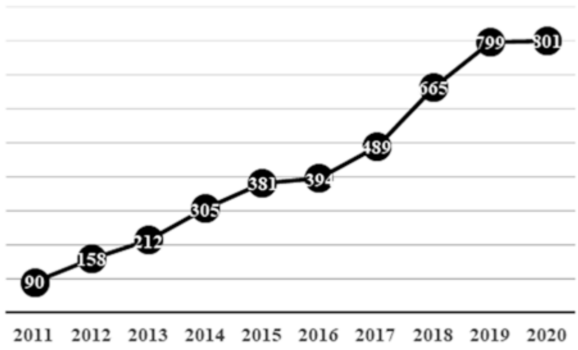

Fig. 1 Year wise publications' growth

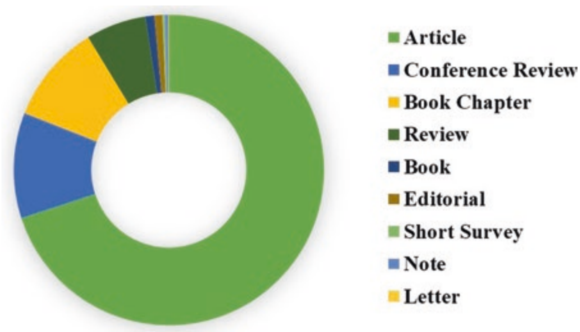

Fig. 2 Document Type on Cloud for Healthcare

reviews are next in line. Book chapters and other review papers account for 5.47 percent of all publications and 3.33 percent, respectively. Books, editorials, note, short surveys, and letters are at the bottom of the list, with a minimum proportion of documents published of 0.48 percent, 0.44 percent, 0.18, 0.11 percent, and 0.046 percent, respectively.

3.3 Countries contributing documents on Cloud in healthcare sector

The Table 2 presented shows top 20 countries which have published documents related to cloud in health care. The data presented in table considers documents published from 2011 to 2020, total count of documents is 4294. From Asia continent, 9 countries are present in the table. India is at the top most position with 1067 number of publications. China has also a significant count of research papers in the field. South Korea and Taiwan has number of publications from 150-200 range. Malaysia, Pakistan, Japan, Egypt and UAE have number of publications in the range of 50-100. From Europe continent, 7 countries are present in the table. United Kingdom has highest number of publications in the Europe continent i.e. 224. Italy

Table 2 Country based classification of documents on cloud in healthcare

Country/Territory	Number of Publications (NOP)
India	1067
United States	680
China	439
United Kingdom	224
Australia	179
South Korea	169
Canada	160
Taiwan	153
Italy	142
Greece	121
Malaysia	99
Germany	98
Pakistan	96
Spain	86
Egypt	74
Japan	72
France	61
Portugal	61
United Arab Emirates	61
Brazil	60

and Greece have number of publications in the range of 100-150. Germany, Spain, France and Portugal have number of publications in the range of 50-100. North America has two countries in the table United States and Canada. Unites States has second highest number of publications i.e. 680 in the table. Canada has number of publications in the range of 150-200. From continent Oceania, Australia is present in the table with number of publications in the range of 150-200. From South America continent Brazil is the part of table with number of publications in the range of 50-100. No country in the is having publications in the range of 0-50.

3.4 Funding Agencies Contributing Documents on Cloud in Healthcare

Funding agencies play a vital role in motivating researchers for bringing innovation and introducing new techniques for enhancing the quality and stability of research work. The table shows the top 20 funding agencies in the field of cloud in healthcare. The highest number of documents are funded by China's 'National Natural Science Foundation'. 'European Commission', 'National Science Foundation, King Saud University', and 'Horizon 2020 Framework Programme' have a number of documents in the range of 50-100. ‘Deanship of Scientific Research’, ‘King Saud University’, ‘National Research Foundation of Korea’, ‘National Institutes of Health’, ‘U.S. Depart- ment of Health and Human Services’, ‘Ministry of Science, ICT and Future Planning’ and ‘Fundamental Research (Table 2)

Funds for the Central Universities’ have a number of documents in the range of 30-40. ‘Ministry of Science and Technology of the People’s Republic of China’, ‘Ministry of Education of the People’s Republic of China’, ‘European Regional Development Fund’, ‘MinistA˜©rio da CiA˜ªncia’, ‘Tecnologia e InovaA˜§A˜£o’ and ‘Engineering and Physical Sciences Research Council’ has a number of documents in the range of 20-29. ‘Conselho Nacional de Desenvolvimento Cientı́fico e Tecnoĺogico’, ‘Ministry of Finance’, ‘Institute for Information and Communications Technology Promotion’ and ‘Government of Canada’ 10-19.

3.5 Top Institutes Contributing Research on Cloud Health Applications

In the previous ten years, a total of 160 institutes around the world have worked and published extensively in the topic of cloud application in health care. Based upon the Scopus database publications the top twenty institutes have been shortlisted are listed in table. it has been observed that out of the top twenty institutes seven of them from India, three from China, two from Saudi Arabia and Greece, along with one from each country of SPAIN, Italy, Morocco, South Korea, Romania, and Qatar. In terms of continents, Asia has fourteen institutes, Europe has five, and Africa has one. According to the ranking of QS World University 2021, four of the top twenty universities, namely King Saud University, Huazhong University of Science and Technology, Qatar University, Kyung Hee University, and King Abdulaziz University, have a ranking of less than 400. With 99 papers, the ‘King Saud University’ of Saudi Arabia took first place in cloud research in health care. India’s Vellore Institute of Technology is next on the list, with 78 publications. University of Piraeus, Anna University, and Instituto de Telecomunicacoes come in third, fourth, and fifth, with 44, 40, and 31 articles, respectively. The remaining universities not published more than 30 papers from last 10 year as per Scopus database (Tables 3 and 4).

3.6 Author Wise Publications’ Trend

Cloud computing for healthcare is a boon that is making its way into every aspect of life to make human jobs easier and faster. Many academicians have concentrated on this topic in the previous 10 years. The top 20 writers on the subject of implementing cloud computing for healthcare applications are listed in Table 5 in descending

Table 3 Top 20 funding agencies contributing documents on cloud in healthcare

Funding Agency	Number of Documents (ND)
"National Natural Science Foundation of China"	157
"European Commission"	83
"National Science Foundation"	69
"King Saud University"	53
"Horizon 2020 Framework Programme"	52
"Deanship of Scientific Research, King Saud University"	43
"National Research Foundation of Korea"	39
"National Institutes of Health"	38
"U.S. Department of Health and Human Services"	35
"Ministry of Science, ICT and Future Planning"	32
"Fundamental Research Funds for the Central Universi-ties"	30
"Ministry of Science and Technology of the People's Re-public of China"	29
"Ministry of Education of the People's Republic of China"	25
"European Regional Development Fund"	23
"MinistA˜©rio da CiA˜ªncia, Tecnologia e InovaA˜§A˜£o"	22
"Engineering and Physical Sciences Research Council"	20
"Conselho Nacional de Desenvolvimento Cient'ıfico e Tecnol'ogico"	19
"Ministry of Finance"	18
"Institute for Information and Communications Tech-nology" Promotion	17
"Government of Canada"	16

order of their number of publications. The table also contains the h-index, the h-index including self, the total number of documents by the author in Scopus, and total citations of the author. The "h-index," which refers to the number of publications with the largest number of citations, is an essential factor to examine in the table. The following column, "H-index excluding self," displays the author's h-index without the citations made by the author back to their research publications. An author's total number of publications is always more than or equal to his or her h-index. The number of research articles in the Scopus database related to the author is listed under "Documents in Scopus." The "Total citation" column shows the total number of citations made by other authors as well as the number of citations made by the author to their own study (also known as self-citation).

Vassilacopoulos, G. from the University of Piraeus, Piraeus, Greece has the highest number of research articles published in this field, his h- index is 14. However, the author in second place Malamateniou, F. with the same affiliation as the first author has an almost similar number of research publications. The author Marwan, M. is third in the list with the lowest H-index as 7. The author with the highest

Table 4 Top 20 Institutes Contributing research on Cloud Healthcare

Institutions	Country	Number of Publications	Rank
“King Saud University”	saudi arabia	99	287
“Vellore Institute of Technology”	india	78	–
“University of Piraeus”	Greece	44	–
“Anna University”	india	40	–
“Instituto de Telecomunicacoes”	SPAIN	31	–
“Chinese Academy of Sciences”	China	30	–
“Huazhong University of Science and Technology”	China	30	396
“Xidian University”	China	28	–
“Guru Nanak Dev University”	india	27	–
“Amity University”	india	27	–
“K L Deemed to be University”	india	27	–
“Qatar University”	Qatar	26	245
“University Politehnica of Bucharest”	Romania	24	–
“Thapar Institute of Engineering & Technology”	india	23	–
“Kyung Hee University”	South Korea	23	236
“King Abdulaziz University”	saudi arabia	23	143
“Universite Chouaib Doukkali”	Morocco	23	–
“Vellore Institute of Technology, Chennai”	india	23	–
“Universit’a degli Studi di Messina”	Italy	22	–
“National Technical University of Athens”	Greece	21	–

H-index of 70, the highest H-index of 68 excluding self, and also the highest citation count of 18417 is Chen, M. ranked fourteenth in the list with 14 published documents in this field. The last author among the list of top 20 authors has published 13 documents in this field. The author with the highest number of documents as 967 in the Scopus is Rodrigues, J.J.P.C. ranked at the tenth place in the list with a total of 18 documents published in this field over the last 10 years.

3.7 Top 100 Title Words’ Analysis

Any academic document’s major goals are classified by its title. The right title can pique the curiosity of other researchers while also presenting the research aims, breadth, and trials. As a result, the author’s vision and the appeal must be reflected in the title. For popular trends and standards, this section evaluates the top 100 most commonly used words in titles of the 4294 research publications recorded in the Scopus database over the last ten years. The 100 most useable terms were determined after extensive filtering and pre-processing, and the Fig. 3 illustrates a word cloud produced based on the frequency of selected words. After deleting duplicate terms from the abstract analysis, title analysis is performed based on the remaining

Table 5 Author Wise Publications' Trend

Author Name	NP	University/Organization	H-index	H-index excluding self	Documents in Sco- pus	Total citation
Vassilacopoulos, G.	26	"University of Piraeus, Piraeus, Greece"	14	13	102	685
Malamateniou, F.	25	"University of Piraeus, Piraeus, Greece"	10	10	83	467
Marwan, M.	22	"Universite Chouaib Doukkali, El Jadida, Morocco"	7	5	31	118
Sood, S.K.	21	"NationalInstituteofTechnologyKurukshetra, Kurukshetra, India"	23	23	130	2240
Hossain, M.S.	20	"King Saud University, Chair of Smart Cities Technology and Department of Software Engineering, Riyadh, Saudi Arabia"	47	42	318	8530
Kartit, A.	20	"Ecole Nationale des Sciences Appliqúees d'El Jadida, El Jadida, Morocco"	8	7	55	212
Muhammad, G.	20	"King Saud University, Department of Computer Engineering, Riyadh, Saudi Arabi- aKing Saud University, Center of Smart Robotics Research, Riyadh, Saudi Arabia"	44	39	280	5845
Ouahmane, H.	20	"Ecole Nationale des Sciences Appliqúees d'El Jadida, Laboratory of Information Technologies, El Jadida, Morocco"	8	7	49	215
Hassan, M.M.	18	"King Saud University, Department of Information Systems, Riyadh, Saudi Arabia"	38	37	310	5980
Rodrigues, J.J.P.C.	18	"Universidade Federal do Piau'ı, Teresina, Brazil"	63	61	967	16,037
Villari, M.	17	"Universit'adegliStudidiMessina,DipartimentodiScienzeMatematicheeInformatiche, Messina, Italy"	27	25	248	3282

(continued)

Table 5 (continued)

Author Name	NP	University/Organization	H-index	H-index excluding self	Documents in Sco- pus	Total citation
Kumar, N.	15	"ThaparInstituteofEngineering&Technology, Department of Computer Science and Engineering, Patiala, India"	66	60	575	14,588
Celesti, A.	14	"Universit'a degli Studi di Messina, Messina, Italy"	23	20	165	2258
Chen, M.	14	"Huazhong University of Science and Technology, Wuhan, China"	70	68	407	18,417
Costa, C.	14	"Universidade de Aveiro, Aveiro, Portugal"	13	10	131	721
Alamri, A.	13	"King Saud University, Department of Software Engineering, Riyadh, Saudi Arabia"	33	33	184	4284
Deters, R.	13	"University of Saskatchewan, Saskatoon, Canada"	20	19	162	1689
Fazio, M.	13	"Istituto Nazionale di Alta Matematica "F. Severi" (INdAM), Rome, ItalyUniversit'a degli Studi di Messina, Messina, Italy"	22	20	159	1906
Khalil, I.	13	"RMITUniversity,DepartmentofComputer Science and Software Engineering, Melbourne, Australia"	28	25	211	3409
Poulymenopoulou,	13	"European Commission Joint Research Centre, European Commission, Brussels, Belgium"	7	7	29	179

words. According to research, the world of cloud environment deals with the interactive transition from "owning and managing the Information Technology system" to 'accessing and outsourcing Information Technology systems as a service". The main factors that contribute to the evolution of cloud computing are distributed systems and their peripherals, virtualization, web, and utility computing, etc. Clouds can be adapted and utilized for different needs. Therefore, three different service models are available for cloud computing, each of which satisfies a specific business requirement i.e., platform as a Service (SaaS), Infrastructure as a Service (IaaS),

Fig. 3 Title words analysis

and Software as a Service (SaaS). Numerous cloud applications are available in various sectors such as image processing, education activities and assessments, media and entertainment industry, multimedia services, telecommunication, engineering, healthcare, etc. To provide security various cryptographic algorithms, techniques, 7schemes such as certificate-less authenticated encryption with keyword search are used in cloud computing. In the cloud computing arena, fully homomorphic encryption provides the best client data security.

Machine learning is playing a significant role in cloud technology as by incorporating cloud technology; it is possible to gain access to intelligence without requiring advanced knowledge of artificial intelligence or data science. Integrating machine learning into the cloud is called cloud-based machine learning. Although the cloud is used mainly for computing, networking, and storage, through cloud-based machine learning architecture. In the healthcare sector, machine learning has virtually unlimited applications. Machine learning algorithms like classification, regression, etc. on various platforms like Hadoop, Map Reduce are used to analyze and predict diseases.

Healthcare is undergoing a digital transformation and the cloud acts as a middleware for handling dynamic heavily loaded healthcare demands. Healthcare in context of cloud computing refers to the practice of storing, managing, analyzing, monitoring, and processing hospital as well as health clinic-related data on remote servers via the Internet. It is far different from installing a data center with a server's on-site or hosting data on personal devices. Emerging developments in cloud computing technology have big potential and opportunities to improve healthcare services and the living style of humans, according to experts and researchers. Remote healthcare service system comprised of various latest innovations such as Portable medical devices, Cloudlets (cluster of computers that can provide cloud computing services), intelligent terminals (smart mobiles, tablets, etc.), cloud services platform, real-time sensors such as GPS receivers, accelerometer, ECG, body temperature sensor). Severe problems such as Epilepsy seizures (a fatal neurological disorder), hypertension (HTN), etc. can lead to severe complications. With the advancement of the internet of things and machine learning techniques, combined with cloud computing services, healthcare has become a trustworthy sector with powerful verifiable technology to solve many issues. Professionals are also exchanging genetic and medical records through a federated ecosystem, which has resulted in the early interpretation and development of therapies for uncommon diseases.

A pandemic like Covid-19 has undoubtedly thrust cloud computing into the spotlight in healthcare. There are ramifications on all aspects of society due to the pervasive coronavirus disease of the 2019 (COVID-19) pandemic, including the physical, social, and mental well-being of a human. During pandemic times, healthcare simulation software enables transformational healthcare. They also provide fine-grained data verification, authentication, and authorization control over multiple cloud server-based Healthcare Applications.

3.8 Top 100 Abstract Words' Analysis

The authors specify and limit their study goals in the form of an abstract. The abstract summarises and describes the overall flow of the work. Other scholars can recollect and follow the essential techniques of a whole paper from the abstract. To determine current recommendations and trends, this section looked at the top 100 most often used words recovered after pre-processing from abstracts used by various researchers during the last 10 years from the Scopus database. In Figure 4, you can see a cloud of words based on the frequency of matched phrases. According to the studies, the popular term cloud computing deals with the delivery of services that includes databases, networking, software, analytics, prototyping, and intelligence over the internet. Utilizing the technology, the cloud enables the deployment, sharing, and use of data, applications, and resources and eases the lives of users in rural as well as urban locations.

Cloud computing plays a crucial and significant role in various sectors with special interest built around the healthcare sector which helps to increase efficiency. The vast amount of data can be accessed from a multitude of internal sources and can be generated by healthcare providers, including electronic health records (EHRs), pharmacy sales, lab tests, patient treatment, and interaction data. The

Fig. 4 Abstract words analysis

ability to maintain, centralize and manage patient information in digital form has been made possible by advancements in IT in the healthcare sector. According to the research statistics, the traditional paper-based system has been transferred to a digital healthcare system which cannot be possible without the cloud computing platform. Doctors can connect with patients through remote consultations via phone calls or video conferencing. Hence cloud computing is the primary choice for futuristic healthcare professionals.

3.9 Top 100 Keywords' Analysis

Keywords define the overall focus of the research. This section analyses the rest of the words chosen from the top 100 keywords after filtering duplicate words from the top 100 title and top 100 abstract words. The Fig. 5 for top 100 filtered words based on their frequency

The trends show that introduction of new technologies such as Artificial intelligence (AI) robotics and cloud computing is transforming the healthcare practises. Information technology has proved several applications in the field of healthcare such as ECG analysis telemedicine interfaces SaaS (Software as a service) Azure Healthcare

APIs, cloud-based medical image visualization, biometric security, etc. Cloud computing allows these applications to be operated from anywhere. The prediction of clinical disease can be performed using machine learning and AI-based models i.e. smart random forest classifier, SVM, and Naive Bayes. In cloud computing, medical records are typically stored online through an Electronic medical record (EMR system). The Internet of things (IoT) and No SQL database technologies have been implemented to support a new generation of cloud-based PHR(Personal Health Record) services. The use of Software-defined networks is a major contributor to the adoption of IoT as they support efficient resource utilization. Preserving Anonymity in Cloud Environment is an important task because preventive control components make the cloud environment more resilient to attacks by eliminating

Fig. 5 Keywords analysis

vulnerabilities. HIPAA (Health Insurance Portability and Accountability Act) compliance becomes a major issue for healthcare businesses when it comes to security and data breaches. Data security can also be enhanced by using a digital signature and encrypting of ciphertext. In order to develop effective and efficient cloud-based healthcare applications, Hadoop-based healthcare security communication, ECC (Elliptic Curve Cryptography) can be used.

3.10 Most Cited Publications for Cloud in Health Care

Any research study may rely on the work of other researchers and the author must acknowledge the contributions of other authors by citing their work. To ensure academic integrity, research ethics necessitates appropriate citation. The use of systematic citations demonstrates that the work is genuine and reliable. During the last 10 years, the first 20 most cited published papers in cloud for healthcare sector have been presented in this section. Table 6 below shows the list in decreasing order of the matching citation index.

Rahmani et al. [29] suggested a fog computing-based architecture explore the IoT-based healthcare system by building an intelligence intermediate layer in the middle of the cloud and sensor node [29]. It can deal with numerous issues in ubiquitous computing of the distant healthcare center. The gateways of Smart e-Health can support the widespread distribution of healthcare monitoring equipment if these are implemented well. The authors also show UT-GATE, a Smart e-Health Gateway prototype that incorporates some of the higher-level capabilities addressed. This IoT-based healthcare system is also known as Early Warning Score (EWS). Zhang et al. [41] proposed a cloud cyber-system that depends upon big data analytics technologies for a patient- centric healthcare system [41]. The findings of this work suggested that cloud and big data-based technologies data helps to improve the healthcare system performance, allowing users to get benefit from a variety of smart healthcare tools and services. Hossain et al. [18] introduced a HealthIIoT-enabled monitoring system in which data is captured from ECG and other devices used for healthcare systems by using sensors and mobiles [18]. This captured data is accessed with security in order to easy access by healthcare experts from the cloud. The augmentation, watermarking systems are used to avoid the risk of individuality theft or any error related to the clinic from providers of the healthcare system. By installing an ECG health monitoring system that is based upon IoT technology in the cloud environment, the suitability and validity of the system are approved by experiment and simulation results.

Xu et al. [38] suggested a data model for keeping and understanding the IoT data [38]. To maximize the utilization of IoT data, a resource-based IoT data access technique known as UDA-IoT is devised to cap- ture and analyze the IoT data on a global scale. The results reveal that in a dispersed heterogeneous envi- ronment, the resource-based IoT approach is beneficial for data access quickly in the cloud and mobile-based approaches. Farahani et al. [9] described a comprehensive IoT

Table 6 Most cited documents on cloud in healthcare

SN	Authors	Title	Year	Cited by
1	Rahmani A.M. et al.	"Exploiting smart e-Health gateways at the edge of healthcare Internet-of-Things: A fog computing approach"	2018	475
2	Zhang Y. et al.	"Health-CPS: Healthcare cyber-physical system assisted by cloud and big data"	2017	401
3	Hossain M.S. et al.	"Cloud-assisted Industrial Internet of Things (IIoT) - Enabled framework for health monitoring"	2016	391
4	Xu B. et al.	"Ubiquitous data accessing method in iot-based information system for emergency medical services"	2014	374
5	Farahani B. et al.	"Towards fog-driven IoT eHealth: Promises and challenges of IoT in medicine and healthcare"	2018	360
6	Alamri A. et al.	"A survey on sensor-cloud: Architecture, applications, and approaches"	2013	299
7	Esposito C. et al.	"Blockchain: A Panacea for Healthcare Cloud-Based Data Security and Privacy?"	2018	279
8	Doukas C. et al.	"Bringing IoT and cloud computing towards pervasive healthcare"	2012	265
9	Flores M. et al.	"P4 medicine: How systems medicine will transform the healthcare sector and society"	2013	238
10	Chen M. et al.	"Smart Clothing: Connecting Human with Clouds and Big Data for Sustainable Health Monitoring"	2016	230
11	Gia T.N. et al.	"Fog computing in healthcare Internet of Things: A case study on ECG feature extraction"	2015	230
12	Wan J. et al.	"Cloud-Enabled wireless body area networks for pervasive healthcare"	2013	221
13	Yang Z. et al.	"An IoT-cloud Based Wearable ECG Monitoring System for Smart Healthcare"	2016	212
14	Mutlag A.A. et al.	"Enabling technologies for fog computing in healthcare IoT systems"	2019	210
15	Gu L. et al.	"Cost efficient resource management in fog computing supported medical cyber-physical system"	2017	205
16	Aazam M. et al.	"Fog computing micro datacenter based dynamic resource estimation and pricing model for IoT"	2015	203
17	Abbas A. et al.	"A review on the state-of-the-art privacy-preserving approaches in the e-Health clouds"	2014	199
18	Minelli M. et al.	"Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses"	2013	197
19	Sultan N. et al.	"Making use of cloud computing for healthcare provision: Opportunities and challenges"	2014	193
20	Liang X. et al.	"Integrating blockchain for data sharing and collaboration in mobile healthcare applications"	2018	185

e-health design that necessitates a shift from clinic to the patient-centric healthcare system in which everyone i.e. hospital, patient, and its services seamlessly connected to one another [9]. To enable the processing of complicated data related to category, potential, and latency and implementation of various tools and applications for healthcare systems, this patient-centric IoT e-health ecosystem requires a device, fog computing, and cloud. Alamri et al. [3] offered a detailed review of sample infrastructure for sensor-cloud works, which provides an understanding of the sensor and cloud platform like the concept, design, and its applications [3]. In recent years the Sensor and Cloud infrastructure has grown in popularity as it provides an open-source, adaptable, and customized platform to execute a variety of intensive care applications. In this study research problems, existing methodologies, as well as prospective research directions are also thoroughly discussed. Esposito et al. [8] also demonstrate the aspects of using Block chain technology to secure the data stored in the cloud for the healthcare system [8]. The authors also discussed the challenges and directions of future work related to the confidentiality of data stored in the healthcare system. Doukas et al. [7] demonstrated a platform based upon Cloud Computing for managing mobile devices and sensors used in healthcare, illustrating how the IoT paradigm may be applied to pervasive healthcare in this fashion [7].

Flores et al. [10] described how systems biology and medicine are now starting to give individualized information based upon the experience of individual's health and disease at cellular, and structure levels to patients, consumers, and clinicians [10]. By tailoring therapy to each person's individual biology and reasons of disease instead of symptoms, this information will drastically reduce the cost of disease care. It will also serve as a springboard for customers to take tangible steps to enhance their health as they notice the effects of their lifestyle choices. Chen et al. [5] presented smart clothing system designs, technologies, and realistic implementation methodologies [5]. Smart clothing collects electrocardiograph impulses, which are utilized for mood monitoring and emotion recognition. The authors also point out some of the design problems and unresolved concerns that must be addressed in order for smart clothing to become ubiquitous for a variety of applications. Gia et al. [12] presented an improved healthcare monitoring framework by utilizing fog computing with smart gateways and data services like mining of data, storage in the distributed system, and services of notification at edge level of networks [12]. The findings show that fog computing has capability to reach over 90% bandwidth utilization with minimum latency at the network's edge. Wan et al., [36] presented a WBAN model and its services for healthcare schemes [36]. This model focused on the efficient routing techniques which save energy, efficient provisioning of resources, and security of the information processed in transferring data over the cloud.

Yang et al. [39] offered an Internet of Things (IoT) a based novel method for ECG monitoring. The data is collected by ECG devices through the monitoring edge and transferred to the IoT cloud [39]. The experimental results demonstrated that the suggested system is reliable in collecting ECG data. Mutlag et al. [26] conducted a thorough review of the impact of fog computing in the realm of IoT-based healthcare systems [26]. Providing inspiration, addressing research limits, and making recommendations to analysts for enhancing this important field of study. All of the research investigated fog computing in the healthcare industry in a systematic manner. All of these experiments show that resource sharing improves fog infrastructure by providing minimum latency, higher scalability, distributed manner processing, improved privacy, fault tolerance. Gu et al. [13] embedded fog technology with medical systems to create a fog computing-enabled Medical cyber-physical system [13]. Medical cyber-physical systems (MCPSs) are an emerging trend in healthcare that enable the interaction between computing elements and medical equipment intelligently. Cloud capitals are frequently used to process the captured data from medical equipment in order to support MCPSs. The proposed system delivers an optimal solution with efficient cost and outperforms a greedy algorithm. Aazam et al. [1] suggested a model that addresses the prediction of resources, customized based prediction of resources, reservation, its cost predictions for new and existing IoT clients [1].

Abbas et al. intend to cover the most up-to-date privacy conserving methods used in e-Health cloud systems [2]. In addition, the privacy-conserving methods are divided into cryptographic and non-cryptographic methods. In addition, the strengths and weaknesses of the proposed methodologies are discussed, as well as certain unresolved difficulties. Minelli et al., [25] reviewed the impact of bid data and analytics related to the business world [25]. This work focused on the strategies to collect the varieties of structured and unstructured data sets for analytic purposes, and data security and its visualization as per business needs. Sultan et al. [34] focused on the evolution of cloud computing and investigate its prospective areas which enhanced the healthcare delivery systems [34]. Liang et al. [21] suggested a novel data sharing healthcare system based on blockchain technology that protects data through a channel-formation scheme which further enhances the identity management characteristics by using membership service of blockchain technology [21]. To manage massive data sets collected and uploaded via mobile devices, a tree-based data processing and the batching mechanism were developed. By utilizing the concept of fog computing, Verma et al. [35] presented a monitoring system that observes the health conditions of patients at remote locations [35]. The services offered by the model are distributed storage access, notification and data mining etc. To process the real-time information of any patient an event-triggered approach is used at the fog layer. The proposed system's utility is boosted by implementing smart decisions on real-time healthcare data.

4 Future Trends of Cloud Computing in Healthcare

Healthcare providers can use cloud computing to cut costs while providing better, more personalized care. It also aids in the development of efficient workflows, resulting in improved service. Parallel to this, cloud computing enables patients to receive faster replies from the healthcare business and to maintain a better track of their health thanks to cloud-based healthcare data [16]. Cloud computing is increasingly being used by healthcare professionals and hospitals around the world to solve problems such as care coordination, data security, and population health [15]. Advanced cloud computing enables medical research innovation by allowing researchers secure access to critical data sets [6]. Cloud computing has also shown to be an effective tool in hospital settings [17]. Artificial intelligence and machine learning techniques, paired with advanced computation, storage, and database capabilities, assist the healthcare business in developing solutions and offering services to patients [40].

Innovative cloud computing technology will help to give fair access to care, allow healthcare providers to make the best decisions, and provide access to important medical research. Following are the latest industry trends of healthcare utilising cloud computing.

Cloud Adoption to Cloud Optimization The focus will shift away from cloud adoption and toward cloud optimization in the future [32]. Almost all healthcare providers are now using a cloud host, and they are now looking for more from their supplier [24]. Cost reductions, multi-cloud management, and data optimization are some of the areas where improvements will be made [33]. Healthcare businesses are expanding vertically and horizontally, and they require a technology partner who can help them outline their requirements. Data that must be stored to comply with governing rules but isn't accessed on a regular basis can be handled differently than data that is constantly aggregated to produce public health trends or research statistics [28]. Based on pricing, term lengths, and access restrictions, a range of cloud-based providers can suit a single healthcare organization's application demands. As companies grow, they will aim to open source all areas of their technology in order to prevent becoming reliant on a single developer.

Data access to Patient's Patients can take charge of their own health via cloud computing [17]. Patients may access their data via the cloud, which motivates patients to actively keep track of their own health decisions.

Telemedicine Capabilities Information and communication technology have recently exploded in popularity as a way to support and provide patient care services outside of medical establishments [31]. Telemedicine technology such as telesurgery, audio/video conferencing, and teleradiology offer a new way for healthcare stake- holders to collaborate and communicate. Telehealth care services allow patients to receive clinical treatment with- out having to leave their homes, and they also allow medical specialists to give their expert opinions in order to cope with complex medical issues [4]. Doctor-patient and doctor-doctor interaction, as well as the transmission and preservation of medical pictures, might all be made possible with cloud-based software.

Drug discovery Drug discovery is the process of finding new therapies and validating their efficacy as well as any potential negative effects. To find prospective medicinal molecules from a trillion conceivable chemical compositions, the method necessitates vast computing capacity. Clouds against Disease, a collaboration between Molplex, Newcastle University, and Microsoft Research, uses cloud technologies to help with medication discovery [11]. Pharmacists may now use the IaaS cloud to acquire computing infrastructure to analyse complex biological datasets. This ground-breaking method has substantially reduced the time and resources required for drug development.

Digital Libraries Medical students, scholars, and doctors rely heavily on libraries to expand their expertise. Furthermore, due to its cost constraints, paper-based medical libraries, especially in undeveloped nations, are unable to fulfill community demand. Cloud-based collections have been viewed as a promising prospect. Libraries can use cloud platform for a variety of services, including storing files, archiving, scripting languages, web hosting, and resource operational processes [16]. The individuals benefit from cloud based educational resources in the following ways:

- The access is provided on demand to both organizations and people.
- The material can be read by multiple people at the same time.
- Scholars don’t have to comb through a heap of documents, thus data is available instantly.
- A conceptual query simplifies the search procedure.
- Physicians could become more informed of present healthcare developments and, as a result, enhance their work practices.

