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Smart Healthcare System Using IoT, Cloud and AI/ML

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Abstract

This survey presents various insights on the IoT system and its architecture used to implement a smart health-care system, along with the implementation of the latest technologies such as Cloud Computing for storing data, Machine Learning for predicting various diseases. These technologies are also used to improve the existing management and administration system in hospitals. Various solutions for tackling the health-care crisis have been proposed most of them sound promising but a practical low-cost implementation and feasibility of IoT and ML integrated system is yet to be designed. The present chapter also deals with the standard protocols designed for body area networks for health monitoring applications. The IEEE 802.15.6 standard is used for the body area network which provides high data rate and low-range communication. The integration of the standard body area network protocols with 5G technology can be used for high throughput real-time reliable operations.

Keywords: AI/ML, Health-care, IoT, Machine Learning

1 Introduction

Health-care system has always been a top priority in everyone's life, while the development of infrastructure and technologies used in health-care have been improving every year, it's not affordable and accessible to everyone, and rural places lack basic health facilities. To bridge this gap, this article looks over some of the proposed solutions to implement and improve the e-healthcare system so that we can help people who do not have access to basic healthcare by providing them with one.

In this survey, we go through various solutions proposed by authors using the latest technology such as Artificial Intelligence, Cloud, Internet of Things and Machine Learning. Let us see how each of these technologies is used to build a healthcare system. In some countries, paper-based storing of reports is still being used. To go to a completely paperless and hassle-free management and administration system, we investigate how cloud computing takes a major role. These days due to less qualified and fewer assistants available to support doctors and patients. AI/ML models can be used in health systems to predict diseases in their early stages and in managing the records of a hospital to make the system more elegant with less human error. Now, that we have seen how these technologies can be used in hospitals, we shall further look into how to integrate these technologies with IoT to make a compact healthcare system. In the year 2016-17 we came across how IoT is used to build smart healthcare systems, all these systems are driven by a microcontroller. There are several low-power, low-cost microcontroller units present in the market with their own advantages and disadvantages. Various sensors are used to check the patient's body parameters. Once the data is collected it is processed by a microcontroller and then to a server for storing those sensory data. In this survey, we see solutions proposed by different authors using IoT and then integrating IoT with AI/ML and cloud technologies.

The purpose of this survey is to find the best-optimized solution for the upcoming smart hospitals. This survey gives us information about the sensors, processors, machine-learning algorithms and other components; we may need to achieve an efficient and affordable system. As we intend to work on making a personalized e-health care system where patients with different diseases can customize the system s as per their requirement, all the data collected from the sensors will be uploaded on a server where the data is simultaneously compared with threshold values of the data. A machine-learning algorithm is run throughout the data to check if there are any irregularities; if such exists it gives feedback or alerts doctors so necessary precautions can be taken.

Furthermore, this article presents IoT-related work in section II. In section III, we are discussing AI/ML and cloud-related work in IoT. Section IV, discusses the timeline of IoT-related technologies. Section V deals with health monitoring body area network protocols. Finally, section VI and section VII deals with the conclusion and future scope.

2 Literature Study

A health monitoring system proposed by Yuan Falee et. al. [1], where a patient can share his health readings such as blood pressure, Electrocardiogram (ECG), glucose level on blood etc. via a platform which is connected to the internet i.e., IoT using this platform doctors can monitor the patient's data on a regular time interval and also a patient can share his data to a different doctor for a second opinion. The data is collected through individual components which are connected via Bluetooth and smartphones. The author proposes a completely interconnected hardware and software setup

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which uses a microcontroller and a healthcare system, these are connected to a system host, and the system is connected through the internet to a server where a patient can consult a doctor without visiting the hospital. In 2016, an idea for tele monitoring health-care system within the hospital was proposed by Vikas Vippalapalli et al. [2], where they established a Body Sensor Network (BSN), which connects various sensors present in a human body, the sensory data from each sensor are collected through Arduino transmitter and wirelessly transmitted to Arduino receiver, which can be read in LabVIEW. In the LabVIEW, the sensed data is compared with the threshold values, if such a condition exists where the sensed values overcome the threshold values, an alert is sent to doctors. Thus, the system helps the doctors in attending to the patient as soon as possible in case of an emergency.

