REMOTE PATIENT MONITORING USING IOT, CLOUD COMPUTING AND AI

A PROJECT REPORT SUBMITTED
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Under the supervision of

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Submitted to

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GHAZIABAD-201206

(APRIL- 2022)

DECLARATION

I hereby declare that the work presented in this report entitled "REMOTE PATIENT MONITORING USING IOT, CLOUD COMPUTING AND AI ", was carried out by me. I have not submitted the matter embodied in this report for the award of any other degree or diploma of any other University or Institute.

I have given due credit to the original authors/sources for all the words, ideas, diagrams, graphics, computer programs, experiments, results, that are not my original contribution. I have used quotation marks to identify verbatim sentences and given credit to the original authors/sources.

I affirm that no portion of my work is plagiarized, and the experiments and results reported in the report are not manipulated. In the event of a complaint of plagiarism and the manipulation of the experiments and results, I shall be fully responsible and answerable.

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CERTIFICATE

Certified that **Anubhav Maurya (200029014005707), Uddeshya Sharma (200029014005812) and Vishal Singh (200029014005820)** have carried out the project work having "REMOTE PATIENT MONITORING USING IOT, CLOUD COMPUTING AND AI" for Master of Computer Applications from Dr. A.P.J. Abdul Kalam Technical University (AKTU) (formerly UPTU), Technical University, Lucknow under my supervision. The project report embodies original work, and studies are carried out by the student himself / herself and the contents of the project report do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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ABSTRACT

Healthcare is a rapidly evolving field of technologies and services. Remote patient monitoring has expanded the reach of traditional clinical practice by removing geographical barriers as well as clinical limitations. The continuous advancement of technology and capability has affected healthcare and brought medicine, first into our homes and increasingly into our pockets. Iot fitness tracking systems save your frequent visits to doctors and meetings among sufferers and medical experts. The future of telehealth fits into a consumer world that expects high quality, instant access, and personalized health propositions. As the demand for personalized medicine rises, more devices are released to capture vital signs, well-being metrics, and background data.

In the past decade, various experts have widely proposed remote patient management to monitor patients suffering from various diseases such as heart disease, nervous system disease, blood pressure, body temperature, chronic disease, diabetes, and obesity. Cloud Computing is a complex technology consisting of a remote server that acts as a remote access gateway and connects smart sensors and smart devices with an IoT concept. AI is a unique decision-making technique that uses deep learning (DL) methodologies in conjunction with cloud data sets.

In the clinical setting, this could allow real-time monitoring and pre-emptive doctor/patient interactions to prevent adverse incidents.

This study provides an overview of recent advances in remote healthcare and monitoring in both contact and non-contact methods.

Keywords: IOT, Remote Patient Monitoring, Artificial Intelligence, Cloud Computing in Healthcare

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Anubhav Maurya

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Abbreviations

The following abbreviations are used in this manuscript:

IOT	Internet Of Things
AES	Advanced Encryption Algorithm
AI	Artificial Intelligence
RPM	Remote Patient Monitoring
ML	Machine Learning
DL	Deep Learning
BG	Big Data
BP	Blood Pressure
ECG	Electrocardiogram
LTE	Long-term evolution
ALS	Amyotrophic Lateral Sclerosis
LCD	Liquid Crystal Display
Iaas	Infrastructure-as–a-Service
Paas	Platform-as-a-Service
SaaS	Software-as-a-Service
AWS	Amazon Web Services
IoMT	Internet of Medical Things
EC2	Amazon Elastic Compute Cloud
VPC	Virtual Private Cloud
SNS	Supplemental Nursing System
DCNN	deep convolutional neural network
ALS	amyotrophic lateral sclerosis

FDA	Food and Drug Administration
RPM	Remote Patient Monitoring
EDU	Emergency Department Utilization
Hvac	heating, ventilation, and air conditioning control
VM	Virtual Machine
WAN	Wide Area Network
IPv6	Internet Protocol version 6
BAN	body area network
PAN	Personal Area Network
LAN	Local Area Network
Wi-fi	Wireless Fidelity
Gps	Global Positioning System
TCP/IP	Transmission Control Protocol/Internet Protocol
IC	integrated Circuit
MEMS	Micro-electromechanical System
LED	Light Emitting Diode
GPRS	General Packet Radio Service
GSM	Global System for Mobile communication
IMEI	International Mobile Equipment Identity
IoHT	Internet of Healthcare Things
AUC	area under the curve
NLP	Neuro-Linguistic Programming

1. Introduction

Health is always a major concern in every growth humans is advancing in terms of technology. Like the recent corona virus attack that has ruined the economy of countries to an extent is an example how health care has become of major importance. In such areas where the epidemic is spread, it is always a better idea to monitor these patients using remote health monitoring technology. So, Internet of Things (IoT) based health monitoring system is the current solution for it.

Remote Patient Monitoring arrangement empowers observation of patients outside of customary clinical settings (e.g., at home), which expands access to human services offices at bring down expenses. The core objective of this project is the design and implementation of a smart patient health tracking system that uses Sensors to track patient health and uses internet to inform their loved ones in case of any issues. The objective of developing monitoring systems is to reduce health care costs by reducing physician office visits, hospitalizations, and diagnostic testing procedure. Each of our bodies utilizes temperature and also pulse acknowledging to peruse understanding wellbeing. The sensors are linked to a microcontroller to track the status which is thus interfaced to a LCD screen and additionally remote association with have the capacity to exchange alarms. If framework finds any sudden changes in understanding heartbeat or body temperature, the framework consequently alarms the client about the patient's status over IOT and furthermore indicates subtle elements of pulse and temperature of patient live in the web. In this manner IOT set up tolerant wellbeing following framework viably utilizes web to screen quiet wellbeing measurements and spare persists time.

1.1 Importance of Health Monitoring Product

Importance of health monitoring products is shown in Figure 1. Regarding product problems, 72.8% of the population believe that it is important to design a product to provide elderly care services for the elderly; 56.3% of the population believe that it is important to wear health monitoring equipment, save health data in real time, and allow their children to see their health status every day; 50.5% of crowd believe that real-time positioning that allows your children to see your specific location is of general importance. 40.8% of the population believe that real-time positioning that allows your children to see the services of your specific location is very important. (ese data results show that most of the survey sample people think that it is important to design a product to provide elderly care services for the elders, wear health monitoring equipment, save health data in real time, and allow children to see their health status every day.

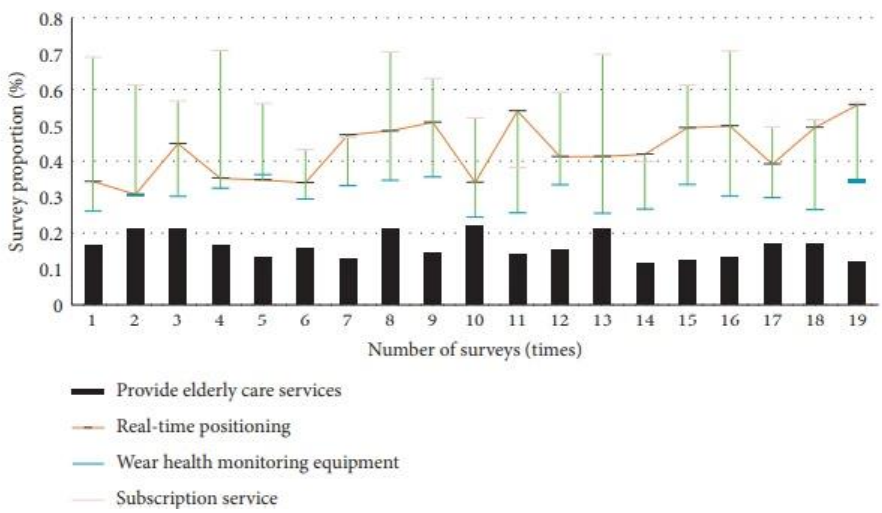


Figure 1

1.2 Artificial Intelligence (AI)

Artificial Intelligence (AI) is a technology which immerses human intelligence so that computers have perception ability, learning ability, and an ability to understand natural language through the computer programs (Kaur & Mann, 2017). AI systems rely on their input data. AI in healthcare supports the patient's health monitoring with, for example, vital checks in real time (Kaur & Mann, 2017). In addition, AI systems can explore the patients' data, and then, providing personalized health monitoring, recommendation, and treatment.

1.3 Cloud Computing

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models

1.3.1 Properties and characteristics

- High scalability and elasticity
- High availability and reliability
- High manageability and interoperability
- High accessibility and portability
- High performance and optimization
- Enabling techniques

1.3.2 Deployment Models

Deployment models define the type of access to the cloud, i.e., how the cloud is located? Cloud can have any of the four types of access: Public, Private, Hybrid, and Community. Below figure n0.o 2 represents deployments models of cloud.

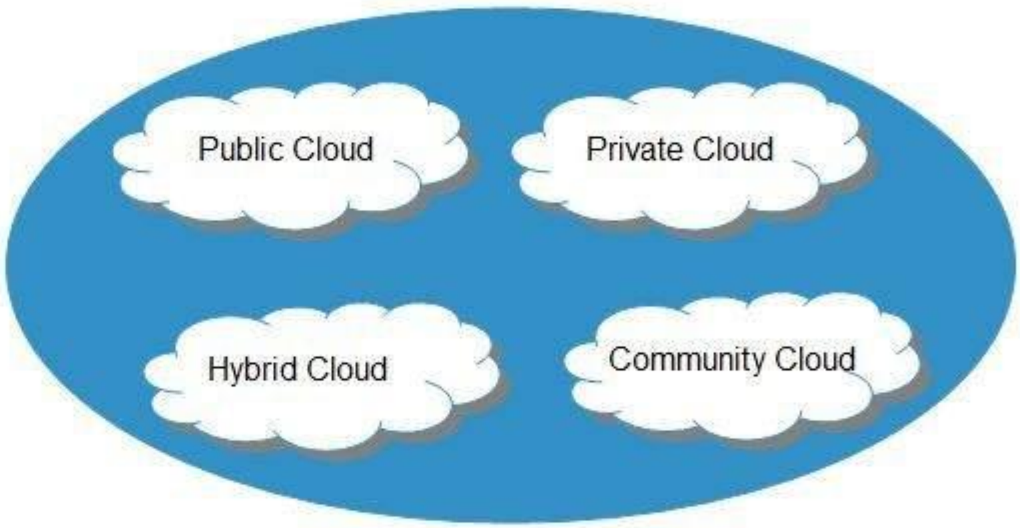


Figure 2 Visual representation of deployment models

- **Public Cloud:** The cloud resources that are owned and operated by a third-party cloud service provider are termed as public clouds. It delivers computing resources such as servers, software, and storage over the internet
- **Private Cloud:** The cloud computing resources that are exclusively used inside a single business or organization are termed as a private cloud. A private cloud may physically be located on the company's on-site datacentre or hosted by a third-party service provider.
- **Hybrid Cloud:** It is the combination of public and private clouds, which is bounded together by technology that allows data applications to be shared between them. Hybrid cloud provides flexibility and more deployment options to the business.
- **Community Cloud:** The community cloud allows systems and services to be accessible by a group of organizations.

