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Exploring Early Detection of Diseases in Smart Healthcare using IoMT Devices

Dr. Ranjana Rajnish

Amity Institute of Information Technology, Amity University Uttar Pradesh, Lucknow, Uttar Pradesh, India

ABSTRACT: In the current world, Information and Communication technology and digitalization with a strong support of Internet of Things have become backbone of various developments. Healthcare domain is also not untouched with these developments. Lot of data is being produced in healthcare, which when analyzed in a systematic manner can be very useful. The concepts of big data, due to their characteristics of variety, velocity and volume have brought big data in focus for various research purposes. In context of big data, data generation from various IoT devices has also gained popularity. Lot of data is being generated in healthcare domain, where IoT devices have found great contribution to capture real time data. Technology is allowing these devices to generate, collect, analyze and transmit data, creating the Internet of Medical Things (IoMT) – a connected infrastructure of health systems and services. IoMT has gifted numerous sensors and devices with the increased accuracy, productivity and reliability to the healthcare industry.

In this paper, we are exploring the definition and use of IoMT devices in healthcare domain. Paper also discusses how data generated from these devices can be used for detection of various diseases.

KEYWORDS: Internet of Things (IoT), Internet of Medical Things (IoMT), Machine Learning, Artificial Intelligence, Deep Learning

I.INTRODUCTION

Recent developments in disruptive technologies like artificial Intelligence, Big data and Internet of Things (IoT) are positively contributing towards various domains in healthcare. Artificial Intelligence and Big Data Analytics are serving as important technologies for Smart Healthcare and adding value to the developed solutions for both practitioners and experts.

Due to rapid growth in the use of numerous technologies like IoT (Internet of Things), Internet of Medical Things (IoMT) and wearable devices, there in increase in the volume of data generated in the healthcare domain. These devices enable to gather (big) data collection of various health-related parameters like body temperature, blood pressure, heartbeat, respiratory rate, oxygen saturation, blood glucose level, wrist pulse signal, magnetoencephalogram (MEG), galvanic skin response (GSR), electrooculography (EOG), mechanomyogram (MMG), electromyogram (EMG), electrocardiogram (ECG), and electroencephalogram (EEG) [1]. Bigdata analytics, that has huge potential in knowledge discovery, pattern discovery and computational intelligence can be used to turn this big data into insights. Numerous data analytic techniques can be applied to analyze the data in order to realize.

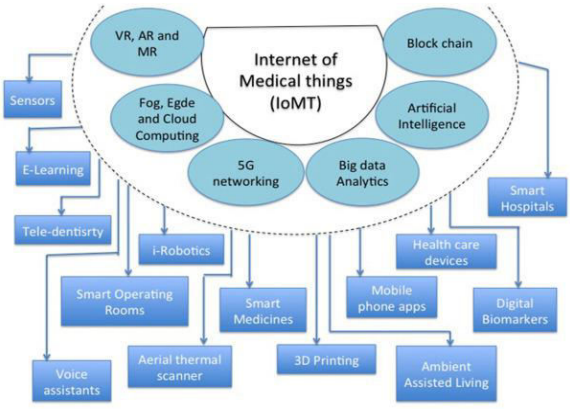

Figure 1: Smart Healthcare environment

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In this paper we aim to gather the contemporary exploration of cutting-edge developments in this domain and to identify the issues and challenges in big data analytics for smart healthcare. The paper would serve as review of the work to identify gaps for identifying further research in this domain.

II.INTERNET OF THINGS (IoT)

The Internet of Things (IoT) literally means interconnected network of physical objects or 'Things' integrated to exchange data between devices/systems using internet. Since its first mention by Ashton in 1999 an exponential growth has been witnessed leading to approximately 10 billion connected IoT devices at present with a predicted increase to about 25 billion till 2025[8][9] Technically, it involves optimization of the data exchange and storage of the information on a secure cloud server from where interconnected computing devices forms a network to share data and communicate across the server. Multiple inventions are done on products/devices to make them "smart" with embedded software that either update their existing functionality with new features or enables newer functions/applications. During COVID-19 pandemic, continuous monitoring of health condition in unexpected huge number of patients during both pre and post infection stage is considerably indispensable. Internet of Medical Things (IoMT) enabled remote patient monitoring, screening and treatment via telehealth have been successfully adapted by both care givers or health providers and patients. IoMT based Smart devices are making an impact at a skyrocketing pace ubiquitously particularly in the global pandemic state. However, considering the vast magnitude of need, healthcare is foreseen as the most challenging areas for IoMT.

How IoMT works

The integration and habitation of internet into our environment has paved the path for IoMT applications and systems into our lives on a daily basis. Most of the IoMT systems work in the following main layers that integrate different technologies, devices, sensors and systems interconnected via electrical– electronic and wired or wireless connection. The structure and functionality of each layer is shown below in figure 2.

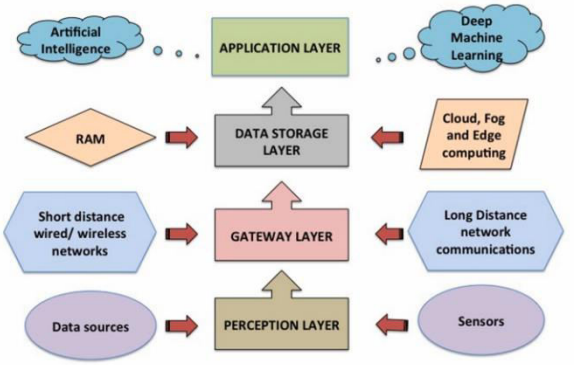

Figure 2: Layers in IoT infrastructure

2.1 Perception Layer

Perception layer is the lowermost layer and consists of the smart objects (IoT devices) that act as data collection point for this entire model. These data sources are smart objects that are used for health monitoring (like smart watch) or mobile apps, or medical sensors, smart device sensors, RFID camera and global positioning systems (GPS). These objects perceive/ sense change in the environment and convert information to digital format and transmits this data through a wired or wireless network. Some of these devices can also store and memorize data for future references.

