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Transformative Effects of IoT towards Smart Medical: Internet of Medical Things (IoMT) & Internet of Healthcare Things (IoHT)

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ABSTRACT: In this modern era of technology, Internet of things (IoT) is playing a vital role to improve the ways of communication in every walk of life. It has enabled us to communicate, analyze and manage our daily activities in an efficient manner by making seamless connectivity with digitalized world around us. Healthcare is also one of the essential domain which has been transforming human lives by the revolutionary changes of IoT. In today's world, it becomes easier to connect with medical and healthcare services effectively and to keep track of every health-related aspects. Hospitals are using modern IoT applications to manage the health-related data of their patients, making appointments with the doctors, sending automated health-related notifications and reminders to the patients. It has also enabled doctors and medical staff to review the reports, ongoing treatments and medical history of the patients using powerful analytics tools. Medical labs are equipped with smart testing facilities which are able to connect, generate and send automated reports to connected computing devices. Wireless body sensor networks are integrated with patients to transmit real-time health stats. Besides all the advancements offered by IoT in the healthcare domain, it also faces modern challenges related to the security, vulnerability and privacy of its users. Security of IoT applications is the major concern in medical and healthcare systems. In this research paper, a systematic review is conducted to highlight the contributions of IoT towards smart medical healthcare. IoT applications in medical and healthcare, corresponding medical sensors are elaborated. Furthermore, this work contributes by reviewing up to date IoT contributions in healthcare sector.

Keywords: Internet of Medical Things (IoMT), Internet of Healthcare Things (IoHT), Smart Medical, Healthcare Applications, Healthcare Sensors, E-Health

I. INTRODUCTION

In this modern era, the internet of things (IoT) is an emerging technology connecting the world via automation. It plays a vital role to increase living standards. Automated devices are accelerating with sensors, actuators, software and wireless sensor networks which allows them to collect and exchange data. The IoT empowered systems can be remotely controlled in the current network infrastructure. IoT enabled computer-based systems are improving efficiency of processes [1]. There is a strong mutual dependency between healthcare and internet of things. Healthcare is also one of the domains which have been transformed significantly by the revolutionary changes offered by IoT to make it smart healthcare. Formerly when the IoT was not developed, people faced a lot of problems specifically in the health sector. Before they had an appointment with doctors, on spot waiting issues, previous health records, examining history etc. [2]. But in today's modern age, everything is digitalized. In today's world, it become easier to connect with healthcare services and to keep track of every health related aspect on one platform. In recent years, healthcare and coordination between technologies has made a huge leap across the world. Internet of things and big data analytics are booming and getting popularity for the next generation of e-health and m-health Services. They have also brought new challenges, especially when the goal is healthcare that is itself complex systems, security and privacy aspects, proper disease investigation and sustainable solutions. Traditional methods for dealing health emergency cases cannot be directly evaluated because they include delays. So, there is a need of more forward solutions in this sector. The priority is to develop the most appropriate and advance approaches in health sector. And moreover, the use of modern technology has been encouraged to rapid developments that has been neglected so far. Hospitals are using modern IoT applications to manage health related data of their patients, making appointments with the doctors, sending automated health related notifications and reminders to the patients. These application has made people's lives easier. History stats gives all the information about patient's history [3]. It has also enabled doctors and medical staff to review the reports, ongoing treatments and medical history of the patients using powerful analytics tools which helps them to treat a large number of patients in a short time. Medical labs are equipped with smart testing facilities that allows to connect, generate and send automated reports to connected computing devices for quick decisions. IoT has also introduced smart devices which are able to record statistical data about your daily health parameters (i.e. number of steps, heart rate, calories burnt in a day, sleeping hours) and

compiles the data in formatted reports to review daily health related activities [4]. With all pros, healthcare faces many threats and challenges regarding security and privacy. Security and sustainable decisions are major concern in healthcare systems[5]. Cloud computing and big data providing platforms to healthcare to ensure security and privacy, secure exchange of data between devices, data management, storage, and ubiquitous access[6]. Artificial intelligence based healthcare systems providing base to future systems and opening many challenges [7].

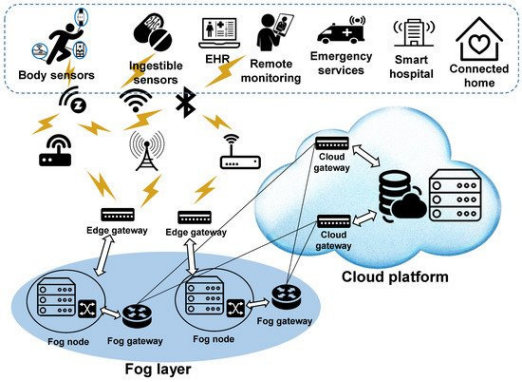

Fig. 1. Automated Healthcare system [8].