In 2017, a paper was presented by Jian Qiang li et. al. [3], in which a new approach to continuously monitor blood pressure was used. It was done without using mercury-based analog blood pressure instruments and modern pressure sensor-based BP meters, which are best suited for taking instances of blood pressure reading. The author proposed a model (that can be implemented and tested using both hardware and software) to continuously monitor blood pressure using ECG signals and pulse waves, which can be measured easily with the help of smartwatches or ECG sensor devices.

In this paper, the author describes a model whose function is to collect the pulse waves that are generated and passed through the vessels to measure the shallow surfaces of multiple arteries and usually the measurement of the radial artery at the wrist is easier and in the process of ECG signal acquisition is done using an ECG sensor and these two signals are amplified and sent to hardware processing where noise filtering takes place and certain signal processing takes place where the author uses continuous wavelet transform to detect extreme and abnormal signal points [3].

An e-healthcare system was implemented by S. Lavanya, et al [4] which can be used for emergency medical services. It helps to reduce health-related costs and improve risk analysis by recording, collecting, and analyzing data in real-time and efficiently. It just focuses on the heartbeat rate of the patient. The data collected from the patients is stored on cloud. Raspberry Pi processor is used as it provides a combination of features of a traditional computer and an embedded device.

This concept consists of three parts- Smart medical services, management and cloud integration. The heartbeat is measured using an ECG sensor and is fed to Raspberry Pi and then to a computer for analysis. The data is sent to patients and their corresponding doctors through a text message using GSM. The doctor can see full sensor readings with time stamps using cloud storage.

The concept of solving health care issues by using the latest technology was also depicted by Durga Amarnath M. Budida et al. [5]. As people these days do not visit hospitals for general check-ups frequently, due to time constraints, this leads to a rise in the load of health issues and people in rural areas are deprived of basic health facilities. In [5], proposed a solution for this problem with a two-part functional building block, the main block consists of a Microcontroller ATMEL89S52 and a few sensors (like ECG, temperature sensor, pulse rate sensor etc.) the microcontroller collects all the sensory data required to monitor patient's health, whereas the second block stores all these data on MySQL database server, so that the doctors can access it. A web user interface is built, where the patients are registered, once registered they get login credentials, and with this, they can access all their health reports anytime, on this application patients can log all their data collected from the sensors, once all the data are uploaded, they can expect results from the doctor who also has access to this data.

To make this healthcare system more efficient and reliable, Soumya Yattinahalli et. al. [6] proposed a novel idea for a health-care system using an IoT model. Real-time data of patients is uploaded to the cloud from the sensors using Raspberry Pi 3, if any data exceeds the threshold, the cloud server warns the patient about the climate of the location which is affecting them and helps them to locate nearby hospitals with information such as the availability of physicians. This paper also talks about the security and cost-effectiveness of the individual's data by using cloud technology compared to the traditional use of servers.

A condition like Type I diabetes can also be monitored as described in the system by Peng Zhang, et. al. [7]. In Type I diabetes the blood glucose levels are very hard to keep in control and to keep it under control a patient has to be very careful with his diet, physical activity etc. but the control depends on the behavior of the patient, also stress factors do matter. In [7], proposes a software application where the user must record diets and physical activities and also about their mood swings etc. in the Application Programming Interface (API) which is in the smartphone. In addition to that, glucose meters and parents' devices are connected to the internet. All these data are stored in a cloud and if any sudden changes in glucose level it notifies the parents or doctors to take care of the patient.

