A SEMINAR REPORT ON

IoT In Healthcare

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BY

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DEPARTMENT OF COMPUTER ENGINEERING

CERTIFICATE

This is to certify that the Seminar report entitled **“Iot in Healthcare ”** being submitted by **Aarushi Singh (T150604203)** is a bonafide work carried out by him/her under the supervision and guidance of **Vandana V Navale** in partial fulfillment of the requirement for **TE Computer Engineering** course of Savitribai Phule Pune University, Pune in the academic year 2020 - 2021.

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LIST OF FIGURES

ABSTRACT

The Internet of Things (IoT) is a system of wireless, interrelated, and connected digital devices that can collect, send, and store data over a network without requiring human-to-human or human-to-computer interaction. The IoT promises many benefits to streamlining and enhancing health care delivery to proactively predict health issues and diagnose, treat, and monitor patients both in and out of the hospital. Worldwide, government leaders and decision makers are implementing policies to deliver health care services using technology and more so in response to the novel COVID-19 pandemic. It is now becoming increasingly important to understand how established and emerging IoT technologies can support health systems to deliver safe and effective care. The paperwork provides an overview of the current IoT technology in health care, outline how IoT devices are improving health service delivery, and outline how IoT technology can affect and disrupt global health care in the next decade. The potential of IoT-based health care is expanded upon to theorize how IoT can improve the accessibility of preventative public health services and transition our current secondary and tertiary health care to be a more proactive, continuous, and coordinated system. IoT-based health care has great potential to improve the efficiency of the health system and improve population health.

Keywords: IoT, IoT in health care, IoT Technology, Healthcare

INDEX

CHAPTER 1

INTRODUCTION

The challenges presented by an aging population with multiple chronic conditions are ubiquitous worldwide. The medical, lifestyle, and personal health needs across aging populations will continue to place a burden on health care resources. Meeting these challenges requires a focus on empowering populations to self-manage their health through health innovation to improve well-being and attenuate health resource burden.

Before the introduction of IoT in Healthcare, the healthcare industry continued to face challenges with respect to setting up a responsive and professional system. Especially, with aging being a natural process, access to the right medical care at the right time for senior citizens was always going to be a challenge, if not impossible**.** Though technology can't bridge the gap completely, it could make the process faster and easier and relieve the patients from the all-important stress factor, which is one of the main causes for chronic diseases to increase.

The Internet of Things offers a rising technology to attain the next level of health services. It assures for the affordable, low-cost, reliable and handy devices to be carried or embedded with the patients, so that to enable seamless networking between the patients, medical devices and physicians. The sensors will record signals in a continuous manner, they are then correlated with the essential physiological parameters and communicated over the wireless network. The resulting data is stored, processed and analysed with the existing health records[1].

Background of Digital Devices and the Internet of Things

Entering the 2020 decade, more devices are connected to the internet than ever before, and this will continue to grow at a rapid trajectory. Worldwide, more than 21 billion devices have been estimated to be connected to the internet in 2020, which is 5 times the number of devices 4 years prior [3]. The Internet of Things (IoT) can be defined in its simplest scenario as a network that connects uniquely identifiable devices (or *things*) to the internet, enabling them to collect, send, store, and receive data. From a health care perspective, IoT can be considered as any device that can collect health-related data from individuals, including computing devices, mobile phones, smart bands and wearables, digital medications, implantable surgical devices, or other portable devices, which can measure health data and connect to the internet [4].

The growth of IoT technology has driven interest in a wide range of health practices to improve population health more specifically. Recent reviews have overviewed the various services and applications of IoT in health care (e.g., eHealth, mobile health [mHealth], ambient assisted living, semantic devices, wearable devices and smartphones, and community-based health care). These services have been detailed extensively and can have many applications across single condition and cluster condition management, including, for example, the ability to track and monitor health progress remotely by health care professionals, improve self-management of chronic conditions, assist in the early detection of abnormalities, fast-track symptom identification and clinical diagnoses, deliver early intervention, and improve adherence to prescriptions. These applications can make better use of health care resources and provide quality and low-cost medical care.