Virtual Medical Universities Because of its adaptability and pay-as-you-go nature, cloud computing has also found a home in academia. Amazon, Google, Microsoft, IBM, and HP are among the IT giants that have developed software for both on-campus and off-campus support [23]. This methodology can be used by medical universities to offer online courses, hold seminars, and improve collaboration among academics all around the world. It can assist medical institutions in reaching a larger number of learners at a lower cost and with less effort, particularly in underdeveloped nations. Models of cloud computing service can be used efficiently for academic purposes.

5 Conclusion and Future Aspects

The primary idea of proposed work is to review and to highlight the key component of cloud computing in healthcare sector. Total 4294 Scopus indexed papers on cloud in the health sector from 2001 to 2020 have been reviewed. In this study, a total of 10 different types of documents were reviewed, including 2011 conference publications (48.8%), 1593 articles (37.9%), and 250 conference Review reports (5.82%), which were further classified into 26 core disciplines, with computer science (75.36%) being the most significant contribution discipline in the area of cloud in healthcare. The engineering discipline has (40.63 percent), medicine has (17.07 percent), mathematics has (14.01 percent), and decision sciences with (8.57 percent). are the key contributor fields in the cloud in healthcare. The publication statistics suggest that cloud had the most increase in 2017, with 174 publications, and least in 2020, with only two papers relating to health care will be published. In the previous ten years, cloud research has been conducted in around 112 nations. India has the most publications (1067), while Bhutan, Armenia, Nepal, and other countries have done no research in this subject. The study identifies and analyses the contributions of the top 20 universities, sponsored agencies, and writers in the subject of cloud in the health sector. The current study focused on the core topic of healthcare, but it might be improved by delving deeper into other cloud application areas. The survey only looked at Scopus-indexed databases, but this effort could expand to include other databases in the future, as well as uncovering research opportunities in the cloud.

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Secure Authentication in IoT Based Healthcare Management Environment Using Integrated Fog Computing Enabled Blockchain System

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1 Background

Internet of Things (IoT) has emerged very rapidly in the field of technology in the recent few years. There has been a rapid change in the industry of medical devices and services provided by them. With the help of the Internet of Medical Technology, very important advantages are being received in the field of medical services, in which diagnostic tools are connected with each other and with the help of which one can get health-related information anytime and anywhere. The development and rise of Internet of Things in the medical field can play an important role in improving the quality of life of citizens by enabling Internet of Medical Technology based health monitoring systems that can control the limitations of time and location. Also, this technology can be used to provide individual and user-focused healthcare services. Because Internet of Things based health monitoring systems in medical work by integrating various medical devices such as biosensors, actuators, wireless access points etc. with various communication technologies such as WLAN, Bluetooth, Zigbee etc. to synchronize and exchange data. Internet access at this point raises many challenges to the security and privacy of personal and confidential health care information. In this way, security systems that meet key security requirements (i.e.,

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user authentication, user authorization or service access control, data integrity/privacy, and availability) may lead to widespread adoption of frameworks for IoT in medical area or medical based services. Such systems are fundamental to future technology. In any case, the high asset requirements of complex and heavyweight traditional security devices cannot be managed by asset-bound IoT edge computing networks, which comprise critical fundamentals of IoT-based medical care monitoring systems. Likewise, the centralization approach generally took on by the cutting edge security systems isn't well pertinent to IoT enabled medical devices with edge computing networks because of weak link issues. To wrap things up, it is beneficial to feature that regular cutting edge guard instruments can't guarantee total carefully designed frameworks for safeguarding of IoT enabled medical devices with edge computing networking. Subsequently, there is a dire requirement for novel security mechanism to address the squeezing security difficulties of medical technology enabling with IoT edge networks in a viable and effective way before they gain the trust of every single included partner and arrive at their maximum capacity in the medical services market [20]. In this specific circumstance, instruments innovation with blockchain technology has been anticipated by the business and examination local area as a troublesome innovation that can be coordinated as proper solution into novel security for IoT enabled medical instruments with edge computing networking edge computing network, as it can assume a important part as: (a) providing a high authentication services to the IoT enabled medical devices and (b) controlling unauthorized access during the transformation of data. Despite the fact that there are already a number of blockchain-based security tools actively proposed for various types of IoT edge computing networking, blockchain for IoT edge computing networking in medical technology -based security components are sorely lacking. There is hope for work on planning and improving security systems based on blockchain technology for such computing networking. Towards this direction, it is imperative to have an in-depth understanding of the following two types of blockchain-based security components at an early stage (a) the many existing ones that are explicitly intended for IoT edge computing networking in medical technology, and (b) Those that are intended for different types of IoT. However, systematically organizations in IoT edge computing networks can be taken up in medical due to comparable capabilities and distinctive qualities. Along these lines, this paper is focusing on the audit the best in the class of the over two kinds of blockchain-based security systems to give an establishment to getting sorted out research endeavors towards the plan and advancement of reliable blockchain-based countermeasures tending to the squeezing security difficulties of medical technology based on IoT edge computing networks in a viable and proficient way. It is worth focusing that we limited our attention on the combination of blockchain technology into the: (a) user authorization mechanisms, as both include the main degree of compelling security in any system, and (b) Anomaly-based Intrusion Detection Systems (AIDSs), utilizing Machine Learning (ML) methods, due to their capacity to distinguish new, beforehand obscure network attacks.

2 Literature Review

In recent technological developments, fog computing based IoT has emerged as the most used technology. Some important security approaches were not included in the previous research, which are: (a) Data transferred from medical care IoT enabled devices to cloud servers is usually decoded and easily tempered and attacked. This allows patient sensitive health related data to be publicly disclosed (ii) As far as technology adaptation is concerned IoT enabled devices in medical care are the key to identifiable proof-of-stake that allows the user to verify the data and authenticate this medical care information. This security framework can be made complete and more secure by using blockchain technology. In-detail concerns, servers must perform some tests on the network edge in a somewhat verifiable and decentralized manner. This section covers the current strategies, approaches, and calculations about being fully connected to medical services IoT, Fog, Cloud and Blockchain. These methods mainly focus on security, unbreakable quality, digital attack, IoT information verification, and IoT Gadget ID. A portion of the current chips in IoT security, blockchain and medical services, summarized as follows:

Researchers [19] proposed a core framework called BeeKeeper which is integrated with Blockchain and IoT technology. This proposed framework enables a centralized cloud server to process the data by performing calculations on the data offered by the user. In this, any node that can be considered leading to authenticate to the server is chosen by the current administrator of the framework. Researchers have used the Ethereum blockchain to deploy Bee Keeper. While the researchers, Somino et al. combined private and public key attributes used different verification processes. Users who own these combinations of attributes can use them in the verification process. Users here are individuals using IoT enabled devices. However, their proposed strategies cannot drive identifiable proof of IoT enabled devices. They have incorporated various operations of cryptographic approaches integrated with blockchain strategies in IoT to limit deferrals and streamline network traffic. Anyway, no work has been done on the adaptability issue of blockchain and IoT.

In the same research series, Resarcher [14] proposed a centralized protocol that acts partially. In this the fundamental authority was accountable for creating parameters for users and excavators. The authenticated users used attributes based on encryption schema with the goal that they could be checked and decoded by some explicit excavators and users who own the attributes. The strategy was somehow conducive to keeping up with IoT secure transmission. In any case, their proposed work does not mark the issue of gadget distinguishing proofs and verification of keys. They center on secure transmission in a concentrated manner for the most part. A communicated environment is missing in this proposed work.

Resercher [17] used blockchain for information incorporation and secure transmission. The decoded information is usually stored away in various areas on the receiving site following a shared document storage convention. They created conventions for edge gadgets such as FCs, which help end-clients handle information while maintaining trustworthiness via the blockchain.

In any case, the existing methodology does not provide effective access control for information discovery on the blockchain in view of blockchain for patient well-being records or clinical records. As the latest research shows, blockchain is not search-adjustable; seeing a particular record will be extraordinarily delayed with information escalation. [13] A new blockchain-based human asset executive's strategy. The technology relies on the broadcast record strategy (DL). The creators depict the security protection process used to provide a straightforward framework when dealing with human asset records.

The public-private key pair was generated with an association ID, a privacy scheme, and a hash [7]. The work's exhibitions were dissected in light of the frustration point distinction proof, timing, read-write latency, and memory usage. In the interim, it performed better for all limits except the use of time. Still, the performance is high. [1] Introduced a clever intensive blockchain-based Trusted Security Savings Infrastructure (DBTPPS) to address difficulties such as security, trust, security and centralization factors. The creators attached three modules: a two-level security protection module, trust authorities, and a feature detection module [18].

The core module depends on the BC which is aggregated with an autoencoder. The reliability module is made up of the BC-based address infamous framework. The last one was remembered for its deep brain network-based approach. The location rate and accuracy of work undertaken were 93.87 percent and 98.97 percent, respectively. Anyway, they did not assess the general feasibility of the proposed approach [6]. Le et al. articulated an original method known as Underground Insect State Augmentation (ACO) for security and secure and reliable IoT information sharing; He took a multi-part support vector machine with a circular bend cryptosystem (ECC). Insurance and honesty were achieved by blockchain.

Test checks demonstrated that the work achieves superior accuracy and review and thus guarantees safety, security, confidentiality and dependability. In any case, securing the various parts of the scrambled dataset is challenging. [8] introduced an original strategy known as blockchain-based combined learning (BFL) to deal with security protections for traffic stream expectation. The creators similarly demonstrated that the strategy can be used to empower dependencies and that decentralized promotion achieves joint learning without involving an integrated model facilitator. The work provided better security insurance and prevented attacks from damaging information. However, in this method the above correspondence is a bit excessive. [4] Outlined a basic advanced trust model integrated with a multi-faceted, versatile and trust-based weighting framework. The creators introduced mathematical methods to deal with belief evaluation. The inexhaustible quality of the technology that fosters flexibility is greatest, however, as the creators didn't zero in on the control-circle idea and their coordination to complete a decentralized IoT framework. [2] Expressed a new blockchain-based Trust the Executive Instrument (BBTM) to deliver improved reliability of the Sensor Hub. The creators featured better trust assessments and checked the evaluation cycle. This work achieved improved confidence accuracy, flexibility and cohesion against attacks. Be that as it may, there is no opportunity for continuous application.

In the customary symmetric origin model, encryption is accomplished using a symmetric key. The information owner separates the information into a few assemblies and later scrambles these gatherings using a symmetric key. Clients who have private keys can interpret the scrambled information. In this scheme, the accepted customers are entered in the ACL [11]. The significant disadvantage of this scheme is that the amount of keys becomes straightforward as the number of information increases. Similarly, assuming that any change occurs between the customer and the information owner, it will affect different customers in the ACL. Accordingly, in short, this scheme is not viable for use in various situations [9]. Finextra referenced in its 2021 expected pattern for blockchain, that it is normal that the worldwide blockchain market will grow to US$39.7 billion by 2025 [10]. In 2019, Deloitte Global Blockchain Overview revealed that the industry is going through a period of growth in blockchain areas, for example, media transmission and inside fintech applications before its underlying major use [3]. Similarly, it was determined by Gartner that blockchain will generate an annual business honor of over USD 3 trillion by 2030 [16]. With these fascinating reports and patterns, there has been some interest in the adoption of blockchain in IoT-based systems. This is because IoT has had a huge market in various sectors over the years. A report by Business Insider suggests that by 2027, the IoT market will reach an annual growth of over USD 2.4 trillion [15] in a row.

With this tremendous growth, a great interest was revealed by Industry 4.0 drive to digitize modern resources. Industry 4.0 is the fourth modern upheaval that includes accompanying patterns including man-made consciousness (AI), high-level mechanization, and information testing [5]. In any case, with this massive development, there are security gambles that come into play when impacts this extended network is empowered within the basic foundation, for example, IIoT [12].

3 Proposed Methodology for Secure Authentication

Here's a high secure authenticated algorithm that allows their users to scramble next to them and transfer it to the circulating records. Through this proposed extended secure, validated computation, clients can search for watchwords anonymously using the Blockchain Client API. If the customer loses the key, they can reject the strategy and request another key. It protects against dynamic plot attacks. The details of the various limits and numerical documentation used in our proposed structure are displayed in Table 1:

In the algorithm I, characterize a technique which is based on the users' attributes-based signature technique. This proposed admittance control depends on traits and element determination. On the off chance that a client satisfies the rules in light of the necessary credits, he is given admittance, in any case, the entrance is denied. Our proposed admittance control system utilizes a half and half brain network with property based admittance control, which makes it adaptable and safer. Our proposed system comprises of four fundamental members, i.e., administrator,

Table 1 Considered parameters for the proposed algorithms

S.No.	Considered Parameters	Parameters Description
1	CID	Clinician ID
2	BN	Blockchain network
3	LID	Lab ID
4	Rs	Ring signature
5	PHR	Patient health record
6	U_{Name}	Username
7	P^K	Private key
8	R	Integer
9	N	Number of nodes
10	G	Bilinear order group
11	P^1	Generator of additive first group
12	P^2	Generator of additive second group
13	Id	Bilinear identifier
14	H	Homomorphic encryption
15	K	Degree of signature

specialist, patient, and lab expert. We propose designation strategies and calculations for every hub.

Algorithm I: Users Selected Attributes Based Signature Technique

Input: Signature ace public key $P_{pub} \rightarrow s$ of region of interest, framework boundaries parameters of area, message M_0, e's personality I_De, and advanced signature (h_0, S_0)

1. Convert the raw data values sort of h_0 to number;
2. If the event that $h_0 \in [1, N - 1]$ doesn't hold
3. Confirmation falls flat;
4. End if
5. Component t = gh_0inG^T;
6. Number h = $H_2(M||w, N)$;
7. Number l = (r − h)mod N;
8. If l = 0,
9. Go to stage 2;
10. End if
11. Number $h_1 = H_1(I_De||h_{id}, N)$;
12. Component $P = [h_1]P_2 + P_{pub} - sinG_2$;
13. Component $u = e(S_0, P)inG^T$;
14. $w_0 = ut_{in}G^T$;
15. Conversion of the data types of w_0 into a bit string;
16. Number $h_2 = H_2(M_0||w_0, N)$;
17. If $h_2 = h_0$ holds the values ***then***,
18. Check a positive outcome;
19. Else
20. The confirmation falls flat;

21. End if

Process output: Verification result: Succeed or fail (with error occurrence).

4 Proposed Algorithm for Secure Access Control

Algorithm II proposes an improved homomorphic encryption process for users, which includes setup, installation, update, and discovery steps. The arrangement step gives the design to the calculation, where the installation arrangement introduces the limitations. This section promotes the coupled illustration of Spring Search (BSS) computation. Double numbers, such as 1 and 0, indicate a double rendering of the SSA. Since prey location is discrete, each variable on the axis must be addressed by the appropriate twofold properties. Since there are only two numbers in the paired form, that is, one and zero, the position shift is characterized by adjusting the position from zero to one or from one to zero [18]. A probability ability is used to execute the possibility of being displaced in a double form. The new area of every part in every aspect of the issue may change or remain in one piece depending on the value of this potential. The probability is ID_Y, IDD_Y which becomes one or zero in the BSS calculation. In both parallel and real forms, the means are refreshed as do the amount of transfer of friendly individuals from the population. The steady fluctuations of the spring yield constant benefits of the spring [6].

A population where the difference between the two types is refreshed, where 0 and 1 are the potentials. The position below traces the space of every facet aspect. The probability of each individual from the population fluctuates in its position given the above condition. In aspect D, the higher article I denotes the probability of increasing with a higher value of $I = D_Y$. The specific circulation tracks a 0 to 1 stretch in the light of an arbitrary number. Standard abilities are seen to depict the way the ideal arrangement is viewed.

Algorithm II: Improved Homomorphic Encryption Technique algorithm

Input: Public Key

1. T ← 0 ordered by index values W;
2. Choose key K_S for P_{RF};
3. Choose keys K_X, K_I, K_Z f or P_{RF} F_p;
4. Z^*_p and parse DB as $(id_i, W_{idi})d_i = 1$;
5. t ← N;
6. $K_e \leftarrow F$ (KS, w);
7. *For* id ∈ DB(w) d_o
8. Counter c ← 1;
9. Compute $x_{id} \leftarrow F_p(K_I, i_d)$, $z \leftarrow F_p(K_Z, w\|c)$;
10. $y \leftarrow x_{idz} - 1_e \leftarrow E_{nc}(K_e, i_d)$;
11. $x_{tag} \leftarrow gF_p(K_X, w)\ x_{id}$ and $X_{Set} \leftarrow X_{Set}\ Ux_{tag}$;

12. Append (y,e) to t and c ← c + 1;
13. T[w] ← t;
14. End *for*
15. $(T_{Set}, K_T) \leftarrow T_{Set}.Setup(T)$;
16. Let $E_{DB} = (T_{Set}, X_{Set})$;
17. ***Return*** E_{DB}, $K = (K_S, K_X, K_I, K_Z, K_T)$;
18. Generation of token (q('w), K);
19. Client's feedback is K and inquiry $q(\text{'}w = (w_1, \ldots, w_n))$;
20. Compute $s_{tag} \leftarrow T_{Set}.GetT_{ag}(K_T, w_1)$;
21. Client sends stag to the server;
22. ***For*** c = 1, 2, … Until the server stops do
23. ***For*** i = 2, …, n do
24. $x_{token}[c,i] \leftarrow gF_p(K_Z, w_1 \| c)F_p(K_X, w_i)$;
25. ***End for***
26. $x_{token}[c] \leftarrow (x_{token}[c,2], \ldots, x_{token}[c,n])$;
27. ***End for***
28. $T_{okq} \leftarrow (s_{tag}, x_{token})$;
29. Return T ok_q;
30. Apply any sorting and searching technique;
31. $E_{Res} \leftarrow$;
32. $t \leftarrow T_{Set}(retrieve)(T_{Set}, stag)$;

Process output: Verification result: Succeed or or fail (with error occurrence).

5 Conclusion

Blockchain has probably been the most advertised innovation in the last 5 years due to the notoriety earned by the various cryptographic forms of money. Many use cases have been executed using bitcoin, Ethereum, and other blockchain innovations.

Be that as it may, none of these use cases involve infrastructure with information in the form of fragile structures and their resources. While blockchains including Ethereum highlight the importance of privacy, honesty, and reasonableness for their customers, there are significant safety and security gambles with them that have been examined and linked to their use in fundamental situations such as IoT situations in this paper. These security issues exist in other blockchains because one of their primary planning standards is the use of record propagation.

The current guide to Ethereum 2.0 contains future improvements that address the security issues examined in this paper. Nevertheless, with all the additional security and security highlights, it is important to dissect and focus on the presentation of any blockchain structure before expressing passivity in critical situations. We carried out the core comprehensive methodology of homomorphic encryption within the framework of computerized medical services, using blockchain innovations that provide a protected watchword search office at the client end. Our test strategy maintains durability and resistance to tampering and delivers secure information, minimizing security breaks for medical services. Data addition, our core system allows blockchain clients to scramble the information next to them and transfer it to the broadcast records for record purposes in the fog environment. With homomorphic secure signature encryption technique in mind, customers can securely view ideal health information without decoding it.

In addition, it protects dynamic collaboration and repels attacks due to the sacrifice of adaptable strategy. Blockchain innovation additionally maintains circulating information, uncovers duplication, and highlights the intrinsic failures of computerized structures. In this proposed research, motion difficulties and issues in writing seen by the advanced medical services industry will be tackled. This paper proposes a set of algorithm that empowers the secure access control strategy for clients to meet the safety and security of patient well-being information in the PHR framework. The proposed technology gives customers more autonomy, and it maintains adaptability and great catchphrase search. With this proposed methodology as the most cutting-edge approach to medical services, blockchain innovation and fog computing equipped devices, further developed security and privacy in contrast to benchmark models such as Separately Medic, MedChain, and Medicaid.

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Sentiment Analysis of COVID-19 Tweets Using Voting Ensemble-Based Model

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1 Introduction

Sentiment analysis is the process of communicating and interpreting feelings, views, ideas, and written emotions to enhance the consistency of various ML and DL methods. With the increased use of digital media for users to express themselves and engage with one another, sentiment analysis is an important technique for extracting their opinions, sentiments, and emotions. It has been one of the most active study fields, using numerous DL and ML models to analyze viewpoints and sentiments. Today, Twitter and social networks discussed what is trending in social media, whether locally or internationally.

The Corona Virus Disease 2019 (COVID-19) Disease has spread exponentially all over the world. By May 9, 2021, there will be 22,295,911 confirmed cases across India [1]. This pandemic has sparked widespread public interest in India. Since the coronavirus emerged so quickly in China, learning the public opinion variations will help the government manage and monitor the pandemic's growth, as well as support more scientific and successful work. For eg, is it feasible and appropriate for people to lock down in India because it is the first time this has occurred in India? Sentiment analysis is a valuable tool for quickly obtaining people's insights from vast amounts of text data. From opinion analysis, direct input from the public on government policy on coronavirus can be found, which is critical knowledge for government decision-making for pandemic prevention. However, since India already has 1.36 billion inhabitants, it is difficult to ask anyone how they feel about coronavirus. At

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the moment, the emotion classification methodology allows one to investigate public sentiment heterogeneity.

According to dsayce.com, in May 2020, there would be an average of 6000 tweets in each second, 350,000 tweets in each minute, 500 million tweets in each day, and 200 billion tweets in each year [3].

In the year 2020, blog.twitter.com announced that #COVID 19 is the most famous hashtag this year. It was tweeted nearly 400 million times, and #StayHome was the third most popular hashtag [blog.twitter.com]. They also stated that this year, 7000 tweets about TV and movies are sent every minute [2].

According to the “DSAYCE” website, 6000 tweets are posted every second on average, with 500 million tweets being reported every day. In Japan, Twitter users set the highest world record of “143,199” tweets in each second when watching Hayao Miyazaki’s animation classic “Castle in the Sky” on Saturday third August 2018. In 2016, 6000 tweets are received each second, 350,000 tweets are sent in each minute on average, 500 million tweets are received every day, and 200 billion tweets are in every year [2].

This research paper has organized into five sections in the II-section we have reviewed the research papers that have already been done, in section-III has covered the theoretical background of the research paper, in the section-IV, we have given proposed methods that I have used, and finally, in section-V, we have given the conclusion and future scope of this research paper.

2 Literature Review

In this section, we review the research work that has already been published by the researcher in the area of sentiment predictions and opinion mining, as well as numerous methods and strategies for analyzing sentiment; we have chosen the best research papers in the area of sentiment predictions.

In sentiment analysis, ML-based methods are commonly used; these approaches include training and testing datasets. Supervised classifier learning was used to prepare the dataset [14]. Uni-grams, bi-grams, n-grams, parts of speech (POS) codes, and bag-of-words (BOW), for example, are features of ML-based strategies. It employs three models: NB, SVM, and maximal entropy (ME). Machine learning analyses sentiments using supervised, semi-supervised, and unsupervised methods.

Kumar, Sudhanshu, et al. propose [15] that this paper aims to use the feature extraction method to evaluate the impact of user’s emotions based on their gender and age, as well as to create a dataset with user reviews and gender and age information, as well as to present user’s expression through extensive experiments, and finally to discuss the comparison of dictionary-based and machine learning methods. This paper employs various sentiment analysis strategies on 900 Facebook users with age and gender records, divides the 900 users into four categories, and then applies sentiment analysis to individual groups. With an accuracy of 78%, [15] used Feature Extraction, Dictionary-Based Classifier, Machine Learning-based Classifier, SVM, NB, and Maximum Entropy to evaluate sentiment analysis.

Kabir, Monika, and colleagues suggest [16] In this case, data sets are mined from various forms of feedback. These data sets are of various sizes and domains, and different methods are used to improve precision in the data sets. For sentiment analysis, [16] employs various ML and classification methods, including RF, DT, SVM, Boosting, Bagging, and DT. For sentiment prediction, three popular data sets such as Amazon, Yelp, and IMDb on various fields such as brands, Movies, and restaurants are used [16] employs data sets to categorize and test emotion polarity.

Jagdale et al. suggest [17] that this paper used a dataset from the Amazon website that included six categories of product reviews: laptops, cameras, televisions, mobile phones, tablets, and video surveillance. Analyze and describe each product review using various ML techniques such as SVM and NB. Using NB and SVM, they achieved accuracy on camera 98.17 percent and 93.54 percent, respectively. They have used a mixed approach, which is a mixture of lexicon-based and machine learning techniques. Machine-learning and lexicon-based methods are used to improve precision.

Jain Achin et al. suggest [18], and this paper is mostly concerned with analyzing English tweets. This paper used R studio and the Twitter API to compile tweets with blogging hashtags. This paper evaluates and implements sentiment analysis on "RenewableEnergy" using five different forms of ML techniques on 5000 Twitter tweets (SVM, KNN, NB, AdaBoost, Bagging). Using the CfsSubsetEval function selection process and SVM, they finally achieved 92.96 percent precision.

Saad, Shihab Elbagir, and colleagues suggest [19] Data sets are derived from the Twitter API and categorized as positive or negative tweets [19] performs sentiment analysis in five stages. Step 1: Assume that each tweet is classified as positive or negative. Step 2: Determine each tweet's polarity. Step 3: Determine each class's total emotion polarity. Step 4: assign a score of +2 for high positive, +1 for moderate positive, −1 for moderate negative, and − 2 for high negative to each level [5] analyses emotions in the Twitter data collection using ordinal regression and four ML-based algorithms. These algorithms are used for categorization: SVR (support vector regression), SoftMax, RF (Random Forest), and DT (Decision Trees). For sentiment analysis, SVR and RF have almost identical precision but outperform the Multinomial logistic regression classifier. The Decision tree classifier achieved the best precision of 91.81 percent in this case.

Yadav, Nikhil, and colleagues suggest [20]. This paper makes use of a dataset from Twitter as well as the Kaggle repository. Often employs numerous ML-based algorithms such as NB, RF, DT, SVM, and XGBoost, and then compares multiple classifiers to distinguish tweets on a certain product based on positive or negative sentiments [20] assists the corporate company in developing stronger strategic business strategies for their brands. The dataset is evaluated in five measures in this article. The first step is to compile a list of data sets. Step 2 is the preprocessing step. Step 3 is the feature extraction process. Step 4 is the grouping process. Step 5 is the assessment process. This paper relies mostly on English tweets and dissects human thoughts and emotions.

Chaturvedi, Saumya, et al. suggest [21] that this paper uses some ML-based strategies like NB and SVM for exploring business intelligence emotions that are used for business process decisions, as well as Big-data principles. The decision used the following measures to evaluate the emotions for the market process.

(a) Collection of Data
(b) Preprocessing and cleaning the dataset
(c) Prediction of the sentiments
(d) Classification of the sentiments
(e) Final output

Dataset collected from online services and analyzed using machine learning algorithms for market intelligence and sentiment analysis.

Hemalatha et al. suggest [22] that this paper is used to test emotions using ML tools such as Sentiment140, Twittratr, and Tweet feel, as well as ML techniques such as the Naive Bayes (NB) algorithm, the Maximum Entropy (ME) algorithm, and data-sets gathered from the social networking fields such as Twitter and others. Then, on the data collection, apply maximum Entropy and sentiment analysis methods, and finally, equate the Maximum Entropy algorithm to other sentiment analysis tools. Figure 1 shows the comparative analysis of maximum Entropy and sentiment analysis tools.

The Fig. 1 above explicitly reveals that maximum entropy outperforms sentiment analysis methods in terms of precision.

The [23] use over 4000,00 ratings for sentiment predictions by using three ML algorithms, and this paper aims to improve sentiment analysis accuracy using NB, DT, and SVM. The evaluation was carried out using a ten-fold cross-validation procedure. They performed sentiment analysis on cell phone ratings, sorted them into favorable and negative emotions in almost equal proportions, and then analyzed the dataset using machine learning models. SVM has the highest precision of the three versions, at 81.75 percent.

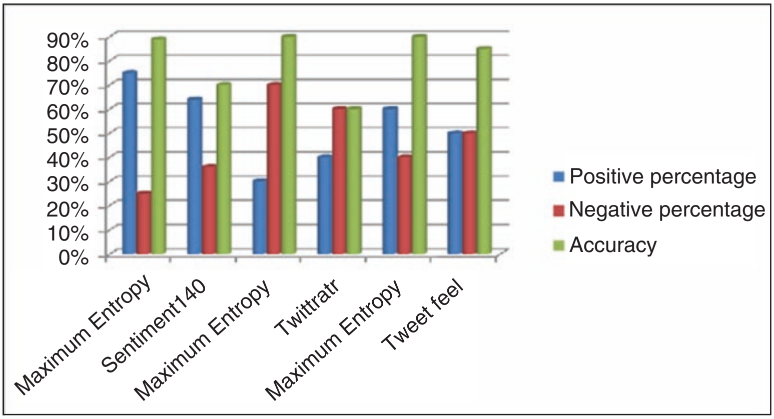


Fig. 1 Comparision of Maximum Entropy and Sentiment Analysis Tools [22]

Many authors use Deep learning models for sentiment analysis, DL is a form of artificial neural network (ANN) that uses several layers of networks to learn tasks. The composition of a neural network works the same as the human physiological brain and its processing units are known as neurons. Neurons can learn to do tasks in the same way as the brain does. Recurrent Neural Networks (RNN) and Feed-forward Neural Networks (FNN) are the two types of neural networks.

Chandra, Yogesh, et al. suggest [24]. A machine learning model, a deep learning model, and polarity-based approaches are used in this article. To determine the percentage of trust in classification systems, tweet data is first obtained from Twitter and then transmitted through a machine learning classifier. The ratio of positive and negative tweets is calculated using polarity-based techniques. Deep learning algorithms are then used to interpret the tweets. The tweets were classified using CNN-RNN, LSTM, and RNN templates. Deep learning models, such as CNN-RNN and LSTM, outperformed machine learning models. This paper has used the Twitter API to retrieve live tweets and identify them using voting-based classification and polarity-based classification. The dataset was obtained from the Twitter API/Kaggle repositories and the Kaggle kernel. Using machine learning classifiers, we achieved an accuracy of 81 percent to 90 percent for training and testing datasets.

Alarifi, Abdulaziz, et al. suggest [25] This paper gathered data from Amazon and employs a greedy approach since it uses the best classifier, a cat swarm optimization-based long short-term memory neural network (CSO-LSTMNN). The CSO-LSTMNN algorithm, the greedy method, and the particle swarm optimization (PSO) algorithm are used to compare results. The CSO-LSTMNN algorithm produces better results in terms of multifaceted nature and proficiency. CSO-LSTMNN employs five polarity levels: negative, relational negative (RN), neutral, positive, and relational positive (RP), with each level's threshold value balanced.

Mohamed Neha et al. suggest [26] and uses four deep learning methods for processing movie reviews datasets. This paper uses a data collection from IMDB that contains 50 k movie ratings. The data set is also split into half positive and half negative data sets. The dataset is first pre-processed with Word2Vec before applying deep learning algorithms such as LSTM, RNN CNN, Multilayer Perceptron (MLP), and a hybrid model that combines CNN and LSTM. Finally, the Hybrid model had an accuracy of 89.2 percent, while CNN, LSTM, and MLP had an accuracy of 87.7 percent, 86.64 percent, and 86.74 percent, respectively.

Alharbi et al. [27] provides sentiment analysis for the Arabic language. Many Arabic datasets are gathered from various sources and then subjected to sentiment analysis and comparison with other languages' datasets. The first small dataset is taken from Opinion Corpus for Arabic (OCA), and it has 500 movie comments. The second dataset is taken from Large Scale Arabic Book Reviews (LABR), and it contains book reviews from consumers on a scale of 5 to 1, and it is taken from www.goodreads.com, and it contains 63,000 Arabic reviews [27] considered three major levels: text, statement, and entity aspect. Find the issue and articulate the dataset with positive or negative sentiments at the document level. They have calculated individual sentences at the sentence level.