1.3.3 Service Models

Cloud computing is based on service models. These are categorized into three basic service models which are -

- Infrastructure-as–a-Service (IaaS)
- Platform-as-a-Service (PaaS)
- Software-as-a-Service (SaaS)

1.4 Internet of Things (IoT)

The Internet of Things (IoT) is a physical object that has a network connection (Vermesan & Friess, 2013). There can be different types of devices, such as medical instruments, home appliances, Smartwatch, industrial systems, people, buildings, vehicles, and Smartphones. These devices are connected and communicate with each other based on the required protocols to enable personal online monitoring, process administration, tracing, and positioning (Vermesan & Friess, 2014). IoT in healthcare can support health monitoring systems, wearable health monitoring, remote health monitoring, Smartphone health monitoring, etc. (Sahu et al., 2020). Patients keep monitoring their vital health conditions, for instance, body temperature, blood pressure, blood glucose, respiration rate, and pulse rate, using the sensor which is attached in the patient's body (Kumar & 9 Gandhi, 2018). Monitored patient's vital health condition can be used for disease prediction and further treatment (Madakam et al., 2015). Moreover, the monitored data can be stored in the repository so that healthcare professionals have access to the data for future medical treatments (YIN et al., 2016).

1.4.1 ROLE OF IOT IN REMOTE MONITORING

Medical devices today monitor many types of patient behaviours and conditions (e.g., glucose monitors, fetal monitors, electrocardiograms, and blood pressure monitors). Today, while patients still need to often follow-up with a physician, the smarter monitoring devices of tomorrow may change that. Meanwhile, recent achievements in micro-/nanofabrication, flexible and stretchable functional materials, and wireless communications offer attractive and versatile capabilities in wearable electrochemical sensors.

1.4.2 Features

• Wearable, wireless physiological detection system applies to arrhythmia monitor
• Continuously tracks patients' heart rhythms and sends the data to a smartphone app via Bluetooth.
•Wearable IoT device
• Attaches to the upper torso using skin-safe adhesive
• Tracks precursor symptoms of asthmatic attacks, including cough rate, respiration patterns, heartbeat, and body temperature
• A soft disposable silicone contact lens embedding a microsensor that captures spontaneous circumferential changes at the corneoscleral area
• Smartphone-connected blood pressure cuff
• Wireless, biometric data collection

• Flexible, body-conforming rechargeable sensor patches
• Measures, records, and displays general activity, postural classifications, vital signs, and sleep metrics
• Smartphone-based blood tester
• Blood glucose monitoring dongle for smartphone

Though many new devices are being developed, there is still a challenge to aggregate, consolidate and share data, as well as communicate reliable and securely.

1.4.3 IoT Application :-

Remote Patient Care In several parts of the globe, people live miles away from the nearby hospital. When there is an urgent situation, it takes time to arrive at the healthcare service centres. Likewise, it is difficult for healthcare service providers to visit patients with persistent circumstances regularly. The matter with long travel can be solved with remote patient care power-driven using the IoT. The connectivity can permit healthcare professionals to help outpatients through recommendations, medication and well compute their biometrics using sensors and distant equipment. For example, patients can unite any wearable gadget to the cloud moreover revise the data instantaneously. Some of the IoT devices assist personally converse above the internet. This can offer healthcare experts the required information to organize care strategies. These aids generate a schedule of the patients' daily physical condition information for patients with chronic disorders. The composed data can outline charts and diagrams to be effortlessly visualized by healthcare experts. Live video and audio torrents can be used to monitor patients' current condition, exclusive of the need for the exchange.

1.4.4 Advantages and Disadvantages of IoT:

Some of the advantages of IoT include the following:

- ability to access information from anywhere at any time on any device;
- improved communication between connected electronic devices;
- transferring data packets over a connected network saving time and money; and
- automating tasks helping to improve the quality of a business's services and reducing the need for human intervention.

Some disadvantages of IoT include the following:

- As the number of connected devices increases and more information is shared between devices, the potential that a hacker could steal confidential information also increases.
- Enterprises may eventually have to deal with massive numbers -- maybe even millions -- of IoT devices, and collecting and managing the data from all those devices will be challenging.
- If there's a bug in the system, it's likely that every connected device will become corrupted.
- Since there's no international standard of compatibility for IoT, it's difficult for devices from different manufacturers to communicate with each other.

1.5 Internet of Medical Things (IoMT)

The Internet of Medical Things (IoMT) is the combination of Internet of Things (IoT) with medical devices (Razdan & Sharma, 2021). IoMT is aimed to manage patients' health by using sensors implanted in medical objects and transmitting the monitored data via network so that patients can communicate with their healthcare providers (Vishnu et al., 2020). According to Figure 1, the collected data from patients goes to the healthcare professionals, and then, feedback goes back to the patients. In the near future, most medical devices could connect and be monitored through the internet by healthcare professionals. Such systems will reduce the cost of medical treatment and allow faster access to medical care. In addition, IoMT with the integration of AI, big data, and cloud computing will accelerate the IoMT usage in healthcare.

1.6 Cloud Application

The data located in one central location rather than being distributed apart in different places provides higher feasibility and data security. Since, it is an ethical requirement to protect the critical medical data of individual' bio signals, hence the centralized architectural design pattern was chosen for the ECG Android app. In our architectural design, the data monitored for all the patients will be stored in one centralized location, which will be separated through a unique identifier to identify the data for different individuals Since all the data are stored in one place, it will be easy to query the database and perform data analysis out of the combined data. The following are some advantages of centralized architectural design pattern:

1.6.1 Advantages:

- The data are easily placed in the server.
- There is an effective use of space for the storage of the data within the cloud.
- All the related data are kept together.
- Data redundancy are avoided.
- It is a uniform service provided to all users.
- The data security is improved in comparison to decentralized system.

1.6.2 Principles and Assumptions :

Managing the needs of an IoT Cloud Architecture for Medical clients requires balancing the users' business activity and workflow issues and the associated information needs (effectiveness) with the cost (efficiency) and dynamic, improvement-readiness (dynamic efficiency) issues of the Cloud infrastructure.

This translates to balancing the (efficiency-based) need for standards with the (effectiveness-based) needs for user applications and user information. Keeping this in mind, the following principles were applied to this Capstone Project:

- Use of managed services – we believe that where there are market leader products available to fulfil a particular function, where these products have been proven to perform, then such products should be leveraged, in preference to embarking on the expensive and error-ridden path of building a custom application from scratch or possibly less expensive but less well designed and supported products. The choice of AWS platform managed services, for example, satisfies this principle

- Use of modular components with granularity and loose coupling – loose coupling refers to the decoupling of the platform and language in which the services are implemented, the communications protocols used to interact between them, and the data formats used to store, and exchange information between the modules.

- Security – The Application uses Sensitive Patient Information (SPI) – device access must be restricted not only to registered devices, but also by IP address so that unauthorized IP addresses are blocked. Administrative access to the dashboards must also be restricted only to authorized IP addresses due to SPI requirements

1.7 AI Application

Data analysis and collaboration, patient monitoring remotely, and intelligent diagnoses and support are the most common AI use cases in telehealth. The potential of AI may be used to assist doctors in diagnosing and treating patients, as well as to reduce professional burnout and improve the whole patient experience.

1.7.1 History of AI in medical field:-

Great advances have been made in using artificially intelligent systems in case of patient diagnosis. For example, in the field of visually oriented specialties, such as dermatology, [12,13] clinical imaging data has been used by Esteva et al.[6] and Hekler et al.[14] to develop classification models to aid physicians in the diagnosis of skin cancer, skin lesions, and psoriasis. In particular, Esteva et al.,[6] trained a deep convolutional neural network (DCNN) model using 129,450 images to classify images into one of two categories (also known as binary classification problem in machine learning) as either keratinocyte carcinoma or seborrheic keratosis; and malignant melanoma or benign nevus. They further established that the DCNN achieved performance at par to that of 21 board-certified dermatologists. Their research demonstrated that AI systems were capable of classifying skin cancers with a level of competence comparable to dermatologists and required only a fraction of the time to train the model in comparison to physicians who spend years in medical school and also relied on experience they developed through patient diagnosis over decades.

Much work has also been done in the realm of AI and patient prognosis. For instance, researchers at Google[7] developed and trained a DCNN using 128,175 retinal fundus images to classify images as diabetic retinopathy and macular edema for adults with diabetes. There are several advantages of the existence of such an artificially intelligent model, such as:

- Automated grading of diabetic retinopathy leading to increased efficiency in diagnosing many patients in shorter time.
- Serving as a second opinion ophthalmologists.
- Detection of diabetic retinopathy in early stages due to capability of the model to study images at the granular level-something impossible for a human ophthalmologist to do;
- Vast coverage of screening programs reducing barriers to access.

Huge strides have been made in application of AI systems to drug discovery[15] and providing personalized treatment options.[16] Companies, such as Verge Genomics, focus on the application of machine-learning algorithms to analyze human genomic data and identify drugs to combat neurological diseases, such as Parkinson's, Alzheimer's, and amyotrophic lateral sclerosis (ALS) in a cost-effective way.