For a well-operated healthcare system, storing information is very important. To do this, Shiva Rama Krishnan, et al [8], developed a health monitoring system which shows and transmits a patient's temperature and heartbeat with timestamps. It consists of microcontroller, Heartbeat sensor, temperature sensor, LCD display, Wi-Fi module, buzzer and a website used to display information. The microcontroller being used is Arduino Uno with an ATEMGA controller. A benchmark analysis is done between different microcontrollers and Arduino Uno is preferred mainly based on cost. The temperature sensor used is Lm-35 and an ECG sensor is used to measure the heartbeat (BPM). The Wi-Fi module used is ESP8267, which offers a self-helping Wi-Fi structure administration.

For monitoring the health of the elderly daily, a system was designed by Ashwini Gutte et. al. in [9] by using a basic MQTT protocol of IoT. In this proposed system Raspberry Pi 3 Model B, which has onboard Wi-Fi, Bluetooth and USB boot capabilities, various sensors are connected to this board, data collected from these low-power sensors are processed and stored in an IoT server, which can be accessed by doctors to review and provide necessary prescriptions. An alert system is built, and in case of an emergency, an SMS alert notification is sent to targeted users, when values from the sensors go beyond the decided range.

To prevent future epidemics, Prajoona Valsalan, et. al. [10], designed a healthcare system that could check and control the instrument that screens and monitors patients' condition and stores the data. Authorized personnel and the patient can use the IoT platform to access these stored data. Based on the values received the disease can be diagnosed by the doctor remotely. A system which consists of monitoring sensors, a control unit and wireless communication. In this, the sensors used are temperature sensor, heartbeat sensor and humidity sensor [10]. All information is initially displayed on

LCD. Zigbee protocol is used for the information transmission. The sensor values are sent to the database server and authorized users can access this data from the cloud using the IoT application platform.

3 Paper Selection Methodology

The relevant paper selection is the crucial process for the systematic literature study and the detailed analysis of the existing contribution of the researchers. In the present work, the inclusion and exclusion criteria are decided for selecting research papers. The manuscripts are classified into three categories based on the contribution of the researchers into 3 core fields, i.e., AI/ML-based contribution, health monitoring contribution, and standard MAC protocols.

3.1 Transparency in Article Selection

Transparency in article selection is a crucial aspect of conducting a systematic literature review. Transparency ensures that the readers can understand and evaluate the objectivity of the selection process. For this, the specific characteristics or attributes of a research paper are considered for inclusion in the review. The factors of exclusion criteria that would lead to the exclusion of a research paper from the study. This could include papers that do not meet the inclusion criteria or have significant methodological flaws.

3.2 Methodology of Article Selection

The flowchart-based article selection method is used for the article selection. To ensure the quality and validity of the selection process, many methods are used, e.g., double-blind screening, resolving conflicts among reviewers, or conducting a pilot study. If applicable, mention the degree of agreement among reviewers when screening papers. High interrater reliability indicates a robust and consistent selection process. If any statistical methods are used to analyze the data or assess the representativeness of the selected papers, their results and analysis are described.

4 AI/ML and Cloud-Related Work in IoT

Alzheimer's disease can be diagnosed in early stages because diagnosing Alzheimer's is very complex at early stages. Amira Ben Rabeh, et al [11], proposes that in order to diagnose the disease, they used three sections of brain such as Hippocampus, corpus callosum, cortex. The author also uses an MRI head scan. They employed a machine learning and image processing methodology which prescribes the use of Support Vector Machine (SVM). A model is created which is trained by lots of sample MRI scans to detect any abnormalities in these parts of brain, they also use a decision tree algorithm to reach a perfect diagnosis of Alzheimer's on early stages.

In this paper Ahlem Rhayem, et al [12] focus on solving an issue of arranging the data and analyzing it and reaching to a useful conclusion, the problem to maintain these data on a permanent system is critical and also in the process of retrieving the data after long time there is a chance of loss in data hence to solve this problem the author proposes a distinguished algorithm. In this algorithm the author proposes a protocol to store data in an orderly fashion without risking the loss of data and also concentrates in reaching a useful conclusion such as reaching an accurate diagnosis. A stroke rehabilitation system based on smart bands and machine learning for patients with a stroke history and also this kind of recovery system is crucial in order to recover from the stroke as physical therapy is a long way road in order to improve the efficiency and to recover this kind of rehabilitation system is needed. So, Geng Yang, et al [12-13] proposes a complete system which includes a robot hand 3D printed and a Surface Electromyography (sEMG) sensor to sense and send sEMG signals to know the blood flow in hands. Hence, the robotic hands capture this signal and passes it onto the robotic hands so they can recover from the stroke.