Ramadhani et al. suggest [28] for sentiment analysis using deep learning models; they retrieved tweets in both Korean and English from the Twitter API and used three stages for text mining from the Twitter API: information acquisition, information extraction, and data mining. Finally, they ran data into two DL models, Multilayer Perceptron (MLP) and Deep Neural Network (DNN), and obtained 67.45 percent and 77.45 percent accuracy on the training dataset, respectively.

Heikal et al. propose [29] for sentiment prediction of the Arabic dataset, taking 10,000 tweets from the Arabic social sentiment prediction dataset (ASTD). They used an ensemble-based CNN approach and the LSTM deep learning model. First, they used an individual variant on the sample and obtained 64.30 percent and 64.75 percent accuracy using CNN and LSTM, respectively. Eventually, they used an ensemble-based approach using a soft voting classifier and obtained 65.05 percent accuracy.

Wang, Jian, et al. recommend [30] for Chinese online shopping product reviews. They collected 13,000 votes, 7000 of which were positive and the rest were negative. They used three models for sentiment analysis: LSTM, LSTM dependent on Nadam with L2 regularisation, and Bi-directional LSTM. After reviewing the performance of both models, they discovered that the LSTM based on Nadam with L2 had greater accuracy than the other two models, which provided about 98 percent accuracy.

3 Theoretical Background

ML: For sentiment predictions, we have taken many machine learning techniques SVM, RF, DT, K-Nearest Neighbor (KNN), Logistic Regression (LR), and ensemble voting classifier.

SVM: Support vector machines are supervised machine learning algorithms that are both efficient and scalable. They are used for classification and regression. However, they are most often found in classification problems. SVMs were initially developed in the 1960s, but they were refined in 1990. As opposed to other machine learning algorithms, SVMs have a distinct implementation process. Because of their ability to manage several continuous and categorical variables, they are highly common [4].

An SVM model is essentially a representation of various groups in a hyperplane in a multidimensional space. SVM creates a hyperplane iteratively to minimize error. SVM aims to classify datasets to find the maximal marginal hyperplane (MMH) [4].

Support Vectors: Support vectors are data points that are in marginal lines which are parallel to the hyperplane. These data points are mainly used for separating the data sets into classes.

Hyperplane: As seen in the above Fig. 2, it is a decision plane or space that divides the dataset into different classes.

Fig. 2 SVM Working [4]

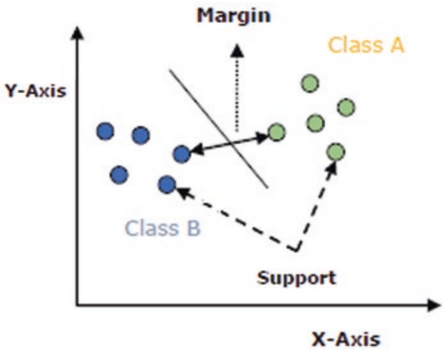
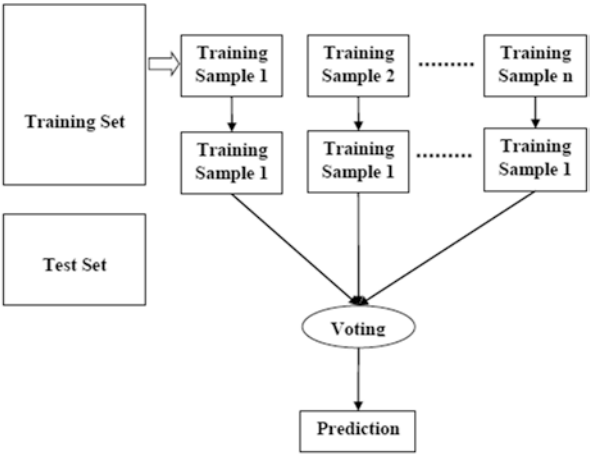


Fig. 3 Working of RF [6]



Margin: It can be described as the distance of the hyperplane and marginal plane that separates groups of closet data points. It is computed as the distance between the hyperplane and the marginal line. A maximum margin is regarded as a positive margin, whereas a small margin is regarded as a poor margin.

RANDOM FOREST: Tin Kam Ho prepared a random forests decision algorithm in 1995, with the help of the random subspace technique, in which Ho described how to apply Eugene Kleinberg's "stochastic discrimination" approach to classification.

RF, also known as random decision forests, is an ensemble-based technique for classification, regression, and other tasks that works like training a large number of decision trees and then outputting the class that is the mode of the classes (classification) or mean/average estimation (regression) of the individual trees [5] (Fig. 3).

Random Forest Algorithm took the following four steps to classify the dataset.

(a) Selection of Random sample
(b) Construct a decision tree and predict the result

(c) Perform ensemble technique
(d) Select the best result as the final prediction

DECISION TREE: these are statistical modeling techniques used in ML and DT for analytics and data processing. It employs a DT to progress from assumptions about the item (represented by nodes) to judgments about the items and target value (represented in the leaf nodes). Classification trees are tree structures in which the target nodes have a distinct range of values [7] (Fig. 4).

Root Node: The decision tree begins at the root node. It contains the whole dataset, which is then split into two or more homogeneous sets.

Leaf Node: Leaf nodes are the tree's last output node, and the tree cannot be further separated until obtaining a leaf node.

The decision tree uses three main methods to make a decision which are the Entropy, Gini index, and Information gain.

ENTROPY (E): It is used to assess a dataset's impurity or randomness.

$$\mathbf{E}(\mathbf{X}) = \mathbf{I_E}(\mathbf{P1,P2,\ldots\ldots,Pj})$$

$$\mathbf{E}(\mathbf{X}) = -\sum_{i=1}^{j} \mathbf{p_i} \log_2 \mathbf{P_i}.$$

INFORMATION GAIN (IG): To identify the best function that can be used as a root node in terms of information gain.

$$\mathbf{IG} = \mathbf{E}(\mathbf{X}) - \mathbf{E}(\mathbf{X|a})$$

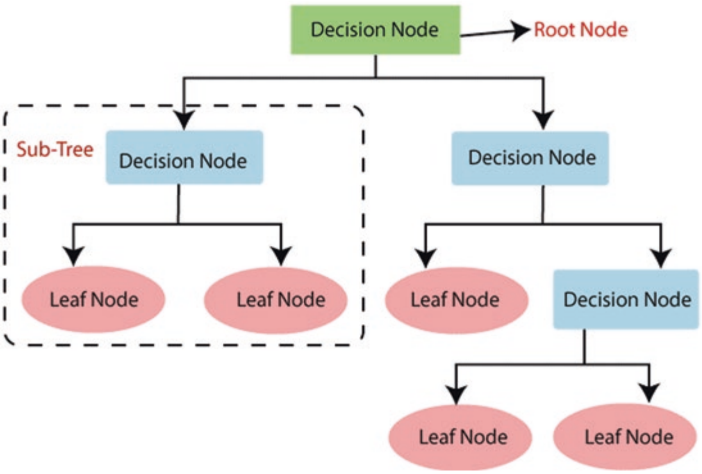


Fig. 4 Working of DT [8]

$$\mathbf{IG} = -\sum_{i=1}^{j} p_i \log_2 P_i - \sum_{i=1}^{j} p_{(i|a)} \log_2 P_{(i|a)}$$

Where E(X) Entropy of X and E(X|a) Sum of all entropy children P is the probability.

GINI INDEX (GI): It is calculated by subtracting the total of every class's squared percentages from one. It always considers the largest partitions that are simple to enforce, whereas information gain always considers smaller partitions that have distinct values.

KNN: k-NN is a non-parametric classification technique introduced in 1951 by Evelyn Fix and Joseph Hodges and then enhanced by Thomas Cover. It is used in both classification and regression problems. In all circumstances, the response consists of the k closest training instances in the data set [9]. KNN predicts the new data points based on 'feature similarities,' and the new data point will predict a value based on how exactly it resembles the points in the training collection [10] (Fig. 5).

KNN uses the many steps to classify the datasets which are.

(a) 'K' number of neighbors selection.
(b) Euclidean distance calculation for 'K'.
(c) Taken k as per the Euclidean distance
(d) Count the number of data points in each group among these k neighbors.
(e) Assign the latest data points to the group with the highest number of neighbors.

LR: it is a classification technique that uses supervised learning to predict the likelihood of a target value. Because the target variable is dichotomous, means there are only two possible classes [12].

An LR model forecasts P(Y = 1) as a function of X mathematically. It is a very basic ML technique that can be used to solve various classification problems such as spam diagnosis, diabetes prediction, cancer detection, Sentiment analysis, and so

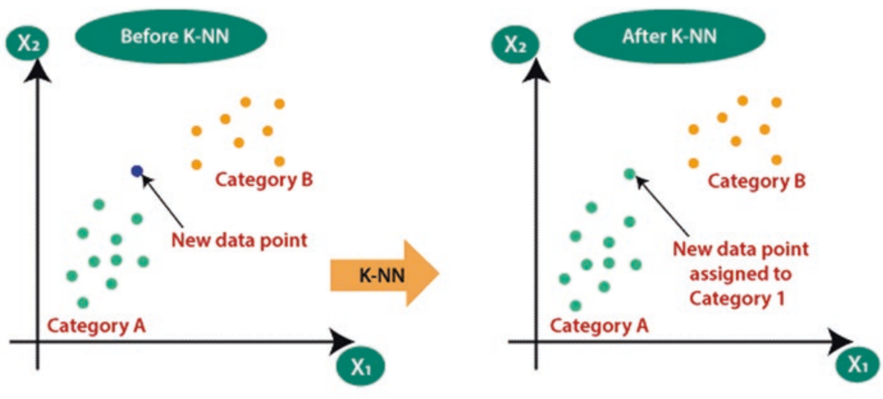
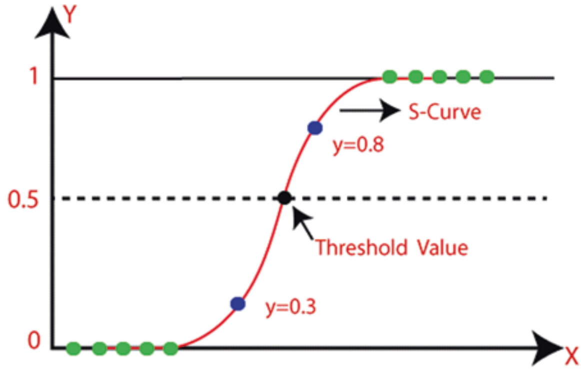


Fig. 5 working of KNN [11]

Fig. 6 working of LR [13]



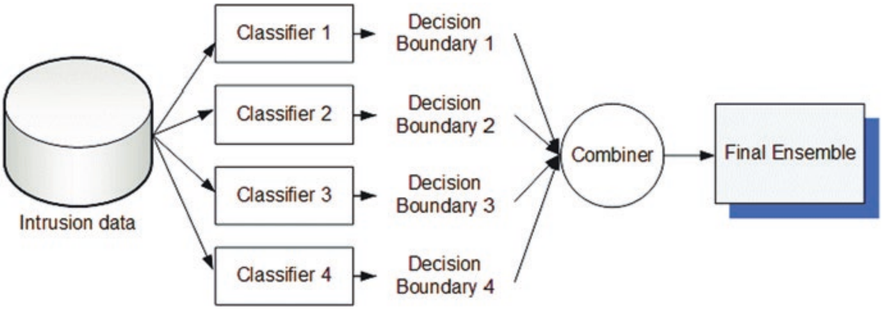


Fig. 7 Architecture of voting classifier [33]

on [12]. We fit an "S" form logistic function that predicts two maximum values in LR (0 or 1) (Fig. 6).

The logistic feature curve shows the probability of anything like whether the cells are cancerous or not, when a mouse is a fat or not depending on its weight, and so on [13].

ENSEMBLE VOTING CLASSIFIER: Ensemble approaches are strategies for developing different models and then combining them to achieve better performance. Ensemble models usually yield more reliable results than a single model [31]. A Voting Classifier is an ML technique that trains on various ML and DL models and predicts an outcome (class) based on the highest likelihood of the taken class as the output [32].

It essentially merges the results of each classifier that passed into Voting Classifier and then predicts the output class depending on the voting majority. Instead of developing individual dedicated models and determining their precision, we can develop a single model that trains on these models and predicts performance based on their cumulative plurality of voting for every output class [32] (Fig. 7).

The voting classifier has two methods to ensemble the models.

Hard Voting Classifier: The predicted performance class in hard voting is the class with the maximum majority of votes, i.e. the class with the high probability of being analyzed by any of the classifiers. Assume that we have three classifiers that have their output classes (A, A, B), and the majority predicted A. As a result, A will be the final prediction [32].

Soft Voting Classifier: The performance class of soft voting is the prediction technique that depends on the average of the probabilities assigned to that class. Assume that provided any input to three models, the estimation chances for each class A = (0.30, 0.47, 0.53) and B = (0.30, 0.47, 0.53). (0.20, 0.32, 0.40). So, if the average for class A is 0.4333 and the average for class B is 0.3067, class A is the winner since it has the highest likelihood averaged by each classifier [32].

PIPELINING: Pipelines are used to divide the machine learning workflows into separate, interchangeable, scalable sections that can then be pipelined together to continually increase the model's accuracy and produce a reliable algorithm. Generally pipelining includes the following steps.

Preprocessing and Vocab building: Unwanted texts (stop words), punctuation, URLs, handles, and so on that have little sentimental meaning are removed. Then adding unique preprocessed words to a vocabulary.

Feature Extraction: Iteratively going through and data illustration to remove features using a frequency dictionary and then creating a function matrix.

4 Proposed Method

In this part, we will go over the methodology we used in this paper. We build a Voting ensemble of ML models for the sentiment prediction of Covid-19 tweets. In the Voting ensemble-based model, we have included various ML classifiers for classifying the dataset into positive as well as negative tweets. It is divided into four major stages. The first stage is data preprocessing, which includes word sorting and tokenization, as well as stop words elimination and cleaning the dataset. The second stage is pipelining, in which we have passed two methods first one is TFIDF vectorizer and the second one is a machine learning classifier. TFIDF vectorizer and classifier model are used in the third stage for making a single model. In the fourth stage, we have applied a hard voting classifier (Fig. 8).

Figure 1 shows the working of the ensemble-based technique, in the preprocessing stage of the technique we have used the following steps.

Remove special characters: in this step, we have removed special characters from the tweets like _,? $, etc.

Remove Accented characters: In this, we have removed accented characters from the tweets like â, î or ô, etc.

Remove Emails: In this step, we have removed emails from the tweets.

Remove html tags: In this steps we have removed html tags like <html>, </html>, etc.

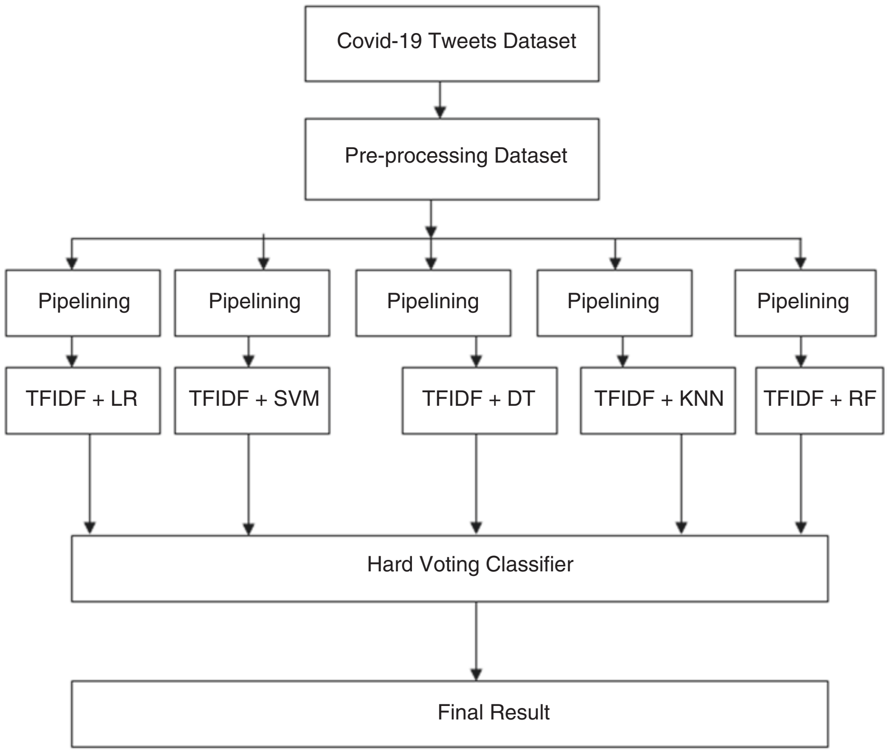


Fig. 8 Working of the ensemble-based model

Remove URLs: In this step, we have removed all URLs from the tweets.
Lower case: In this step, we have converted all upper case tweets into lower case.

After preprocessing we have used pipelining in that we have passed TFIDF vectorizer and machine learning classifier. Then prepare a single pipeline model. Finally, we have compared all models with their accuracy.

After preparing all models, we used an ensemble voting classifier to make average accuracy. By using the Hard voting classifier we got 94.7% accuracy on the testing dataset.

5 Experiment and Results

For the experiment, we have used Covid-19 tweets which have been downloaded from the Kaggle repository that has 1.4 million tweets related to covid-19. Dataset has four types of sentiments which are positive, extremely positive, negative, and extremely negative. For the experiment purpose, we have converted extremely positive as positive and extremely negative as negative. Then by using an individual

Table 1 Individual model accuracy

ML - Model	Accuracy
Decision tree	81.11%
CNN	72.33%
SVM	81.10%
Logistic regression	76.81%
Random Forest	90%

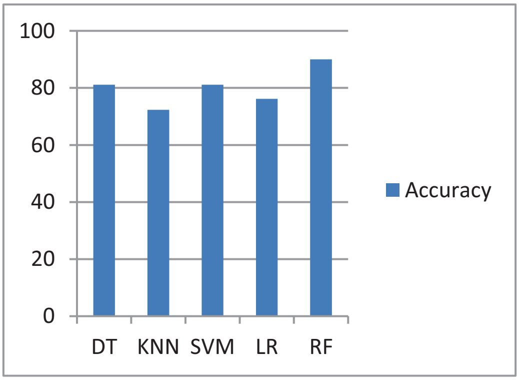


Fig. 9 Comparative analysis of classifiers

Table 2 Pipeline model accuracy

Pipeline model	Accuracy
TFIDF + LR	89%
TFIDF + SVM	95%
TFIDF + DT	91%
TFIDF + KNN	77%
TFIDF + RF	94%
Adaboost + DT	87%

machine learning classifier we got the following results (Table 1) by using Random Forest ML – classifier we got 90% accuracy which is better than other classifiers. Figure 9 shows the comparative analysis of individual models.

After calculating the individual accuracy we got that some classifiers perform well and some are not performing well so we have used the concept of pipelining with the help of TFIDF vectorizer. In the pipeline, we have passed one ML-classifier with TFIDF vectorizer and prepared a model, After preparing all models we have compared their results using Table 2 which shows the accuracy of each model.

After preparing models using the concept of pipeline techniques, we got that some models perform well and some are performing poorly so to overcome this problem we have used an ensemble model for the average accuracy. Figure 10 shows the comparative analysis of pipelining models.

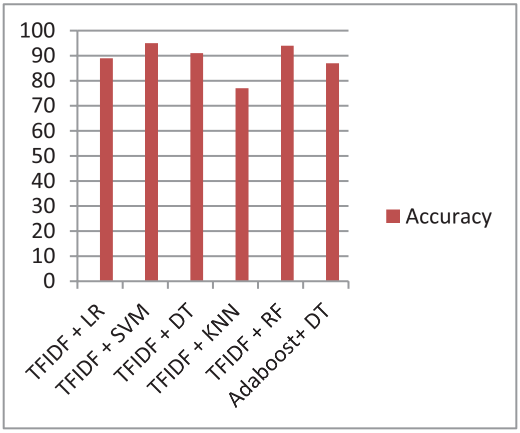


Fig. 10 Comparative analysis of pipelining models

Figure 10 shows that the pipeline model using TFIDF + SVM has the highest accuracy and TFIDF + KNN has the worst accuracy compared to other models.

To overcome the above problem we have used the concept of ensemble model using a Hard Voting Classifier. Finally, we have passed all models in the voting machine and got an accuracy of 94.70% which is better than other classifiers and pipeline models.

6 Conclusion and Future Scope

In this research paper, we introduced an ensemble-based model for sentiment prediction. This paper aims to support the government in this pandemic situation for taking the right decision using public opinions, it will also be helpful for the researcher to research in the area of sentiment predictions. This paper uses the concept of pipelining in which we have passed a machine learning classifier with a TFIDF vectorizer.

This research paper implementation part is divided into four levels, The first level is data preprocessing, which involves word sorting and tokenization, as well as stop words removal and dataset cleaning. The second level is pipelining, by which we have passed two methods: a TFIDF vectorizer and a machine learning classifier. In the third level, a TFIDF vectorizer and classifier model was used to create a single model. We used a hard voting classifier in the fourth level. We have used covid-19 tweets which have been downloaded from the Kaggle. We have also calculated the accuracy of the individual model and then finally by using hard voting we got an accuracy of 94.70% which is better than all models.

For future studies, we have observed that if we train our model using the BERT model and some neural network models, we can improve accuracy. I have also found that no work has used ensemble-based models using BERT and Neural networks.

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Cloud and Machine Learning Based Solutions for Healthcare and Prevention

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1 Introduction

The capacity to acquire, exchange, and distribute information is growing more important as digitalization disrupts each sector, such as healthcare. Machine learning (ML), big data, and artificial intelligence (AI) may equally assist towards overcoming the difficulties that large quantities of information provide. Healthcare companies may use ML to address rising professional needs, enhance procedures, and save expenditures [1]. ML development at the point of treatment may assist healthcare professionals in detecting and treating illness more quickly, with greater accuracy, and with far more customized attention. A look at ML in medical services shows how technological advancements may contribute to better productive, comprehensive nursing methods that can enhance customer welfare. Among the most popular types of AI involves ML. It analyzes and discovers trends in big input collections in order to aid judgment. Healthcare information is very important, and keeping it confidential and safe should be a primary concern for all. However, since

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the epidemic has resulted in many client examinations and consultations taking place through telemedicine services, it does will get even simpler to compromise custody of that information. It does not have to be like this. There are alternative ways to ensure that a patient's health information stays confidential. The future of where and how health data is stored is just on the horizon (mobile devices) [2]. Algorithms are the building blocks of ML technologies, which are a sequence of commands for completing a series of work. The algorithms are programmed to extract knowledge without the need for manual interaction. ML techniques increase forecasting precision over period without the need for computing. The three essential elements of techniques are illustration, assessment, and refinement. The term "representation" refers to the classification of information in a format and syntax that a computer may understand. This element prepares the groundwork for the following step, assessment, which will evaluate if the dataset categories are helpful. The program then determines the optimal design for the most efficient and precise results as part of the refining stage. AI and ML might undoubtedly drive care development in 2020 whenever it concerns to improving Canadians' wellness. AI and ML technologies are assisting doctors with information findings to enhance medical results and the patient satisfaction, from customizing the client medical trip to speeding accurate treatment. Cloud computing is indeed a critical facilitator, allowing for simpler evolution of new creative ideas. We're developing a tomorrow for Canadian medical that grows on the smart utilization information to enhance treatment by making it easier to create and implement sophisticated AI, analysis, and ML technologies [3].

Vancouver General Hospital is indeed an excellent case of AI assisting doctors (VGH). VGH utilized AWS infrastructure to create a novel ML algorithm that accelerates detection of pneumonia on chest X-rays and decreases duration to therapy in collaboration with scholars at the University of British Columbia. This AI technology is seamlessly integrated into the therapeutic process. When a client visits to the VGH Emergency Unit having pneumonia signs, the resulting chest X-ray is evaluated by the AI system before it is sent to a radiologist. If the program detects pneumonia, the research is flagged and moved to the front of the radiologist's queue. The radiologist will examine the images considerably sooner than if they were just put in the catalog in the sequence they got acquired. For the client, a speedier evaluation implies a speedy assessment and therapy. This framework was created with the help of 2 Aws products. First one, Amazon Comprehend Medical, enables it simple to retrieve important health knowledge from unorganized content, such as clinical graphs or doctor's comments, using ML. The second scenario, Amazon SageMaker, combines each of the ML elements into a unified toolkit, allowing simulations to be deployed quicker, with little work, and at a cheaper price. Forecasting patient's medical occurrences, customizing the medical experience, and fostering connectivity are three areas where AI is being used to improve treatment [4].

Forecasting patient's medical activities: ML algorithms are being used by medical companies to find creative methods to increase customer management, boost health results, and eventually rescue people. As the healthcare sector transitions to value-based care, AI and ML, along with information accessibility, will enhance patient experiences while increasing administrative efficiencies and lowering total healthcare costs. Doctors will become more easily capable to utilize innovation to anticipate medical occurrences such as strokes, cancer, or heart attacks, increasing the possibility to timely diagnosis, by allowing information availability safely and assisting healthcare practitioners with diagnostic ML algorithms. Cerner, for instance, can identify Congestive Heart Disease 15 months before it manifests clinically, thanks to the capabilities of AWS' ML solutions. When this prediction technology is combined with actual connection to personal health data, it may help providers make better decisions in real time. With a cardiovascular forecasting model, future studies will aim to enhance which was before decision-making and treatments for chest discomfort [5].

The importance of personalization in the medical voyage: For many pharmaceutical companies, providing patients with a more smooth and customized service is at the front of the priority checklist. Consumer-centricity defines our environment, and we demand to have the greatest service possible wherever and whenever. For instance, Aidoc's every time, AI-based judgment technology examines CT images stored on AWS in order to identify severe anomalies, promote essential investigations, and accelerate patient treatment, among other functions. The Aidoc system has evaluated over than 3.2 million situations in some more than 300 healthcare institutions across the globe to this time, according to the company. At one large U.S. healthcare facility, the Aidoc treatment decreased the mean length of patient ED trips by 59 mins and the total length of admission by 18 h, respectively. Encouraging interconnection in healthcare is a multifaceted endeavor. The majority of digital medical information platforms (EHRs) do not track individuals' progress beyond the confines of an institution or a medical clinic. A part of medical information is thus only accessible at any moment of treatment, providing in a fragmented picture of the patient's medical status. Among the most significant roadblocks currently exists in the fact that the majority of health and patient records is kept in an unorganized medical style, making it difficult and time-consuming to find this content. In order to improve the patient treatment, AI has the potential to tear through this wall [6]. Modern analysis and ML may be used to improve clinical and scientific discoveries that are linked to patient results in a reliable, accessible, safe, and fast way when all relevant data is made accessible to it.

For the time being, federated education (also known as federated AI) ensures that the user's information remains on the gadget, and the apps executing a particular software are still studying how to handle the information and creating a smarter, more effective framework of the client. Medical evidence about patients is protected under HIPAA regulations, but federated AI takes that protection a step beyond by not exchanging the information with third-party organizations. Health care may develop in tandem with technological advancements by using federated training. When it comes to conventional ML, a framework must be trained and built by centralizing information. Integrating additional privacy-preserving methods, such as federated learning, may be used to construct algorithms in a distributed resource setting without revealing critical knowledge from the collection. Going to where the information is: with the consumers, medical practitioners will be able to be more accessible and discover more variety in the information. Almost everybody today has a cellphone, which is capable of collecting information about their health. It is possible to meet such customers via federated learning. That includes pictures with healthcare knowledge, an accelerometer that can detect movements and expose wellness digital signal, GPS facts that can expose health messages, and incorporation with many different health gadgets, including those that comprise biometrics statistics, interoperability with patient history such as Apple health, and more besides [7].

The use of AI-based prediction algorithms may integrate information gathered on a mobile including both potential and retrospective clinical study, allowing for more accurate wellness measures to be provided in live moment. For certain time now, the intelligence in our smartphones has been giving us with data on air condition, but with federated ai, I anticipate applications to begin interacting with consumers and clients throughout particular occurrences on a more personalized level. When a client with asthma becomes too near to a location that is suffering a raging wildfire or when a person with allergy symptoms is in an environment where the pollen level is strong, I keep expecting the application to interact with that person and offer suggestions to minimize the scenario [8].

These observations cannot be given without any of the assistance of a platform that obtains this critical data from the client. Through the use of confidentiality methods (such as differentiated security), this information is just kept regionally and on the border, and it is not transmitted to the cloud or disclosed to a third person. We constantly emphasizing the need of confidentiality, but it is impossible to exaggerate how important it is. Consumers should be in control of their information and be able to see how their information is being transmitted and exchanged. Every kind of information must be approved before it can be collected, and the manner in which the information will be utilized must be made transparent [9]. When medical solutions are designed with security in mind, you may include more individuals in the information learning loop, allowing staff to discover a more varied group of customers who may be more comfortable with the idea of giving exposure to their personal data. The adoption of more legitimate and comprehensive medical solutions, in which algorithms train more quickly from a broad population of users rather than a small number of customers, will result in improved medical results [10].

In the sad reality of modern medical, information sharing is frequently hard and costly due to the proliferation of fragmented systems. For instance, EMR information is not accessible with claims and medication information, and determining either or not a medication was obtained is only possible via other platforms. Incorporate information layers including such genes, diet, social variables of wellness and exercise information to create a multi-node issue that can be solved by a specific individual. There is no one supplier of complete truth, and attempting to centralize everything is very difficult. Federated teaching offers the best chance of avoiding these stumbling blocks in the first place. It is possible to give the appropriate opt-ins to educate from individual health information throughout these different platforms by placing the user/patient in control of organizing their health information throughout these separate platforms. As a result, it is now feasible to see

Fig. 1 Health Care role in AI [13]

federated learning being deployed among companies that hold confidential information and working together to jointly develop more productive and productive algorithms in the healthcare industry [10, 11].

AI is a rather ambiguous phrase. There are several distinct kinds of methods and methods that comprise up the large group of AI approaches, and defining the border between them may be difficult. In this Section, we give an outline of the main developments and methods that are relevant to AI in the health field in general. AI methods are often discussed in the context of a variety of distinct elements or technical areas [12] (Fig. 1) shows the health care role in AI.

It is the goal of Prediction Analysis and Information Ai to obtain conclusions from current facts – frequently from huge datasets where it would be impossible for people to draw such conclusions. In information intelligence, the goal is for discoveries to be generated from the bottom – up approach; that is, to discover patterns and thoughts from the facts, which is frequently at the lowest layer. In the field of Knowledge Representation and Reasoning, it is concerned with how we describe or categorize facts about the environment in a way that even a computer system could use to perform difficult jobs, thus allowing us to predict (new) expertise. The goal here is to provide a machine-readable and comprehensible representation of scientific entities (such as illnesses) as well as their characteristics and connections in the context of treatment delivery. When it comes to information organization, the most difficult issue to solve is often the most straightforward: once the information has been expressed correctly, the issues become "achievable" – that is, they can be handled with sufficient compute power in a reasonable amount of timeframe [14].