Artificially intelligent systems are also being applied in the healthcare sector to enhance patient experience, patient care, and provide support to physicians through the use of AI assistants. Companies, such as BotMD have built systems that can help 24 h with clinical related issues regarding:

Instantly finding which physicians are on call and scheduling the next available appointment; the AI system can also search multiple scheduling systems across different hospitals

Answering prescription related questions, like drug availability and cost-effective alternative drugs

Assisting doctors search hospital protocol, list of available clinical tools, and available drugs all through the use of a mobile application, thus improving workflow in the hospital.

1.7.2 Future of AI in medical Science:-

Despite the above limitations, AI looks well positioned to revolutionize the healthcare industry. AI systems can help free up the time for busy doctors by transcribing notes, entering and organizing patient data into portals (such as EPIC) and diagnosing patients, potentially serving as a means for providing a second opinion for physicians. Artificially intelligent systems can also help patients with follow-up care and availability of prescription drug alternatives. AI also has the capability of remotely diagnosing patients, thus extending medical services to remote areas, beyond the major urban centers of the world. The future of AI in healthcare is bright and promising, and yet much remains to be done.

The application of artificially intelligent systems in healthcare for use by the general public is relatively unexplored. Only recently the FDA (U.S Food and Drug Administration) approved AliveCor's Kardiaband (in 2017) and Apple's smartwatch series 4 (in 2018) to detect atrial fibrillation. The use of a smartwatch is a first step toward empowering people to collect personal health data, and enable rapid interventions from the patient's medical support teams.

There are many negative effects of modern technology on mental health. However, researchers at the University of Southern California (USC) in collaboration with Defense Advanced Research Projects Agency and the U.S. Army found that people suffering from post-traumatic stress and other forms of mental anguish are more open to discussing their concerns with virtual humans than actual humans for fear of judgment. This research[23] has promising results for the role of virtual assistants resulting in the collection of honest answers from patients that could help doctors diagnose and treat their patients more appropriately and with better information.

Most global pharmaceutical companies have invested their time and money on using AI for drug development of major diseases, such as cancer or cardiovascular disease. However, development of models for diagnosing neglected tropical diseases (malaria and tuberculosis) and rare diseases remains largely unexplored. The FDA now incentivizes companies to develop new treatments for these diseases through priority vouchers.[24]

Given the impact that AI and machine learning is having on our wider world, it is important for AI to be a part of the curriculum for a range of domain experts. This is particularly true for the medical profession, where the cost of a wrong decision can be fatal. As identified here, there is a lot of nuance in how an AI system is built. Understanding this process and the choices it entails are important for appropriate usage of this automated system. The data used to learn from and the optimization strategy used has a deep impact on the applicability of the AI system to solve a particular problem. An understanding and appreciation of these design decisions is important for medical profession.

AI has the potential to help fix many of healthcare's biggest problems but we are still far from making this a reality. One big problem and barrier from making this a reality is data. We can invent all the promising technologies and machine learning algorithms but without sufficient and well represented data, we cannot realize the full potential of AI in healthcare. The healthcare industry needs to digitize medical records, it needs to come together to agree on the standardization of the data infrastructure, it needs to create an iron-clad system to protect the confidentiality and handle consent of data from patients. Without these radical changes and collaboration in the healthcare industry, it would be challenging to achieve the true promise of AI to help human health.

1.8Remote Patient Monitoring Application

Remote patient monitoring is applicable in treatment or providing care for many critical ailments including-

1.Heart Ailments- Heart patients, in some cases, require continuous monitoring of their heart rates, weights, and other vitals. Expert intervention is required when the vitals cross alarming levels. In such scenarios, remote patient monitoring can be highly useful in continuously assessing the health of a patient and alerting the care team when required.

2.Diabetes and Hypertension- Patients suffering from diabetes or hypertension need continuous monitoring of blood pressure and blood sugar and quick care when the comfort levels are crossed. A remote system can be established for such patients wherein the BP and sugar readings are continuously communicated to the care team for them to prescribe medication when necessary.

3.Patients from remote areas- Accessibility to quality care is still a challenge in healthcare. There are regions where good care is still not accessible. Remote patient monitoring solutions can help patients living in those geographies to access quality care from cities.

4.Elderly- Remote monitoring can also help the elderly or people with limited mobility who require continuous monitoring post-hospital discharge. Such patients can be continuously assessed from their homes and provided care.

1.9 IoT Framework for Heathcare

The IoT in healthcare framework is considered the most fundamental aspect of IoT in healthcare because it helps healthcare applications to completely utilize the IoT and cloud computing. The framework also provides protocols to support the communication and broadcast of raw medical signals from various sensors and smart devices to a network of fog nodes.

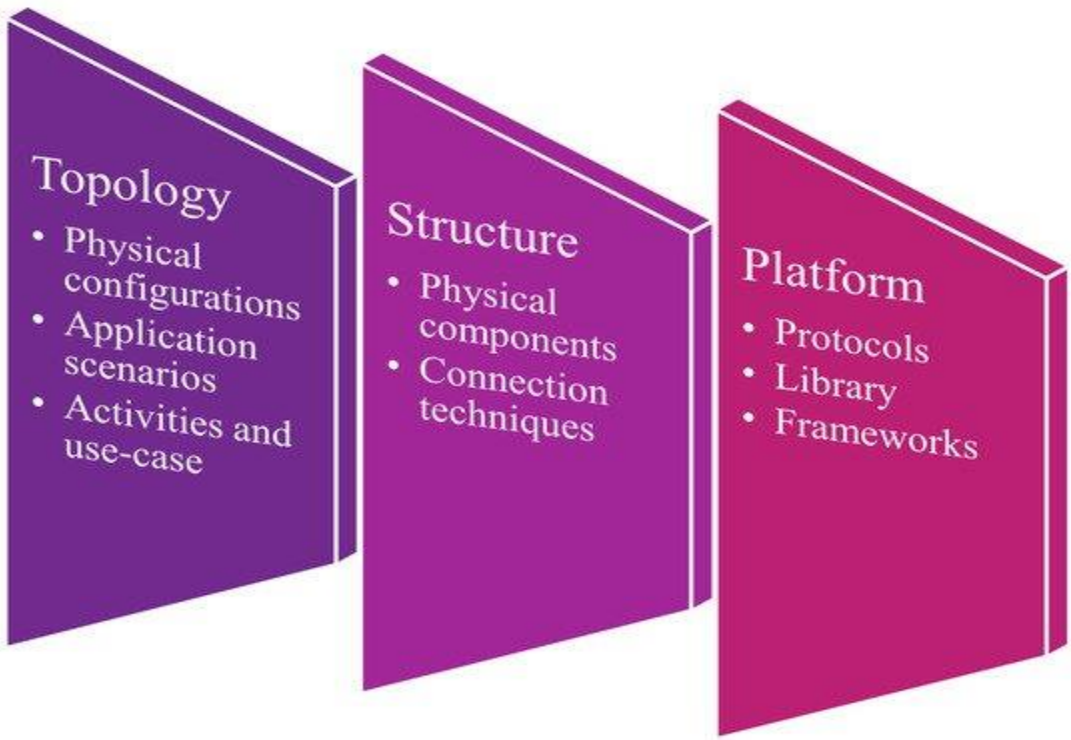


Figure 3

As shown in Figure 3, there are three essential components, which include topology, structure, and platform. Each component serves a specific function in the IoT healthcare framework, all of which will be discussed in detail in the following sections. The readers are recommended to review proposed IoT architectures to gain insights into the IoT architectures for healthcare. The systems can collect data about patient health status through multiple sensors. After that, the collected data were transmitted to the remote server for analyzing, and the results were displayed in real time.

2. Literature review

Implementing RHM in smart cities requires IoT and ML technologies (Pawar et al., 2018; Qi et al., 2017) These operations are commonly an assemblage of IoT devices connected to execute predictive analysis, prognosis, remote monitoring, surgeries, and preventative analysis, as the case may be (Ermes et al., 2008; Pawar et al., 2018). Remote healthcare monitoring requires specific models and designs to operate by integrating them into the patient record system for efficient data management. RHM aims to create applications such as glucose level sensing, ECG monitoring, blood pressure monitoring, body temperature monitoring, oxygen saturation monitoring, rehabilitation systems, medical management, wheelchair management, and other imminent healthcare solutions. During the COVID-19 Pandemic, IoT introduced medical devices, including linked imaging, hospital procedures, drug distribution, patient care, diagnostic tests, and pharmacy control, as well as the advancement of health safety with smart instruments, such sa blood gas analyzers, thermometers, smart beds, glucose meters, ultrasound, X-rays, and I-patient biological services (Javaid and Khan, 2021). Some technologies are mainly built to function with IoT or machine-to-machine (M2M) applications, which require a vast regional range, extended battery-consuming lifetime, low-cost devices, and low bandwidth. These technologies are referred to as low power wide-area network (LoPWAN) (Raza et al., 2017). Moreover, the majority of IoT applications cannot function without the transfer of data using cellular technologies, such as 2G (DAMPS, GSM, and PDC), 2.5G (GPRS), 2.75G (EDGE), 3G (UMTS/ WCDMA, EvDO, HSPA, and HSUPA), 4G (LTE, and LTE-A), and 5G. A network connection is denoted with cellular representation or machine-type communication (MTC). Furthermore, some 3G and 4G technologies like 3GPP LTE cover a vast expanse range and work well with QoS. The technology is enabled with mobile and roaming services, scalability, highsecurity levels, billing, and organization clarity. Their integration allows for the connection of sensors with the aid of a standardized API (Palattella et al., 2014). Long term evolution advanced (LTE-A), mobile worldwide interoperability for microwave access (WiMAX) release 2, Wire-less MAN—Advanced or IEEE 802.16 m—aids improvements such as better scalability, higher speeds, and low costs to adapt to future IoT market requirements and also to prevent technology fragmentation. These technologies fulfill part of the prerequisites for IoT. However, they still contain some problems yet to be resolved. For instance, QoS and network congestion prove to be challenging problems due to many nodes or devices connected (Trencher and Karvonen, 2019). A thorough study of the 5G cellular network framework and some other critical developing technologies, like cloud computing, interference management, spectrum distributing with cognitive radio, softwaredefined network (SDN), etcetera, have been outlined in Gupta and Jha (2018). IoT-based healthcare systems' have an efficient healthcare technologies, such as the IoT-Fog-Cloud continuum, the standard platform that facilitates communication among ifferent layers and types of fog device (Kumar et al., 2019). However, some authors contemplate that there is a considerable extension between 5G and IoT. 5G design undertakings are in motion to aid the use of devices on a larger scale to facilitate universal IoT, and at the same time, also reduce the consumption of energy with reduced costs. A summary of distinct qualities and some comparisons betwee et al., 2018). However, each of the proposed methods has challenges such as inaccuracy andhigh error of recommendations.