Health Systems Are Changing

With the 2020 public health response to the novel COVID-19 pandemic to effectively shut down traditional modes of health service delivery worldwide, efforts to reduce implementation barriers to technology-supported health delivery highlight the potential to reframe traditional models of care into virtual and distance modalities. In response, many countries have successfully implemented technology-supported services to maintain health care practices and social distancing. As global leaders consider policies that potentially provide more access to technology-supported health services in response to (and considerations post) the current COVID-19 crisis, it is becoming increasingly important to understand how established and emerging IoT technologies can support health systems to deliver safe and effective care in either a complementary or an alternative way during times of crisis or health epidemics.

This viewpoint paper will overview current technologies in health care, outline how IoT devices are improving health service delivery, and outline how IoT technologies can affect global health care in the next decade. This viewpoint paper also overviews how the disruption in health care from IoT can lead to improved access and equitable primary, secondary, and tertiary smart health care, which is more proactive, continuous, and coordinated.

CHAPTER 2
MOTIVATION

Existing methodologies in patient monitoring system focuses on providing better healthcare facilities to a number of patients with limited medicinal resources. These monitoring systems limit the patients to the bed and enable them to move around only a particular range from the bed side. Out of this range there is no possibility to collect the data from patients. The decisions or suggestions given by the system are not highly accurate. The traditional forecasting techniques do not provide timely and accurate results. This increases the risk of error in providing appropriate clinical services. Remote patient monitoring system eliminates the hurdles such as distance and improves the access of medical services. Patient monitoring through android mobile phone enables the clinicians to monitor the patient from multiple locations. Pattern Matching Algorithm is used to determine the type of diseases and give the indication to Doctor. It helps to protect the person from risk factor.

CHAPTER 3

LITERATURE SURVEY

Internet of Things (IoT) and cloud computing plays a vital role in today's Tele-monitoring health system. This system keeps track of patient's physiological parameters through collection of body sensors' data using Raspberry Pi board. The patient's health card are developed by the doctors and displayed on a webpage where doctors and patients can access and communicate each other without physical presence [1]. Using cloud computing, the data can be stored, updated and accessed from anywhere in the world. In Remote health monitoring system using IoT, Body wireless sensor Network (BWSN) is used to transmit the patients' health parameters collected through Raspberry Pi microcontroller to the physicians and caretaker wirelessly. Being long range wireless technology, emergency situation of the patient's health is quickly detected and timely intervention leads to save the life of the patient. Owing to costlier healthcare and long waiting time in hospitals, the concept of in-home patient monitoring system have been emerging in the recent years. This system collects data of various body parameters through Biosensors, wearable devices and smart textiles and it transmits the data to central node server securely through Cipher text Policy Attribute Based Encryption (CP-ABE) method. In turn, the server shares the collected data to the hospitals for further treatment. The server rings alarm to the ambulance during emergency situation. It is very beneficial for elders and chronic patients who require continuous monitoring. The specialized healthcare monitoring system for elderly people is a growing need in the aging population world. This system performs basic health checkups by measuring the body parameters regularly and report the data to the doctors. The result data are then displayed as statements in a web application where doctors and patients can interact with each other. Evaluation is of two parts: 1) Qualitative interviewing and 2) Quantitative Survey. The main challenge is to make elders equipped with for growing new technologies and to become familiarity towards Smartphone, computer, etc. IoT based Smart healthcare with the help of smart devices and objects improves the healthcare monitoring system effectively, thus by reducing the inefficiencies of existing healthcare system. Smart devices with new and upgraded technologies enhances the data accuracy to be collected, real-time accessibility of patient's condition, intelligent integration of data collected, maintaining the integrated data smartly through cloud service, etc. IoT along with smart devices reduce complexity and complications in the healthcare system. The full-fledge utilization of M-health and E-health applications in today's world is made aware to the people for improving and maintaining the good quality of life. Apart from regular monitoring of patients' condition through M-health system, the main objective is to educate them through recommendations of healthy eating habits and effective workout routines for improving their quality of healthy life.