Fig. 1 shows a scenario of automated healthcare system that integrates multiple emerging technologies to provide the access over shared medical data and offering on demand services with enhanced performance and optimized operations to meet with growing needs of health sector.

This research is arranged in the following parts. In part two, we discuss literature that with help us to increase understanding with underlying domain.

II. BACKGROUND AND SECURITY PERSPECTIVE

Various health-care systems were proposed in literature with specific disease oriented solutions and general solutions. As health-care technologies are advancing, consumer awareness and consciousness increase when it comes to consumer health. In such a situation, the demand for remote care is more encouraging than ever. However, current, health care ecosystems are not equipped with technologies that allow patient care to be updated with real-time patient information and to take practical measures for treatment [9]. Then IoT solution for the healthcare sector allows hospitals to improve the quality of care while focusing on the overall cost reduction [8]. Researchers have also proposed new clinical applications. Similar technologies for remote health monitoring systems which includes features for recording long-term status and medical access to the patient's physical information [10]. Most remote health monitoring systems suggested framework with three-tier architecture: The status of the body sensor network units acts as wearable sensor units for data acquisition. Such as blood pressure, heart status and body temperature, the second level includes communication and networking. A service that collects and transmits data from sensors [11]. The third level consists of processing and analysis nodes and the architecture of the healthcare system. It involves monitoring the environment in three steps to achieve it. The data is then collected and transferred to the third stage. For data analysis and investigation.

For healthcare security challenges, there are two main types of device identification security solutions recommended: physical security solutions and confidentiality based authentication solutions. Physical protection designed to protect the device from malfunction or attack by applying physical concepts to the surface of the physical layer [12]. On the other hand, confidentiality-based authentication, the outlook is designed based on IoT radio frequency Identification (RFID) device generates an identity security field. Many algorithms recently Recommended on the basis of IoT RFID. The approach to authentication uses the HTTP protocol. As a result of using communication, the top heads suffer HTTP protocol that is not good for resource constraints IoT environment. For other approaches use AES Communication Encryption [13]. AES uses long encryption Keys and complicated calculations that resulted in high power. Two-step verification protocol for wireless distributed sensor network in IoT applications is proposed. This protocol is a certificate-based authentication from a standpoint, two-step verification allows both IoT devices and control stations to verify and identify each one. Second, a secure connection is established and data is there Move safely. They used the protocol resource resources limit and maintain sensor nodes. Network expansion and distance certificate authority (CA) has been accustomed to issuing certificates. CA can accurately identify and communicate sensors with other network agencies. To network members Initiate a connection, they first connect to CA with confirm destination Id. Group authentication based on threshold cryptography is proposed with the ICO (TCGA) scheme. This model provide authentication of all IoT devices based on the group Communication model. The TCGA is designed to be implemented for Wi-Fi environments. This creates a secret channel or session. The key can also be used to validate each group and for that group request. Each group has a group which is responsible for key generation and distribution of these new keys each time a new group joins to save the member group key leak. The head of this group is called a group Power. The proposed algorithm has five main modules: the key distribution, key updates, group credit generation, Authentication listening and message decryption [14].

Following are the well-known diseases with larger impact on world-wide health,

- Heart related disease
- Cancer
- Hyperthermia and hypothermia
- Neuromuscular diseases
- Respiratory disease
- Diabetes
- Asthma
- Covid-19

III. SENSORS IN HEALTHCARE

The following table 1 shows the various healthcare sensors with short description. There are hundreds of sensors available for healthcare. We have discussed few which are mostly used in healthcare applications.

Table 1: Sensors in Healthcare [15, 16].