Table 1. Comparing the advantages and disadvantages of previous methods

Reference	Method	Disadvantage	Advantage
[4]	A new platform for the smart home to analyze IoT big data with cloud computing technology	Insufficient accuracy	Energy conservation
[5]	Provide a patient remote monitoring system with the aim of effectively managing hospital resources through patient monitoring at home	Insufficient accuracy of diagnostic information, high classification error	High classification speed, removing outliers, using IoT
[10]	An innovative IoT-based system for identifying medications and monitoring prescription medication	Insufficient accuracy of diagnostic information high classification error	High computational speed, simple model, removing outliers
[11]	A remote monitoring and decision support system to assist physicians in diagnosing, remote monitoring, treating, prescribing, rehabilitating, and advancing patients with Parkinson's disease.	complicated model, long computation time	High classification accuracy, simple model
[12]	An IoT-based health monitoring system considering the role of smart data in the smart home for patient-centered remote health monitoring	Insufficient accuracy of diagnostic information, high classification error	High classification accuracy
[13]	An IoT-based mobile gateway (e.g. mobile/tablet /PDA, etc.) for health scenarios	complicated model, long computation time	High accuracy in classification, simple model

[14]	IoT-based health monitoring system for children with Autism	complicated model, long computation time	High accuracy in classification, simple model
[15]	An industrial IoT-based monitoring framework for healthcare	High error, complicated model and low computational speed	Optimal accuracy in classification
[16]	Smart Architecture for In-Home Healthcare	Insufficient accuracy of diagnostic information, high classification error	High computational speed, simple model, removing outliers
[17]	An IoT-based patient monitoring framework in the intensive care unit	complicated model, long computation time	High accuracy in classification, simple model
[18]	medication reminder and monitoring system for health using IoT	Insufficient accuracy of diagnostic information, high classification error	High computational speed, simple model, removing outliers
[19]	IoT based patient monitoringsystem	complicated model, long computation time	High accuracy in classification, simple model
[20]	Patient monitoring system using IoT	Insufficient accuracy of diagnostic information, high classification error	High accuracy in classification
[21]	A smart patient monitoring system to monitor patients' health	High error, complicated model and low computational speed	Optimal classification speed, removing outliers and using IoT platform
[22]	New generation technology and IoT for managing and analyzing big data	Insufficient accuracy of diagnostic information, high classification error	Optimal accuracy in classification
[23]	An IoT-based healthcare monitoring and analysis system	High error, complicated model and low computational speed	Optimal accuracy in classification
[24]	A practical solution for use, Developing features of fog computing and smart e-health	Insufficient accuracy of diagnostic information, high classification error	Optimal classification accuracy

	gateways for IoT-based health systems		
[25]	A model for effective management of cardiac patient data with the iFogSim tool in the cloud computing environment	complicated model, long computational speed	High classification accuracy Simple model
[26]	Things to know about fog computing and the pattern of edge computing	Examine edge computing	Papers are “review article” type
[27]	Deep neural network algorithm to determine user categories	Insufficient accuracy in diagnosis	High computational speed
[28]	Using clustering techniques, deep neural networks, online hybrid similarity criteria as a method for analysis	long computation time	High classification accuracy

Table 2 :-   Role of Cloud Services

Sl. No.	Cloud Service	Usage	Comments
1.	AWS EC2	For hosting the Web Server for the Dashboard Application	This is located in the IoT VPC and is the platform for the Web Server and the Dashboard Application
2.	IoT Core	To create the IoT landscape – Policy, Thing & Rule	The IoT Core defines the IoT Policy, Registers Sensors, maintains subscribe and publish queues, Test Client, and IoT Rules for downstream processing of the incoming Sensor traffic.
3.	Lambda	Processes device_id and device_date into composite partition key, with timestamp as the sort key; and to processes Kinesis Application output streams and deposits to a separate DynamoDB table	Enable rapid retrieval of patient records by date for a particular set of timestamps associated by day for a particular device.
4.	SNS	To trigger email notifications based on the “rule” setup in DynamoDB Lambda 2	The Lambda function enables configurable emails and SNS notifications based on the Anomalies detected in the incoming streams.
5.	CloudWatch Administrative Dashboard	To provide a comprehensive dashboard including web server performance log metrics as well as component log metrics	Operations / Management Dashboard

6.	DynamoDB	To store the incoming device data. Two tables are proposed, one for the original device data, and the other for the Anomaly streams	Main table will store ALL incoming IoT data; the other to bifurcate based on the Heart Rate – High and Low
7.	S3	To archive all incoming data including patient data	Backup of all incoming data
8.	Kinesis Data Stream & Kinesis Firehose	To stream all incoming IoT data for further upstream processing	IoT Rule sends incoming data to the stream and then to Firehose
9.	Kinesis Data Analytics	To analyse the incoming data stream and bifurcate this into separate data streams for high and low heart rate timestamps	To create separate streams for high and low heart rates for further downstream processing. We have increased the role of the analytics for this iteration (interim report)
10.	Glue	Definition of Data Catalog, Database & Table for Athena	N A
11.	Athena	Creation of table as defined in Glue, populating all incoming data fields	For interface with Quicksight
12.	Quicksight	Dashboard delivery	Historic Data Dashboards

3. Benefits Of Remote patient Monitoring

Benefit #1: Improves data driven clinical decision making

Remote patient monitoring benefits providers by improving their clinical insight on patients' status, in between office visits and offering them tools to inform proactive care delivery. With RPM, the provider sees how a patient's symptoms change over time, allowing the provider to identify trends or alter the patient's care plan accordingly.

Benefit #2: Helps patients improve self management and care plan adherence

For a variety of patient populations, including those experiencing single or multiple chronic comorbidities, COVID-19 infection, post-surgical recovery, maternal and child needs, malignant neoplasms, and more, remote patient monitoring benefits patients by providing them with readily available, condition-specific, and easy to use tools to manage their condition.

Benefit #3: Cost of Care reduction for payers and providers

Remote patient monitoring has demonstrated significant impact in reducing potentially avoidable ED utilization as well as a reduction in unnecessary hospital admissions and readmission. It enables ED diversion and earlier acute discharge, resulting in shorter lengths of stay and lower cost of care. RPM enables movement of appropriate levels of acute care and chronic care monitoring into the home, reducing the high costs of inpatient services.

Benefit #4: Boosts net patient revenue

The cost of caring for a patient virtually is less than Brick and Mortar associated costs. Due to improved workflow efficiencies, enhanced staff productivity, and reduced administrative costs, net patient revenue can increase when an organization adopts RPM. RPM also provides opportunities for reimbursement and competitive advantage.

Benefit #5: Reduces patient's expenses and improves work productivity

The patient is able to avoid the associated costs of an in-person visit when they receive care via RPM. Patients avoid the inconveniences and expenses of travel, parking, childcare, and/or taking time off work.

Benefit #6: Improves access to care

Remote patient monitoring bridges the barrier of access by providing care to patients where they are, when they need it. It can be used to reach patients in rural areas, and connect patients to specialists who they otherwise would not have access to. It also serves as a great way to reduce appointment breaches.

Benefit #7: Builds patient engagement

Remote patient monitoring is a fantastic patient engagement strategy as it provides the patient with tools to assist them in understanding their health. When a patient understands their condition, their unique care plan, and what their responsibility is in bettering their health, they're more likely to experience positive health outcomes. Convenient access to health education materials further improves their engagement.

Benefit #8: Optimizes clinical staff efficiency and combats clinical staff shortages

Remote patient monitoring benefits clinicians by helping them prioritize care delivery, enabling them to triage each patient and case based on close to real-time patient status. Many RPM tools are able to integrate with the provider's EMR, reducing duplicative documentation.

In the face of severe staffing shortages, RPM can help reduce the burden of over-scheduled in person visits by allowing clinicians to provide some of that care virtually. It leverages a team-based care model that allows for provider flexibility.

Benefit #9: Prevents the spread of infectious diseases and Hospital-Acquired Infections

Another advantage of remote patient monitoring is in preventing infectious disease. With RPM, patients do not have to visit the hospital or clinic where they are vulnerable to contract an infection. Avoiding an in-person visit eliminates the risk of unnecessary exposure—particularly for the elderly and those who are chronically ill, pregnant, or otherwise immunocompromised.

Benefit #10: Boosts caregiver connectivity and involvement in care

Remote patient monitoring not only benefits patients, but their caregivers as well. Many RPM tools today involve the patient's caregiver into the plan of care by enabling their access to the patient's vital sign recordings and progress. With RPM, the caregiver can engage in and influence their loved one's care and outcomes. It provides the caregiver with an extra layer of external support should a question arise, or an emergency occur.

Benefit #11: Improves patient experience and satisfaction

RPM conveniently meets patients where they are, and where they want to be. It removes the burden of a hospital visit or stay, allowing patients to receive efficacious and safe care from the comfort of their own homes.

3.1 Features of the Remote Monitoring System:-

Reliability: For starters, this can contribute to increased efficiency: With remote care's simple, near-instant communication capabilities, practices may move to a more automated scheduling system, skipping in-person appointments while decreasing doctor-patient facetime.

Timeliness: Another important benefit of IoT healthcare is that it can lead to earlier intervention. The extra minutes provided by continuous monitoring may mean the difference between life and death, especially in more urgent, time-critical medical incidents.