The real time health parameters are measured through wearable sensors and transmitted to a smart phone which shows the patient health status in graphical interface. This system provides a data to family member and doctor through web interface for further monitoring. It provides real time alarm if the patient is at emergency situation such as heart attack, etc. Despite monitoring, there are quite few challenges in using the wearable tracking devices for a long time. Firstly, the daily use of wearable tracking devices is based mainly on small size, rough use and low energy consumption. Secondly, the major challenge is of the accuracy, validity and integrity of measurement data with other devices. Thirdly, the usability and the experiences of the user with the device and its friendly supporting software play vital role in continuing regular and long period use of wearable tracking devices. The use of Internet of Things (IoT) and its e-Health applications in the Tele-medicine health system leads to seamless flow of information between doctors and patients, thus making healthcare cost effective and improving the quality of patients' treatment. This system uses the K53 Tower System platform for e-Health applications to expose the benefits of IoT in medical system. The two fundamental aspects in monitoring people at risk are: 1) Prevention 2) Effective and early intervention during medical emergency.[5]

As the risk of chronic diseases increases day by day there is an immediate need to discover solutions to enhance the quality of life. The focus is on how the IoT is suitable framework for e-healthcare applications making it possible to integrate heterogeneous hardware devices and services to smoothly interact with one another is the key to removing any operational barriers and making it possible to create a holistic health acre that's available on the internet. The E-health applications comprise of services and software that relay, control and keep track of medical healthcare information and relay on the Internet to transmit and store patient's information.[5]

The figure below provides an overview of the healthcare monitoring system. The patients' data such as heartbeat, pulse rate is continuously collected using various sensors and is stored on the cloud service. The data collected can be processed analyzed and better decision making can be provided for the patient. This reduces staff work and human error in the process. Medical emergency can be alerted through this system as well. MQTT is light weight protocol used for transfer of messages.

As the system continuously monitors and sends reports there are various new problems arising.

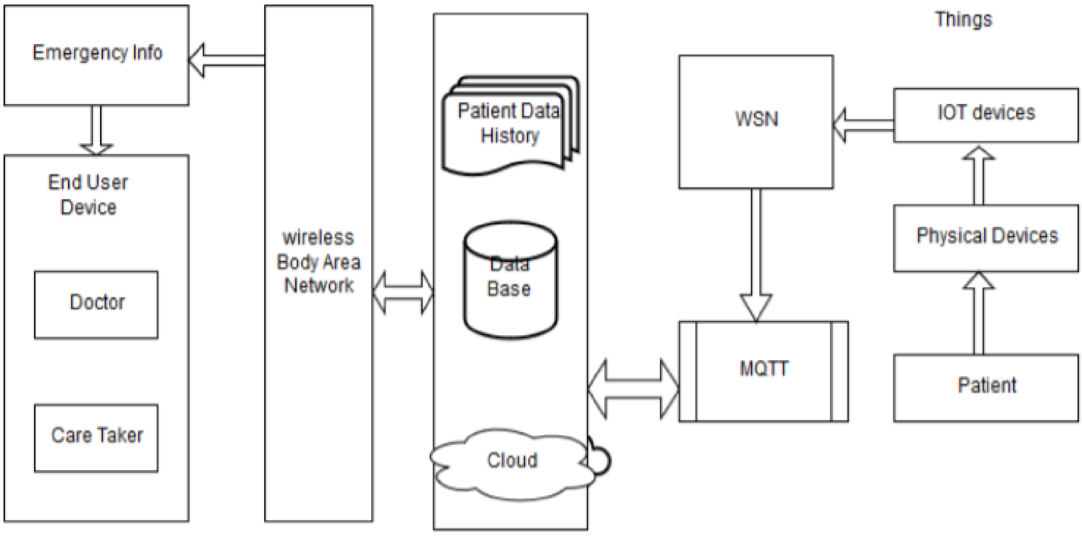

Fig1: Overview of health monitoring system[5]

Enlisting some wearable Healthcare systems mentioned in IEEE report[1]:

(1) Pulse Sensors:

Perhaps the most commonly read vital sign, pulse can be used to detect a wide range of emergency conditions, such as cardiac arrest, pulmonary embolisms, and vasovagal syncope. Pulse sensors have been widely researched, both for medical purposes and for fitness tracking. Pulse can be read from the chest, wrist, earlobe, fingertip, and more. Earlobe and fingertip readings provide high accuracy, but are not highly wearable. A chest-worn system is wearable, but wrist sensors are generally considered most comfortable for a long-term wearable system.

Pressure sensors aim to mimic a healthcare professional manually reading the radial pulse by pressing down with their fingers. As shown in Figure 3, the sensor is placed firmly against the wrist, and pressure is continuously measured to acquire a pulse waveform.