Medical Imaging and Vision is the study of pictures or recordings in order to gain understanding into the causes and consequences of medical disorders. Computer vision and image computing are two fields that have been changed by new AI techniques, especially deep learning-based techniques, and are expected to continue to be changed. Scanning and visual are important areas of AI – they are being used to interpret knowledge from pictures and to generate choices. It is possible to utilize pictures captured by ordinary cameras in imaging systems as well as images collected by sophisticated imaging equipment, which are usually used in the healthcare industry. If you are using a vision software, pictures are analyzed in real moment and utilized for robotic technologies. Robotic purposes are becoming more popular in medical apps, ranging from surgical robots to social robots. Diagnostic medical scanning (together with genomics) has emerged as one of the most important components of precise medicine in modern healthcare organizations. Because of the initial use of X-rays in 1896, the disciplines of Radiology and Nuclear Medicine have contributed to the advancement of medical science by making it possible to diagnose and treat a wide variety of medical problems. An extensive range of diagnostic scanning strategies are presently accessible, including X-ray radiography, magnetic resonance imaging (MRI), ultrasound, endoscopy, electrography, tactile imaging, thermographic imaging, clinical photography, and atomic treatments operational scanning methods such as positron emission tomography (PET) and single-photon emission computed tomography (SPECT) (SPECT). In hospital, the innovation used to acquire medical pictures, as well as the understanding and transmission of those pictures, all influence the result [15]. The old way of interpreting medical images is for qualified specialists to provide a qualitative interpretation. Developing methods to collect and evaluate quantitative image biomarkers for use in monitoring, clinical risk, diagnosis and therapy for a variety of clinical and scientific applications is one of the main focuses of our center's work. The newly created technology converts pictures into data that may be utilized for illness diagnosis early in the course of the illness and increased diagnostic precision. A significant portion of this job has engaged the application of AI, specifically ML and deep learning strategies, which deliver a powerful methodology to execute or enhance image-based duties such as image acquiring, rebuilding, quantification (segmentation), and assessment. Explanation responsibilities such as clinical grading (of pathology), detection, and prognosis are enabled as a result of it. Not that all scanning procedures need the use of costly clinical scanning equipment. For instance, pictures obtained with ordinary lenses are used in other AI technologies, such as when analyzing skin diseases or wounds. Pics captured using cameras that capture shots of portions of the eye are used in other AI technologies, such as for retinal picture processing. Approaches encompass automated approaches for enrollment of retinal pictures that have been gathered over period (longitudinally), or that have been acquired using various retinal scanning smart objects, or that have been recorded from a variety of perspectives [16].

Despite our efforts to normalize information and get it machine understandable, people interact in basic language, and as a result, there will still be information in this format to be found. AI techniques, on the other side, are designed to deal with natural speech by gathering insights, analyzing, summing up, and categorizing it. Naturally occurring language is uncertain, doesn't really adhere to precise lexical and syntactic norms, and is thus challenging for computers to comprehend. A significant focus has been placed on avoiding the use of colloquial language and instead utilizing established terminology as an answer (e.g. SNOMED CT and ICD). But for some purposes such as human interaction natural speech continues to be the most successful medium available today. Because of this, computational techniques for natural language interpretation (NLP) and, more broadly, natural language knowing (NLU) are becoming more popular. With the introduction of new deep learning algorithms for natural language processing, significant advancements have been achieved in the area. One of the most important techniques in the medical domain is content extractor that is, evaluating and then collecting ordered knowledge from unorganized text which is a fundamental method in the medical sector. When it comes to identifying particular diseases, treatments, or diagnostic findings, material exploitation comes in handy. This information may subsequently be utilized for a wide range of downstream activities, ranging from clinical choice assistance to invoicing and administrative functions. A common job is to convert the text into a common clinical language; for example, converting a text into SNOMED CT codes is a common activity. In addition to data collection, AI has been utilized to detect the connections between medical ideas retrieved from free text, according to the authors. A significant role in the collection of content from free text is played by connection recovery [17]. The connection between medicines and adverse occurrences or diseases as well as risk elements may be discovered using this method for instance. In this area, improved deep learning algorithms have once again demonstrated encouraging actual outcomes. It is possible to utilize natural language processing to categorize documents; for instance, from a patient documentation, it is possible to document danger or triage classifications. Additionally, new NLP techniques include the generation of concise abstracts of lengthy texts (e.g. generating patient summaries). It also includes new methods in search machine innovation, where AI algorithms now allow "semantic research," which is search focused on the meaning of request terms that is hidden underneath their surface appearance. ML-based search techniques are becoming more popular. They take a collection of previous questions and related useful articles and use them to "learn" how to order answers by an unknown request [18]. This field of natural language comprehension is rapidly expanding as a result of the introduction of new methods, the accessibility of large quantities of learning material, and the exponential increase in computer power (including the introduction of dedicated CPUs known as GPUs). It is expected that this field of AI will play an increasingly important role in healthcare.

2 The Health System Analytics Group

With AI and ML, the Health Systems Analytics group is working to enhance health structure efficiency, enhance patient security, and provide greater treatment to more people across the world. In order to optimize patient, physician and resources layer processes, and to provide intelligent judgment assistance, the technologies have been developed. AI and ML systems, along with allied scientific fields like as virtual environment modeling, are used to anticipate and optimize medical processes, as well as to assist medical and managerial decision-making in the development of these systems. Having collaborated extensively with physicians and health managers, the organization has made important contributions to the fields of patient management statistics and hospitalization escape [19].

Using facts gathered from electronic medical records (EMRs) and other medical data platforms, the Medical Informatics study unit seeks to enhance patient results as well as the efficiency and production of the healthcare sector. Using global data protocols, the organization is capable to do statistical analysis and language handling in order to assist clinicians in formulating medical decisions in digital medical networks. The group uses ML, natural language processing, formal reasoning, statistics, and virtual environment methods to issues requiring choice assistance, network modeling, and accounting, among other things. The organization collaborates extensively with 2 important global norms: SNOMED CT – the worldwide standardized medical nomenclature and FHIR (the Fast Healthcare Interoperability Resources). The workgroup is well-known for its contributions to the creation and acceptance of both SNOMED CT and FHIR principles, including for implementing these guidelines in a wide range of products spanning analysis and text handling. Our products have been created in collaboration with professionals from a variety of healthcare settings, spanning cancer databases, hospital radiology and emergency medicine sections, as well as worldwide governing organizations. They make use of the vast amount of clinical information collected from many partners in the health sector to assist in selection making and monitoring. Sixth and seventh editions of the AEHRC Example Research in Information Organization and Explanation and Case Studies in Natural Speech Processing, respectively, include case studies from the Health Informatics section [20].

2.1 Data, Big Data and Health Records

The contemporary healthcare sector is becoming more data-rich, with digital media overtaking paper-based methods as a result of technological advancements. In other ways, this shift has taken place freely and spontaneously with certain parts of the health-care system making the switch earlier (for example, lab findings), while other sectors have been more recently conversions (such as full electronic health records). An unintended result is that, although the organization may be data-rich, sections inside it may be isolated from one another, unconnected from one another, and devoid of common content norms. Because of the growing recognition of the necessity for enhanced information administration and exchange, much work has been put into developing protocols and architecture to effectively portray patient records. Furthermore, because there is so much information accessible, there is a great desire to derive useful information from it using big data processing techniques. However, although this goal may indeed be held by numerous, the fact is that dismantling information silos and creating a uniform, well-structured, and interconnected portrayal of clinical understanding has proven to be a lengthy and challenging process. However, improvement has been made as a result of a number of various initiatives, with AI operating while behind curtains to assist in this process. A major goal is to figure out how to express medical variables [21]. While effective data organization is not the first thing that comes to thoughts when considering about AI in medicine, it is the basis for many technology innovations, including AI as well as non-AI. Having organized, documented, and freely distributable clinical information has a slew of advantages: it allows various platforms to communicate with one another; it vastly enhances data performance and decreases missteps (that can have serious consequences in clinical information); it opens the door to possibilities for supplementary need (big data analysis tools); and it segregates the information from the device that was used to collect and hold it. Organized, codified, and freely distributable medical expertise is becoming increasingly popular. Once a solid information visualization base has been established, a plethora of analysis choices become accessible. This is frequently a situation in which AI techniques may be used – and in which they depend on well-organized original information. Protocols such as the SNOMED CT and FHIR make this possible by supplying AI algorithms with structured information in a standardized format. Obtaining the information correct and then building the AI on front of that as well does not really equate to a successful use of AI in medicine. The last – and most important – stage is adoption with the existing healthcare infrastructure. The difficulty of integrating an AI system into complicated healthcare processes is often underestimated. New AI infrastructure systems, on the other hand, are developing that may assist with incorporation. Merging is made easier with this innovation, but the technique is also made more rigorous to guarantee security and reliability in the end product. The majority of the work done in the information space is not visible at the customer's premises. In spite of this, data is ubiquitous in the surroundings of all aspects of the health-care sector, and efficient information handling is a critical criteria for performance in electronic medicine [22].

2.2 *Precision Health*

Personalization of healthcare is at the heart of accurate health. The term "personalized medicine" originally referred to the practice of tailoring treatment to a patient's genetic background; nevertheless, it has come to refer to the development of structures, techniques, and medicines that are customized to the person. Medical problems that are detected earlier than usual enable for prompt treatment, which is strongly associated with positive medical results. Timely diagnosis is especially beneficial in the treatment of childhood neurological disorders because treatment may be administered when the mind is among the most flexible, thus alleviating abnormal growth in answer to a neurological damage or insult. Finding evidence is not always straightforward; it is frequently reliant on minor signals that are not immediately apparent. Certain initial indications may be identified with the use of AI in these situations It is possible to identify early symptoms of Cerebral Palsy and Autism Spectrum Illness using magnetic resonance imaging (MRI). However, although magnetic resonance imaging (MRI) may offer very important information, obtaining a scanning is costly and can be intrusive for younger youth. Non-invasive detector and ML of sensing information are examples of possibilities that may be used to offer additional resource of monitoring for timely illness diagnosis. As more datasets become accessible, the chances of early diagnosis and focused innovation will increase, as will the likelihood of the both. Understanding the individual genome promises to provide valuable information into individual wellness. The growing accessibility of genetic information is being matched by an increase in the number of attempts to analyze this information in order to provide improved therapy choices for individuals [23]. The use of AI in this domain is very diverse and many. ML algorithms that can deal with huge quantities of genetic information are the subject of a significant body of research on the operational half of the field. The introduction of cloud computing has provided a major lift to this research, enabling it far more simpler to start up and conduct genetic studies on distributed computer resources. There is also the advancement of new ML techniques that may be used to identify genetic risk variables for specific illnesses. Explainable Intelligence is crucial to most of this development, as it ensures that the augmented reality application is capable of providing a justification for why a particular forecast or result was provided in the first place. A mutated gene may be accountable for the danger of a particular illness in genetic testing, and this must be determined. This will get more important to be able to describe AI algorithms as they grow more incorporated into healthcare decision-making processes. In the field of significant treatments, where symptoms may be severe, AI is assisting in the improvement of focused therapies. Even while some medical advancements are unquestionably beneficial, they may also have serious negative consequences. Radiotherapy for treating cancer, for instance, may be very efficient in killing cancer cells but it can also cause damage to good cells. In such situations, it is critical that the radiation be delivered to a highly specific region of the body to get the desired results. After the AI has been utilized to design and plan out this region, the AI may then administer radiation to only the region that has been modelled and mapped out by a physician. Every participant's anatomy and illness are unique, which necessitates tailoring the technique for every particular person. Accuracy is made possible via AI-based anatomical modeling and tailored therapy. Innovation and AI may not be associated with social connections as a health-related domain, but AI techniques are being developed to aid individuals with autism and speech difficulties, as well as in telemedicine emotion classification. The use of AI technologies to interact with individuals who have autism in a predicted and customized manner has significantly improved their capacity to converse effectively. Socially minded robots will become more capable of assisting patients in a variety of various situations as robotics continues to progress. Significant advancements in talking AI techniques are propelling this field forward (e.g. chatbots). General-purpose assistants including such Siri or Alexa are now equipped with this kind of capability. It is the ability to comprehend and react in natural language that is the fundamental underlying innovation, and it is expected to have a wide variety of advantages in the medical sector [23, 24].

3 AI Cloud Computing Transform the Healthcare Space

When it comes to clinical, AI cloud computation aims to bring together cloud-based processing systems with the ML skills of AI in order to make interconnected, smart health coverage encounters a fact. Start taking, for instance, the situation of Beth Israel Deaconess Medical Clinic, an educational facility affiliated with Harvard University, which is utilizing AI to detect possibly fatal blood illness such that their impacts can be remedied once they have a negative impact on the patients' health. AI technologies are indeed being quickly used in the medical industry nowadays in order to provide greater benefit on current cloud infrastructures [25]. The following are few of the benefits that may be gained by combining AI with cloud computing in medicine:

3.1 Enhanced Clinical Productivity and Improved Access to Care

When AI technologies are utilized in combination with cloud infrastructure, they have the potential to successfully automated a large number of manual procedures and simplify work with both doctors and their employees. The elimination of fewer essential patient paperwork chores may free up caretakers' time to devote greater attention to providing optimum care options while simultaneously improving the end result of their profession's revenue. Some other benefit of utilizing AI cloud technology in medicine is that it has the potential to substantially improve patient accessibility to treatment. As of nowadays, the overwhelming large proportion of Americans live in rural areas of the nation, and availability to health services continues to be a significant source of worry in these isolated neighborhoods. This is being progressively altered by computerized devices driven by AI and cloud computing.

Such areas may benefit from the deployment of a telemedicine network driven by cloud computing, for example, which can be utilized to enhance accessibility to care. AI may then be used to generate understanding of the information collected on such networks. Through the examination of information from a cluster of people who exhibit comparable characteristics, AI programs may quickly discover trends in this dataset and assist in performing population health analyses or developing treatment modalities for these patients. In the long term, this has the potential to significantly enhance healthcare results.

Lastly, there is worry about the shortage of transparency as far as how programs are taught to operate in medical, which is compounded by systemic bias that is present in most AI systems. However, apart from advancements in AI methods, approaches engaged on one information pair cannot be smoothly transmitted to some other information pair, which is particularly true as the involvement of operational information and social factors of wellbeing in population wellbeing threat evaluation grows in importance. In a world where cloud platforms are increasingly being used as data warehouses for creating AI-enabled solutions, security worries about the information are driving the confidence and permission needed to advance the acceptance of AI technologies forward. The rapid rate of AI deployment in organizational tasks offers a ray of hope for AI in healthcare. Healthcare administrators must broaden the scope of these technologies to include new functional activities such as availability and patient interaction in order to increase efficiency and enhance patient satisfaction. Healthcare practitioners must seek to increase the usage of AI technologies with caution, concentrating on operational domains that do not seek to substitute human perception and decision. At Penn Medicine, for instance, AI is being used to improve chemotherapy regimens. In order to speed up the acceptance of AI, medical executives must thoroughly consider the expenses and advantages of the work required in creating and implementing AI-based systems. Always, the issue of what we can accomplish with the information obtained by AI systems gets back to us. If we are unable to shift the scale as a result of the ideas and facts, healthcare practitioners must evaluate the usefulness of the project and the amount of work that was used in order to get the discoveries. Investing in sectors where we can see demonstrable benefits is essential, and then expanding from there. AI will not be widely used in fundamental medical areas of healthcare for many decades yet. The only thing we can do till then is keep pushing the boundaries.

3.2 Greater Healthcare Cost Savings

Modern AI techniques need a significant amount of computing power in addition to operate properly and provide relevant conclusions from the information at available. For this purpose, using AI systems in a significant way has been prohibitively expensive for most healthcare organizations up until this point. A significant shift has occurred as a result of the combination of cloud computing infrastructures with AI. It is now feasible for even the tiniest doctors to benefit from the strength of this service without having to raise their expenditures or drill a trench in their wallets. Some AI-enabled solutions have the ability to automatically separate client information collected on integrated cloud networks, allowing doctors and their employees to access it quickly and easily at a later point. This improves the interconnectivity of information across the enterprise. It is when healthcare organizations begin to use insights gained from data to perform analysis without the need for human's involvement, provide improved treatments choices or deploy more effective treatments that the true savings are realized. Customers will get more value as a consequence of this, and the firm's bottom line will benefit as a consequence of this.

3.3 Better Use of Healthcare Data

Through, the use of cloud architecture, ML is a subclass of AI, may be improved for performance and made more precise and resilient. Wearable technology, distant patient observation gadgets, and health monitors may all benefit from the variable resources accessible in the cloud, which allows for more last-mile information to be tracked. Afterwards, this information may be kept in a cost-effective way on a cloud platform. ML algorithms may then be taught to perform heavy-duty research on this huge quantity of information, allowing them to become more efficient and accurate throughout period as the information source grows in size. Because of the huge quantity of information accessible for learning, ML algorithms are able to scale much faster. For many jobs in diagnostic imaging and assessment, for instance, the model's performance is extremely near to that of living beings in terms of precision. In addition, ML algorithms may be made more customized so that they can begin to provide suggestions that are very particular to individual patients.

3.4 Types of Learning

ML enables computers to operate via a cycle of training without the need for human intervention. It accomplishes this by establishing fundamental frameworks for problem solving. Ml algorithms change the framework each moment they search through information and discover new trends. This is called reinforcement training. This method facilitates learning while also producing outcomes that are becoming more precise. This training procedure is carried out by a method without the need for any coding. ML may be done in a variety of ways, including guided, unstructured, semi-supervised, and reinforcement learning. Supervised learning. As predicted by Gartner, guided computing will likely to be the most widely adopted form of ML by 2022. Guided research is a sort of ML in which past and categorized source and outcome information is delivered into systems. Unsupervised learning. Unsupervised learning is the process through which computers can detect trends in information despite the need for prior categorization. It may be used in a variety of ways. Predictive management, for instance, may detect problems in manufacturing processes ahead they occur, which is very useful in the industrial business.

Semi-supervised learning. Semi-supervised training is a middle-of-the-road option among guided and unstructured learning. Semi-supervised training techniques may be used to create problem-solving systems by combining input from both confidential and unrestricted sources. Using a semi-supervised teaching strategy to accelerate drug development, a fresh research demonstrated the potential of this approach. Reinforcement learning. Reinforcement education is a technique for teaching techniques via the use of a rewards structure. Numerous outcomes are produced by methods, which adapt to choose the most appropriate ones over time; they are awarded for desirable activities and penalized for unwanted behaviors. The use of reinforcement thinking may be beneficial in a variety of situations, namely autonomous robotic nanostructured, as per a new research [26, 27].

4 Impacts Healthcare

4.1 Record Keeping

Using ML in medical computing, documentation, especially digital health logs, may be made easier (EHRs). The use of AI to enhance EHR administration may enhance patient service while also lowering healthcare and operational expenses and optimizing workflows, according to the American Medical Association. As a sample, consider natural language processing, which allows doctors to collect and document patient records without the need for human intervention. By offering medical decision assistance, automating imaging techniques, and combining telehealth services, ml methods may also make EHR administration systems more user-friendly for doctors.

4.2 Data Integrity

Ml models that make incorrect forecasts as a consequence of shortages in healthcare facts may have a detrimental effect on decision-making in medical environments. Because healthcare information was initially designed for utilization in electronic health records (EHRs), it is necessary to organize the information prior ML models can make efficient use of the information. Safeguarding information quality is the responsibility of health informatics experts. Collecting, evaluating, categorizing, and cleaning data are some of the tasks that health informatics specialists do.

4.3 Predictive Analytics

It is possible to enhance healthcare operations via the use of ML, medical computing, and predicting analysis. It is also possible to change medical judgment assistance systems and assist better patient results. Analytical tools, which can be used to forecast medical results, has the potential of revolutionizing healthcare. It will allow for more precise assessment and therapy while also enhancing doctor perspectives for customized and cohort therapies, according to the National Institutes of Health. ML can also bring value to forecast insights by converting data into meaningful information for decision-makers, allowing them to identify workflow holes and enhance overall company processes in the healthcare industry [28].

5 Applications of ML in Healthcare

By using computational methods, machine-learning systems have the capability to enhance the precision of therapy procedures and medical results. Deep learning, for instance, is a kind of sophisticated ML that resemble the way the natural minds work and is rapidly being utilized in radiology and diagnostic imaging. Deep learning technologies can diagnose, acknowledge, and evaluate cancerous lesions in photographs by employing neural networks that can handle big information without the need for any guidance. Faster handling data rates and cloud infrastructural facilities enable ml methods to identify abnormalities in pictures that are beyond the human eye's ability to identify, thereby assisting in the diagnosis and treatment of illness and injury. In the near decade, advances in ML will likely to revolutionize the healthcare sector. ML software in progress include a screening instrument for diabetic retinopathy as well as predictive analysis to detect breast cancer recurring related to clinical information and imaging data. ML has the potential to have a beneficial effect on patient treatment providing methods. For instance, it may assist physicians in the identification, diagnosis, and treatment of illness. Usage of ML in hospitals may also help to simplify healthcare activities and improve the strategy, organization, and implementation of surgeries, among other things [29].

5.1 Disease Identification and Diagnosis

The use of ML methods may identify styles linked with illnesses and medical problems by analyzing millions of healthcare reports as well as other individual information collected over time. Modern advancements in ML have the potential to improve healthcare coverage in poor nations while also innovating cancer diagnostic and cure methods and protocols. According to an article in Entrepreneurship, a deep learning-based forecasting system created at the Massachusetts Institute of Technology may anticipate the expansion of breast cancer months before it occurs. Furthermore, as per a study in the American Medical Association Journal of Ethics, AI systems in medical are now capable of diagnosing skin cancer with greater accuracy than that board-certified dermatologist. The post discusses the extra advantages of ML, such as the quickness and accuracy with which it can diagnose problems, as well as the lesser period required to train a system compared to a person [30].

5.2 Medical Imaging Diagnosis

CAT scans, Magnetic resonance imaging (MRI), and other diagnostic tools provide great technical skill that sifting through the megapixels and information may be difficult for even the most skilled radiologists and pathologists to manage. ML has shown to be beneficial in assisting healthcare practitioners in increasing their efficiency and accuracy in their work. Recognizing cardiovascular problems, diagnosing musculoskeletal problems, and monitoring for cancers are just a few of the applications for ML in diagnostic imaging that are popular.

5.3 Robotic Surgery

ML may be used to enhance the precision of operating autonomous instruments by incorporating true statistics, knowledge from prior successful operations, and health histories from the past. Decreased human mistake, assistance during more complicated operations, and far less invasive operations are just a few of the advantages. For instance, robots may be used to accurately perform procedures such as artery unclogging and even assist in spine treatment. Surgical robots may also provide doctors with more than just automated help by designing surgical routines and executing surgical operations, among other things.

5.4 Robotic Patient Support Tasks

Machines can immediately assist in improving the skills of patients. Examples involve assisting paralyzed patients in regaining their walking capacity as well as completing duties like checking heart rate and reminding individuals to take their medications, among other things. Even ill and elderly people may benefit from the fellowship provided by robots.

5.5 Personalized Medicine

Medical information from a variety of resources, such as electronic health records (EHRs) and genetic information, may be used to improve customized treatment. Providing precise treatment to individuals requires extensive information analysis, which takes time that a medical professional just does not have in a day. The capacity of ML to utilize large amounts of information and prediction analysis, on the other hand, provides researchers with possibilities to design customized therapies for a variety of illnesses, like cancer and depression [31].

5.6 Ethics of AI in Healthcare

ML's contributions to advances in medical productivity and patient treatment administration are not without moral ramifications, though. Health analytics experts may play a critical role in resolving AI-related problems, and also the morality of AI in hospital, such as those mentioned in the subsequent parts.

5.7 Sharing Patient Information

When it comes to releasing patient records, there are many issues to consider: patient privacy, the federal legislation limiting the publication of clinical records, and expressed permission. Information is the building block of successful ML. Nonetheless, patient data is intended to be protected against dangers including info leak under the provisions of security and trust regulations. Clinical knowledge transfer is prohibited by law, except where it is necessary for professional purposes, such as when a physician discusses medical facts on a client with an oncologist or a cancer expert in order to enhance health status [32].

5.8 Patient Autonomy

There are also concerns about patient autonomy. The majority of elderly and mental individuals are unable to make choices about their treatment on their own. ML may be used to analyze facts from electronic health records (EHRs) as well as other medical systems to assist in making crucial choices in certain situations. On the other hand, an artificial procedure should not be used to completely substitute the autonomy of the patient in any situation. ML, on the other hand, has the potential to become a useful tool in the field of medicine [33].

5.9 Patient Safety and Outcomes

It is the characteristic of information intake that affects the dependability of ML programs and their outcome. Information that is incorrect or defective may cause network dependability to be compromised, causing choices relied on the information to be called into question as whether they were correct or incorrect. Misleading data may also result in a lack of cultural competence, which is something to be concerned about. In certain cases, for example, since minority groups are usually underrepresented in statistics, individuals may be at danger of being over- or under-diagnosed. To summarize, ML methods may produce erroneous results due to worries about platform dependability and a lack of cultural competence because of inaccurate data [34].

5.10 Future of Healthcare Technology

ML's deep learning algorithms may reduce the time needed to check patient and medical data, resulting in a quicker diagnosis and a more rapid patient recovery. In the present worldwide epidemic, ML has already shown helpful. According to Health IT Analytics, a deep learning technique in US nations can anticipate COVID-19 spikes with about 65% accuracy. As medical organizations strive to incorporate ML in health care and medical procedures, health information technology specialists have a key duty to guarantee that health data is accurate. Different technology-driven health care ideas show potential in the years ahead to improve care delivery. These technologies will also alter the job of the healthcare practitioner. You may argue that this is the start of AI in the healthcare industry. From robotic surgery to patient counseling, the AI will be able to carry out many tasks that help physicians make better choices.

Now that AI technology is progressing and being inculcated in health care, physicians must also guarantee that the future of AI in healthcare is not immoral. Physicians must verify compliance with the appropriate laws and AI systems comply with the best practices. In the present scenario with COVID-19, AI has enormous testing possibilities. The pandemic requires an AI system that can help detect future pandemics and enable patients to test further. AI is a benefit in health care, as it demonstrates in detecting future epidemics so that the world is ready to cope with this. AI is changing the development field of healthcare applications as we know it now. In future, AI will act as a tool for better predictive analytics to prepare ahead of time for a health issue. At the individual level, AI applications in healthcare will double as the technology advances from helping physicians serve patients. With regard to therapy, ML solutions and AI have the greatest potential for determining which patients are the most essential and which require no further treatment. Health hazards are growing daily and intelligent solutions are needed to assist professionals minimize these risks before they are too late [35].

5.11 Virtual Reality in Healthcare

Virtual reality (VR) changes healthcare by improving the lives of patients and making training for physicians simpler. For example, surgeons using customized VR headsets may broadcast procedures and provide medical students a unique perspective of an operation. In another example, VR is utilized to accelerate physical therapy recovery. Physical therapy patients frequently undergo rigorous physical exercises that may be stressful. Recovery programs may be customized and enhance physical treatment activities via VR training exercises with ML [36].

5.12 Augmented Reality in Healthcare

According to The Medical Futurist, Augmented Reality (AR) is among the top three technologies changing healthcare. Similar to VR, AR healthcare apps may assist medical students to prepare better. AR technology allow trainees to learn firsthand from surgeons who conduct real-life operations. For instance, AR allows medical students to get comprehensive, realistic representations of human anatomy without examining actual human beings.

5.13 Wearable Tech

Different types of wearable gadgets offer information that may keep people active, from counting steps to heart rhythm monitoring. Other wearable technologies may include cardiac rhythm, blood pressure and heart rate, as doctors with vital patient health information. According to the Pew Research Center, around 21% of Americans use wearable gadgets such as activity trackers and smartwatches. More people use wearable technology to enhance communication and data sharing between these devices and the health information systems used by doctors [37].

5.14 Genome Sequencing

Genomic data may help doctors create personalized therapy regimes for individual patients. Computer ML enables genetic anomalies to be evaluated faster and helps to identify disease-related issues. Sequencing genomes may have an impact on cancer diagnosis, can have an impact on treatment, and can decrease infectious disease burden via ML applications. The first human genome sequencing research cost approximately $3 billion. More than 13 years were required, according to the World Economic Forum. People may spend less than $600 for genome sequencing get results within a week. Health information technology specialists with cheaper genome sequence and improved machine training can help promote genomics to treat the world's worst conditions.

5.15 Nanotechnology

Nanotechnology is described as 'the study and control of nanoscale matter, at sizes between 1 and 100 nanometers,' as per the National Nanotechnology Initiative. In healthcare, nanotechnology is called Nano-medicine. Tasks such as medication distribution, in which molecules, biological structures and DNA are at action may be assisting nanotechnology. For example, future nanotechnology medicines include drug delivery techniques which, according to Engineering, "allow site-specific targeting to prevent the buildup of medications components in healthy cells and tissues." This means that medicines may be given to specific regions that are not impacted by illnesses, skipping places in the human system [38].

6 Transforming the Healthcare Industry

In 2025, the AI healthcare industry will rise to more than $31.3 billion, which represents an increase of 40% from 2018, according to Imaging Technology News. Those who want to expand their IT professions to incorporate machine education may begin by researching educational options. This may involve enrolling in health information technology graduate programs. They can assist change the healthcare sector with the skills and information they acquire in graduate courses. The health-related data analytics improves treatment from super-specialized tertiary to secondary and primary care services in the health sector. Those insights are made accessible via telemedicine at the place of attention which leads to better and better diagnoses. Both innovations provide more dependable, in-house treatment over the last mile, which helps to bridge the gap between many patients and a limited number of healthcare providers. In the case of widely dispersed populations, access to care is an important problem. However, digital tools and resources may be provided via the cloud, with data network connectivity, across the final mile. This enables primary centers to diagnose, collect and transmit digital samples to third-party centers.

Tertiary centers are able to access data via the cloud and offer cost-effective insights and analysis. This also enables the digital recording, analysis of the patient's long-term development and comparison of common treatment methods by a group of patients. Overall, this results in cost-effective improvements in the quality of treatment. Cloud infrastructure may make ML models more resilient and precise. The flexible cloud resources allows you to monitor more data from devices, wearables and health trackers in the latest miles and then stream them and add them in cloud-based storage at a low cost. This huge number of data may be analyzed using the heavy-duty cloud computing infrastructure effectively. This in turn helps to more effectively train the ML models and over time increase their accuracy. The huge quantity of information provided for training enhances the scalability of ML models. For example, model accuracy already has reached human level for a number of image processing tasks. In order to start producing suggestions extremely particular to each patient, ML models may be made more customized [39].

6.1 Regulatory Considerations

This whole calculation is subject to regulatory expenses. In order to be unique to a patient, data must be protected during rest and movement and anonymized before input into ML models and suggestions must be reconfigured. This includes resources not from one but from many cloud providers that operate hybrid. The Digital National Health Blueprint asks for rigorous compliance with the privacy and patient data protection laws. In order to prevent patient data from inadvertently being revealed to non-intentional receivers, sophisticated technological check points must be introduced.

It is also essential to implement consent-related rules that enable patient data to be used with and for a certain period of time exclusively by healthcare providers. This needs a strong focus on ensuring cloud infrastructures and enforcing data access restrictions, processing and insight distribution. ML models also absorb large quantities of patient information from individual devices, such as mobile phone health trackers or wearable devices such as Fitbit monitoring or sleep monitoring, insulin monitoring and even the monitoring of blood pressure. In order to finish data processing, these devices must be linked with the cloud resources. Data privacy and access must be monitored and regulated, given strict regulations and privacy standards. This requires the usage of data and cloud management technologies. IT teams must be able to combine personal and corporate devices and execute the required guarantees with extensive management framework frameworks. Modern unified frameworks of management enable this issue to be managed more effectively and apply the best governance principles required to manage consumer devices, mobile applications and cloud backend platforms [40].