Efficacy: Another significant by-product of Healthcare IoT is the ability to improve quality and early detection. Connecting all devices and alarms to the same advanced GPS network allows for early intervention for flagged patient symptoms. It allows relief teams to respond quickly and more clearly in emergencies, especially for patients.

Security and safety are paramount: As a result of sophisticated network security: Patient surveillance improves physical safety by providing better fall prevention resources and improves digital protection by providing access to a highly protected network where patient health information can be accessed. Several smaller hospitals have used Remote Patient Monitoring integration to help improve their in-house data protection activities.

Adaptability: This can aid in the improvement of customer satisfaction Patients are seeking more access to treatment through their daily consumer devices. Allowing them this choice and then satisfying their standards with engaging, simple-to-use content and interactivity would help to ensure higher contentment rates. This development has been linked to the growth of FitBit and other mHealth technologies like Smart watches etc.

The progressive technology will change everybody's life and health monitoring, reduce healthcare costs remarkably and take steps forward in predicting the accuracy of the disease.

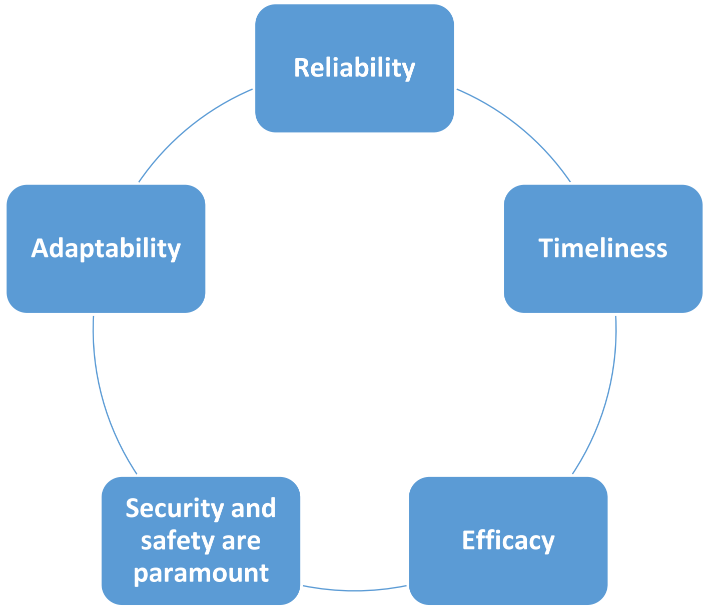


Figure 4. Features of Remote Patient Monitoring System

4. NON-CONTACT PATIENT MONITORING TECHNOLOGIES

The innovations are categorized based on technology types such as infrared, sound analysis, video analysis, doppler radar, sensor, mobile platform, and ultrasound technologies. The report also enlightens the growth opportunities in the non-contact patient monitoring segment for different indications.

Even after huge market adoption of wearable devices, patients still complain about the inconvenience and uncomforting issues pertaining to the long period of wearing such devices. High cost of the wearable devices also restricts its availability for economically stable patients. Some of the technologies already developed and in use such as Video.

Analysis Technology are as follows:

• AI-powered, Video-based Vital Signs Monitoring
• 3D Motion Tracking Technology for Estimating Heart Rate and Rhythm
• Breathing Pattern Analysis Based on Acquired Video Data
• Video-based Software Technology for Vital Signs Monitoring It is already Experiencing High Demand for In-home Monitoring

5. Reviewed research work process

In the healthcare context, designing an efficient IoT-based system is a challenging task due to the following main issues. First, the chosen sensor networking technology must be resource-efficient and customized for e-Health applications. Medical sensor nodes, especially implanted ones, have much lower processing power, memory, transmission speed, and energy supply than sensors in other sensor networks domain. Second, unlike common sensor networks where interval-based data transmission is used (e.g., temperature and humidity monitoring), e-Health applications often need to manage streaming-based transmissions where realtime requirements need to be considered. Consequently a considerable energy is dissipated during the transmission process. For instance, Electrocardiogram (ECG) signal transmission requires 4 kbps bandwidth per channel. Third, in multi-patient applications such as in smart hospitals, hardware platforms with a high processing power and parallel processing features (e.g., multi-core processors) are needed in the gateway due to concurrent nature of the workloads. However, as we discuss in this section, the existing general-purpose gateways are not designed for such scenarios. Fourth, reliability in e-Health application is of utmost importance and even short system unavailability often cannot be tolerated. Thus, as we discuss in the following, the limited resources of medical sensor nodes render the use of general-purpose gateways inefficient in most circumstances with respect to delay, energy, and reliability.

Using a three-tier architecture, with varying computational capacity, for IoT applications is common in both industry and research. The focal point of most of the related works is the gateway used in the middle tier of the IoT architecture. One of many such efforts is presented in which proposes gateways to transparently connect sensor networks with different protocols such as ZigBee, Bluetooth, and Ethernet to the Internet. However, these gateways have limited flexibility as they cannot be customized for different applications. In a different category of related work, Mueller et al. present a gateway called SwissGate which handles and optimize the operation of a sensor network. They specifically apply SwissGate on home automation applications such as measuring heating, ventilation, and air conditioning control (HVAC) parameters. Bimschas et al. aim at providing some levels of intelligence to gateways by enabling them to execute application code. They propose a middleware for the gateway to offer four possible services: protocol conversion, request caching, intelligent caching, and discovery.

Another work by Jong-Wan et al. present a sensor network system comprising of a main server and several sensing-servers acting as gateways and connecting with different sensor networks. Using network-dependent sensing-servers as gateways results in high implementation and hardware cost as well as poor scalability, making such a design inefficient for many IoT applications. In a related work presented in, a plug-configurable-play service-oriented generic gateway is proposed in order to provide simple and rapid deployment of various external sensor network applications. The gateway offers a proper level of interoperability by facilitating heterogeneous sensor networks to work together. However, the middleware presented in their work lacks intelligence and runs on PC, limiting its applicability for many IoT applications. In a similar attempt, Guoqiang et al. propose a general purpose smart gateway. It provides pluggable architecture which enables communication among different protocols, unified external interfaces fitting for flexible software development, and flexible protocol to translate different sensor data.

In order to save energy and reduce the cost of smart home, Bian et al. present a new type of intelligent home control system, using an Android Phone as a temporary home gateway instead of the default home gateway. The aim of the work is to automatically shut down the unused devices by predicting user behavior. In a different application domain, the work presented in proposes a prototype of a smart 6LoWPAN (IPv6 over Low power Wireless Personal Area Networks) border router which makes local decisions of health states using a Hidden Markov Model.

In another work, Satyanarayanan et al. propose that mobile devices can use complex algorithms such as facial recognition and language translation to augment human cognition. However, limitations in processing power and long WAN latency are unacceptable. The authors then propose cloudlets which consist of a computer with wireless connectivity in the vicinity of the mobile device. A base virtual machine (VM) is installed in the cloudlets. VM instances are launched from the cloudlets and configured using an overlay script from the mobile device with desired application. The VMs are designed to migrate from one cloudlet to another to allow ubiquity. The authors claim that applications run faster with this configuration due to lower latencies and higher processing power. However, the authors face challenges regarding long launching times. In Stantchev et al. present the benefits of three-level (i.e., fog based) architecture for a remote patientcare infrastructure from servitization and business point of view. However, they only focus on high level architectural modeling aspects and do not discuss real world implementation and experimental evaluation of the services.

Although efforts of using a gateway in IoT have been greatly expanded in recent years, there are only small improvements towards realizing smart gateways streamlined specifically for the healthcare domain. Most of the presented efforts focus on general purpose gateway designs which affects the provided level of intelligence due to lack of information about the application domain. Some of these efforts limit their level of intelligence only for the sake of plug-and-play ability, or reconfigurability to various domains. Some others just focus on specific domains such as smart home.

Existing contributions using a gateway as an intermediary between sensors and cloud storage, consider a minimal role for the gateway, for example applying simple set of rules. In few cases, a gateway is leveraged for domain specific purposes. However, such platforms fail to satisfy the requirements of other domains. In the healthcare sector, particularly for remote health monitoring, a high level of reliability, availability and robustness is demanded. Moreover, security and privacy issues are of critical importance. The purpose of our smart e-Health gateway is to satisfy these domain-specific requirements by customizing gateways for the healthcare domain and providing intelligence closer to patients.

Our proposal is motivated by the fact that in a smart hospital or in-home healthcare, the gateway is in the unique position between both the BAN/PAN/LAN and the wide area network (WAN). This promising opportunity can be exploited by different means such as collecting health and context information from these networks and providing different services accordingly. By geographically distributing and networking smart e-Health gateways, a smart intermediary layer can be formed to provide smooth and efficient healthcare services without limiting the mobility of patients. In general, the motivations of utilizing a Geo-distributed network of smart e-Health gateways for Health-IoT are manifold.

6. **Proposed System**

The implementation of the proposed system involves a three-tier architecture of various technologies coupled together to achieve the goals of the system. The tiers of the proposed system are the patient tier, cloud tier, and physician/specialist tier. The three-level system architecture of the proposed system is shown in Figure and described as follows.

A) **Patient Tier**: -The patient tier consists of the patient itself and IoT modules. The IoT module consists of a set of biomedical sensors that measure key data (heart rate, oxygen saturation, body temperature, etc.) and a WiFi-based microcontroller that processes this sensitive data, encrypts it using the AES algorithm, and transmits it directly to the cloud database via Wi-Fi.

   The MAX30102 is a high-sensitivity pulse oximeter used to measure heart rate and oxygen saturation. The DS18B20 sensor is used to measure body temperature. This sensor is connected to the ESP8266 NodeMCU microcontroller to control the entire system and provide processing and transmission functions. The ESP8266 NodeMCU is an emerging IoT device capable of small size, low cost, offline Wi-Fi module, fast processing speed and offline application execution.

B) **Cloud Tier**: - The cloud layer serves to provide a secure place for personal health data. The cloud receives confidential data from the patient layer and stores it in an encrypted format, making the system more resistant to external attacks as well as internal attacks that can be launched by the cloud service provider itself. The cloud tier is not charged for data processing but passes the data as-is to the next tier.