Furthermore, the signals are transmitted to a host where ML and other processing happens, and these two systems are connected through internet. The ML algorithm used is SVM. A system which classifies the data by using cloud-based architecture was proposed by Martin Miškuf, et al [14]. This paper explained the concept of Healthcare In- dustrial Internet of Things (Health IIoT). They presented a case study basis on real data obtained from the hospitals in Královsky Chlmec, Slovakia. They used Azure SQL database as a data warehouse and Microsoft SQL database for exported data. The analytics tool used was Power BI which provided visualizations of the collected data. Azure ML studio was used to build, train, evaluate and publish ML model. In the model, R Shiny web application and Shinyapps.io server was used as User In- terface. Comparison between ML models such as Averaged Perceptron, Bayes Point Machine, Decision Jungle, Local-Deep SVM was done. After evaluation, Decision Jungle was used as the Area Under the curve (AUC) was 0.878.

To improve traditional healthcare system by applying IoT and Machine Learning to personalized healthcare system, Farhad Ahamed, et al [15] uses disease progression technique. This system is self-management, clinical intervention and thus disease prediction can be improved by applying AI and ML to a collected dataset. They concentrated on the issues and challenges faced while applying ML and IoT to personalized healthcare. IoT and ML can contribute to the areas such as Diagnostics, assistive and monitoring. Various sensors collect data and store it in a database. The ML analyses the data and sends various updates. Many issues and challenges and mentioned and if we overcome these shortcomings, we can enhance personalized healthcare.

Lejla Alic et al. [16] designs a ML algorithm to diagnose diabetes using a hospital database of different parameters to train a model which uses SVM algorithm to train these models the author categorizes the patients' health record based on their ethnic- ity and demographic details etc. To train the model, the author arranges two kinds of table or datasets which are a healthy people dataset and people diagnosed with diabetes which in simple terms positive class (people diagnosed with diabetes) and negative class (healthy people) These data are compared in order to avoid a biasing result. The selection of cases was done randomly in both classes. To achieve precision, they used an unbalanced dataset and each of the SVM classifiers was trained over 10 variations and the precision was improved by performing iterations.

Cardiac disease predictor using IoT, and ML was proposed by Shaira Tabassum Md, et al [17], cardiac disease is a very serious problems this kind of diseases need a lot of medical attention, to keep a healthy body in check the author proposes an IoT system which has all necessary sensors to keep the health in check. In this paper [17], the author proposes a system which has MCU, all necessary sensors such as heart rate sensor, ECG sensor, cholesterol sensor module and blood pressure module are connected and the collected is shared through Wi-Fi or Bluetooth to a smartphone and the data collected is sent to cloud where the data is fed to a machine learning model which uses a SVM(support vector machine) algorithm in order to predict the risk of cardiac diseases and also the model is pre trained with already available hospital datasets.

IoT based heart disease prediction system was proposed by Aanshi Gupta, et al [21]. It consisted of three phases- data preprocessing, model training and live prediction. The data was collected from reliable sources. In order to address the missing data, statistical method 'mode' was used which replaced the missing values with most frequent value of each feature. Different algorithms were used to train the model and based on the performance KNN (K Nearest Neighbor) algorithm was selected for further live predictions. The live data was collected through different sensors (ECG sensor AD8232, Temperature sensor MAX30205 and Pulse sensor HW01 and was fed to training model as input and results were predicted. All sensors are connected to Node MCU ESP8266. MCU is powered through laptop externally.