6.2 Disease Prediction

Modern approaches in the area of healthcare include prevention, rather than therapy after diagnosis, including early intervention. Traditionally, the risk calculator is used by physicians or doctors to evaluate the development potential of diseases. These calculators use basic information like demographics, medical conditions, routines of life and more to calculate the probability that certain conditions will develop. These calculations are carried out using mathematical methods and tools based on equations. The difficulty is the poor precision using a comparable method based on equations. The Framingham study, for instance, can predict hospitalizations of a cardiovascular illness with just 56% accuracy. But new technological developments, such as big data and ML, can lead to more accurate disease prediction outcomes. Physicians and computer scientist's work together to create better tools for illness prediction. Experts in the area create and refine ML methods and models to detect, develop and refine ML algorithms. We may use data gathered from research, demographics for patients, health records and other sources for the development of a stronger and more accurate model for ML. The difference in the number of dependent variables to examine is between the conventional method and the machine approach to illness prediction. They look at very few variables in a conventional approach that can be based on age, weight, height, gender etc. (due to computational limitation). On the other hand, ML may take into account a great variety of factors that lead to improved accuracy of medical data on computers.

AI affects many industries, and healthcare is no exception. Indeed, the patient care industry is one of AI‘s major beneficiaries. Today, many doctors and institutions are looking for healthcare AI solutions to enhance their treatment results. In the healthcare industry, AI is fundamentally altering. Although thinking about AI in healthcare may evoke thoughts of robots and computers that are physicians and nurses, the truth is a little different and better. Operations always need a human touch to guarantee appropriate care and have an emotional effect. On the other hand, the healthcare advantages of AI are related to enormous data processing and the generation of live information with useful insights. The purpose of AI in healthcare is primarily to determine illness and to discover the appropriate treatment approach. The objective of healthcare professionals is to get a quicker and timely diagnosis and the right route to better outcomes for patients.

One of the finest instances of AI in healthcare is Google's AI, 99% more accurate than other systems for breast cancer detection. Mammograms are analyzed and the underlying symptoms of breast cancer are determined. ML, the healthcare AI technology, analyzes large information to provide insights into risk evaluation, illness diagnosis and the efficient treatment of patients. Hospitals and doctors have been collecting healthcare information for decades – AI in healthcare will assist to utilize the data to get the best possible results and minimize treatment problems [41].

7 Applications of AI in Healthcare

Now as the technology sector advances, AI‘s possibilities in healthcare are numerous. It revolutionizes healthcare provision and impacts the area of medical science to improve research results. Here are 6 distinct health examples of AI applications:

7.1 Brain-Computer Interfaces

1. One of the most significant health advantages of AI is the use of Brain Computer Interfaces aligned with the neurological system and which enable patients, if they have lost that capacity, to talk, hear and communicate.

2. AI services facilitate brain-computer interactions. They assist to decode brain processes related to hand, hearing and gesture, so that individuals are able to communicate the same as others.
3. AI may save millions of lives in the health care industry and offer individuals with disabilities the capacity to speak like regular people. This technique is great for individuals with spinal injuries and who lose their capacity to communicate via gestures.

7.2 Medical Diagnosis

1. A medical diagnosis is another potential application for AI in healthcare. Tons of data sets for correct medical diagnosis are provided by ML and AI in the medical research before it is too late for therapy.
2. Medical imaging and AI-based scans are great instruments for extremely early diagnosis of the illness. The AI algorithm traverses thousands of pictures and body scans to detect any symptoms of the illness identified.
3. It enables physicians to start therapy before anything serious occurs. AI technologies that help cancer detection are becoming a life saver for people worldwide. They are becoming an instrument progressively for fighting the illness and saving more lives.

7.3 Drug Development

1. Medical practitioners and researchers frequently perform drug-development tests and exams to assist patients recover quickly and better. ML in healthcare supports pharmaceutical researchers via millions of data points assessing medication feasibility.
2. It involves identification and effect of the optimum ingredients for the medication composition. Through ML and AI in healthcare, researchers can develop and test various compounds without putting human lives at risk.
3. AI robots may also monitor the various impacts of the medication on participants throughout drug trials and collect information to offer useful insights into the process.

7.4 Analyzing Health Records

1. One of the most important uses for AI in healthcare is to analyze the health record of patients in clinicians and physicians, similar to medical diagnosis. By using intelligent gadgets and wearables, AI applications may gather and update

health information in real time enabling physicians to access it and make educated choices.
2. AI systems may pass through a medical history of the previous patient, integrate it with his medical images and scans and ensure an accurate health state of the patient. It may give information about any illness the patient may experience in the future.
3. By analyzing patients' health data, physicians and healthcare workers get insights into their patients' health and the next step to monitor health. The robots gather, analyze and provide data far more quickly than human researchers can.

7.5 Virtual Assistants

1. AI has enabled the use of virtual assistants by healthcare professionals who can aid them with operation and nursing. By using preoperative knowledge and giving the correct route, the AI systems may enhance the surgical processes.
2. There are robot programs for people who require frequent care like virtual nurses. Patients may book appointments, cancel their appointments, ask common inquiries and update health information in order to provide health care providers with real-time access.
3. Virtual nurses additionally provide health inspections, dietary needs, medication records and support patients when any anomalies are discovered. In healthcare, highly sophisticated AI can notify the healthcare center if the patient has any health differences besides their usual diagnosis.

7.6 AI-Enabled Hospitals

1. This is definitely one of the latest healthcare AI applications. While hospitals are still largely humane, AI apps now take over duties and make care more intelligent. In healthcare instances, AI allows hospitals to track medication, patient alert, patient mobility monitoring and evaluate patient performance.
2. AI has a major advantage in healthcare by reducing the likelihood of a dose mistake, a frequent source of possible injuries and hazards to health. Medical practitioners frequently find themselves concerned by the misdose of nurses. AI systems can assist in precise measurements and a correct dosing regimen.
3. AI-enabled hospitals will also guarantee that payments, billings, and formalities are made by AI systems, which minimize medical personnel's load from such boring tasks. The personnel will take longer to concentrate on tasks directly linked to patient care and the delivery of results [12].

8 Research Challenges in Healthcare

8.1 Edge Medical Cloud Based on 5G

Compared to 4G, 5G has high speed, low latency, broad connection, quicker mobile speed, increased security and flexible service deployment, which have significant effect on cutting-edge computing technology innovation. Furthermore, 5G and edge computing together provide a technological basis for the development of smart medicine, in particular telemedicine. Telemedicine needs in real time ultra-high definition picture quality, medical image and other enormous data transfers, including consultation on remote and remote surgeries in the United States which also supports the development and implementation of '5G + edge computing.' Currently effective instances of cross-domain remote control and guiding have occurred. "5G + edge computing" is very important to reduce medical resources of high quality, to reduce the unfair allocation of medical resources and to reduce the expenses of medical patients [42]. The future of telemedicine methods will emerge ceaselessly with the advent of the 5G era and the continuing growth of edge computing. However, the 5G also presents a number of security issues, including opening up security capacities, security of virtualization, heterogeneous authentication and authentication paradigms and other local challenges, security of VR/AR content, traditional security and data security and confidentiality, and other applications worth studying in the future.

8.2 Edge Device Security and Privacy

We know they are more vulnerable to data manipulation, privacy information, malicious nodes and other service facilities, service deniance, middleman, gateway and other network-installed attacks, and virtualization facilities, as well as numerous other security and privacy attacks, because of performance, cost, resource limits and scattered geographical location. The enhancement and expansion of hash function, symmetric and asymmetric encoding and encryption algorithms are extremely essential for avoiding and reducing the incidence of such issues. The mutual authentication of many Nodes should be addressed in order to authenticate the edge nodes even for a single edge node [43]. Moreover, future study also focuses on creation of a protocol on communication security, trust management of edge nodes and distributed edge intrusion sensing technologies to avoid malicious assaults. It is also extremely essential to create the appropriate edge node isolation method or scheme that can continue serving the service facilities in order to address security and privacy issues that have emerged.

8.3 Edge Caching and Energy Consumption

Because the edge node caching is locally done, the core network strain may be efficiently relieved and the overhead, interaction latency and bandwidth costs of the network are minimal. However, edge nodes are just restricted in cache capacity. An urgently necessary issue is how to identify the cached material, cache strategy and approach. Fully using the multifaceted nodes for collaborative caching and adaptive caching is a promising option, but the creation of a confidence management framework is equally challenged. The key to improving the quality of the cache is how to choose trustworthy and secure edge nodes and the credibility updates method. It is one of the current research areas for integrating and using 5G technology and Blockchain to edge caching. Using ML and big data technologies also allows for the cache strategy to be adjusted and cache strategy for video content is the challenge. Furthermore, owing to the limited edge devices, it is also a challenge to resolve how to minimize the consumption of energy. We also need to examine the computer download method and how to minimize the overhead of edge devices in addition to cooperative caching of edge nodes that may efficiently reduce energy consumption. The more the computer sophistication, the higher the energy usage. The creation of an efficient and low complexity algorithm is thus extremely essential in order to minimize energy usage [44].

8.4 Optimization of AI

The development of cutting edge computers is promoted via AI. Most smart computing edges rely on the embedded AI chip on the edge [45]. Using AI algorithms in edge computing, data can be processed quicker, safer and easier, and edge resources can efficiently be allocated, minimizing the costs of edge services. Currently DL is the main AI Research Directorate which needs to concentrate on how the algorithm can be optimized to solve its non-convex issue, gradient loss problem and fit problem. In reality, the majority of DL objectives are complicated, thus without analytical solutions there are numerous optimization difficulties. It is thus an excellent way to discover solutions based on numerical techniques, such as the random gradient descent, utilizing the optimization algorithm. However, two major difficulties in optimization are how to escape from local optimum in low-dimensional space and saddle space in the large area. The edge devices can only reach the most value by continually improving the algorithm and then better serve different application scenarios in the medical sector [46–48].

8.5 Knowledge Representation

Data collected may be sent to different staff, processed in different methods and formats, and utilized for a variety of uses. Consequently, maintenance support organizations may utilize part of this information for the development of proprietary software, which other applications may not be able to identify – owing to lack of industry standards. Similarly, it may not be in the format that is suitable with health monitoring programs if the information are processed for cost/budgeting purposes. Managing staff and diagnostically monitors are frequently accessed via expertise, process models or budgeting apps through a priori data storage. Finally, it is difficult to take judgments about the availability needs due to the time required to monitor big systems such as a fleet of airplanes and monitor individual failures on each [49–51]. An AI cloud-based platform may address such issues via access to and subsequent real-time application of data from different geographic areas. It may ask for and process information and store that information in a standard format, which other cooperating organizations can access and utilize [52–54]. This integration guarantees better personal security, increased process and equipment operations, reduced false alarms, reduced costs, enhanced availability and the capacity to operate within design and production limitations. It also enhances the quality of troubleshooting efforts to identify failure root causes.

Other notable research issues associated with the concept includes

- Knowledge Gathering: Loss of connectivity
- Lack of real-time data
- Extrapolation of data
- Cost of analysis
- Appropriate visualization methods
- Need of computing skills

AI has already impacted a cloud infrastructure generation. The Internet of Things (IoT), often referred to as industry 4.0, is an intriguing proposal in relation to this technology. With this in mind, the ability of IoTs to offer services that allow backend capabilities should be implemented as backend services that may be utilized by mobile apps (and other IoT devices). On the other hand, AI applications are needed not only to offer advanced backend services but also to give special working times suited for AI solutions' high processing needs. Despite these momentary restrictions AI cloud-based ideas offer a great promise and research opportunity for the maintenance sector and practices [55–57].

9 Conclusion

This technique enables data from a number of sources to be merged in real time and provides the proper information in the process at the right time. With health institutions collecting more data, consumers are seeking for information about health and treatment. The patients do not know what the doctor's instructions at a hospital are, how much care, for example diabetes, may be costly for them in the recovery period. Patients tend to have difficulties obtaining their own health records since they can understand and combine them with data from other physicians. It is not most essential to safeguard every patient's data because of a severe pandemic problem. We will then offer the newest technical problems and solutions in the field of healthcare. On the other hand, AI applications are needed not only to offer advanced backend services but also to give special working times suited for AI solutions' high processing needs. Despite these momentary restrictions AI cloud-based ideas offer a great promise and research opportunity for the maintenance sector and practices.

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Interoperable Cloud-Fog Architecture in IoT-Enabled Health Sector

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1 Introduction

Earlier, the idea of Internet of Things has been generally taken commonly for healthcare extremely in apps, which consists of omnipresent detectors and activators transferring with WSN alongside answers for continuous information investigation and suggestion. At the point when applied in basic situations, the administrations are very inactivity delicate and request quicker handling of the produced information. Additionally, the enormous usage of sensors, versatility, and geographic dissemination lead to issues of information volume, speed, and variety, alongside prerequisites for exactness, security, Quality of Service (QoS), client assumptions, and functional expenses.

As reported in, parallel processing establishments have been broadly authorized to assist Internet of Things-enabled Healthcare arrangements, providing solutions for adaptability, data investigation, and unshakable quality [1]. Nonetheless, the

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territorial concentration for Internet datacenters needs information acquired from sensors to be transferred via non - linear and non-range for processing, which has a negative impact on the arrangements' inactivity responsiveness. Furthermore, administrators of Virtual machines in heterogeneous Healthcare environments demand difficult administration projects to avoid regular asset distribution modification in light of imbalanced and doubtful data inputs from healthcare arrangements.

By studying lightweight and adaptable boosting processing assets closer to the Internet of Things information source in healthcare arrangements, haze registering is a viable arrangement in this circumstance. Recent trend registering instruments, including as converters, switches, processing equipments, so on, seems to be engaged with processing foundation, administrations, also the executives' models in carrying out local lean apps in this arrangement. As a consequence, a few information handling operations may be performed nearby information origin, scattering asset requirements, limiting the requirements of multi-trust information correspondence, reducing idleness, and improving aid adaptability. Despite the fact that Fog assets likely to be consists of power and processing capacity, those have been adaptive sufficient in change as per the app situation [2].The complexness that is appearing for monitoring also activity dispersed registration circumstances must adapt to a mix of changeable demands also pressured processing assets in order to ensure implementation, reliability, as well as protection.

Despite the fact that there are a few examples of fog registering in healthcare arrangements in the writing, there is still a demand for techniques to improve interoperability of administrations that would consider settling apps directly from Cloud components into Fog components while adapting to the intrinsic compositional differences. The commitment of the document is recorded as follows in this case:

I. An interoperable Fog-based Internet of Things-Healthcare arrangement structure (framework engineering and app model) with generic Cloud-based Healthcare arrangements.
II. The base engineering in Cloud-Fog administration reconciliation also coordination by a thought of exchange and use of Internet of Things in Health-care setups.

Assessment to the Fog-based Internet of Things-Health-care arrangements in terms of cutoff time fulfilled help conveyance, expense, energy usage, and administration dissemination using reproduction concentrates.

Our study is coordinated as follows:

1. the inspiration through an investigate of the best in class
2. A portrait of the overall Cloud-based and proposed Fog-based Healthcare arrangement structure.
3. An incorporated reference engineering of Cloud-Fog stage for Internet of Things-Healthcare.
4. Execution assessment of the proposed arrangement in various use designs through reproduction situations created.

2 Structure of Healthcare Solutions

Based on the literature study, we examine the whole architecture (development environment (ide) and app design) of Cloud-based Internet of Things-Healthcare solutions. Following that, a Fog-based Internet of Things-Healthcare system structure is developed that is compatible with Cloud-dependent solutions.

2.1 General Cloud-Based Solutions

Mostly Cloud-based Internet of Things-Healthcare setup follows up the same framework engineering and app paradigm. They simply conflict with the programs' utility.

A few substances are commonly present in the framework engineering of a Cloud-based Internet of Things-Healthcare solution (Fig. 1);

Internet of Things Sensors or Wearable Gadgets
Gadgets connected to body, like beat oximeter, ECG monitor, dazzling-watches, etc., are used in the healthcare industry to monitor the customers' health. Through Bluetooth, ZigBee, also Infrared transmission, these devices may communicate with other client-premises gear [3]. Most of the time, the data recognizing repetition of these devices is fixed, then once set on, they consistently generate health data.

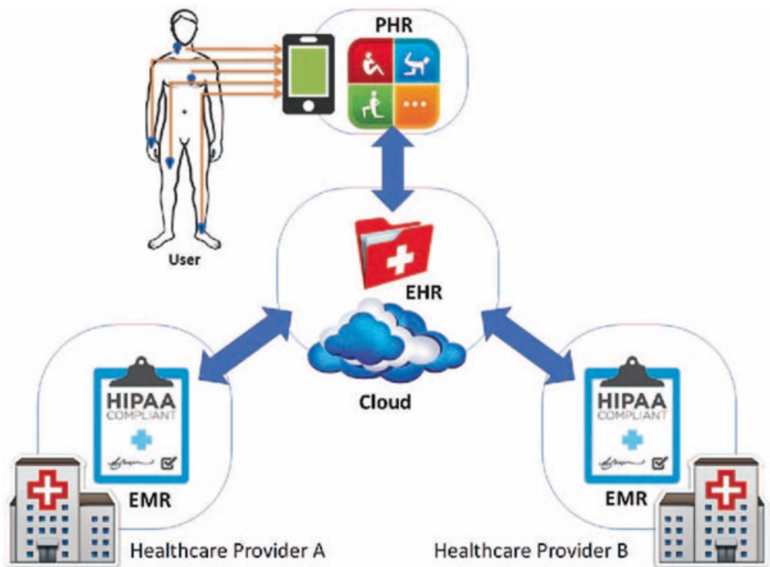

Fig. 1 Cloud-based healthcare systemoverlay

Regardless, the great majority of such devices are based upon resource & power requirements.

Advanced Cells

In general, smart phones are used in a variety of healthcare situations. Because Internet of Things devices lack system administration as well as management capabilities, smart phones assist them in providing app points of engagement also transferring generated data to cloud datacenters. To obtain the discovered data, advanced mobile phones maintain a continuous communication with Internet of Things devices. The program can customize the information that modern mobile phones get on a regular basis [4]. The embedded sensors in smart phones, such as the accelerometer also the Global Navigation Satellite system - GPS, may view context-oriented information.

Cloud Datacenter

The cloud datacenter serves as the central hub for IoT-enabled healthcare arrangements. Despite the fact that it has a large extent computation, these functions utilizing strength, utilities operations, but also flexibility. Cloud systems (computing foundations, agencies) likely to be virtualized & connected in a fundamental approach. The parts of Cloud data-space,whichseems like Health-care equipment's are as Fig. 1.

- Asset Manager: The resource administrator is responsible for handling Internet of Things-enabled Healthcare data while arranging Cloud assets. It really distributes, supervises, & monitors the Healthcare arrangement's foundations & administrations. It can plan, terminate, scale assets based on interest, burden, also setting. It also ensures greater access control to the assets at a higher level. Furthermore, Resource Manager describes the circumstances among resources in order for them to be appropriately operated as well as performed.
- Servers: Cloud datacenters are a collection of servers that can be homogenous or diverse in terms of equipment configuration (memory, centers, limit, & capacity). Two types of servers are predominantly used in the Cloud-based Healthcare framework: App Server also Database Server. The backend apps & web administrations are enabled by App Server, whereas Database Server is solely responsible for the information storehouse and partner operations. A collection of arrangements specified by the Resource Manager for distributing data transfer capacity, memory, and capacity to the dwelling occurrences is carried out in a Server.
- Virtual Machines: Virtual Machines are instances within a server (VM). The equipment assets provided by the host Server are approached by each VM. In terms of accessible memory, CPU, and capacity size, a virtual machine (VM) exemplifies some information. Significant apps & internet establishments usually operated in App server VMs in healthcare arrangements. The massive amount of health data is distributed among the Database server's virtual machines. Distributed instances of the two types transmit simultaneous moment when working on a Healthcare setup. Pictures of operating virtual machines can be

reproduced in order to make healthcare arrangements that are somewhat open minded. The relocation of projects among the VMs is also a possibility.

The app model of different Virtualized Clinical tool is comparable to the framework engineering. The summed-up prototype of Cloud based Health-care apps could be portrayed according to Fig. 2.

As majority of cloud dependent apps can be categorized into a pair. First half of this app operates on to clients' smart phones, while the other runs on Cloud VMs. The confirmation data is requested at the start of the program on the client's smart phone [5]. It can include a client's secret word as well as biometric recognition. Such verification information can be used not just in Smart phones, as well as in Cloud and safety purposes.

Smart phones are constantly connected to Internet of Things detectors or wearable gadgets via the app to obtain health information from customers. Advanced mobile phones can do some data preparation on their own. Regardless, the information is safely moved off the Cloud for broad handling. App and organization-driven cryptography can ensure the secure transfer of data.

The second portion of the program in the Cloud VMs collects information from authorized Smart phones and does direct information deliberation. Fundamental data are extracted from the crude discovered data and treated in a gain opportunity with the purpose of making them suitable for further inquiry through information deliberation.

Investigation additionally is direct at this time. Consolidation of the client's factual evidence, data analysis, design recognition, highlight extraction, and layout matching methods are all examples of information research [6]. In this case, a connection of key facts from the Healthcare arrangement's information storehouse may

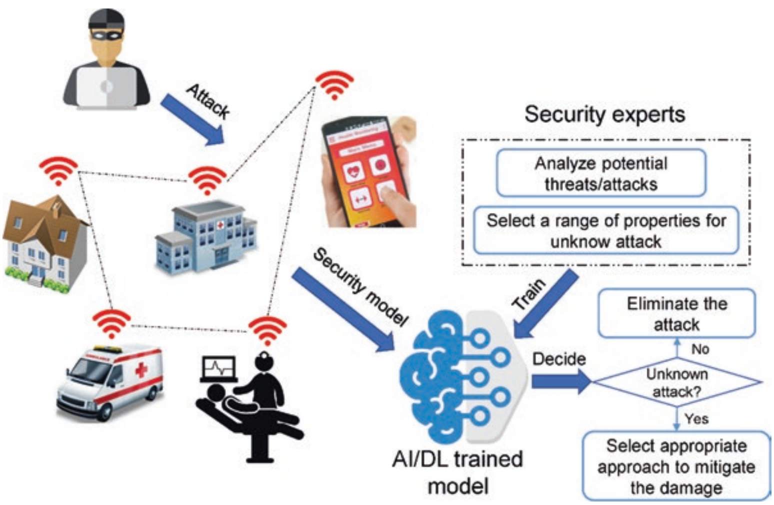

Fig. 2 Model for a cloud-based healthcare app

be necessary. External computer program administrations are occasionally used to break down the data.

Following the investigation of the information, the client's health is evaluated in light of the examination results. This evaluation should be accomplished either through a comparison of the studied data with preset parameters or through a direct interaction between clinical professionals [7].

The Healthcare app's final outcome can be like information about a client's disease settings or a cautionary signal for client. Most of the setting seems to be protected of continuous client observation, and a signal is sent returned for contractor's Computer or smartphone. This cycle will continue till the customer closes the service on his or her smart phone.

Partner apps can handle torrent or group data according on the suitability of the Healthcare setup. The apps' assets might also change from time to time as a result of approaching data loads. Furthermore, any app can be executed on a single virtual machine or distributed across several virtual machines. Regardless, the great majority of Cloud-based Healthcare apps use standardized procedures to process data [8]. Only when medical configuration has many apps and maintains a variety of healthcare data, equal handling can begin.

2.2 Interoperable Fog-Based Solutions

Mist registering weather is kept in certain systems administration devices known as Fog hubs to do various computing tasks at the enterprise edge (Fig. 3). Distributive is arranged in increasing Fog levels via mist hubs. Handling centers, memory, storage, and data transport capacity may all be added to a Fog hub. Basic fog instruments are much closer to the Internet of Things devices and typically provide points of engagement for partner apps. As a result, basically Fog hub could be designated like an App entrance hub for a certain Fog-based Healthcare configuration [9].The observed Health information can be dealt with by the app entrance hub, or it can be forwarded to the higher-level Fog hubs known as Computational hubs for processing. Assets (such as data centers, memory, capacity, and data transmission) could be abstracted and consumed like Tiny Computation Units in a Fog hub (MCI).

Every hub really isn't maintained computationally active in a fog climate. When the information load decreases, the calculation part in the Fog hubs might be inactive, and this can be activated by the interest. As a result, the Fog atmosphere may form more adaptive also effective. Additionally, security features may be implemented to each hub's correspondence interface for information security and interruption guarantee. Or something along those lines, dependable data transfer may be assured (Fig. 4).

Regardless, Fog and Cloud likely to be basically differ with category of asset limitation, capacity, and coordination. In this way, cloud-based Internet of Things-Healthcare agreements allow for interoperability when Fog is predicted. A group-based Fog framework engineering is discussed in the following parts to deal with

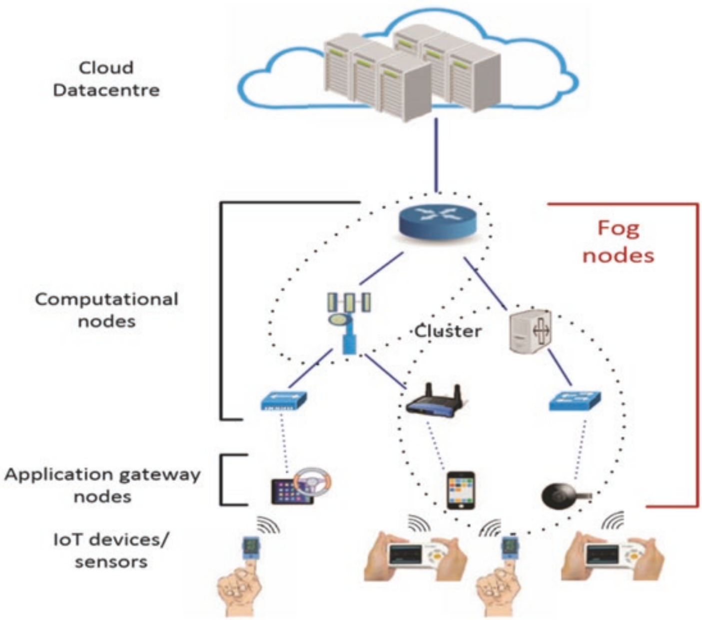

Fig. 3 Simplified Fog Structure

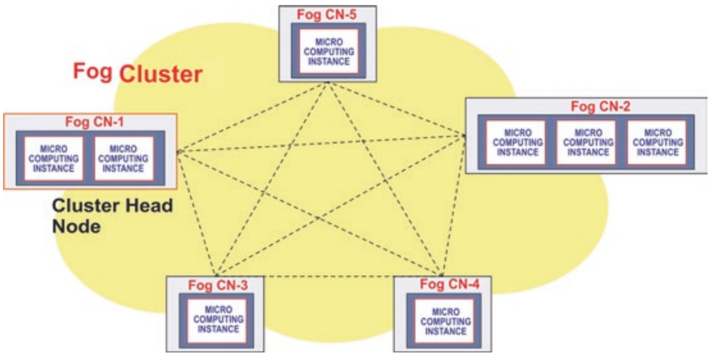

Fig. 4 Architecture of a fog-based healthcare system

the arrangement of Cloud-based Internet of Things-Healthcare arrangements in Fog environment.

Several hubs from distinct Fog levels might form a clump among themselves by following faster organization criteria. Inactivity is given a higher priority when forming a group between nodal correspondence. A few hubs in a group run the programs, while others maintain a data base or keep track of contact with various groups. Each Fog group is primarily responsible for a certain Healthcare arrangement. A single Healthcare arrangement might also be conducted in several groups [4].

The unconnected hubs, which have no affiliation with any organization in such engineering, are just used as a system administration tool. The heap can enhance the number of computationally dynamic hubs in a group.

A particular hub dubbed Cluster head hub is responsible for all the entomb and intra-bunch correspondence in a group. Each Fog hub may acquire health information from other related hubs, according to the overall Fog engineering. When a hub receives data in a group, it evaluates the acceptability of the data with the partner Healthcare arrangement and informs the Cluster head hub. In response to the alert, the Cluster head hub either advances the information to the comparing bunch or schedules it for handling by MCIs in a comparable group, as suggested by the app model [10].

Furthermore, the CHN establishes asset also administration indicating arrangements to diverse nodes, controls a heap in between the nodes, controls and receives accessibility with communication, monitors MCI activities, and protects partner meta-information. Cluster head hub can replicate the image of APIs from that hub to another hub in the cluster in ensuring feasibility of the Healthcare arrangement amid dubious hub failures. If a CHN is unavailable, another hub from the same group that has been previously identified can serve like a CHN. The group head hub may transmit the obligations for rest of the group, ensuring that no presentation corruption occurs (Table 1).

Table 1 Features of the planned Fog system that have been improved

Information	Fog	Data centre
	Mark	*Information space*
Alliance	Light	Compound
Edges counts	Maximum	Short
Admittance of edges	Variable	Compound
Closeness about information	Single / pair	Various
Geological composition		Inward
Waiting of information from sources	Less	Maximum
Actual communication	Feasible	Compound
	Edges	*Assistance*
Defeat toughness	Maximum	Minimum
Way to connection	Inconstant	Settled
Utilization to spirit	Minimum	Maximum
	Mark edge	*Information management*
Defeat toughness	Maximum	Minimum
Way to connection	Inconstant	Settled
Utilization to spirit	Minimum	Maximum
	API	*Virtual machines*
Settlement/ fixing	Easy	Compound
Theme plan	Minimum	Maximum
Composition	Variable	Tough
Cost	Minimum	Maximum

MCIs from the same hub, bunch, and either health protection arrangement may also spread information also information for the control of the comparable CHN. Because APIs can't have a large asset base, they are able in providing a broad area of medical facilities apps and data. Such provisioning of allocated assets to an API might be done in stages according on the Healthcare arrangement's settings. Every API may be controlled and organized itself, beyond affecting the QoS for more.

Occasionally, previously described bunch-dependent Fog engineering resembles the Cloud-based framework design. The real bunch depicts the Cloud datacenter, where Fog hubs are transported in the same way as servers are. The Cluster-Head-Hub takes over as the bunch's Resource Manager. APIs like VMs, run Healthcare apps and manage information base operations inside Fog hubs. However, a few categorizations for this type of Fog-based-Health protection system, as shown by Table 2, increase its suitability for today's reality [11].

This group-based Fog engineering is productive to operate Cloud-based Internet of Things-Healthcare arrangement noting desired QoS and affordable assistance cost due to the Cloud-like course of action of the parts and better highlights according to alternative points of view.

However, hubs are appropriated and their essential MCIs are compelled in limit in this Fog-based framework engineering. It's impossible to fit a large-scale healthcare app onto a single MCI. Furthermore, there may not be enough MCIs on a single hub to support the full app [12]. The setup of an Internet of Things-Healthcare app

Table 2 Counted Factors

Parameter	Value
Period of calculation	Approx 5 minutes
Cloud information space: Cloud intermission by dataset	120 milli sec
Expenditures on virtual machines	0.9–0.13dollars per min
Consumption of power by virtual machines	12–16 MJ
General count of virtual machines in space	12–16
Fog based system: Cloud intermission by dataset	12 milli sec
Cloud intermission by general late clustering	6–12 milli sec
Expenditures on API	0.02–0.04dollars per min
Consumption of power by APIs	3–5 MJs
General count of APIs in space	4–12
Function operation processing timeline	300 milli secto700 milli sec
Generalized information transformation span of function in cloud along a specific app	200 to 250 milli sec
Generalized information transformation span of function in cloud along a specific app in cloud	120 to 150 milli sec
Span for information optimization of internet of Things detectors	220 to 650 milli sec

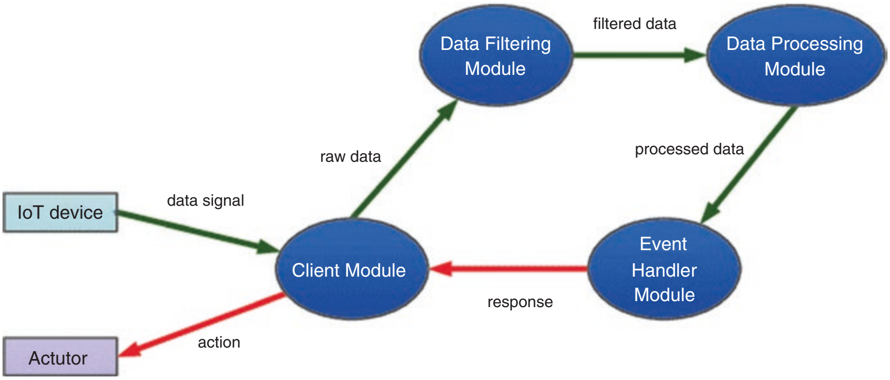

Fig. 5 A model of a fog-based healthcare app

in such a framework will not be as simple as it is in the Cloud. Along these lines, it is anticipated that the Cloud-based app model would be changed to a Fog feasible one without affecting the over-simplification and consistency of the project. The following is a Fog-based app model for a Healthcare arrangement.