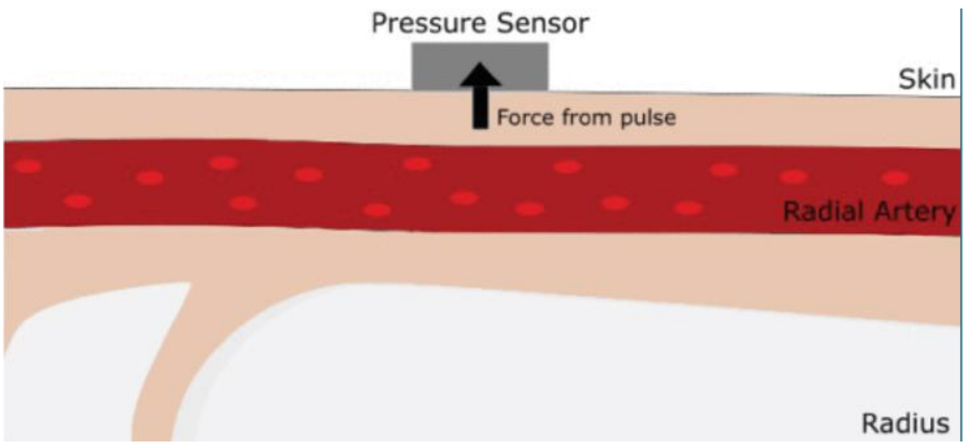

Fig: Pressure based pulse sensor

A flexible and highly-sensitive pressure sensor for pulse detection is developed and tested, showing promising results. However, increasing the sensitivity to better detect pulse also increases the amount of noise that is detected due to movement of the wearer.

Based on these works, it is strongly recommended that PPG sensors are used for pulse sensing. These have repeatedly been proven to be effective for measuring pulse rate, and techniques have already been developed to algorithmically reduce the impacts of noise on the signal quality.

(2) Respiratory Rate Sensor:
Monitoring respiration could aid in the identification of conditions such as asthma attacks, hyperventilation due to panic attacks, apnea episodes, lung cancer, obstructions of the airway, tuberculosis, and more.

The first is nasal sensor. The principle that these sensors are based on is that air exhaled is warmer than the ambient temperature. As such, the sensor uses the rise and fall of temperature to count the number of breaths taken. This is shown to work reasonably well, but accuracy may be compromised by other sources of temperature.

Echocardiogram (ECG) signals can also be used to obtain respiration rate. This is called ECG Derived Respiration (EDR), and is used in to determine respiration patterns and detect apnea events. This method reads respiratory rate reasonably well, but is again limited by the wearability.

One study [6] developed a fiber optic sensor in an elastic substrate, that was sensitive enough to measure vibrations caused by respiration. This was shown to work in a single test, but it is not known whether it would work well under all conditions.

A pressure-type sensor was developed in [7]. Two capacitive plates are placed in parallel, with one resting on the abdomen. During breathing, the plates move further apart and then closer together during inhalation and exhalation respectively, allowing for calculation of respiratory rate. This study showed a 95% confidence in respiratory rate calculations when compared to a nasal sensor. This is fairly accurate, and far more wearable than the nasal sensor it was compared to. However, the nature of a pressure sensor may mean it is susceptible to noise if it is affected by external pressures, such as while walking into wind.

(3) Blood Pressure:
Recent work surrounding the measurement of body temperature all use thermistor type sensor, negative-temperature-coefficient (NTC) or positive-temperature-coefficient (PTC) were used. In all studies the thermistors were shown to measure a suitable range of temperatures for monitoring the human body, with acceptable level of errors. The

accuracy of temperature sensing is limited by how closely the sensor can be placed to human body.

(4) Pulse Oximetry Sensor:
Pulse Oximetry measures the level of oxygen in the blood. It measures blood oxygen by obtaining PPG signals. Usually, two LEDs- one red, one infrared, are directed through the skin. The amount of blood not absorbed by the blood is received by measuring photodiodes and the difference between the received light is used to calculate blood oxygen. Classically, pulse oximeters are worn as a finger clip wired to a medical monitor.