In their proposed system, David Angyal et al. [18] mainly focuses on monitoring blood pressure of a patient, there are two methods to measure it, namely auscultatory and oscillometric, this paper focuses on oscillometric, though there are many measurement devices available on the market, this device is driven by a microcontroller as it is required to store the patient's data periodically under examination,C8051F064 MCU is used to control the signals from the sensors with the help of microcontroller, these data can be stored over a sever with the help of internet. A PC based application is built to show the real-time data and for the doctors to view the log of all the pressure readings. Two algorithms are used to determine the blood pressure, the first one performs band-pass operation when the values from the sensor are read, the second algorithm finds the maximum and the minimum values and constructs a histogram, which finds the difference between maximum and minimum pressure of the same heart beat and computes the mean arterial pressure, the values obtained from the algorithms is compared with minimum values to find whether the algorithm provides expected results or not.

An architecture for a smart hospital using Machine Learning and Cloud Technology was proposed by Asif Ahmed Neloy et al. [19]. Here various ML models are used such as, Naive Bayes Algorithm is used as Information retrieval, like number of ventilators, pulse of a patient. Logistic Regression is used for sending alert, SMS when patient's health is critical. Decision Tree Classifier is used prioritizing patient's check-up depending upon their conditions. Neural Network Classifier evaluates the data and classifies accordingly. All the data gathered are stored in IBM Cloud. IBM Watson is used to create and run all the ML models. Accuracy of each model is increased by using Ensemble methods. A mobile application CPMS (Critical Patient Management System) is built, which is used for viewing real-time data and the reports.

In order to make a hybrid cloud system model, Naveen Ananda Kumar J et al. [20] talks about integrating ML and AI models into the cloud which lacks in current sys- tem, with public data available to the ML models, we can train it in such a way, the AI will assist in diagnosis of the patient. It also talks about improving the management and administration of hospitals using the latest technologies. This system enables patients to have all their medical records linked to a Unique ID which can be accessed across any hospitals in the country, with this ID, in case of emergency, doctors can access and diagnose the disease in no time. It also offers Unique ID to doctors as well, with their rating and reviews, so that the patients can choose the doctor of their desire for regular check-ups. With this system implemented everywhere, it makes the hospitals self-sufficient and makes the entire process easier for doctors and patients. An idea for e-health care data management and administration framework proposed by Inderpreet Singh et al. [22] solely focused on using the latest technology for the database used for storing patient's medical reports and protecting that data from other individuals. Cloud computing is suggested for storing the data as it has many advantages over the existing model, it's fast, easy to handle and provides better security, and biometric authentication is also provided, which authenticates access of the database by the patient. A neural system-based model is introduced which has the data set of patient's digital signatures, every time the patient accesses this database, this system confirms whether the mark is bona fide or manufactured. Overall, this system helps to store the data safe and securely, cost effective and saves time.

5 Timeline of IoT Related Technologies

The timeline of IoT related technologies are explained in Table-1, Table-2, and Table-3. Timelines presents different methods used in various studies. The authors employed technologies such as digital image processing, machine learning algorithms, IoT, Arduino Uno, sensors, cloud management, Raspberry Pi, and more. The advantages and scope varied across the studies, including higher accuracy in Alzheimer's detection, cost-effectiveness in paperless management systems, easy data interpretation and representation, and portable wearable devices for continuous monitoring. The table also highlights the use of ML algorithms, cloud computing, and biometric authentication for secure data processing and predictive disease management. Overall, the table provides insights into the diverse technological approaches and their respective advantages in healthcare applications.

6 Health Monitoring Body Area Network Protocols

6.1 Wireless Body Area Network

The architecture of body area network is shown in Fig. 1. The IEEE 802.15.6 physical and MAC layer protocol standard is used for the transmission of the data. The sensor nodes are used on the body. The sensor node senses the data and transmit the accumulated data to the mobile device. Different types of MEMS (micro-electro mechanical system) based sensor and actuator devices can be used for the transmission of the data. ZigBee and Bluetooth based personal area network communication methods can be used for the transmission of the data. The data can be processed by the mobile device and can be transmitted to the external world via internet. Generally, a dedicated mobile application is used for the transmission of the data from mobile device monitoring station.