A single app in Fog may be thought of like selection of App Bunch. It's previously said, any Cloud-dependent Health protection app executes a few standards also standardized procedures on the data received. Every App Module should be prepared in a similar type, like this could execute at least singles specified processing upon information. Additionally, APIs may configure in running of everything as if it were a single module. Based on this view, every Cloud-dependent Health protection app may be divided in four App segments, as per the Fig. 5.

A unidirectional sequential information stream is used to depict the information dependence among the modules. The deferral of information dependency across modules might have a negative impact on app administration delivery [13]. As a result, while determining the aid delivery cutoff time aggregate amongst modules, the modules' information reliance postponement should be prioritized. Modules can be represented in detail as follows:

- *Applicant Segment*: The basic point of interface for the comparative app is provided by the Client Module. This module relays information from connected Internet of Things devices to the app. This module handles confirmation, information recurrence adjustment, and information aggregation from various Internet of Things sources. This module also does information pre-processing, converting dissipating information signals from Internet of Things devices into ordered crude data. Furthermore, the Client Segment could deal with workouts from partner activator based on the aggregated reaction from the resultant modules.
- *Information Filtrate Segment:* The rough information given by the Applicant Segment includes a few additional pieces of information (confirmation, app metadata, – so on) together with true healthcare data. The Information Filtrate Segment separates the health protection information from the non-relevant components so that they may be incorporated for the final segment to operation.

- *Information Processing Segment:* This module handles separated information by the Information Filtrate Segment. This module effectively combines several processes like as information study, correlation, also outcome evaluation. Outside information, processes, and programming pieces can be used to assist this module. Fundamental correspondences must be controlled with the comparing API, Fog-hub, and bunch in this case.
- *Event Handling Segment:* As the information has been processed in the Information Processing Segment, an output might conjure up any interesting event. The Event Handling Segment determines its best appreciable outcome to the situation. The Event Handling Schedule could either save the reaction to later use else convey it revert towards Applicant Segment in determining what movement should be taken in response to the reaction.

Because the functional components of a large number of modules are all different, the asset requirements vary from one to the next. For improved app execution, the Applicant Segment must be located adjacent to the Internet of Things equipment. It's possible that it'll be located upon the App Gateway Node in Fog. Without ignoring the information stream, the generated modules can be assigned to a specific group for that Healthcare setup. Each of the segment could be installed upon particular APIs of a same hub either upon other hubs [14].Though, as compared to other segments, the Information Processing Segment requires more resources, and the deficiency in providing of these belongings to such segment might cause a barrier in such system's assistance. Before placing the module, the array-head hub must be known of such information.

Disseminated improvement and organization is the most effective technique to manage vast scope Internet of Things-Healthcare apps in a forced Fog climate. The suggested app model focuses on improving apps in particular, while the partner between module information dependency prepares for its dispersed organization in a forced Fog atmosphere. Cloud-based Internet of Things-Healthcare apps may be adjusted in this way to work in a foggy environment.

3 Combined Structure

Our proposal for reference engineering is depicted in Fig. 6, which provides the components to aid reconciliation among Fog and Cloud registration foundations during facilitating interoperable Internet of Things-Healthcare arrangements. The goal is to provide the basic models for developing edge-to-edge arrangements, including sensors, as well as appropriate apps and administrations, such as data analysis, artificial intelligence, setting derivation, and suggestion frameworks. The key examination questions are:

- How to advance the reconciliation of Internet of Things/Sensors and appropriated administration conditions?
- How to help support organization of disseminated administration conditions and Fog Computing, considering the prerequisites for neighborhood administration

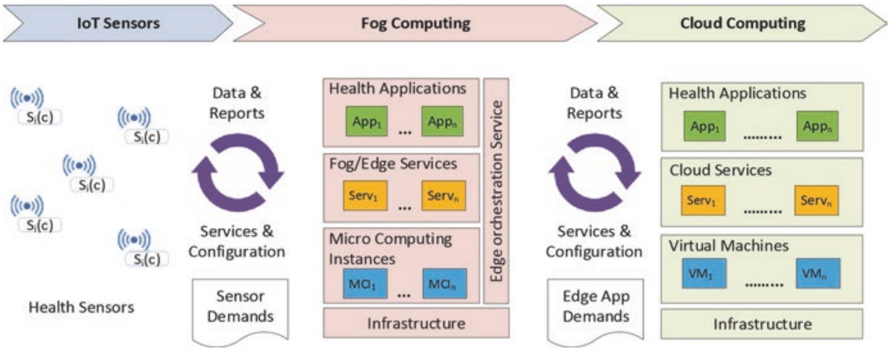

Fig. 6 A Cloud-Fog integration reference design for compatible Internet of Things-Healthcare solutions

support, restrictions of computational assets, systems administration and correspondence, and the nearby climate?
- What are the issues of safety and protection in this climate? How to foster methodologies for disseminated investigation and safety efforts?

We imagine the accompanying difficulties and chances of Cloud Fog-based administrations during incorporating those towards for ability to exchange information in health-care arrangements:

- Insightful Health Sensors: executing micro services for use of languages, training, alsoitself change in detecting gadgets, giving the arrangement on the bottom-edge information gathering also investigation action, for example among Detectors also the Edge-initiatives; in any case, considering the expected limitation of registering capacity, this will be available in execution of micro services to information exchanging, training, and itself-change of detection gadgets, giving arrangement upon the bottom-edge information gathering also investigation procedure.
- Administration Composition Cloud Edge Service: Making administrations for match asset interest also execution data by Cloud Computing and Edge Service constructions to enable asset distribution, management executives, and transformation to improve administration execution and precision. Edge Compositions Services should have the ability to connect data about Fog Computing foundations, such as existing calculation power, available administrations, and others, and put efforts in compel of general apps also accounts to disseminate in handling of Fog _Computing and Cloud Computing requests. This model is dependent upon Edge App Demands, which provide a public manifest of the resource's requests, such as calculated energy, administrations, also foundation, the Cloud Services distribute hence corner Composition Services can determine whether this could allocate segment in handling to the Fog Computing.
- Administration Composition in Sensor-Edge-Service Management: Making administrations in matching of the asset interest among apps and detectors, as

well as advancing sensor change to adapt to app requirements. Proposed Prototype is dependent upon Detector Demands, that likely to be a publicly visible that depicts arrangement requests for related sensors in order to meet the handling necessities on Fog Computing and Cloud Computing administrations; for example, design about information inspection speed, distance between information transmissions, largest information cluster sizes, gather exactness, then so on.

- Appropriated Health Care apps: To enhance perceptive Health Care apps, Cloud Computing and Fog registering components are collaborating to organize and disseminate administrations locally. The edge registration layer will explore and manage the information that is critical to the neighborhood foundation's operations. This item will aid in meeting the challenge of translating massive data into beautiful data while adhering to stringent patient safety and security regulations.
- Security and Privacy Solutions: In the context of the Internet of Things and Edge Computing, security should become more fluid and adaptable. This line of investigation includes distributed administrations that connect data from several levels to deduce security concerns, interruption identification, conduct deviances, and security risks, among other things. This item will aid in the testing of harsh ill person's protection and safety regulations.

Objective of the Cloud-Fog Composition strategy likely to be optimized in use of resources along with utilities by taking into account: (I) current app requirements, such as QoS, recurrence of information requirements, so on; (ii) computational limit and administration accessibility on Fog Processing gadgets; (iii) detectors existed along with level potential arrangements.

4 Calculation of Execution

We recreate both the environment and the included architecture reproduction tool compartment to demonstrate the attainability of our suggested Fog-based Internet of Things-Healthcare arrangement and interoperation with Cloud-based arrangement. We control the reproduction in two ways [15]. At first, the presentation of a Fog group-based Internet of Things-Healthcare system likely to be relate to a Cloud dependent system related with organization lag, power consumption, along with expenses, assuming Fog‘s calculating resources likely to be enough. Following that, the assistance appropriation among Cloud Fog information exchange has been displayed for various numbers of detectors along with PC consumption with administrations when processing programs in Fog with limited computational resources. In this case, manufactured duty is used because the current reality responsibility to replicate such an environment on a large scale isn't now available. The reproduction measurements are summed up in Table 2.

In the suggested procedure, Fog assets can have many administrations with varying CPU utilization rates to handle data from applicable sensor box partner apps. We agree that apps are planned to administrations in light of recurrence appropriation (information detecting time period) comparing sensors, and that when the Fog limit is exceeded, the apps are dispatched to Cloud-based administrations for execution [16]. We guide the research by varying the count of apps, sensors, and the administrations' CPU consumption rates.

4.1 Scheme to Problem

Sharing the same correspondence interface by distinct Healthcare apps in a distant Cloud-based arrangement reduces transmission capacity fragmentation, causes network congestion, and increases information full circle time. As a result, in the Cloud, the typical organization delay visible by the apps turns out to be substantial (Fig. 7). On the other hand, in a Fog-based setup, the usual organization delay for information accessibility to apps is reduced since the information source and general registration sections have separate communication interfaces [17]. In addition, the Cluster head hub can handle the information stream, reducing the time it takes for the organization to respond.

In a Cloud-based Healthcare setup, an app is typically executed by a single VM, but in a Fog-based setup, an app is executed by many MCIs. In comparison to a VM, an MCI is more lightweight and uses less energy. As a result, the overall energy consumption of MCIs while running an increasing number of healthcare apps isn't comparable to that of VMs (Fig. 8).

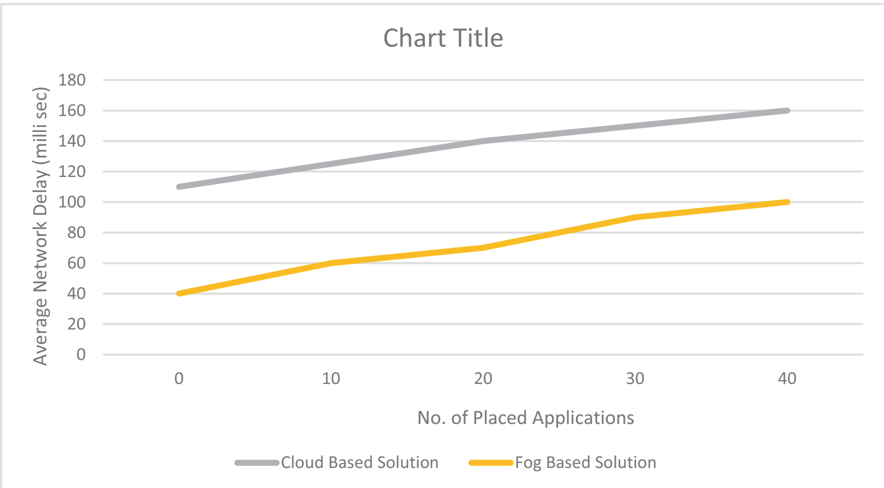

Fig. 7 Fog network variability and cloud-based solution

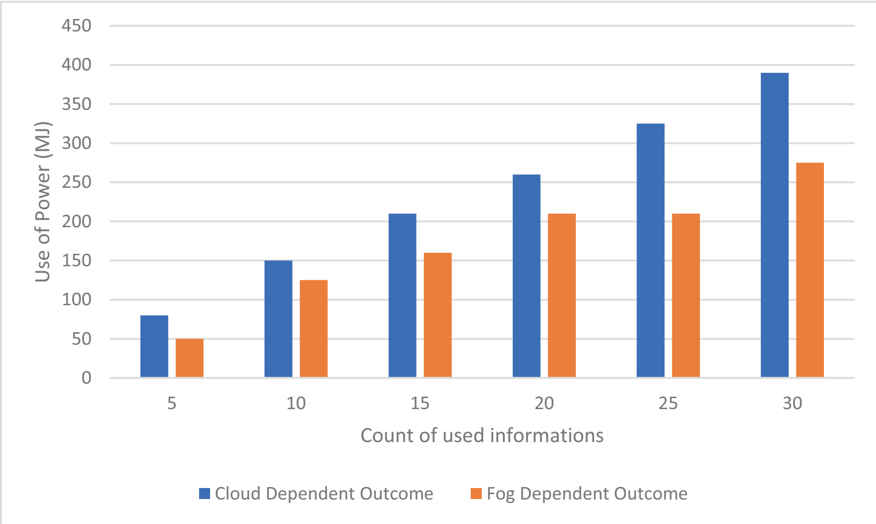

Fig. 8 Use of Power in Fog and cloud-based approach

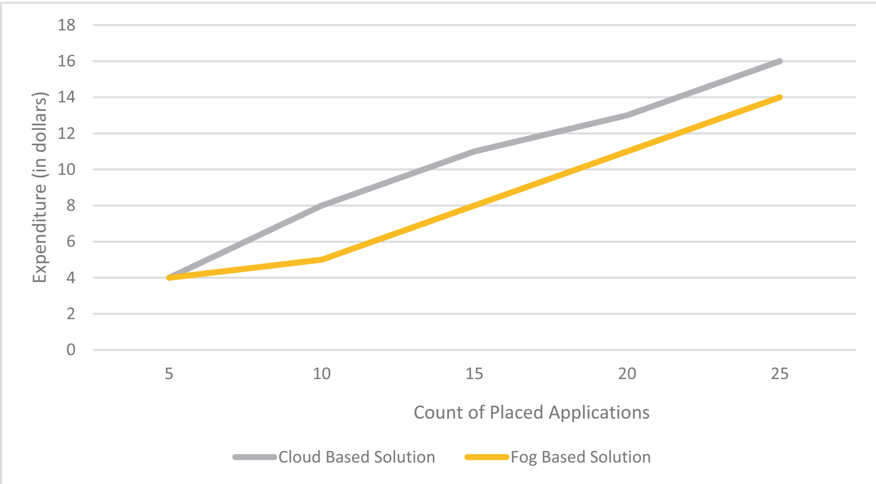

Fig. 9 Fog and Cloud-based solution instance costs

Furthermore, with Fog, a single App Module uses fewer assets than the full project. When an MCI is furnished by a module's requirements, asset over provisioning is less likely to occur [18]. It's difficult to organize VMs in a Cloud-based configuration when the design of the VMs is predetermined. In this way, the administration fee for MCIs may be customized according to the module settings, but for VMs, the administration price is assumed to cover the total use. As a result, when compared to the Cloud-based arrangement, the absolute cost of occurrences is lower in the Fog-based arrangement (Fig. 9).

However, it is critical to settle the heap appropriation of the administrations amid Fog and Cloud in Cloud-Fog reconciliation for interoperable Healthcare arrangements. The reconciliation of Cloud-Fog in aid appropriation is discussed throughout this time of execution assessment.

Figure 10 depicts the Cloud-Fog administration's spread throughout an increasing number of sensors. Partner apps can be taken care of by Fog-based administrations for smaller numbers of sensors [19]. As the number of sensors grows, so does the number of administrations in Fog, and it isn't planned to move apps to the cloud until a certain point. In any case, Fog assets are scarce. Following the achievement of a maximum number of operating administrations with explicit CPU consumption rate, it is outside the realm of possibility for Fog assets to anticipate obliging additional administrations and apps to migrate to the Cloud [3]. In this case, the number of Fog operating administrations remains steady even while the number of Cloud administrations grows.

Figure 11 depicts the quantity of accessible administrations in the Fog registering stage, as well as the Cloud-Fog integrated assistance appropriation by varying the administrations' CPU utilization speed on a distinct number of sensors (three situations of sensor number for this situation; 50, 100, 200). Fog can handle a larger portion of the apps with a smaller number of sensors because to the low CPU utilization rate of administrations [20]. However, with all of the administrations available in Fog, the app requirement cannot be completed when the aid CPU consumption rate and number of sensors increase. Cloud's connection becomes crucial in this circumstance.

The number of operating administrations in the Cloud grows in tandem with the CPU use rate of the administrations and the number of sensors.

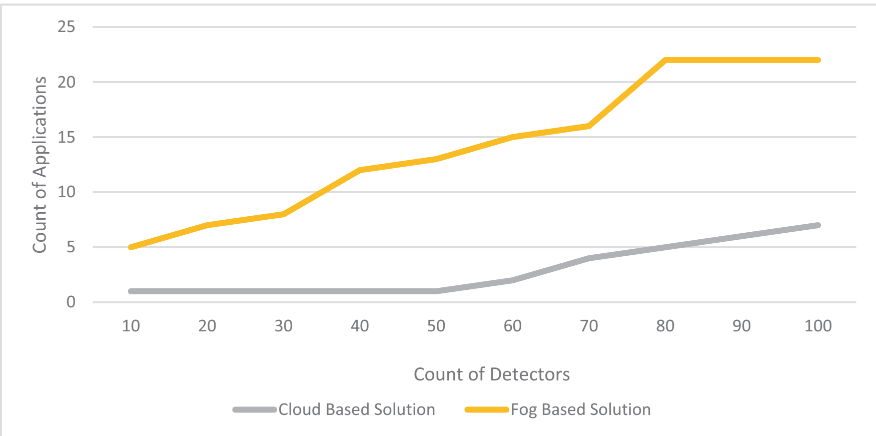

Fig. 10 Cloud-Fog sensor integration with a variable count of detectors

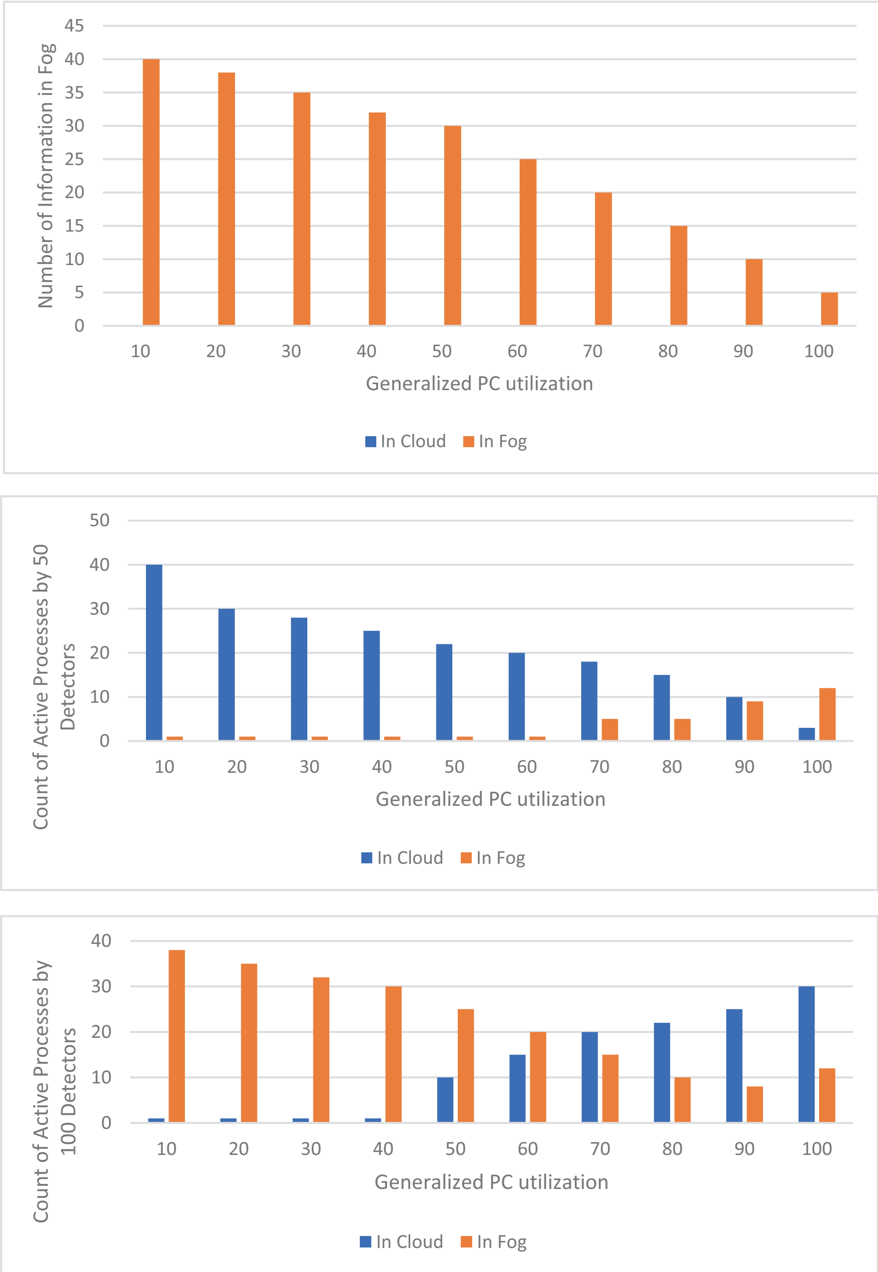

Fig. 11 (**a**) Generalized PC utilization with number of Information in Fog. (**b**) Generalized PC utilization with Count of Active Processes by 50 Detectors. (**c**): Generalized PC utilization with Count of Active Processes by 100 Detectors (**d**) Generalized PC utilization with Count of Active Processes by 200 Detectors

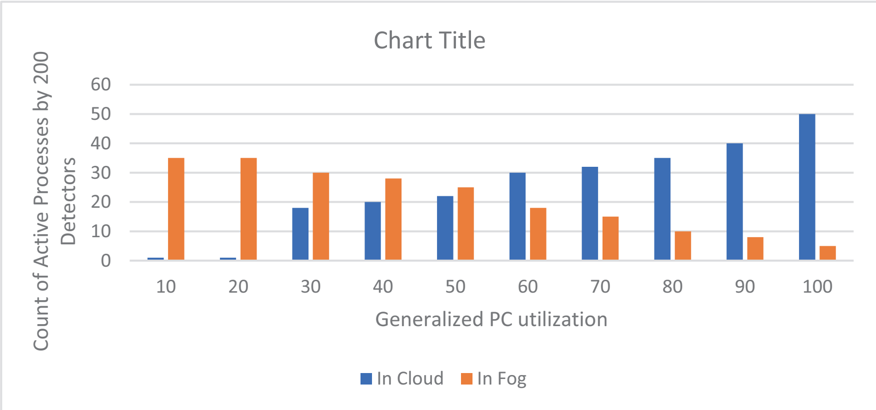

Fig. 11 (continued)

5 Conclusion

Cloud registration and its connections in various fields of study, industry, and clinical advantages is widely discussed for quite some time. There are several potentials and well-known Cloud-based arrangements available right now. These Cloud-based arrangements grow more powerful and client-centered when modern processes such as the Internet of Things are taken into account. However, because of its topographically combined engineering and multi-bounce distance from the Internet of Things information source, Cloud has a limitation. This weight of the Cloud frequently disrupts real-time communication among clients and the registration stage. Disappointment with ongoing collaboration in Internet of Things-enabled healthcare arrangements can sometimes lead to dangerous outcomes. At the edge organization, a new registering worldview called Fog is implemented along these lines. It aids in fulfilling the foundation in Cloud registration. Because of the variations among the pair of registration phases, the present Cloud dependent arrangement can't straight be positioned towards Fog-climate.

We explored the writing survey in this work and were inspired to summaries the Cloud-based Internet of Things-Healthcare arrangement structure in terms of framework engineering and app model. Then, for certain enhanced features, we suggest an interoperable Fog-based Internet of Things-Healthcare arrangement that broadens the overall Cloud-based Internet of Things-Healthcare arrangement structure. Reference engineering is used to discuss the reconciliation of both the interoperable arrangement structure and the interoperable arrangement structure. Regardless, we look at the presentation of both the arrangement structure and the presentation of both the arrangement structure and the presentation of both the arrangement structure and the presentation of both the arrangement structure in terms of administration distribution, occurrences expense, energy consumption, and organization latency, the presentation of Fog-based arrangement is being worked on.

The proposed Fog-based Internet of Things-Healthcare arrangement (framework engineering, app model) can be stretched out for additional exploration.

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COVID-19 Wireless Self-Assessment Software for Rural Areas in Nigeria

Ahmed Abba Haruna

1 Introduction

Wuhan City, Hubei Province, China was the epicenter of an unexplained pneumonia outbreak in December 2019 [5, 10]. After the initial outbreak, a new coronavirus (Severe Acute Respiratory Syndrome Coronavirus2 [SARSCoV2]) was quickly identified as the causative agent and COVID19 was assigned to the associated disease (abbreviation for coronavirus disease, 19 is referred to the year the virus was original detected). The World Health Organization (WHO) on March 11, 2020, declared a pandemic with 3,002,303 cases that were confirmed with 208,131 number of dates worldwide as of April 27, 2020 and many more after [10].

Severe Acute Respiratory Syndrome Coronavirus disease 2019 (COVID 19) caused by coronavirus 2 (SARSCoV2) [5] has physicians, researchers, policy makers, and communities around the world. COVID 19 is the third major coronavirus that has been transmitted from animals to humans in the last 20 years [7]. The global impact was greater than the previous epidemics of 2003 (SARSCoV), 2012, 2015 and 2020 (Middle East Respiratory Syndrome Coronavirus / MERSCoV). Infection by asymptomatic and mildly symptomatic individuals may have promoted SARSCoV2 transmission. This is because SARSCoV and MERS tend to make patients sick, less mobile, and have a higher basic reproduction number (R0) for SARSCoV2 [7]. SARSCoV2 was first detected in China and soon spread around the world. The Americas, South Asia and Europe have been hit hardest ever.

As of the end of March 2021, COVID19 confirmed cases has exceeded 125 million, the deaths caused by the virus has also exceeded 2.7 million, the global

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https://doi.org/10.1007/978-3-031-22959-6_12

mortality rate was 2.19% [2]. As of February 21, 2021, COVID19 casualties exceeded the total number of US casualties in World War II, the Korean War, and the Vietnam War. Incidence of COVID19 in Nigeria is gradually increasing, shifting from imported cases of elite patterns to community transmission. The case fatality rate for this event was 2.8%. Hence, Nigeria was able to block the spread of the virus through a combination of social and medical responses [8]. But during the short period of time when the blockade was lifted, the country saw a surge in COVID 19 infections (52 percent of all cases). However, there are proposed methods for diagnosing COVID19 infection, including Nucleic Acid Amplification Tests (NAAT) such as reverse transcription (RT) PCR to detect viral RNA [4]. Where COVID19 community infections are widespread and laboratory resources are limited or unavailable, a standalone wireless application for diagnosing COVID19 is required.

Nigeria has a self-assessment tool, but it's not on the home page of the NCDC, except on the coronavirus microsite. Also, because this self-assessment tool is visually unobtrusive and small, it is unlikely to be widely adopted by the general public. Coupled with the fact that many Nigerians are not proficient in enough technology to find a way to go to the site to take the test, it is unlikely that it has become widespread in general. Therefore, it is important to develop a self-assessment tool that can assess whether a user is at risk and inform them of the steps necessary to keep themselves and others safe. Easy to access and understand. As a result, this article introduced a stand-alone wireless application for COVID19 self-assessment that follows the guidelines of the NCDC. This software has been developed to address current COVID19 issues around the world. Especially in rural Nigeria, it was developed to support self-assessment because there is no network connection to access NCDC's current web-based COVID19 self-assessment website.

2 Related Research

According to the International Journal of Infectious Diseases, NCDC found that within the first 30 days, among the people (age range between 30 to 60 years) that were tested to be positive for COVID19, 70% were males and females were 30%. The most affected were people between the ages of 31 and 50 (39.0%). Approximately 44.0% [3] of cases were imported and 41.0% [9] of patients had incomplete epidemiological data, concluding to an unidentified source of infection. However, Thirty-five patients (15.0%) are identified acquaintances of positive cases, recommending communal or cross infectivity. Lagos happened to had more than half of all the COVID19 cases in Nigeria, then Abuja became the second (20.3%) and Osun the third (8.6%). Abuja and Lagos are well-known as major international airports as well as national commercial and administrative centers [1]. Similarly, many of the indigenous peoples of Ezigubo, the hotspot for this disease in Osun, work in Côte d'Ivoire and other bordering countries and have handled hundreds of COVID19 cases. Many of them were tested positive for COVID19 after being forced to return to Nigeria for COVID19. Since the first index and other imported cases, it has continued to spread to other states through interstate travel. The distribution of Nigerian disease was elite in the first 30 days of COVID19. Most of the people that were tested to be positive were people that arrived from overseas [1]. Due to the high poverty rate in Nigeria, air travel is primarily elitist. Among the people that were earlier tested to be positive for COVID19 were 3 governors and several political appointees, which placed many political elites at risk. COVID19 was initially considered a disease in which the elite returned from traveling abroad and inter-acted with political bourgeoisie based on (early) patterns. Control efforts have been hampered by this unabated view. COVID19 broke the class barrier earlier than planned, indicating a community infection. It was the responsibility of everyone in Nigeria [1].

Since the transmission route of COVID19 it became very essential for people to take precautionary measures (safe hand washing, social distance, staying at home, etc.). The nature of Nigeria's social life and reality is changing as a result of these behavioral changes. In the face of completely inadequate palliative care, new social normality is negatively impacting livelihood and viability [11]. Experiences and lessons learned from the most affected countries (eg, US, UK, Italy, France, Spain) shows that no government is well prepared to contain the COVID19 pandemic. Few countries in the world have achieved testing all its citizens. In most nations, the COVID19 epidemic has created significant obstacles such as a shortage of medical staff to care for patients, medical resources (especially personal protective equipment [PPE] and ventilators), and infrastructure [12]. Many health experts predicted that if a coronavirus pandemic was identified on the continent, Africa would have a hard time controlling it. Concerns arose from widespread poverty, inadequate treatment, and the illnesses that plagued much of Africa. In Africa, there wasn't any country that was reported to be infected with COVID19 as of seventh June 2020 [1]. General testing is an important A total of 192,721 confirmed cases (Africa) killed a total of approximately 5200 and recovered 85,107 tool for discovering instances. However, due to lack of resources, it may not be possible to conduct a universal testing in various parts of Africa, which includes Nigeria. However, until a solution is found, the imperfect but best effort to stop the infection is a small benefit and a step in the right direction. Between 6 and 8 February, the Africa Centers for Disease Control and Prevention (ACDC) trained experts from Nigeria and 15 other African countries to use the polymerase chain reaction (PCR) to produce COVID19 diagnosis [1]. As a result, most tests were performed in molecular laboratories using PCR assays, but investigations are underway to assess the integrity of the Rapid Diagnostic Test (RDT) kit. As soon as GeneXpert machines are available, their integration is planned, in Nigeria, 76,802 people were tested between February 27 and June 7 (see Table 1). Due to lack of testing and treatment resources, the Federal Government of Nigeria has decided to test only those who need it urgently. This will test other countries in the region that already handle hundreds of COVID19 cases. Many of them were tested positive for COVID19 after being forced to return to Nigeria for COVID19. Since the first index and other imported cases, it has continued to spread to other states through interstate travel.