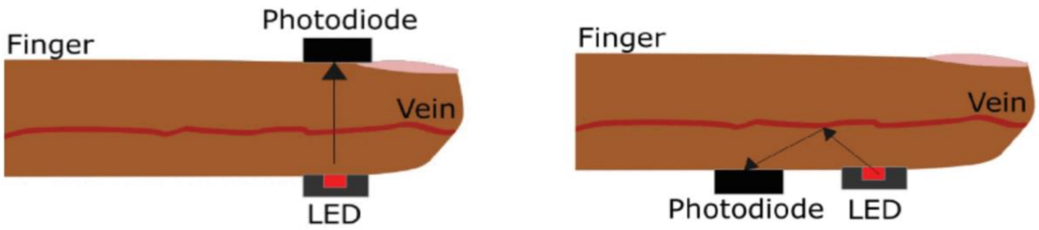

Fig: Absorbance-mode vs Reflective mode PPG sensors for pulse oximetry

Below is an essence of Indian healthcare startups from a report of IISC[3]

The Indian Healthcare and MedTech Startups and SMEs & Their Leap into Digital Health:

Since the beginning of the millennium there has been a growing trend of health technology startups in India and many such as Practo, Lybrate and Mfne have concentrated on digital health mostly focusing on home care and management. These companies have been steadily growing in the fast-growing market of home care in India. In the meantime, over the last two decades, there has been a massive shift in the number of active MedTech (devices and diagnostics) startups and SMEs in India through support provided by different arms of the Indian government such as the Technology Development Board (TDB), the then NMITLI program of the Department of Science & Technology (DST), the Department of Biotechnology (DBT), BIRAC, Millennium Alliance (an initiative supported by the DST, FICCI & USAID) and the Indo USA Science & Technology Fund (IUSSTF), Bill & Melinda Gates Foundation and the Wellcome Trust38–40. Together, these programs have created 3000– 4000 startups in India and over 40–50% are MedTech product development startups38–40. Some Indian startups have predated the funding programs initiated by the Government of India. Startups such as Strand Lifesciences (genomics & precision medicine), Bigtec/MolBio (molecular diagnostics), Perfnt (oncologytumour ablation) have been pioneers of the biotech and MedTech startup landscape in India. Many new startups have taken shape over the last 10 years that are building IoT enabled products for screening, diagnostics and healthcare delivery. These include remote diagnostics and consultation (Neurosynaptic Communications), maternal and child health (CareNx, NemoCare, Sensivision, Janitri, Bempu), AI & imaging (Predible, Qure.ai; BrainSightAI; Adiuvo Diagnostics; Periwinkle) to chronic disease detection and management such as diabetes (Yostra, BioSense) and wellness to name a few[3].

With increase in use of IoT, increase of concerns and issues with it are also increasing.
As the system continuously monitors and sends reports there are various new problems are arising. The problem of standardization among the devices is a huge concern in itself. Most Healthcare information systems cannot exchange information between them. Either the standards are not completely implemented, or national implementation guidelines simply do not exist. This causes unacceptable risk to patients, inefficient use of healthcare resources and sub-optimal development of medical knowledge[2]. Cyber risk is a major obstacle to the broad adoption of IoT. The privacy of the patients must be ensured to prevent unauthorized identification and tracking[1]. IoT is vulnerable to cyber attacks due to main reasons: (1) communications are wireless which leads to high chances of eavesdropping (a cyberattack), (2) most of IoT devices are low energy consumption devices due to which it is hard to implement complex security circuits. IoT healthcare platform requires strategic planning and transparent guidelines to develop and implement robust IoT-based health care policies and models of care[1]. Data storage is another obstacle coming in picture. Since IoT is used for continuous monitoring systems it deals with sending and storing real time data. The data is very huge even for a shirt period of time. Firstly, it is leading to storage problems since data are being produced in enormous amounts. Secondly, lot of data can lead to downgrade in decision making process or increase the amount of error. Affordability is yet another concept, though the IoT devices reduces the cost to a huge extent it is still not yet available to common man yet.

Though these problems sustain with growth of IoT, its growth didn’t seem to be hindered just because of its ease of access, easy to use, access to real time data and continuous monitoring features. The advantages it provides is far greater than the concerns and with evolution in technology it is expected that we will overcome these solutions with time for sure.

CHAPTER 4

SYSTEM ARCHITECTURE

3 Layer Architecture:

The architecture of IoT in health care delivery essentially consists of 3 basic layers: (1) the perception layer, (2) the network layer, and (3) the application layer. It is not our intention to extensively detail these layers; however, a summary and the related health implications are provided in the following sections.