2.2 Gateway

As mentioned above the sensors require connectivity to the gateway established via networks communicating and storing information either locally or centrally. The communication can be over varied frequencies and can be either short range like RFID, wireless sensor networks, Bluetooth, Zigbee, low-power Wi-Fi, NFC and mobile communications or long range like cloud computing, block chain, satellite etc.

2.3 Data Storage Layer

Data storage layer is concerned with storage of big data generated by IoMT devices. Data could be stored in storage servers or cloud as per the requirement.

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2.4 Application Layer

This is the main layer that uses applications (logic layer) for data analytics. This layer employs Big Data analytics, AI and Deep Learning techniques to extract meaningful information from the data. It may also be utilized to monitor trends and changes in the collected data (contextualization of data) by the use of hourly, daily or weekly plots that could help generating decision about diagnosis and early support possibilities.

Data analyzed from IoMT devices can help in various health care applications like drug activity designing, prediction of risk and gene mutation expression, medical outcomes, propose management in diabetes and mental health, and predict the progression of congestive heart failure, cardiac arrhythmia, bone disease, Alzheimer disease and benign and malignant tumor.

IoMT in Healthcare

Due to the oversaturated work schedules, a lot of diseases that are caused due to sedentary lifestyles are becoming very common. Also, due to technological advances and lack of resources in the medical field, technology is helping medical professionals to help in their work. IoMT devices are thus finding great relevance in healthcare, especially monitoring of patients remotely.

The integration and habitation of internet into our environment has paved the path for IoMT applications and systems into our lives on a daily basis. Most of the IoMT systems work in the following main layers that integrate different technologies, devices, sensors and systems interconnected via electrical– electronic and wired or wireless connection.

IoT is an internet of smart and self-configuring things that can communicate with each other using a global network. We can also understand it as cyber-physical systems or a network of networks. As per the definition from IEEE, IoT is defined as “a network of objects each of which is embedded with sensors and these sensors are connected to the Internet” [4]. According to market analysis, the use of sensor-enabled devices is expected to be around 2.1 trillion by 2025 [5]. The healthcare sector alone constitutes of major share of 41% followed by its uses in other domains. These enormous number of devices produce huge data and thus Big Data analytics using data mining techniques has become a new are of research. In healthcare IoT, wireless body sensor is a predominant technology for monitoring patients.

Wireless body sensor network (WBSN) consists of sensors that are deployed around the human body [2]. The layered architecture of WSBN comprises of sensing layer, communications layer, processing layer, storage layer, and mining and learning layer as shown in fig 1.

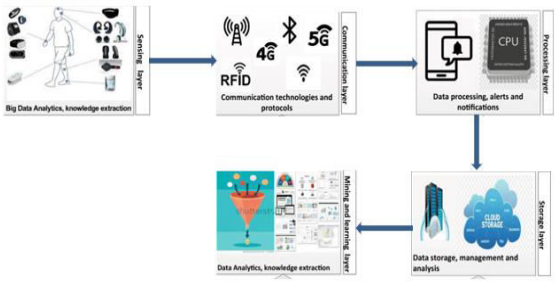

Figure 3: Different Layers in IoT Architecture

In the healthcare sector, IoMT has numerous applications out of which Remote/self-health monitoring of various vital functions such as heart rate, skin temperature, movement monitoring [10] and monitoring of general health conditions, nutrition status and rehabilitation of elderly or infected patients are more significant leading to an increase in life expectancy and decrease in morbidity and mortality [11].

Smart hospitals can be developed where various devices like MRI/ CT are linked to laboratory data to identify medical emergencies thereby facilitating the nursing staff. It is important to understand that in many medical facilities, such support may save many patients by early detection of any abnormality.

IoMT in dentistry has several currently used as well as proposed applications which may become a common scenario in the near future. As the importance of remote care swelled during the pandemic, Tele-dentistry graduated a level up. For instance, MouthWatch's TeleDent service provides a compact tele-dentistry platform allowing patients to click images and forward the relevant information to remotely based dentist for live consultation.

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In the field of Oncology, machine learning models have been developed to quantify immune cells in the vicinity of oral cancer cells with precision so as to provide better insights about spread, and resistance facilitating determination of prognosis. Also, a lot of work is being done in detection of all kinds of cancer in early stages.

III.CONCLUSIONS

Recent developments in IT infrastructure and technology have become enablers of growth in various domains. Healthcare domain is also not untouched with these developments. In the medical domain, many parameters are to be monitored in order to diagnose any disease. Even for patient monitoring regular monitoring of parameters like BP, oxygen saturation, heart rate etc. are to be monitored consistently. Due to lack of sufficient medical staff, various technologies like IoT, IoMT, AI, Machine learning and Deep learning can be used and have become very useful in all these aspects. IoT devices have found a great contribution to capture real time data. Technology is allowing these devices to generate, collect, analyze and transmit data, creating the Internet of Medical Things (IoMT) – a connected infrastructure of health systems and services. IoMT has gifted numerous sensors and devices with increased accuracy, productivity, and reliability to the healthcare industry.

To conclude, it is the need of hour to use these disruptive technologies in the benefit of society and help in diagnosing, classifying and segmenting diseases.

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