C) **Physician/Specialist Tier**: - This layer allows professionals in trusted medical centres to monitor and track critical patient data in real time. This allows professionals to predict unusual activity and prescribe preventive measures to prevent emergencies. A backend mechanism is used to extract and decrypt the received data and forward it to the dashboard.

6.1 Types of the performer involve in remote health monitoring system :-

- **Patient performer**:- They are the main players in the system, where health is the main concern, the system has to deal with. The patient should be provided with an Android mobile device that can tracks the patient's location (using the built-in GPS receiver) and vital signs (obtained from medical sensors) and a special application containing information about the patient's health and location. The mobile device processes the collected health data, stores it locally and periodically transmits it to the server.

- **Doctor performer**: - They use an Android mobile device to inquire about the current patient's vital signs. A medical record ID must be registered in the system. When a patient has an emergency, the doctor is notified with a server-initiated alarm message. You can also inquire about a patient's health status through their online service.

- **System Administrator**:- The system works as an automated as possible; although the system administrator in some cases is needed to change the workflow or take a decision when there is need for human interaction.

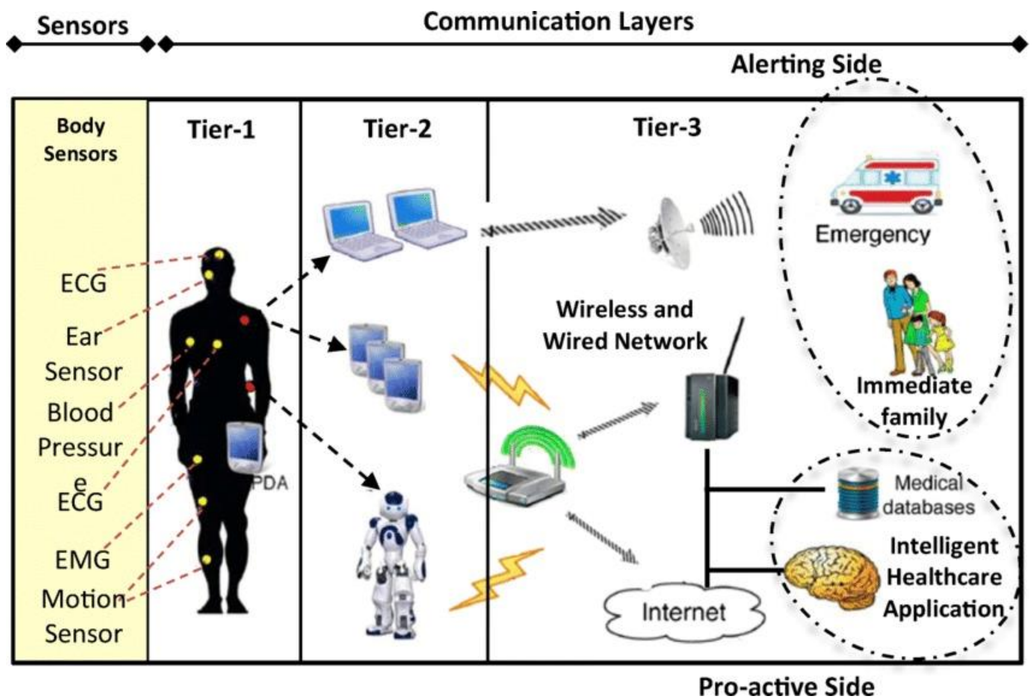


Figure 5

6.2 Health monitoring and data collection:

Sensors are using in health monitoring systems is to collect data and health parameters from patients. This proposed system; sensors monitor the critical health parameter like temperature, blood pressure, respiratory rate, movement, heart rate, ECG, etc. Sensors send the signal data to Arduino .

NodeMCU: NodeMCU is an open-source LUA based firmware developed for the ESP8266 wifi chip. By exploring functionality with the ESP8266 chip, NodeMCU firmware comes with the ESP8266 Development board/kit i.e. NodeMCU Development board. Since NodeMCU is an open-source platform, its hardware design is open for edit/modify/build.

NodeMCU Dev Kit/board consist of ESP8266 wifi enabled chip. The **ESP8266** is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol.

Figure 6: NodeMCU

ECG Sensor: ECG records the electrical activity generated by heart muscle depolarizations, which propagate in pulsating electrical waves towards the skin. Although the electricity amount is in fact very small, it can be picked up reliably with ECG electrodes attached to the skin. The full ECG setup comprises at least four electrodes which are placed on the chest or at the four extremities according to standard nomenclature (RA = right arm; LA = left arm; RL = right leg; LL = left leg). Of course, variations of this setup exist to allow more flexible and less intrusive recordings, for example, by attaching the electrodes to the forearms and legs. ECG electrodes are typically wet sensors, requiring the use of a conductive gel to increase conductivity between skin and electrodes.

Figure 7: ECG Sensor

Temperature Sensor: Temperature sensor is a device which is designed specifically to measure the hotness or coldness of an object. LM35 is a precision IC temperature sensor with its output proportional to the temperature (in °C). With LM35, the temperature can be measured more accurately than with a thermistor. It also possesses low self-heating and does not cause more than 0.1 °C temperature rise in still air. The operating temperature range is from -55°C to 150°C.The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy.

Figure 8: Temperature Sensor

Pressure Sensor: A pressure sensor, as the name suggests, is a device that senses and measures pressure (usually of gases or liquids). The pressure sensor in electronic circuits is in the form of an integrated circuit that acts as a transducer, that is, it replicates (in the form of an electrical signal) the signal it receives as a function of imposed pressure. A pressure sensor is also known as a pressure transducer, pressure transmitter, pressure sender, pressure indicator, piezometer and manometer.

Figure 9: Pressure Sensor 3.2.5

Body Movement Sensor: Unintentional falls are a common cause of severe injury in the elderly population. By introducing small, non-invasive sensor in conjunction with a wireless network, this project aims to provide a path towards more independent living for the elderly or bed ridden patients. Using a small device worn on the waist and a network of fixed in the home environment, we can detect the occurrence of a fall and the location of the victim. Low-cost and low-power MEMS accelerometers are used to detect the fall while RF signal strength is used to locate the person.

Figure 10: Accelerometer Sensor MMA7260QT

Humidity Sensor: A humidity sensor (or hygrometer) senses, measures and reports the relative humidity in the air. It therefore measures both moisture and air temperature. Relative humidity is the ratio of actual moisture in the air to the highest amount of moisture that can be held at that air temperature. The warmer the air temperature is, the more moisture it can hold. Humidity / dew sensors use capacitive measurement, which relies on electrical capacitance. Electrical capacity is the ability of two nearby electrical conductors to create an electrical field between them. The sensor is composed of two metal plates and contains a non-conductive polymer film between them. This film collects moisture from the air, which causes the voltage between the two plates to change. These voltage changes are converted into digital readings showing the level of moisture in the air.

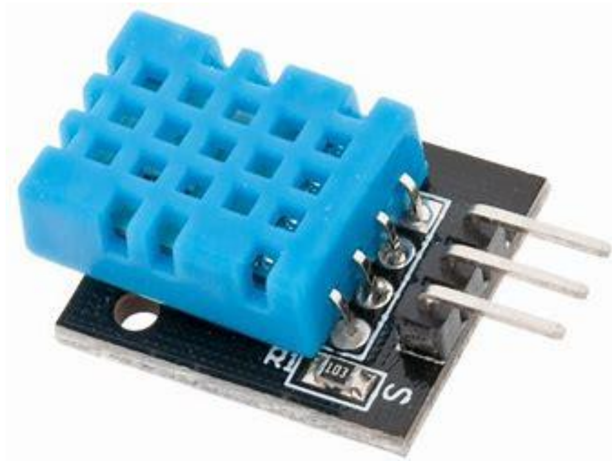


Figure 11: DHT 11 Humidity Sensor

Heartbeat sensor: Heartbeat sensor provides a simple way to study the function of the heart which can be measured based on the principle of psycho-physiological signal used as a stimulus for the virtual reality system. The amount of the blood in the finger changes with respect to time. The sensor shines a light lobe (a small very bright LED) through the ear and measures the light that gets transmitted to the Light Dependent Resistor. The amplified signal gets inverted and filtered, in the Circuit. In order to calculate the heart rate based on the blood flow to the fingertip, a heartrate sensor is assembled with the help of LM358 OP-AMP for monitoring the heartbeat pulses.

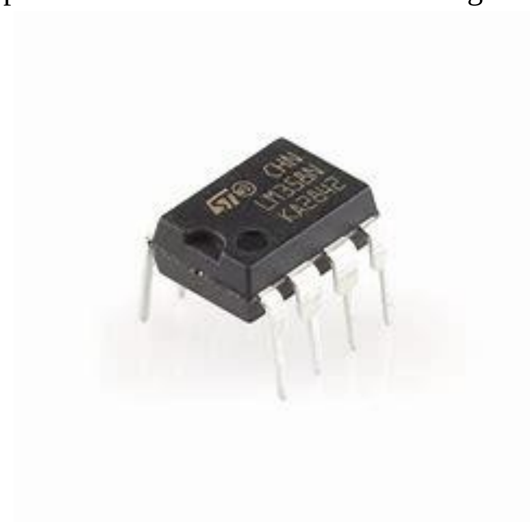


Figure 12: Heartbeat Sensor LM350 OP-AMP

Toxic Gas Sensor: Gas Sensor(MQ9) module is useful for gas leakage detection (in home and industry). It is suitable for detecting LPG, CO, CH4. Due to its high sensitivity and fast response time, measurements can be taken as soon as possible. The sensitivity of the sensor can be adjusted by using the potentiometer.

Figure 13: Toxic Gas Sensor 3.2.9

Air Quality sensor: This sensor is designed for comprehensive monitor over indoor air condition. It’s responsive to a wide scope of harmful gases, as carbon monoxide, alcohol, acetone, thinner, formaldehyde and so on. Due to the measuring mechanism, this sensor can’t output specific data to describe target gases’ concentrations quantitatively. But it’s still competent enough to be used in applications that require only qualitative results, like auto refresher sprayers and auto air cycling systems

.