Perception Layer: Sensing Systems That Collect Data

Perception and identification technologies are the foundation of IoT. Sensors are devices that can perceive changes in an environment and can include, for example, radio frequency identification (RFID), infrared sensors, cameras, GPS, medical sensors, and smart device sensors. These sensors allow for comprehensive perception through object recognition, location recognition, and geographic recognition and can convert this information to digital signals, which is more convenient for network transmission. Sensor technologies allow for treatments to be monitored in real time and facilitate the acquisition of a multitude of physiological parameters about a patient so that diagnoses and high-quality treatment can be fast-tracked. There are many examples of potentially lifesaving IoT sensor devices; however, not all devices are clinically tested or have been proved to be safe and effective.[1]

Network Layer: Data Communication and Storage

The network level of IoT technologies includes wired and wireless networks, which communicate and store processed (layer 1) information either locally or at a centralized location. Communication between things can occur over low, medium, and high frequencies, the latter being the predominant focus of IoT. These include short-range communication technologies, such as RFID, wireless sensor networks, Bluetooth, Zigbee, low-power Wi-Fi, and global system for mobile communications. High-frequency fourth-generation (4G) cellular networks have seen even more communication potential, and evolving 5G networks are becoming more readily available and are expected to be a major driver of the growth of IoT applications for health care, with the potential to provide reliable connection up to thousands of devices at the same time [1].

Communicated data are stored locally (often decentralized) or sent to a centralized cloud server. Cloud-based computing to support the delivery of health services has many benefits, as it is ubiquitous, flexible, and scalable in terms of data acquisition, storage, and transmission between devices connected to the cloud. The use of the cloud can be foreseen to support data-intensive electronic medical records (EMRs), patient portals, medical IoT devices (which can include smartphone apps), and the big data analytics driving decision support systems and therapeutic strategies. However, with more cloud apps entering the health market, it is just as important that an evidence base supports its effectiveness and safety and can deal with the security of health data and the reliability and transparency of that data by third parties. Furthermore, it has been suggested that centralized cloud storage will present issues in the future to users, such as excessive data accumulation and latency because of the distance between IoT devices and data centres.

Decentralized data processing and networking approaches may improve the scalability of IoT in health care. Edge cloud is a newer cloud computing concept that allows IoT sensors and network gateways to process and analyse data themselves (i.e., at the *edge*) in a decentralized fashion, reducing the amount of data required to be communicated and managed at a centralized location. Similarly, blockchain storage uses a decentralized approach to data storage, creating independent blocks containing individual sets of information, which forms a dependent link in a collective block, which in turn creates a network regulated by patients rather than a third party. There are examples of platforms engineering blockchain for medical practice already; however, research on edge cloud and blockchains in health care is still limited and is an important area for future research.[1]

Application Layer

The application layer interprets and applies data and is responsible for delivering application-specific services to the user. Some of the most promising medical applications that IoT provides are through artificial intelligence (AI). The scientific applications of AI have proliferated, including image analysis, text recognition with natural language processing, drug activity design, and prediction of gene mutation expression. AI has the capability to read available EMR data, including medical history, physical, laboratory, imaging, and medications, and contextualize these data to generate treatment and/or diagnosis decisions and/or possibilities. For example, IBM Watson uses AI to read both structured and unstructured text in the EMR, read images to highlight primary and incidental findings, and compile relevant medical literature in response to clinical queries.

IoT-based health care and use of deep machine learning can assist health professionals in seeing the unseeable and providing new and enhanced diagnostic capability. Although diagnostic confidence may never reach 100%, combining machines and clinician expertise reliably enhances system performance. For example, compared with the diagnostic evaluation by 54 ophthalmologists and senior residents, applying AI to retinal images improved the detection and grading of diabetic retinopathy and macular enema, achieving high specificities (98%) and sensitivities (90%). AI and deep learning can also optimize disease management, can provide big data and analysis generated from mHealth apps and IoT devices, and are starting to see adoption in health care. Some examples of this include predicting risk, future medical outcomes, and care decisions in diabetes and mental health and predicting the progression of congestive heart failure, bone disease, Alzheimer disease, benign and malignant tumour classification [1].