Table 1. Literature Study

Authors	Year	Technology Used	Advantage/Scope
Yuan-Fa Lee	2013	Uses Bluetooth to transmit data in be-	High connectivity and lets the user access data without internet [1].

Vikas Vippa-lapalli, Snigdha Ananthula	2016	tween devices Arduino Fio TX/RX LabView	Real-time data can be viewed on web pages, wireless transmission of data [2].

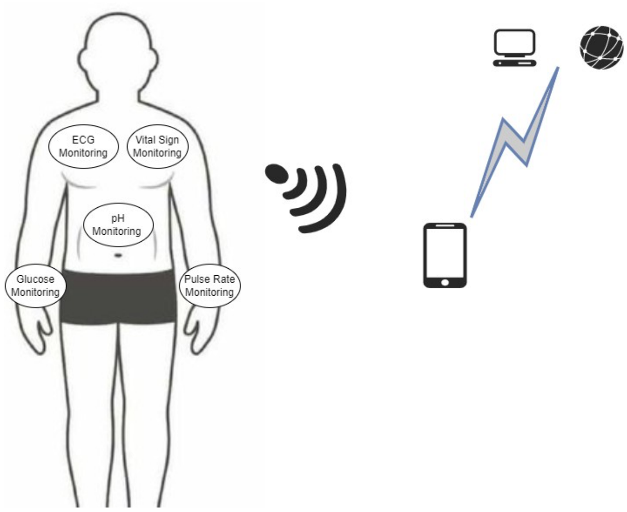

Fig. 1. Architecture of Body Area Network

Table 2 Literature Study (Timeline)

Authors	Year	Technology Used	Advantage/Scope
Amira Ben Rabeh, Faouzi Benzarti, Hamid Amiri, Université de Tunis, El Manar, Ecole, Nationale d'Ingénieur de Tunis	2016	Digital image processing and uses machine learning algorithm (support vector machines and decision tree)	Higher accuracy in detecting Alzheimer using an MRI [11]
D. Shiva Rama Krishnan, Subhash Chand Gupta, Tanupriya Choudhury	2018	IoT, Arduino Uno, Sensors, Buzzers, Wi-Fi Module	Very cost-effective but not much efficient and accurate [8]
Durga Amarnath M Budida, Dr. Ram S. Mangrulkar	2017	IoT, MySQL, M2M	Cost-effective system, paperless management system [5]
S. Lavanya, G. Lavanya, J. Divyabharathi	2017	IoT, Cloud management, Cloud integration, Raspberry PI, GSM	Send text message containing the information gathered. Use of Raspberry PI processor [4]
Ahlem Rhayem, Mohamed Ben Ahmed Mhiri, Faiez Gargouri	2017	Uses health IoT ontology to data interpretation and representation	Makes data interpretation and representation easy [12]
Jian-Qiang Li, Ru Li, Zhuang-Zhuang Chen, Gen-Qiang Deng, Huihui Wang, Constandinos X, Mavromoustakis, Houbing Song, Zhong Ming.	2017	Detection of pulse wave characteristic points based on wavelets transforms	High accuracy and low maintenance Cost and portable [3]
Geng Yang, Jia Deng, Gaoyang Pang, Hao Zhang, Jiayi Li, Bin Deng, Zhibo Pang, Juan Xu, Mingzhe Jiang, Pasi Liljeberg, Haibo Xie and Huayong Yang	2017	Digital signal processing and machine learning (linear regression model)	High accuracy and portable, smart wearables for continuous monitoring [13]
Ashwini Gutte, Ramkrishna Vadali	2018	Raspberry Pi 3, IoT, MQTT	No need for an external Wi-Fi module, sends SMS alerts to targeted users in case of emergency [9]
Farhad Ahamed, Farnaz Farid	2018	IoT, ML, AI	Guides about the issues and challenges faced while working with IoT and ML, and how to overcome them [15]
Aanshi Gupta, Shubham Yadav, Shaik Shahid, Venkanna U	2019	IoT, Data Preprocessing, Model training and Live Prediction, ML algorithms, Node MCU ESP8266	High accuracy. Effective ML algorithms are mentioned [21]