Figure 14: MQ135 Air Quality Sensor

GSM module: GSM (SIM 800L) module is deployed to form a communication path among computers and GSMGPRS systems. GPRS is an expansion lead of GSM that allows high information transmission. GSM/GPRS module comprises of a GSM/GPRS modem amassed with a power supply circuit and communication interface. It needs a SIM card like mobile to form communication with the network. It also consumes an IMEI number for identification. It needs AT command on behalf of interaction with a processor which is connected with serial communication. The controller sends those commands. AT command maintained by modem will be sent by the PC to interrelate with GSM cell network.

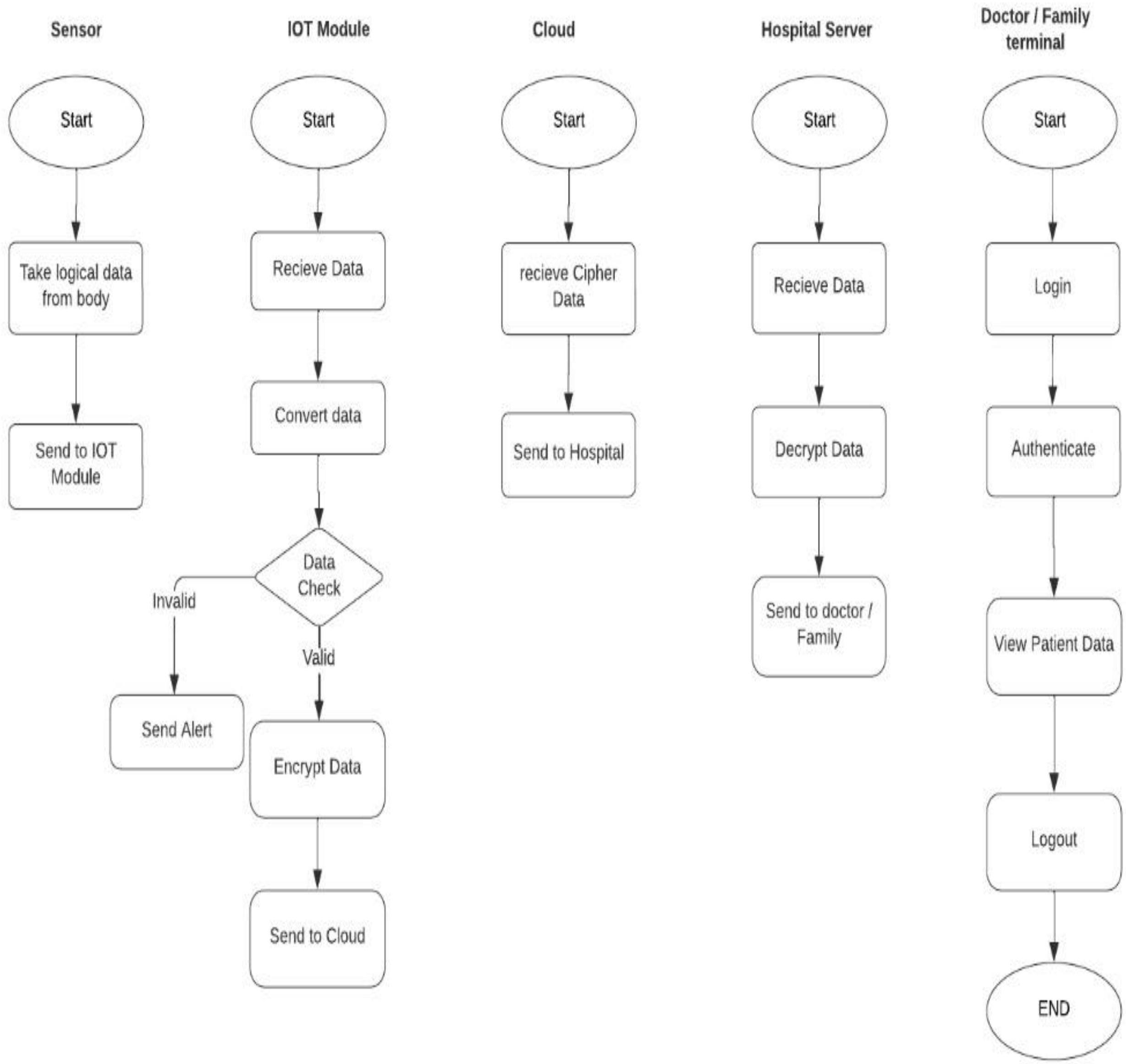
Figure 15: GSM (SIM 800L) Module

GPS module: GPS (Vk-16E) is a tracker use to track anyone location with the help of satellite. For remote patient monitoring system it is quite helpful for patient to inform about his place and doctor and guardian can easily trace his location using this. It is small in size, highest performance, and most sophisticated module.

Figure 16: GPS (Vk-16E) Module

7. System workflow

The system workflow of the remote health monitoring system starts with the sensor parts. These sensors are embedded with the wearable devices using contactless and non-contactless to the body part. These sensors sense the body party and generates the reading on the wearable devices, so it is called as taking the logical data from the body or the readings or degree. Then these readings are sent to the IoT part which receives the data from the body and convert the data into understandable form and then data is being checked whether it is valid data or non-valid data. If it is non-valid data, then send an alert to the device or the person that the data is invalid and if it is valid data then data is to be encrypted so that any third person can't be able to access that data to make interchange in them and then after encryption the data is to be send to the cloud. "The cloud" refers to servers that are accessed over the Internet, and the software and databases that run on those servers. Cloud servers are located in data centres all over the world. On the cloud the data are received in the form of encrypted data and the hospital server is having access to the data on the cloud. The hospital server retrieves the data from the cloud and decrypt the data as the data which is retrieve is encrypted and then through that the doctor and family member can be easily accessible to the reading so that further precaution can be given by the doctor, and it can followed by the patient so that he/she can live happy life. The following figure shows the how system works. The below figure 16 shows the workflow of the system



Sensor
IOT Module
Cloud
Hospital Server
Doctor / Family terminal
Start
Start
Start
Start
Start
Take logical data from body
Send to IOT Module
Recieve Data
Convert data
Data Check
Invalid
Valid
Send Alert
Encrypt Data
Send to Cloud
recieve Cipher Data
Send to Hospital
Recieve Data
Decrypt Data
Send to doctor / Family
Login
Authenticate
View Patient Data
Logout
END

Figure 17

8. Research Objective

The core objective of this project is the design and implementation of a health monitoring system. The sensors are embedded on the patient body through some wearable devices to sense the temperature and heartbeat and pulses of the patient. Many more sensors are place at home to sense the humidity and the temperature of the room where the patient is living. These sensors are connected to a control unit, which calculates the values of all the sensors and save the information on the cloud. These calculated values are then transmitted through a IoT cloud for further treatments and diagnosis. Thus, based on the temperature and heartbeat values and the other sensor values, the doctor can decide the state of the patient and appropriate measures can be taken.

Internet of Things is bringing innovations to many segmentations of the industry. One of the fastest industries to embrace this opportunity is healthcare, turning available a new market based on IoHT. That fact led the authors to develop a comprehensive survey to analyze the state of the art on the topic. To accomplish this goal, the most recent IoHT publications and products were identified, described, and analyzed. It is possible to conclude that there are many services and applications for IoHT, these solutions attend the society needs, but are growing isolated. The discussion on this paper may help developers and entrepreneurs to build solutions that embrace all the society. Additionally, this paper can be considered as a source of information for healthcare providers, specialists, and the general population interested in IoHT , AI in healthcare and Cloud Computing in Healthcare.

Nevertheless, this review does not provide a deep understanding about some fundamental topics, including topologies, architectures, and platforms for AI,Cloud Computing IoT; security requirements, challenges, and proposed models. There are other technologies which are not explored in this review and could be explored further, such as big data, augmented reality, and cognitive systems. Finally, policies and regulations are very important in the healthcare sector and should be considered in future researches.

9. Research Methodology

Internet of Things (IoT) is a large-scale connection where information and communication tools connect various embedded devices to the Internet to collect and convert data. A combination of embedded devices with cloud servers recommends a wide range of IoT functionality in a few areas of human life. This paper has paved the way for using cloud based IoT healthcare sensors to streamline patient monitoring. In conjunction with the implementation of a variety of internal capabilities, multi-network wearable sensors can be used for biomedical data collection to transfer patient data directly to robust cloud systems to monitor health remotely.