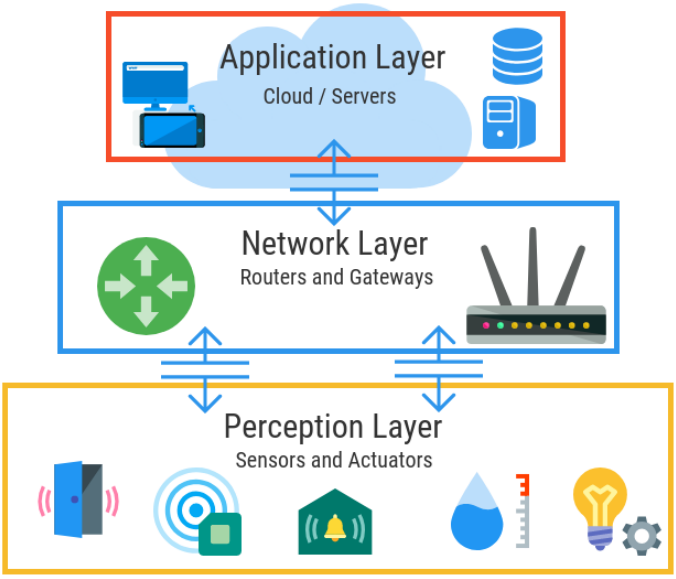

Fig. 2: Three-layer system architecture [2]

4 Stages of IoT Architecture [5]:

1) Connected Objects:
   An Internet of Things implementation wouldn't exist without the presence of connected or "smart" objects. These can be wireless sensors or actuators. They react with the environment and make the data they collect available for analysis.

   Actuators take this one step further since they are able to interact with the environment in a significant way. For example, they can be used to shut off valves when the water reaches a certain level or simply to switch off a light when the sun rises.

2) Internet Gateway:
   Once the sensors send in the data, it has to be aggregated and converted into digital form so that it can be processed. The second stage of the IoT architecture is what makes this happen. It essentially gets the data ready for processing.

   The actual task of aggregating and converting the data is up to the data acquisition system. It's what connects to the sensors and actuators, compiles all of their data and then converts it into digital form so that it can be routed over the network by the internet gateway.

3) Edge IT Systems:
   Pre-processing and enhanced analytics of the data is performed in the third stage of an IoT architecture. Edge IT systems are responsible for carrying out these tasks. Since IoT systems collect a significant amount of data and consequently require a lot of bandwidth, these Edge IT systems perform a vital task in reducing the load on the core IT infrastructure.

   Machine learning and visualization technologies are used by Edge IT systems to generate results from the collected data. Insights are provided by machine learning algorithms while the visualization technology presents the data in a way that's easy to understand.

4) Data Centers and Cloud Storage:
   The data needs to be stored for further in-depth analysis which is why data storage is such an important stage of an IoT architecture. It helps with follow-up revision for feedback as well. Cloud storage is the preferred storage method in IoT implementations.

   That's also because more in-depth processing which doesn't require immediate feedback can be carried out in the cloud or at physical data centers. There, more capable IT systems can manage, analyze and more securely store the data. This is also where sensor data can be combined with other data sources for more detailed insights.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

IoT explores new dimensions of patient care through real-time health monitoring and access to patients' health data. This data is a goldmine for healthcare stakeholders to improve patient's health and experiences while making revenue opportunities and improving healthcare operations. Being prepared to harness this digital power would prove to be the differentiator in the increasingly connected world. The usage of Iot devices since 2017 has shown an upward trend and its predicted it will continue to grow in future as well, with many loopholes and problems the advantage and functionality provided by them cannot be unseen.

Specific future research on IoT technology needs to address how IoT devices can be designed with standardized protocols and interoperability with international and cross-state health systems. From a health system perspective, there is a need for clinical guidelines on digital health prescriptions and robust policy regarding remuneration for primary and secondary care services provided through IoT.

Experts firmly believe that a well-organized and methodical remote healthcare using IoT could substantially cut down the necessity for regular medical check-ups. It would drastically reduce the burden on patients and professionals since patients can be monitored from the comfort of their home and need not wait in the hospital for observations.

With evolution in technology the devices will be more advanced and become more reliable and secure, thus creating pools of new opportunities in different fields to progress in.

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Base paper referred for seminar

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