Table 3 Literature Study (Timeline)

Authors	Year	Technology Used	Advantage/Scope
D´avid Angyal, Anik´o V´agner, Istv´an Juh´asz	2019	Uses their own algorithm and digital signal processing	Accuracy according to standards, Cheaper and portable [18]
Martin Miškuf, Iveta Zolotová, Jozef Mocnej	2018	IoT, AI, ML algorithms, ML analysis, SQL, DBMS	Information about databases, servers, and ML algorithms. High accuracy but costly [14]
Peng Zhang, Douglas C. Schmidt, Jules White, Shelagh A. Mulvaney	2018	Uses IoT and software application	Better management of diabetes type 1[7]
Soumya Yattinahalli, R M Savithramma	2018	Uses IoT concepts	Cheaper, portable, and high accuracy in notification [6]
Inderpreet Singh, Deepak Kumar, Sunil Kumar Khatri	2019	Cloud Computing	Safe and secure data processing using the cloud, biometric authentication [22]
Naveen Ananda Kumar J, Shivani Suresh	2019	IoT, ML, AI, Cloud	Novel idea on integrating mentioned technologies [20]
Asif Ahmed Neloy, Sazid Alam, Rafia Alif Bindu, Nusrat Jahan Moni	2019	ML Algorithms, Cloud, Mobile Application	Various ML algorithms for improving the management system and disease prediction, Smart-Hospital idea [19]
Shaira Tabassum, Md. Ittahad Uz Zaman, Md. Sabbir Ullah, Ashikur Rahaman, Samsun Nahar, and A.K.M. Muzahidul Islam	2019	IoT and biomedical signal processing and ML (logistic regression)	Medium accuracy due to lower data, Individual parameter monitoring [17]

Lejla Alic, Hasan T. Abbas, Marelyn Rios, Muhammad AbdulGhani, and Khalid Qaraqe	2019	Uses SVM (support vector machines) machine learning algorithm	High accuracy in prediction [16]
Prajoona Valsalan, Tariq Ahmed Barham Baomar, Ali Hussain Omar Baabood	2020	IoT, RFID, ZIGBEE.	Information about Zigbee protocol and basic working of healthcare system [9]

6.2 Super frame Structure of IEEE 802.15.6 MAC

The IEEE 802.15.6 follows super frame architecture for the transmission of the data.The super frame architecture can be divided into 9-10 parts as shown in Fig. 2. Thefirst slot is started with the broadcasting of the beacon packet from the CH nodeto all the SN's. The data transmission phase is divided into two phase' i.e.' Phase- 1 and Phase-2. The two phases are further divided into exclusive, random-access phases and Type-I/II phases. The exclusive and random-access phases are contention based phases and are used for the transmission of the data. However, the Type-1/II used for uplink allocation intervals, downlink allocation intervals, blink allocation intervals, delay blink allocation intervals. The transmission phasesfollowed by beacon and contention access period (CAP). The CAP follows carrier sense multiple access/ collision avoidance (CSMA/CA).

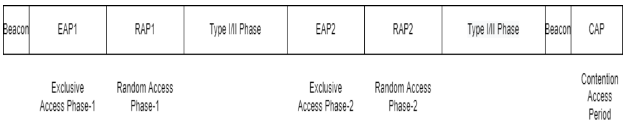

Fig. 2. Super frame structure of IEEE 802.15.6 MAC protocol

The frame structure of the IEEE 802.15.6 is shown in Fig. 3, Fig. 4 and Fig. 5.

The physical header and MAC header is shown in Fig. 3.