Table 1 Age group suitable for Covid-19 test

Adults over 18 years old	Self-testing and reporting, support as needed
Youth in old age 12–17	Self-test and report under adult supervision Adults can run the test as needed
Children under 12 years old	Children under the age of 12 should be tested by an adult. Do not run this test unless you are sure about your child's test. If the child feels pain, do not continue the test

As a result, the following are tested:

1. Those who have returned from an overseas trip and have symptoms between 1 to 14 days of their arrival (they are recommended to quarantine themselves for 2 weeks after their arrival to Nigeria).
2. The people that came in contact with other people that are confirmed to be COVID19 positive and showed symptoms with 14 days.

Individuals with COVID19-related symptoms of unknown origin 4 and individuals with moderate or high prevalence of COVID19.

As a result, the number of molecular laboratories that can test COVID19 has increased from 5 to 23 (as of June 7, 2020). That time, no private molecular laboratories are used for COVID19 testing in Nigeria. Over three months after the index case was confirmed, more than one-third of the 36 states still lack testing labs. If a case is suspected in a state without a test center, the sample should be transferred to Abuja, the federal capital of Nigeria, or one of the accessible molecular laboratories [1]. Despite the fact that there is no cure for COVID19, NCDC reported that treatment of COVID19 patients follows the criteria set by the ACDC.

Figure 1 illustrates the recovery rate from COVID19 as of June 7, 2020. The typical treatment period for positive patients is one month. The majority of people who died from the infection in Nigeria had serious underlying health problems exacerbated by the coronavirus infection. Based on international best practices, NCDC has created a prescription for safe burial techniques that reduce the risk to the deceased's loved ones. COVID19 requires expert laboratory diagnostics and a rigorous treatment protocol. Therefore, while PTFs value this for limited resources and facilities, home care by the primary caregiver (relatives) is not an option. The virus is highly contagious and requires personal protective equipment (PPE), even at the forefront. If implemented, home care options could lead to an increased burden of COVID 19 in Nigeria.

3 Methodology

This software is written in the C ++ programming language developed by Bjarne Stroustrup as an extension of the C programming language. This is also known as "C with classes". The first step in achieving these goals was to consider various self-assessment programs. The fact that some of these self-assessment tools are based on the Centers for Disease Control and Prevention (CDC) standards was our first discovery as shown in Fig. 2.

Timeline of Coronavirus Outbreak in Nigeria (February 27- June 7, 2020).

Incidence of Coronavirus February 27 – March 27 (first 30 days)		
	Number	Percentage
Total positive cases	81	
Total discharged	3	3.7% (of positive cases)
Total deaths	1	1.2% (of positive cases)
Incidence of Coronavirus February 27 – April 27, 2020 (first 60 days)		
Total positive cases	1337	12.2% (of the total tests)
Total discharged	255	19.2% (of positive cases)
Total deaths	40	3.0% (of positive cases)
Total tests	10,918	
Incidence of Coronavirus February 27 – June 7, 2020 (first 100 days)		
Total positive cases	12486	16.3% (of total tests)
Total discharged	3957	31.7% (of positive cases)
Total deaths	354	2.8% (of positive cases)
Total tests	76802	

Source: Nigeria Centre for Disease Control (NCDC, 2020; Worldometer, 2020)

Fig. 1 Timeline of Coronavirus outbreak in Nigeria

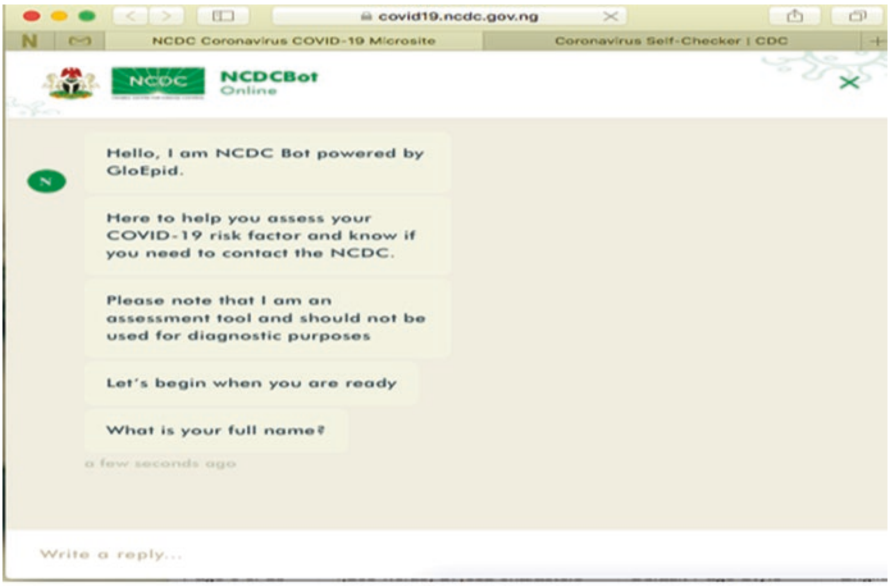

Fig. 2 Example of online assessment tool

Therefore, Fig. 3 shows a list of CDC screening protocols. It serves as a guide for the COVID19 self-assessment test form. This CDC screening protocol also served as a very useful guide to the symptoms and effects of the virus on the body. Therefore, this paper has adapted the CDC logging algorithm to a related version

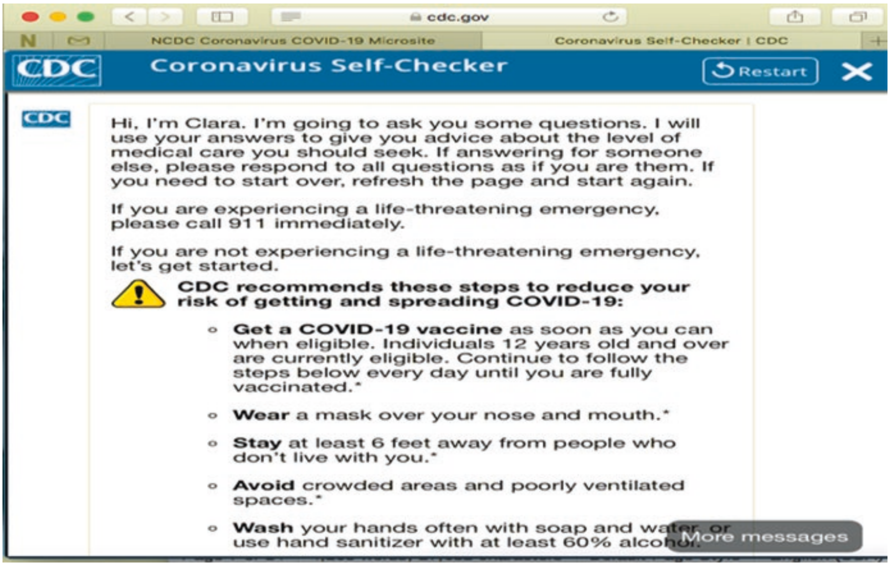

Fig. 3 Example of online assessment tool

that can be used with Nigeria's wireless self-assessment tools. To date, when COVID19 self-testing has been introduced, COVID19 has been used primarily in work environments with a high risk of exposure (such as medical facilities) or a high concentration of people (such as schools), as well as research environment. The Covid19 test is suitable for the following groups of people listed in Table 1.

4 Proposed Program Flow

Start Program
Enter Your Name:
Enter Your Body Temperature (Can Be Checked with Temperature Checker Available Immediately).

Ask About Life Threatening Symptoms.
Base On Your Answer, You'll Be Asked:

If You're Feeling Sick.

Based On Your Answer, You'll Be Asked:
If You Visited or Come Close with A Covid19 Patient.
If Yes, You'll Be Instructed to Seek Urgent Medical Attention.
If No, You'll Be Instructed to Monitor Your Symptoms and Take Care of Your Self and Stay Away from Covid19 Patient.

End of Program.

4.1 Advantages of Using the Self-Testing

1. Reduced risk of infection associated with travel to health care workers (HCW) or visits to laboratory clinics.
2. Convenience that you can take the exam at any time.
3. Reduces the burden on healthcare professionals / laboratory staff for collecting and analyzing specimens and reduces occupational exposure to healthcare professionals.
4. Results are readily available.
5. Cheaper than lab-based testing (taking into account HCW and / or lab staff time, lab consumables, etc.).
6. Reduces equipment and human / machine overhead and reduces pressure on the medical system.

4.2 Step by Step Guide on how to Use the Software

Step 1 - Open the .exe and wait for it to load.
Step 2 - The output screen opens when it finishes loading. It asks for your name first, and then display information about the software as shown in fig. 4.

Step 3 – The self-assessment test starts immediately; well-structured questions are asked. This questions are based on the Center for disease control (CDC) and prevention.

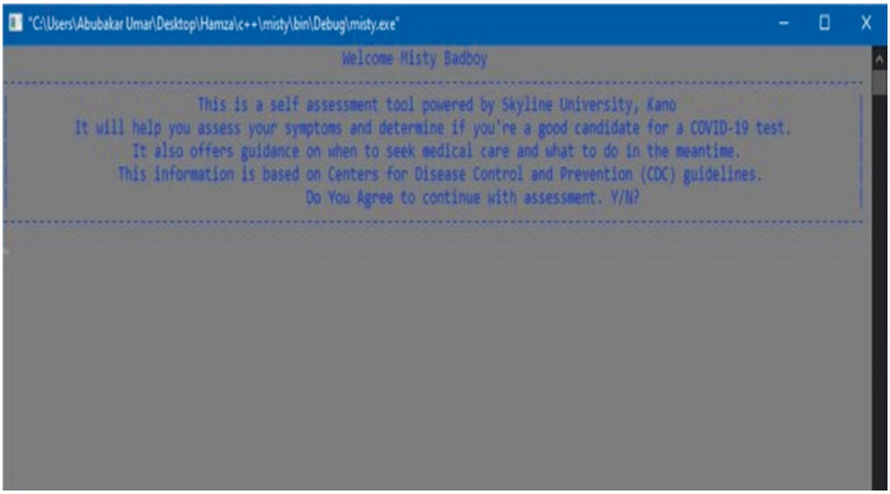

Fig. 4 Welcome page

Figure 5 shows the set of self-assessment questions displayed to the user and the answers are expected to be provided by the user before it moves to the next question.

As shown in fig. 6, at the end of the self-assessment, the result will be available immediately. However, based on the questions answered above, urgent medical attention is needed.

Hence, in fig. 7, based on the self-assessment result, it shows that user is safe, but have to monitor the symptoms. Here, the user answered the questions respectively to determine whether he/she requires medical attention.

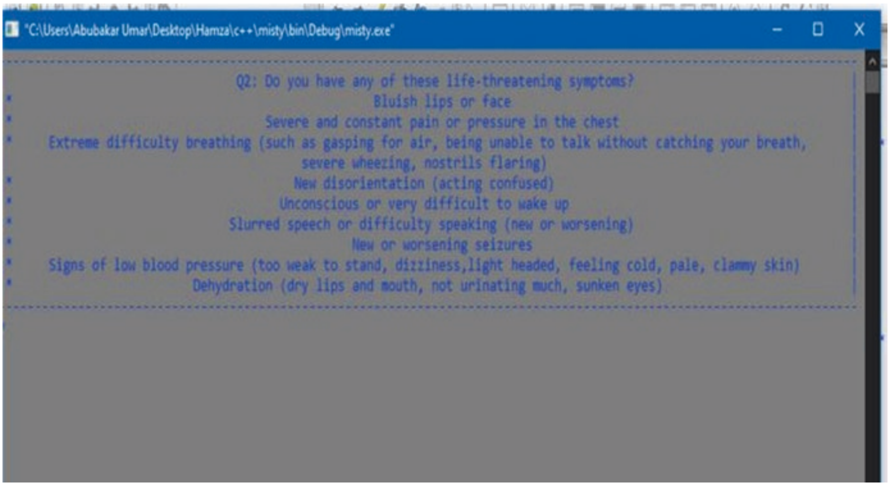

Fig. 5 Sets of self-assessment questions

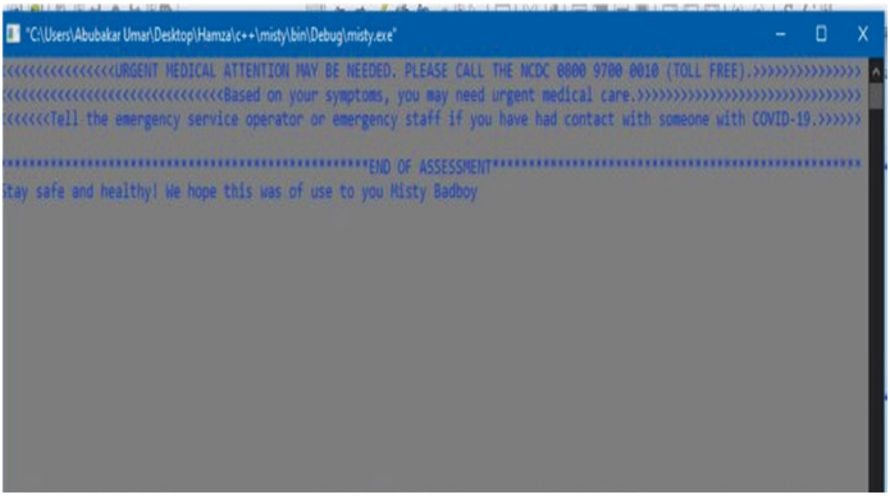

Fig. 6 Self-assessment result – Sample 1

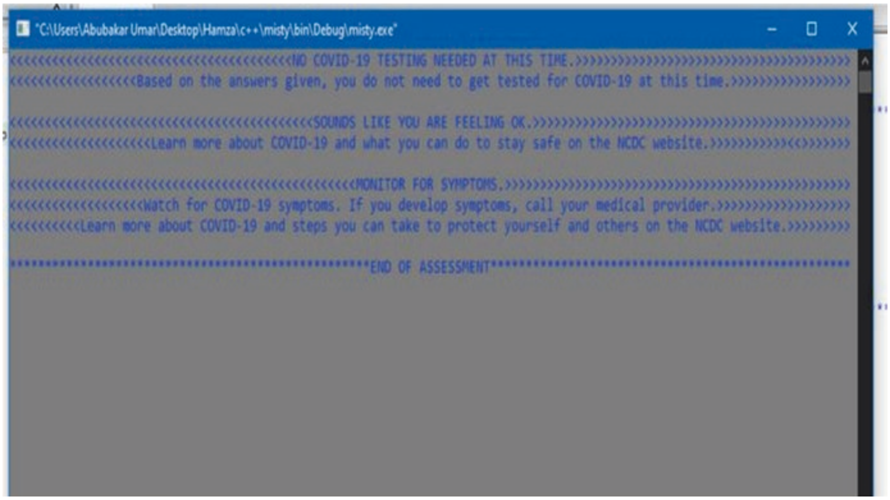

Fig. 7 Self-assessment result – Sample 2

5 Conclusion

In most other parts of Africa, the numbers indicate low levels of COVID19 cases. However, this is partly due to the low level of testing. In addition, many are skeptical of the existence of the virus. Therefore, testing is essential to control the spread of COVID19. If you have symptoms, or if you know that you have contacted someone with suspected or confirmed COVID19, you should be tested regardless of your vaccination status. While there is a self-assessment tool, but it is not on the NCDC web homepage but rather on their coronavirus microsite. And this self-assessment tool is visually unremarkable and small as to make it stand out from the barrage of information on the webpage and coupled with the fact that a lot of Nigerians aren't savvy enough to find their way to the website to conduct the test, it is very unlikely that it has been used extensively by the public. Therefore, this paper proposed a standalone wireless application intended for COVID19 self-assessment while taking into account the NCDC's protocols. The software was developed in view of the current challenges of COVID19 in the world, particularly to help aid self-assessment in the rural areas in Nigeria due to lack of network access for the local people to get the current web-based COVID19 self-assessment provided by the NCDC. Thus, the self-tests can be performed by a person at home or anywhere. This is because many persons infected with coronavirus (COVID19) show just minor symptoms or none at all, they can still spread the virus. Regular self-testing, on the other hand, can help slow the spread and safeguard the most vulnerable members of our families and communities.

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Efficient Fog-to-Cloud Internet-of-Medical-Things System

Mukesh Soni, Sarfraz Fayaz Khan, Dinesh Mavaluru, and Shoaib Mohammad

1 Introduction

The overall budgetary plan related to managing longer infections is brought down during the last 10 years, thanks to technological advancements. Various advancements/procedures include specific regular observing instruments ongoing organs problems. Usage of said instruments accelerated Internet-access, fresh cell phones, enhanced apps also much more. Currently, said instruments in association to most up-to-date applications are linked to telemedicine, also called the Internet-of-Medical-Things-(IoMT). Internet-of-Medical-Things-(IoMT) is an bigger part in the meticulous updating of continuous medical services information. IoMT acquaints several plans of action with the creation and empowerment of variety in work methods, efficiency improvements, cost control, and enhanced customer interactions. Clinical instruction, follow-up, bodily wellness, medical service problems, and more are all supported by versatile applications and wearable gadgets [1]. The new IoMT research has the potential to increase the importance of information examination while reducing the clinical world and allowing for ongoing independent direction. Following that, one fresh batch containing tele healthcare

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consultants would be formed. Said meetings would contain total grasp of abilities & will examine continual medial-reports information. Along with that these will assist consumers in overcoming real-life persistent infections and regaining mental abilities. The Internet allows distributed computing workplaces to be recovered from anywhere on the earth. The Internet of Things (IoT) and distributed computing are largely dependent on one another. Actual organization gadgets fitted with sensors, programming, and organization interfaces that allow the gadgets to collect and communicate information make up the Internet of Things. Clinical informatics is the result of combining data innovation and clinical innovation, and it effectively addresses the deficiencies. Doctors can more easily see how to treat patients more effectively using PCs, the Internet, and various clinical data sets [2]. The use of prosperity data did bring out fresh avenues related to emergency clinics that are better capable successful treatment of sick people, as well as assisting these emergency clinics in smoothing out their current interactions.

IoMT promotes within devices network & continuous information collection, that has a significant impact on healthcare information provided, consistency, & expenses in coming time. Furthermore, person's participation towards decisive calls improves medical care administrations, and IoMT adoption will continue to rise [3]. E_{bb} and flow research in sensor organizations, distributed computing, gadget adaptability, and massive data fields will result in cost-effective clinical devices and a favorable health-care environment. IoMT has a complex and interconnected structure that allows different elements to detect and communicate with one another while also providing constant information to customers. It conveys the connected climate, which combines manual inputs alongside registering-oriented frameworks also employs information-oriented choices selections methods [4].

Sensors with IoMT capabilities regulates proactive actions, living way as well as eating habits. With noticing frameworks related to food, proactive actions and way of living, IoMT instruments have enabled prosperity management. Wearable, implantable, and implanted frameworks, as well as advanced sensor devices, track persistent bodily information on patients' exercises [5]. Clients can inspect and connect various essential exercises with local prosperity conditions using advanced sensor gadgets, converters, and firmware in brilliant gadgets. Furthermore, these sensor devices' remote systems administration capabilities enable clinical master help in crisis situations in any remote location via distributed computing. Continuously monitored data from clinical sensors allows doctors to monitor prescriptions and analyze response during a crisis, reducing the cost of hospitalization [6].

With the rapid evolution of distant breakthroughs, the traditional clinical framework is on the verge of extreme variation. The most common causes of mortality are severe infections; nevertheless, if important conditions develop, traditional clinical assessment is insufficient. Strikes and heart attacks account for more than half of all deaths, according to the review [7]. IoMT medical care with remote correspondences provides ongoing continuous wellbeing monitoring that improves administration quality and lowers costs. It also improves one's ability to predict a certain sickness. The framework's enhancement is contingent on better WBAN. A WBAN is a collection of remote bio detectors attached throughout that monitors human development, temp, also indications from everyday routines. Wireless body area networks collect then analyses continuous data, which is also handled by brilliant clinical servers. The observation of public medical care gives the sense of forming an organization that covers a territory in the vicinity of a community. A successful IoMT organization should be part of a public medical services framework [8]. It is extremely important to bring concerns concerning children's health to light and to educate the society along with younger people on their own about the needs from younger people having delicate thought also psychological well-being difficulties. This has also prompted experts to implement a specialized IoT-based framework.

Outside innovators require landmark structures having optimal apparatuses, called installed setting expectation administration, to build a setting conscious IoMT. Bunched infection and single illness IoMT applications are the two types of IoMT applications [9]. A sickness that affects only one person The Internet of medical things app has been utilized toward single ailment, whereas the grouped illness IoMT application is used for several illnesses at the same time. In light of remote sensor network standards, a slew of non-intrusive clinical sensors has been developed for a variety of clinical applications. These sensors are capable of transmitting the essential data. Wearable clinical sensor devices, on the other hand, have evolved with a variety of needed functions. A Misc. from aforementioned clinical detectors installed in instruments that might be wore is evident. Main foundation for noticing the patient's state since the infection is still at an early stage and may be prevented [10]. The next framework is a wearable clinical computerization device that may provide consistent clinical therapy while also improving personal pleasure. Various electronic-instruments happens to be available, including bright detectors generally worn by person. Said instruments displays a utilitarian structure that is both productive and informative. Close proximity to body gadgets, which are located close to body organs and don't contact exterior layer. Person instruments that close to parts and have a direct line of communication with the external surface [11]. Electronic material gadgets, which are texture-based gadgets that any sick person may accessories (Fig. 1). Inside gadgets implemented within body organ & electronic material gadgets, that happens to be texture-oriented gadgets that any sick person may accessories (Fig. 1).

Here, The range of correspondence of IoMT communications is separated into two categories. Short-run correspondence occurs between WBAN gadgets, whereas long-run correspondence occurs amongst Wireless body area network focal instruments & Operation center.

- Every one of clinical sensors would be coupled with their own group head, also known as a bio-entryway, which divides the entire region into bunches. The bio-main group's task is to transmit collected information towards appropriate BIO-mist, which screens that and then shares that with bio_cloud so that next step is processed.
- For monitoring & detecting, suggested approach comprises three detecting modes: intermittent, rest aware, and constant.

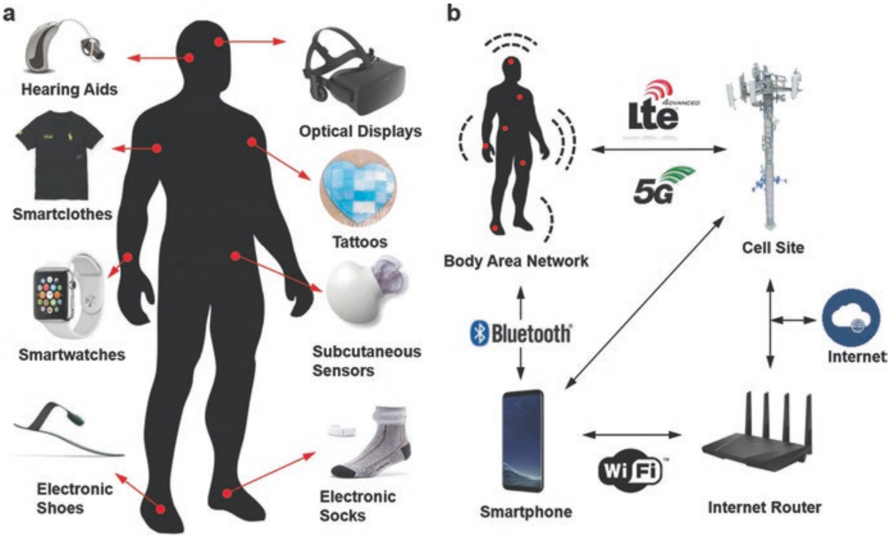

Fig. 1 Smart medical gadgets that can be worn

The following is how the remaining study will be structured: Associated work and issue articulation of the connected work are explored in the segment "Associated work." The suggested study is described in the segment "The proposed an energy-productive FC-IoMT engineering," at which this explains way fog to cloud Internet-of-Medical-Things (FC-IoMT) captures data effectively& processes clinical information. In the "Results and dialogue" part, the evaluations and outcomes of the presentation are examined [12]. Finally, the "Conclusion" portion attracts the ends.

2 Associated Work

Cloud innovations have received a lot of attention as a consequence of their ability to help with the management and handling of large amounts of data. Various shared network oriented Internet-of-Things methods, such as brilliant grid-10 also adaptable distributed computer operations in cell phones, dump difficult computation from low-asset mobile phones to cloud regions before returning the outcome to the cell phone. In the cloud-based clinical frameworks, a number of related research publications have been reviewed. It has been discovered that none of the publications consider all of the benefits and drawbacks of clinical in IoTs. Many studies have recently focused on the advantages of a cloud-based medical services infrastructure. First and foremost, programming as a service provides medical services apps that are anticipated to deal with medical data and other associated actions. Next, stage facilitator creates one platform in which innovators may create and communicate apps. Next, foundation provides virtually accessed assets such as capacity, sharing network, as well as demand-based calculations [13].

Information received from various IoT sensors was often sent to actual server farms through multi-bounce, which might affect inactivity. The organization of cloud-based assets performs numerous tasks in the diverse clinical framework to overcome proceeds with asset redistribution in light of temperamental information over-burden from the medical services frameworks. Mist registering is the greatest option in this condition because it locates excellent and light-weight processing edge gadgets close to the healthcare IoT structure. Switches, and other low-figure devices having computational administration instruments, administrations, and foundation are examples of edge devices [14]. A haze registering system is organized on several levels, with each device having memory for information buffering and handling. The most minimal mist level in a mist-based medical services framework has one app entrance gadget. Any app entrance instrument can receive detected information, analyze that, then transfer it towards higher mist computer instruments to process in next step. Memory, data transport capacity, and other mist assets were profoundly virtualized and shared in a small occurrence framework. A fog-enabled framework enables customers to switch off haze devices when they aren't in use and revive them as needed. In terms of energy usage, the assets of haze registering are managed; they are adaptable to modify as indicated by the application structure. As a result, a haze registering operation would be an optimal energy consuming also adaptive technology. Further consequence, information analyzing may be done near to the edge devices, reducing multi-bounce correspondence idleness and increasing administrative flexibility [15].

In the IoMT, there is an emerging trend in the structure of haze registers. Because Internet-of-things devices show limited computing also organizing capabilities, mobile phones usage is inclusive in this. Mobile phones gives app accessibility then send information towards a cloud server farm, that would be foundation of Internet-of-Things medical care methods.

(i) ***Asset administrator:*** this person is in charge of supervising cloud assets, as well as delivering and monitoring engineering and medical care administrations.
(ii) ***Servers:*** The cloud medical care framework is made up of usage and data base servers, which deal with the planning of asset distribution methods.
(iii) ***Virtual machines (VM):*** The application server's VMs run the most important apps and web administrations.

The data set server's VMs are responsible for a large amount of medical information. The whole cloud-based Healthcare application paradigm is depicted in Fig. 2, where sensors begin monitoring and sending verified information to the dazzling gadgets following the introduction and verification. The cloud framework executes information deliberation, investigation, and evaluation after the brilliant gadgets deliver observed data to it. The cloud framework delivers warnings or cautions to clever gadgets after evaluating the data [16].

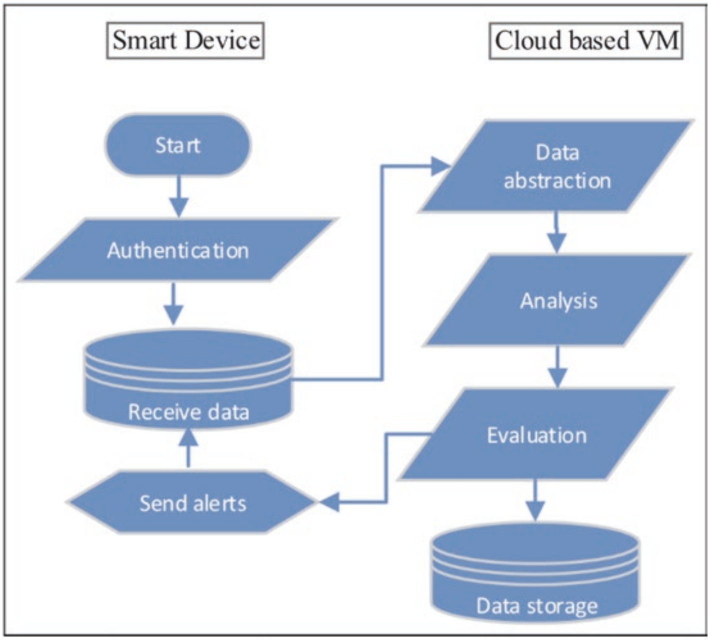

Fig. 2 CBS's health-care system

The issue in broadcasting system framework might be By respect to limitation, capability, & relationship, mist formations vary with data center formations, hence broadcasting system give up interoperability if utilized in mist climates. Furthermore, when the CBSs get information for various patients, they transfer it to the cloud, which deliberates, investigates, and assesses the material. It's also a good idea to send out cautions to your journalist clientele. When a cloud does these tasks for some customers, the cloud framework's presentation may deteriorate and a delay will occur. Dealing with the client's requests in a timely manner would be difficult.

To operate with CBS in a haze environment, a haze-based IoT-medical care arrangement structure with cloud mist administration reconciliation within inter-operable medical arrangements, like described within Fog-Cluster-based Internet-of-Things-Healthcare, was presented (FCIH). Figure 3 shows a summary about inter-operable mist-oriented configurations [17]. The lower-level mist hubs exist closer to the IoT, where mist gadgets are grouped in a logical order. As a result, a reduced level haze device may be regarded an entrance for a specific medical services arrangement. An entrance device can deal with the observed medical information or move towards higher mist instruments. As per process, various instruments with the similar also varied mist form one clump between each other using enhanced organizing principles. Few gadgets in a group are responsible for running programs, while others serve as a host data base or manage communication with other groups. Typically, each mist bunch is in charge of a certain medical services contract.

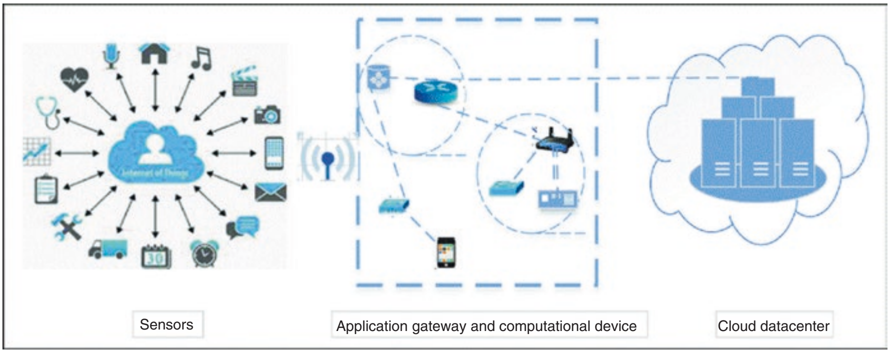

Fig. 3 Compatible CBS

Systems administration gadgets are those that do not belong to any of the groups in this engineering. The group leader is in charge of all correspondence both inside and outside the group. When a gadget gets data in a group, it coordinates the significance of the data with the associated medical services arrangement and glows the bunch head. In light of the alert, the group leader transmits information to process for next step. One issue in FCIH is that this uses extra power since these conducts bunching then choses one group leader outside of total gadgets on various standards, also said method distributes various actions (authoritative assignments such as planning, handling, and putting away) to various gadgets. If a haze device is only responsible for one medical services arrangement and executes in more than one group, it will demand more resources and cause delays for the other medical services arrangements.