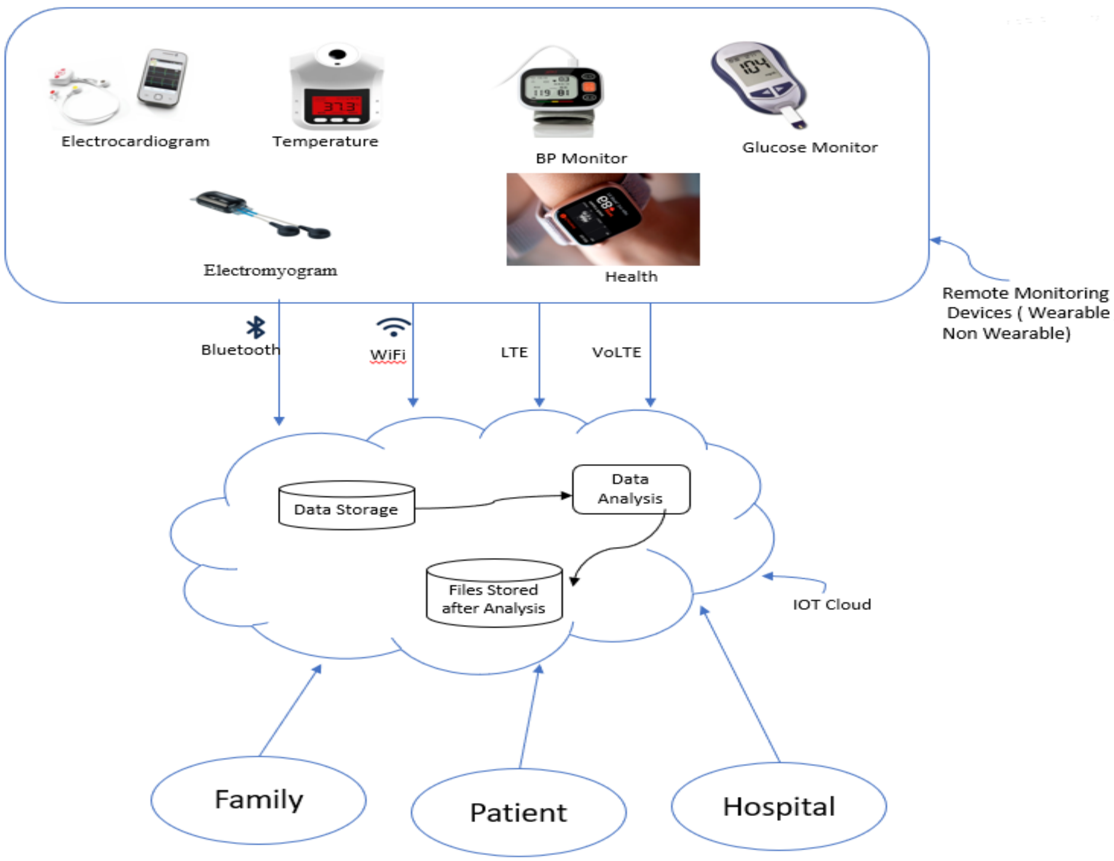


Figure 18

10.Data security in RPM

The data generated by RPM network and IoMT devices are knows as big data or health data. Handling of this healthcare data requires high computational sources and data storage capacity. Cloud computing and cloud storages is the solution to health care data handling. However, most of this data is confidential to patient. The data security and privacy are the major challenges in RPM. The mis use of this confidential data by certain users, individuals, and organization to fulfill personal gains should be avoided. The data security includes the physical security, authentication, network security, computer security and storage security. Cryptography, data encryption, genetic algorithms, enciphering and deciphering techniques are more popular Most of the security and privacy framework offers third party where trust is always an issue. Recently blockchain and Interplanetary file system has gained recognition for secure data exchange technology in the sector of finance and banking .Blockchain consists of data sets in form of blocks connected by chain where each block contains number of transactions. Addition of new block in the chain contains the complete public ledger of transaction history and new blocks are validated by cryptographic means. The presence of time stamp and value of block hash of previous block makes blockchain robust and highly secure way of data transfer. In present scenario, the blockchain has been successfully implemented in the logistics, manufacturing, management and medical services. Several frameworks have been available in the public domain which has shown success in the medical health care services and RPM networks

11.Limitations of RPM and IoT

There are certain limitations of these RPM and medical IoT devices i.e., heterogeneous data collected by various type of sensors prone to be errors crates difficulty to read or to diagnose the patients situations. The wearable sensors generate irritation specially for children hence, the wireless sensors are preferably used. The security issues cannot be neglected for the confidential patient data which can be hacked. By using IoT health care system, the fraudulence is also the subject of matter. Basically, smart medical system is more beneficial to chronic patients rather than general health care services. IoT devices run on battery and/or continuous power which is a not available in remote locations. Major challenges have been presented in the Fig. 5.

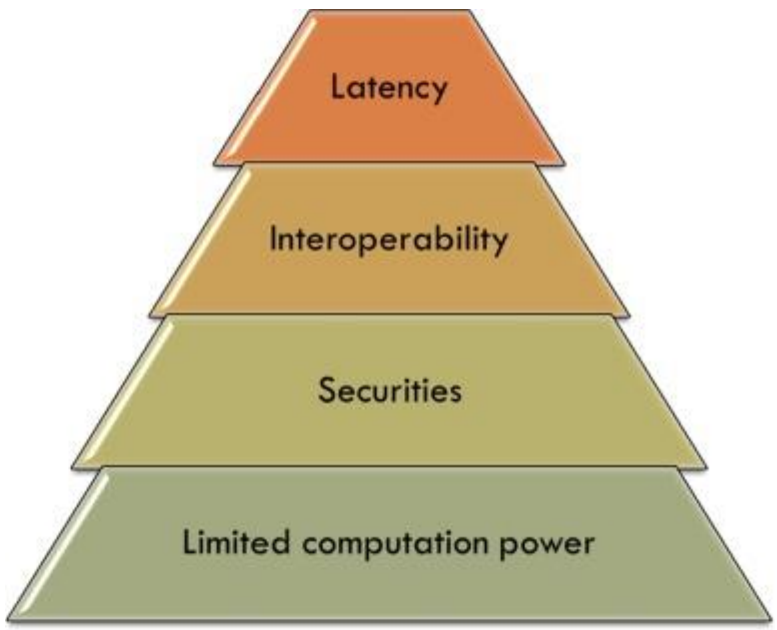


Figure 19 : Limitation of RPM and IoT

12. Limitations and Challenges in the Application of Artificially Intelligent Systems

The application of artificially intelligent systems in any field including healthcare comes with its share of limitations and challenges. The time has come to change our mindset from being reactive to being proactive with regard to downfalls of new technology. Here we discuss those challenges focusing more on those that pertain particularly to healthcare.

Availability of data The first step towards building an artificially intelligent system (after problem selection and development of solutions strategy) is data collection. The creation of well performing models relies on the availability of large quantities of high quality data. The issue of data collection is shrouded in controversy due to patient privacy and due to recent incidents of data breaches by major corporations. Advances in technology have resulted in increased computational and analytic power as well as the ability to store vast amounts of data. Technology such as facial recognition and gene analysis provides a path for an individual to be identified from a pool of people. Patients and the public in general have a right to privacy and the right to choose what data, if any, they would like to share. Data breaches now make it possible for patient data to fall into the hands of the insurance companies resulting in a denial of medical insurance because a patient is deemed more expensive by the insurance provider due to their genetic composition. Patient privacy leads to restricted availability of data, which leads to limited model training and therefore the full potential of a model is not explored.

Creating biased models Biased data

Artificially intelligent systems are then trained with a portion of the data that was collected (also known as training data set) with the remaining data reserved for testing (also known as testing data set). Thus, if the data collected is biased, that is, it targets a particular race, a particular gender, a specific age group then the resulting model will be biased. Thus the data collected must be a true representation of the population for which its use is intended.

Data preprocessing

Even after unbiased data has been collected, it is still possible to create a biased model. The collected data must be preprocessed before it can be used to train an algorithm. The raw data that has been collected often contains errors due to manual entry of data or a variety of other reasons. These entries are sometimes modified through mathematical justification or are simply removed. Care should be taken that data preprocessing does not result in a biased pool of data.

Model selection

With the existence of several algorithms and models to choose from, one must select the algorithm that is best suited for the task at hand. Thus, the process of model selection is extremely important. Bias models are ones that are overly simple and fail to capture the trends present in the dataset.

Presenting biased models

It is important for a user of an artificially intelligent system to have a basic understanding of how such models are built. This way a user can better interpret the output of the model and decide how to make use of the output. For instance, there are many metrics that one could use to evaluate the performance of a model, such as accuracy, precision, recall, F1 score, and AUC score.[21] However, not every metric is appropriate for every problem. When the user of an artificially intelligent system is presented with performance metrics of a model, they need to make sure that the metrics appropriate to the problem are being presented and not just the metrics with the highest scores.

Fragmented data

Another limitation of the application of AI is that models that one organization spends time and effort to design and deploy for a specific task (regression, classification, clustering, NLP, etc) cannot be seamlessly transitioned for immediate use to another organization without recalibration. Due to privacy concerns, data sharing is often inaccessible or limited between healthcare organizations resulting in fragmented data limiting the reliability of a model.

13.Challenges in RPM

The remote healthcare monitoring system is a new revolution in medical science. It makes healthcare services cost-effective. However, using this system has various challenges because there is no medical staff to ensure proper use of this system . To make this system more useable, all problems must be clarified. So the main challenges are:

- **Network connectivity:**
  Remote monitoring system depends on network connectivity and it gives the availability of patients and doctor premises. Wearable devices transmit data over a network, if any interrupts occur it hampers patient health diagnosis. So connectivity is a major issue and challenge.

- **Sensors, wearable device and its wear ability:**
  The remote monitoring system is totally based on sensors and wearable devices. The device must be available upon the patient's requirements, and it should be energy efficient, low cost, low weight, and easy to use.

- **Security and Privacy:**
  This system works on network availability, all networks have a risk of hack and security issues. RPM system must be incorporated with security measures to provide guaranty and privacy of patient's record [21]. To accept this system widely there is a various common issue like cost and affordability, data manipulation and violence of patient's right, the accuracy of data, data authentication and flexibility .

14. Research Outcome

Remote Health monitoring systems play a crucial role in health and early prediction health problems. These systems are also a means of reducing medical costs for regular checks and visitors of hospitals. Therefore, the development of a system that provides data on health from the patient, the location of the opponent, or medical professionals was needed as demand has increased. This document uses IoT technology and cloud computing to provide a safe, inexpensive, reliable health monitoring system that provides real-time monitoring panels for biological indicators in a safe environment. The proposed system is enabled for use in AES algorithms to encrypt important signals captured from the sensor before they are sent to the cloud for storage. A NodeMCU microcontroller is used to perform processing and encryption functions and connect to the cloud via WiFi. The proposed system also provides an alert by sending an email to the patient's relatives or coordination specialists if vital signs are outside the normal range.

15. Conclusion and future scope

The RPM have shown great success compared to traditional health monitoring system which limited to delayed services, latency in medication and precautions. Integration of Cloud computing and blockchain technologies in RPM has gained the trust of medical care professionals as well as the patients in terms of data security and data privacy. RPM found to be able to fulfill the special needs of critically ill patients as well as general health monitoring services to achieve customized health goals and healthy life styles. The Extensive use of RPM in sports and general care is limited and can be explored further with continuously evolving technologies. "The RPM poses several opportunities in the future for medical services which was earlier impossible to achieve. The present work presents the review of the remote patient monitoring frameworks which successfully implemented the deep learning and machine learning approaches and algorithms for achieving higher outputs. The similar review works on RPM lacks the reporting of ML, DL integrated RPM related works. The use of IoT in RPM has led to fast and responsive remote and real time monitoring related medical services.

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