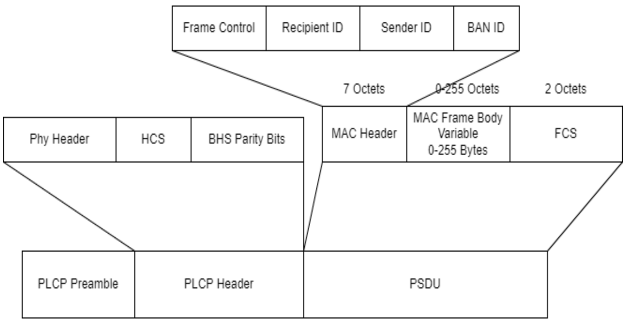

Fig. 3. IEEE 802.15.6 NB PPDU Structure

The physical protocol data unit is started by synchronization bits. The header anddata unit are part of the PPDU.

The PHR is part of the PPDU. The PHR is divided into payload length and CRC.The payload has data rate, pilot info, and sync field in payload length. The CRC consist of the information of BAN ID [23].

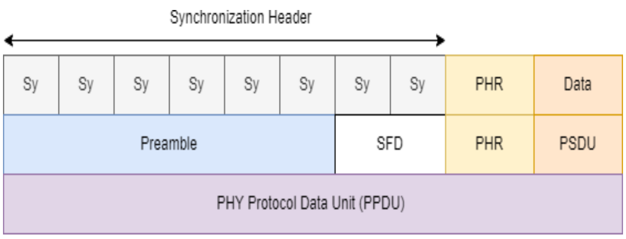

Fig. 4. IEEE 802.15.6 UWB PPDU Structure

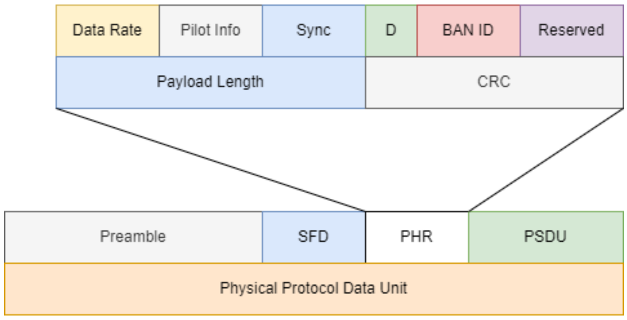

Fig. 5. IEEE 802.15.6 EFC PPDU Structure

6.3 Application of WBAN

The application of WBAN can be categorized into two broad categories i.e. Medical and Non-Medical Application. The medical applications are real time monitoring of patient e.g. ECG monitor, pH Monitoring, Glucose Monitoring, Respiratory Monitoring etc. Non-medical applications involves video streaming, entertainment application, gaming etc. [23]. Furthermore, IoT enabled health monitoring applications have significant role in future smart cities [24].

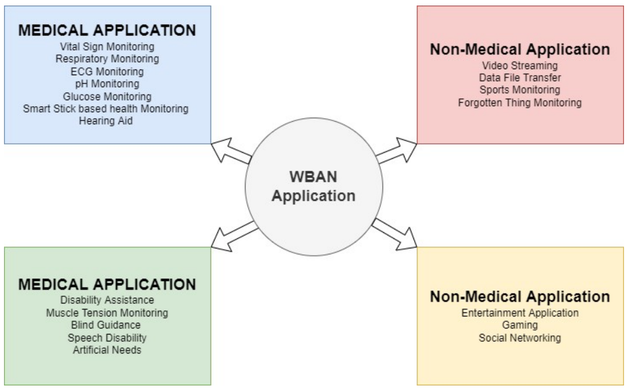

Fig. 6. WBAN Applications

7 Conclusion

Based on literature survey, the referred papers have various solutions to tackle health-care crisis, and by connecting all these solutions, we can make a compactand modern system, which help patients and doctors to diagnose and predict certaindiseases and save many lives. With rapid increase in technology and infrastructure, an affordable system can be achieved. In future, with advancement in smart hospitals, we can establish a smart-medicine wending machine with integration of Artificial Intelligence, so that when user uploads all their symptoms, the machine can predict the disease and provide feedback and medicine within matter of minutes. We can also use this system on a large scale in order to provide an affordable and efficient solution to the people who do not have proper healthcare.

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