It was discovered that wearable clinical instruments had in limit stored energy, adaptable development, also gathering-oriented movement. Natural sensor power sources need to be replaced after a certain amount of time. The framework's major flaw is aid disengagement and information mismanagement. The battery replacement for embedded sensors is quite disorganized. The other major challenge is portability, as WBAN is dynamic and frequently changes its geographical location. Several biosensors along an entrance device are moving at the same time, which is referred to as a group. If there are several groups travelling uninhibitedly in the same place, there will be an impediment. Because biosensors can only communicate with each other at specific frequencies, when transmission distance surpasses frequency, there'll be a blocking. Battery life is reduced as a result of traditional planning tactics that filter the channel as often as feasible. In this vein, a low-energy Internet-of-Medical-Thing's network is required. Biosensors can't always convey information to the primary device directly since they're worn, implanted, or attached to the client owing to energy and design limits [18]. In this situation, a device that can modify the energy while also lowering responsiveness therefore delaying Internet-of-Medical-Things organization is required.

3 Planned Energy-Efficient FC-IoMT System

Figure 4 depicts the general layout of the suggested energy-efficient FC-IoMT engineering, which includes bio-sensors, bio-entryways, bio-fog appliances, with a rear bio-cloud framework. Such appliances have been referred to as bio-gadgets since they are kept for therapeutic purposes. This engineering refers to a framework for depicting real-world devices, their capabilities, tactics, and standards. The biosensors scan the surface also transfer an observed information towards locked bio-entryway, which uses information deliberation to extract the essential data. Bluetooth technology is used to connect biosensors and a bio-gateway. A bio-entryway associates with bio-cloud with Wi-Fi, and it gets the cited information and sends it to the bio-haze towards upcoming research along with management. The bio-fog has also been associated with bio-cloud via Wi-Fi, which provides a client application platform as well as other services like as capacity, investigation, evaluation, alerts, and reporting. End users, such as clinical professionals, may access real-time data and clinical history via a bio-cloud [19].

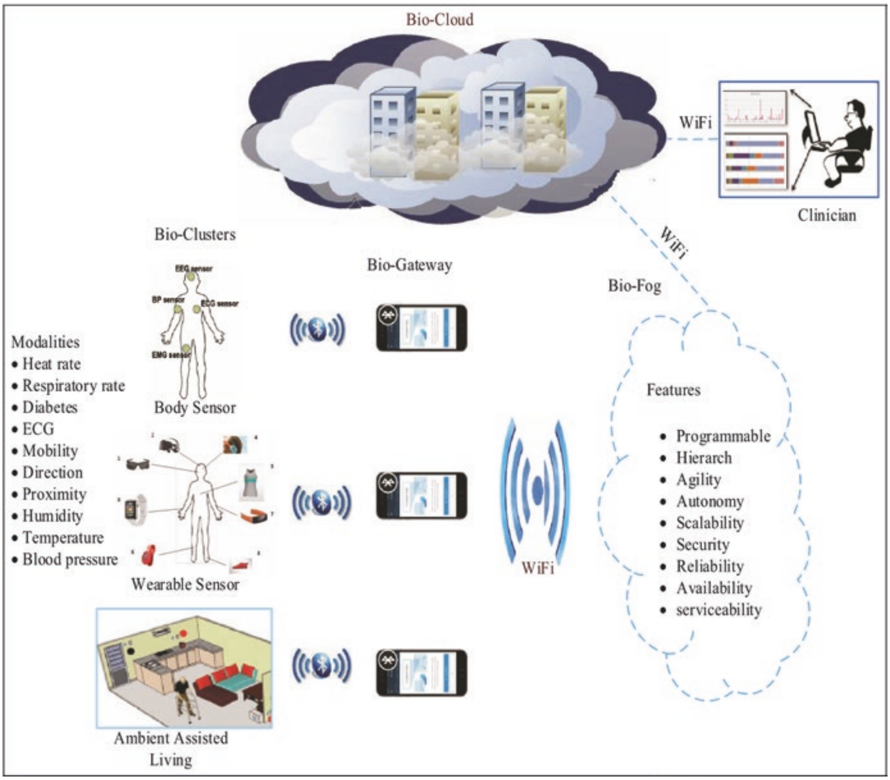

Fig. 4 FC-IoMT framework

In terms of inclusion range, the Fog-to-Cloud-Internet-of-Medical-Things correspondence has been divided in a pair: short reach and long reach. The long-range correspondence displays the correspondence among Wireless-Body-Area-Networks focal gadget along with Wireless-Body-Area-Networks-base-station, whereas the least-area correspondence shows the correspondence between WBAN devices and focal gadgets. Least-area correspondence connections are normally established between sensor gadgets and the focal information managing gadget in the WBAN structure. The least-area equipments make application of BT, and the focal gadget works like a geographic hub, connecting alternative BT-facilitated-sensors. BT innovation has a range of 12 meters, that likely to be enough to WBAN. BT uses very little energy since it operates on a 2.5 GHz frequency. It also has a short idle time (4 milli second), a fast information ratio, and strong safety. The amount of power used likely to be quite lesser. A 185 milli-Ah button-cell might run a BT-chip approx for a span of 20 hours and make 22 million transactions, according to research. While a chip was turned off when it wasn't in practice, the cell span was extended. BT has been strongly suggested with the clinical sensors along with suitable equipment plans also lesser energy utilization. This provides resistance for obstruction as well as a variety of security strategies.

This region has been partitioned in bunches, as per the Fig. 5, as per applied FC with IoMT engineering. Sensors have been linked with bio-entryway, those functions similarly to a compressed. Correspondence may be managed locally using the bundles [20]. The bio linkages accept the discovered information and transfer it to a particular biocluster after that to the biocloud towards next workings. The suggested FC associated IoMT selectively distributes client appeals to FC associated IoMT engineering. Bio-entryways are integrated with mist devices become efficient also

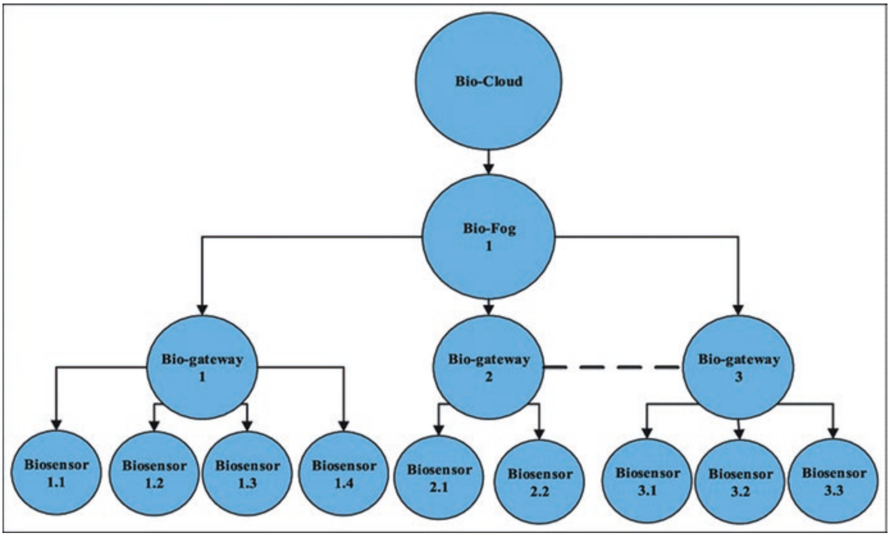

Fig. 5 Fog-to-Cloud-Internet-of-Medical-Things-hierarchy

reduces FC associated IoMT idleness. Bioentryways can respond and augment information quickly, reducing FC-IoMT inactivity. The bio-mist can connect several entryways from a single location, while the biocloud might associate multiple bio-mists to various areas.

It is often assumed that there are k number of bio-gateways $G = G_1, G_2, \ldots\ldots\ldots, G_k$, each with l number of linked detectors $S = S_1, S_2, \ldots\ldots\ldots., S_l$. The asset data and acquired information are sent from the biosensors towards bio entryway, which executes an information deliberation and forwards the information towards bio-mist [21]. Bio cloud has been really situated in neighborhood districts near specific bio-cluster, where they have access to a variety of bio-cloud assets to carry out their requests. In various areas, there are j number of bio-mists $M = M_1, M_2, \ldots\ldots, M_j$. A district is divided into many groups, each with its own bio-entryway. One district has a biohazard with virtualized equipment assets. Memory capacity, processor, data transfer, load balancer, virtual machine screen, and so on are examples of these assets. There are multiple virtual machines in a bio-haze. $V = V_1, V_2, \ldots\ldots\ldots, V_k$. A virtual machine screen is capable of executing several working frameworks and serves as a point of interface between the virtual machine and the working framework. Bio-hazes are devices that sit in the midst of the bio-entryway and bio-cloud spectrum. Condition (1) may be used to calculate the absolute number of solicitations S_a from k bio-entryways as follows:

$$S_a = \sum_{p=1,}^{k} \left(S_p \right) \tag{1}$$

Determining overall handling span (Ht), data on almost all requests and related virtual machines must first be gathered. The situation with a solicitation is depicted with γ. $Ht_{p,q}$ of assigned demand p towards VMq could therefore be found as:

$$\gamma_{p,q} = \begin{cases} 1; if\ application\ p\ has\ been\ assigned \\ \qquad else\ 0 \end{cases} \tag{2}$$

$$Ht_{p,q} = \frac{p^{th}\ duration\ of\ the\ inquiry}{q^{th}\ capacity\ of\ virtual\ machines} Hu \tag{3}$$

$$Hu = P_T + E_T + P_T \tag{4}$$

where Hu denotes the underlying responsive time, P_T is the postpone time, E_T denotes the end time, and P_T denotes the presence time. Hu likely to be span saved with biocloud in getting solicitations from bio-bunches, as shown in Condition (4).

Bio-mists are stationed around the country to collaborate with local bio-bunches, reducing reaction times and increasing asset distribution efficacy. Bio-cloud transports the essential assets and improves overall efficiency [22]. Bluetooth-enabled clinical sensors were used in accordance with the planned FCIoMT protocol. In the demonstrative and clinical gadgets, Bluetooth innovation has shown to be an ideal remote innovation. It's frequently seen in high-tech gadgets and is generally accepted by the medical community. Because of their energy efficiency, Bluetooth-enabled bio-gadgets are becoming more incorporated into devices that patients may ingest, carry, or wear. The usage of Bluetooth was advantageous since it enabled sensor devices to operate in a rest-conscious mode in relation to the occasion and time. The following modules are included in a biosensor:

I. Microcontroller: A circuit that includes memory, a CPU, an input-yield, and a sensor. Executing clear activities is trustworthy. It is safe to interact with the transduced signal and display it. Intensification and sign transformation are performed by the complicated electrical circuitry.
II. Serial fringe interface (SFI): It serves as a point of connection for local communication across short distances. Biosensors using SFI may now communicate in full-duplex mode. Biosensors are regarded slave devices by FC-IoMT engineering, whereas bio-entryways are called expert devices. SFI has been recommended due to fast information transfer and low energy decay.
III. mRF24L01_module: The μc collects a unique information and conveys it to the mRF segment via SPI. It consists of a receiving wire and an integrated circuit. The mRF24L01 was chosen because it is well-suited to the clinical and logical recurrence band. Uplink is the correspondence interface that delivers information; downlink is the correspondence interface that receives control messages.

Following the introduction and filtering, the biosensors choose the appropriate observation mode. “Intermittent, rest conscious, and constant” are the three detection modes identified by FC-IoMT. Observing is done in period mode in light of specified periods; this approach uses a lot less energy [23]. This mode’s observation times are set in stone. The intermittent mode keeps a safe distance from biosensors on the rise, reduces inactive time, reduces information misfortune, and reduces effect. More energy can be saved when biosensors screen occasionally, but we cannot recommend it for actual patients.

In the rest conscious mode, observing is carried out as previously indicated; nevertheless, a few useful modes are switched off, and it is made competent to respond to requests. The rest conscious solves the problems of information transit and decay in power. Application to biosensors with the rest conscious approach demonstrates energy efficiency [24]. The main goal of this approach is to save energy, extend the life of the organization, and reduce the amount of time it takes to complete tasks by using a streamlined rest conscious mode. Prior to entering the rest conscious mode, this likely to be mostly recommended that you observe the power state of your bio detectors. Such power level displays the resting power of bio detectors; if the excess power exceeds the transferrable power limit, rest conscious approach is often applied. As the rest of powerlies in the area network of transportation force also reaches a limit, bio detectors would simply convey the information. If the resting power of a bio detector exceeds the communicate and receive power limit, the biosensor will be regarded a dead hub that can’t screen or transmit information. It is assumed that all of the devices in the company operate at the same time, also detectors could detect these events and predict how much power has been left behind [24]. The following are the assumptions for every bio detector’s observation and advancement among organization: fundamental energy J (in Joules), observing span O_r (in centimeters), information parcel amount A (in bits), also communicate Span C_r (in centimeters). The consumed energy by the bio detectors for information transmission is shown in condition (5). Condition (6) depicts how biosensors use energy to obtain information.

$$J_{Tr}\left(A,l\right) = A * J_{req} + A * J_{com} * l^2 \tag{5}$$

$$J_{Rcv}\left(A\right) = A * J_{req} \tag{6}$$

Here A denotes an information parcel amount and J_{req} is the required energy in transformation of information. $L * J_{com} * l^2$ increases due to information transfer, where l is the length among the detectors and entrance.

Next phase does the constant observation, which is highly recommended in the event of a crisis, despite the fact that it uses more energy. When all of the biosensors are connected to their respective bio-entryways via Bluetooth, the biosensors begin capturing data and saving it as the earliest in, earliest out route in a cluster. The cluster is currently filled, and information is being transferred off to bioentryway using GATT_UART ideal support. Such aid has been applied as it gives the information on the site, identity, and activities of the integrated components [25]. The GATT_UART account solicitation could be changed with contacting the capacity, which is described by GATT_UART Service header. Adjustments have been sent off the bio-entryway after these have been renewed. Bio-entryways are fantastic devices that come with Android apps. The Message Queuing Telemetry Transport (MQTT) convention is used to organize bio-entryways and bio-hazes since it is specifically designed for mist and IoMT devices. In light of the subject and message type, it can cleanse the essential information. After a successful MQTT setup with a secure attachment, the gadgets' IDs and passwords were assigned to buy in or distribute for further security.

Neighborhood mode and unfamiliar mode have been enabled by the FC-IoMT bio-entryways. The neighborhood mode displays all of the data obtained by bio detectors with BT joins. An unknown manner is becoming a component to sensor with bio cloud extension [26]. The observed information is refreshed every 100 milliseconds by an Android-based bio-entryway, which then routes the data. After receiving the important basic information, the bio detectors deliver the information as a byte-cluster structure, which is then sent towards bio cloudto upcoming process. The biomist evaluates information and presents it in a more organized fashion.

A bio-haze collects data from a number of linked bio-bunches, differentiates groups with basic information, and sends it to the biocloud over Wi-Fi to quick selection with clarifications [27]. This consists an ability of showing the doctor and patient results for evaluation. A bio-cloud verifies clients and schedules appointments for them. Following the completion of the client confirmation procedure, the client can download and transfer fresh data in light of IDs. A client might be a patient, a doctor, or someone else who has been approved [28]. These customers may access information at any time and from any location. Figure 6 depicts the construction of the proposed FC-IoMT.

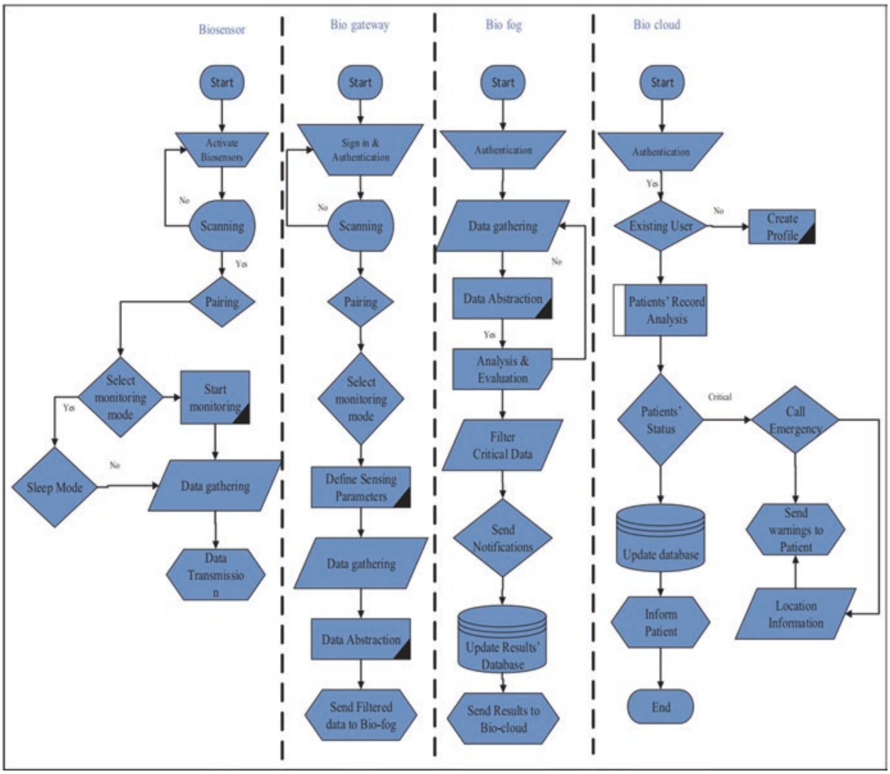

Fig. 6 Bio-sensors channel collected data to the FC-IoMT architecture for assessment

4 Results

4.1 Evaluation Metrics and Modeling Factors

The presentation of the proposed FCIoMT is explored through reenactment in this part. It demonstrates that a patient does not need to use additional energy at the emergency clinic in order to receive a prompt response from the doctors [29]. We have replicated the FC associated IoMT engineering and analysis with the cloud and distributed processing to prove the achievability. The outcomes of the CBS and haze cluster-based IoT medical services are compared (FCIH). The suggested structure is inextricably linked to CBS and FCIH procedures. Table 1 summarizes the reproduction limits.

The company's innovation connects patient sensing devices to remote locations and controls the delivery of observed data. These innovations were included into BT lesser power, Wi-Fi, cell, Zig-Bee, also other technologies. IoMT consist of remote advances that are simple to comprehend and allow the customer to roam around freely [30]. In most situations, remote monitoring devices are seen as having a more

Table 1 Modeling factors

Observing data	Parameter	
System layout	Complex	
Evaluation span	9 minutes	
Evaluation surface	250x250 m^2	
Span of sensing	350–700 milli seconds	
Rollout	Polygon and regular	
Bit dimension	Single	
Bio-clusters' count	5	
Infected persons in each cluster	8	
Bio-sensors in each cluster	30	
Generalized transmission span per packet	8 milli second	
Battery-capacity	600 mAh	
	Criterion	**Count**
Generalized consumption	J_{Ei}	6 milli amp
	J_{Ec}	6 milli amp
	J_{Ere}	250 nano amp
	J_{Eca}	25 milli amp
Battery-criterion	n—a	1.05
	n—b	1.10
	KiJ—k	$4.6x10^{-6}$
	KiJ—c	0.7

user-friendly structure, seeming to ill persons or clients being much comparable to wearing engineering as compared with clinical equipments. Patients are most likely to use gadgets when they appear to be health-related devices. Clinical wearables, such as a wristwatch, dazzling texture, diabetics observing equipments, beat counters, e-cardio strips, and a variety of alternative equipments, are generating a lot of attention [31]. More client companionship, efficient data collection, and effective remote monitoring are all part of the current healthcare gadget craze. Distant health monitoring, as opposed to a specialist's facility or an emergency clinic visit, focuses on individuals assessing the self-diabetic count, circulatory strain, leveled O_2, also rest situations in their own house. As IoMT respond appropriately to such contact also use remote connections to convey information to the medical services association's foundation [32].

4.2 Experimental Outcomes

In medical services applications, network delay is a big barrier; as a result, it is very important to determine the organization delay [33]. A few applications are trustworthy in health-monitoring frameworks for capturing sound/video information from patients and communicating [34]. If there is a postponement and information does not arrive on time, it may result in what is now occurring [35]. The start to finish network delay is defined as the time spent transmitting information from one end to the other, and it is governed by condition (7) [36].

In overcoming to lagging, bunching processes dependent on the situations are applied. Various bio detectors from the group collect information and convey it to the appropriate bioentryway [37]. We employed three techniques of identifying the information to avoid delays (intermittent mode, persistent mode, and rest conscious mode). If a fundamental condition occurs during the perception of a patient for 24 hours, bio detectors activate the persistent condition [38]. Over the patient's general state, while information isn't needed on a regular basis, biosensors switch to an intermittent mode, accumulating and sending data after a certain amount of time. Rest conscious mode is activated when information is expected on demand [39].

The FC associated IoMT investigates an information towards bioentryway and relays the enhanced information for bio cloud [40]. As the bio cloud gets enhanced information by numerous groups in various locations, it may easily carry out its handling and transmit information towards the biocloud in upcoming processes and options [41]. Earlier algorithms CBS with FC-IH take longer since they execute bunching depending upon same or othercloud segments and opt a group leader among the accessible equipments at varied segments. FC-IH enhances an information at haze equipment, which will eventually require some investment in making simpler and transfer towards cloud in upcoming process. As per the earlier FC-IH, certain equipments collect information while balanced have been defined authoritative processes such as planning, managing, and storing [42]. Figure 7 depicts network delay; the diagram depicts the regular postponement from biosensor! bio-entryway is a term used to describe a bio-entryway→ bio-mist→bio-cloud. The graphic depicts the usual organization delay for up to 35 patients in various bunches, each with a different number of sensors. The results show that postponement

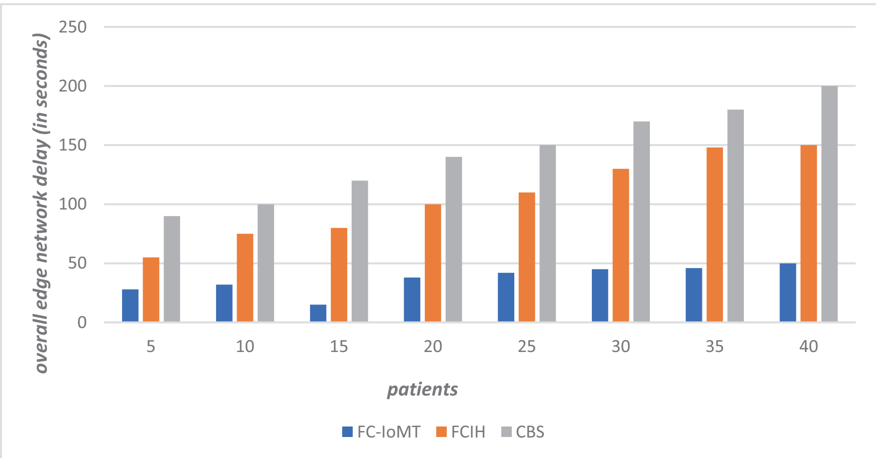

Fig. 7 Various patients' observation resulted in an overall edge network delay

increases as the number of patients increases. As the number of patients grows, so will the number of sensors, and they will ultimately set aside span in settling the equipments and form latest systems.

$$\begin{aligned} \textit{Network latency} &= \textit{Data packet timeframe} \\ &\quad - \textit{data packet commencement time} \end{aligned} \tag{7}$$

The best way to transmit information is to use as little energy as possible. In comparison to CBS and FCIH, Figure 8 shows the FC-energy IoMT's usage rate [43]. When the transmission rate of the sensors increases, the result indicates how typical energy use changes. The planned FC-energy IoMT's usage rate for transmitting various data is not identical to the CBS and FCIH. A wasteful grouping, in which each hazy device is only accountable for a certain medical care arrangement, which executes more than one bunch, is the reason for the higher energy usage of previous FCIH. The task of the organization hub will be performed by unconnected gadgets that have no group. In comparison to earlier technologies, the diagram shows a greater representation of FC associated IoMT [44]. A productive bunching and information deliberation strategy explains the optimal presentation of FC-IoMT. It initially deals with the information set at the bioentryway, and eliminate the workflow and focuses to medical services information at the biopassage with the biofog. Lastly, it sends the most recent assessments to the biocloud in upcoming process.

CSDA with impact aversion convention is applied, which allows a company to simplify its assets, notably energy usage. The amount of consumption by an FC associated IoMT equipment is determined by the counts of processes completed with the equipments in conveying the information. In condition, here are energy-barriers observed as four. As a consequence of various observation techniques in light of patients' situations, the results demonstrate that energy use increases at first, then begins to decline after 200 milli-sec [45]. The organization used more energy

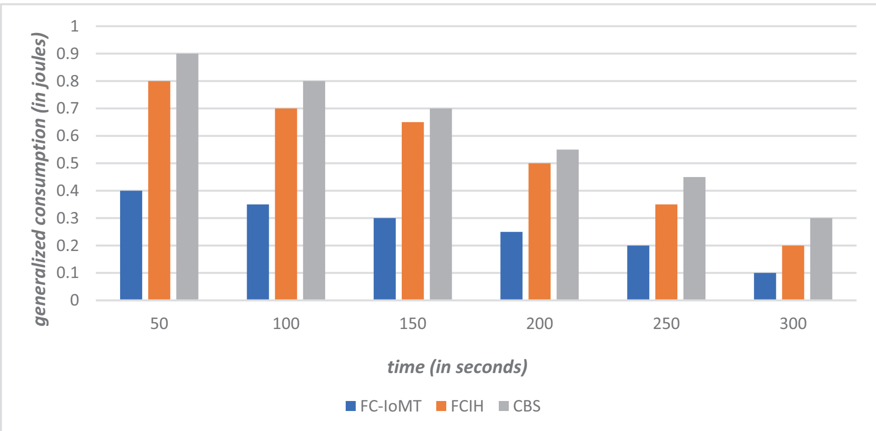

Fig. 8 Over the timestep, the averaged energy usage rate per frame

when consistent modes were set, because the persistent approach is used throughout a fundamental state of the patient, while this had been extremely important in regular scanning of the patients. From the point on, the intermittent approach was used in observing the status of the patient because it required less energy than the consistent mode. Finally, we entered rest aware state, and it was discovered that the overall energy use of the organization was poor.

$$J_{Ec} = J_{Ei} + J_{Ere} + J_{Eca} + J_{Erc} \tag{8}$$

J_{Ec} represents the overall consumption of energy by the FC associated IoMT equipment, J_{Ei} represents the overall energy consumption in transformation of information, J_{Ere} represents the total energy consumed for information retransmission, J_{Eca} represents the consumption of overall energy in accessing the channel, and J_{Erc} represents the total consumption of energy for bundle affirmations.

When compared to other techniques, the FC associated IoMT throughput assessment findings, represented by Fig. 9, yielded the greatest amount of information bundles [46]. The throughput was seen in relation with detectors' count; the throughput grows for a lesser count of detectors, but when more sensors are added, the throughput gradually decreases due to the heavy burden. A postponement might be the cause of the decrease in throughput. Biosensors-bio-gateways-bio-mist bio-cloud biosensors-bio-gateways-bio-mist bio-cloud biosensors-bio-gateways-bio-mist bio-cloud biosensors-bio-gateways-bio-mist bio- One bio-entryway collects data from all connected biosensors and sends it to the bio-haze. Though a bio-mist receives data from a number of interconnected bio-entryways, a single bio-fogmust bear the brunt of the burden. Bio-haze isn't just responsible for moving data; it also has to carry out its own tasks in terms of information deliberation and processing. So, if there is a large amount of data to process, there may be delays and

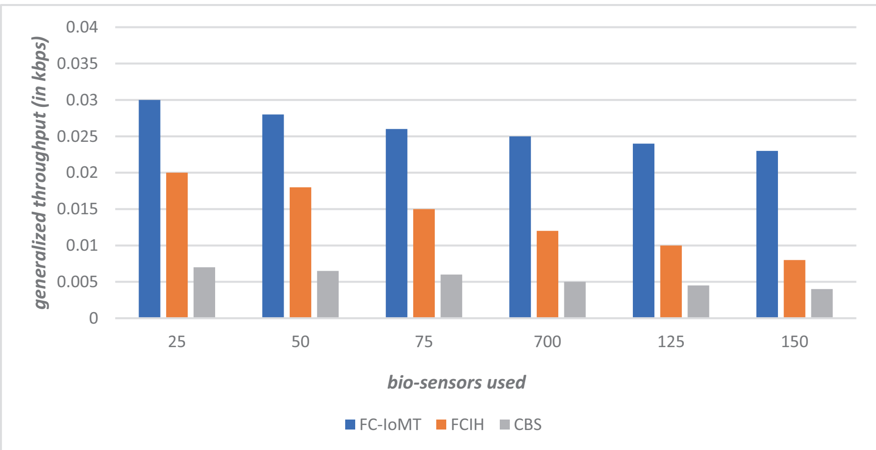

Fig. 9 Network throughput evaluation with bio-sensors

disagreement, resulting in the loss of a few packages [47]. There are two primary causes of bundle misfortune: The first is the expiration of the package lifespan owing to predetermined transmission attempts, and the second is a Bluetooth interface blunder among sensors and entrance gadgets. It may occur as a result of retransmissions or postponement [48].

As can be observed from the results, even with the same amount of sent information bundles, the received parcel rate differs across all tactics. When compared to the FCIH and CBS methods, the suggested FCIoMT has obtained the maximum number of information parcels because FC-IoMT efficiently processes the information throughout each period of information handling. It's a crucial component, especially when it comes to telemedicine and IoMT-based frameworks [49]. It is critical, as the necessity to be on time at their predetermined closures in the most notable information rate may develop. Throughput/passed information by system is a measurement of the average rate at which data packets are received through a communication channel in relation to the total number of information packets sent. It's possible that the concomitant condition determines it.

$$\text{Throughput / passed information by system} = \frac{\mathit{Information\ Intake}}{\mathit{Information\ Sent}}$$

5 Conclusion

Intelligent components have been emerging as a lesser energy, lesser expenditure, along with easily accessible solution in rapid evolution to healthcare utilizations. Afterall, a true capacity to dazzling cell phones in clinical thing scenarios on the Internet should be thoroughly studied. Here an energy efficient FC associated IoMT engineering is discussed, where a collection of dazzling components is envisioned that collects and analyses clinical data. Biosensors and bio-haze are connected via a bio-entryway, which allows for two modes: unfamiliar and familiar. The familiar mode uses Wi-Fi to build connections between bio-entryways and bio-haze, and then between a bio-haze and the bio-cloud, while the neighborhood mode uses Bluetooth to link biosensors and bio-mist. FC-IoMT uses three detection modes to make it an energy-efficient procedure: intermittent, rest conscious, and constant. Various modes are gradually begun during reproduction, depending on the patients' conditions. The resting sensors analyze their napping plan based on the residual power, which achieve a benefit to conservating energy. Identified information is sent on to the major mist with the cloud-gadgets for upcoming process. A FC associated IoMT presentation has been observed by reproduction, also the outcomes have been analyzed with outcomes of earlier observations. It's discovered as the bio detectors have greater power to pull out the existence of the entire organization. Because biogateway may swiftly advance information, a biofog has been inserted among bioentryways for inactivity streamlining. When the reproduction outcomes to FC associated IoMT have been observed with earlier, this is clear that FC associated IoMT likely to be a successful process, as it effectively collects information with the bio detectors also spreads the patients' demand in biocloud-based engineering. The fundamental patients' situations and crises can be educated on schedule to the clinical experts using FC-IoMT engineering in day-to-day clinical frameworks to avoid real results.

Later on, computational reasoning can be used to predict information overload and organizational deficiency. This seems to be critical as bio cloud comprise the prototype, which anticipates and manages the patients' flexibility and entryways.

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