Sr. No	Sensor	Description
1	Optical Heart Rate Sensor	Optical heart-rate sensor is well-known pulse sensor in wearable devices. Normally it records the heart rate data through photoplethymography, the process of using light to measure blood flow. The sensed data is further used for various examination related to healthcare.
2	Thermopile Infrared (IR) Sensor.	This sensor is used to record the temperature of any object from distance. The infrared technology is used to transfer the readings of temperature from distance. It absorbs the current energy of object and transfer the output values via infrared technology.
3	Microelectromechanical Sensor(Mems Sensor)	A magnetic field sensor is a small- saclemicroelectrome chanical System (MEMS) device for measure magnetic field (Magnetometer). The value of the sensor is fed into a micro-controller and transmitted-to-connect zombie system into a real miniature with no delay and data loss.
4	Electromyography Sensor (EMG)	Electromyography sensor (EMG) is used to detect the electrical pulses of muscles and to detect neurological disorders.
5	SpO_2 Sensor	SpO_2 sensor or pulse recorder is commonly used in wearable devices to record the oxygen level in blood.
6	Glucose Sensor.	Glucose sensor is used to measure the glucose level on continuous basis in diabetic patients.
7	Pulse Sensor	Pulse sensor is specifically designed for Arduino to monitor the heart rate by attaching on finger or arm pulse.
8	Force Sensor	Force sensors are used in various medical applications such as physical therapy, infusion pumps and oxygen tanks.
9	Photo Optic Sensor	These sensors are used in multiple medical situations such as ear probes, finger probes and pulse oximetry.
10	Blood Pressure Monitoring Sensor	Blood pressure monitoring sensors are used to measure the continuous situation of blood pressure. Hypertension (high BP) is a leading risk factor for heart disease, including heart attack. It is one of the most common ailments, affecting 32% of adult.
11	Biosensor	Biosensor use in blood glucose and cholesterol testing as well as for testing for drug abuse, infection disease etc.
12	Pressure Sensor	A Pressure Sensor Works Converting Pressure into inject-able electrical signals. Demand for pressure measuring devices increased during the steam period. Nowadays we measure pressure electronically using pressure transducers and pressure switches.
13	Fiber-optics Sensor	These sensors are used to examine the temperature, stress, pressure and other values through fiber optics. Light intensity, polarization, phase, transit and wavelength are further used to assessment of fiber optics.
14	Wearable Body Sensor	This technology is used to measure the real time health stats of any person by putting wearable devices. The wearable devices sense the values of required health parameters and transfer for further analysis.
15	Respiratory Rate Sensor	Another important sign is the rate of breathing, or the patient takes a minute. Respiratory monitoring can help identify such as asthma attacks, hyper ventilation due to panic attacks, episodes, lung cancer, airway obstruction, tuberculosis.

IV. IOT APPLICATIONS IN HEALTHCARE: INTERNET OF MEDICAL THINGS & INTERNET OF HEALTHCARE THINGS

1. Fall Detection: The practice focuses on improving physically disabled and older people to live their disabled life as a normal human being[17].

2. Medical Fridges: These fridges are used to maintain the medical resources on certain level [18].

3. Sportsman Care: These applications are used to examine professional athletes' exercise, weight, blood pressure, sleep and health oriented parameters [19].

4. Patient Surveillance: It is used for remotely hospital supervision for proper care of patients [20].

5. Chronic Disease Management: Caring for a patient with a chronic illness while no physical attendance is required. This type of technology minimize the occurrence of people in the hospital and as a result, costs are reduced, hospital stay is reduced and traffic is reduced (even fuel consumption is reduced [4].

6. Ultraviolet Radiation: It measures the UV rays and inform people to avoid specific areas or retract from exposure to UV rays at a particular location.

7. Hygienic Hand Control: In HNC, RFID is used for measuring emissions through connected devices.

8. Sleep Control: devices that connect with individuals to identify some of the symptoms, such as blood pressure, heart rate during sleep and information can be collected and analyzed.

9. Dental Health: Smartphone apps record some brushing information in bluetooth capable toothbrushes to study the habits related to brushing and share statistics with the dentist.

10. Blood Pressure Monitoring: An encouraging scenario in which BP should be regular. Remote control is presented by showing communication. The structure between the Health Post and the Health Center [21].

11. Body Temperature Monitoring: Physical temperature monitoring is an integral part of health care. Various IoT based systems are available for regular monitoring of body temperature.

12. Infrared Identification: It helps the body temperature of the user. Various IoT based systems are proposed for body care through infrared identification.

13. Oxygen Saturation: Pulse oximetry is used for non-stop monitoring of blood oxygen saturation. Oxygen saturation reveals the different perspective of healthcare decisions.

14. Glucose Level: Diabetes is falls under metabolic diseases that occur due to high blood glucose levels which remains high for long time. Blood glucose monitoring reveals individual patterns helps in blood glucose conversion and meal planning, activities, and medication times.

15. Electrocardiogram: ECG recorded by the heart's electrical activity, Includes simple heart rate measurements and also the determination of the basic rhythm. Diagnosis of multi-dimensional arrhythmias, myocardial ischemia and longer QT intervals. IoT application ECG monitoring has the potential to provide as much information as possible and may be used to the fullest extent [22].

16. Tele- surgery: It refers to remote surgery in which the surgeons are not present at operation venue. Usually, the operation is performed by robotic surgeon system [23].

17. Rehabilitation System: Regularity of medicine and recovery of patients can be increased and restore their ability as well as quality of life via internet of medical things [24].

18. Medication Management: As the medicines are highly valuable and sometime very costly. Further, some medicines are mandatory for the life of patients. IoT providing promising solutions for the security and management of rare and highly cost medicines [25].

19. Wheelchair Management: IoT enabled various wheelchairs are developed by researchers which are fully automated and making the life reliable for wheelchair users.

20. Healthcare Solution using Smartphone: In recent years the appearance of electronic has been observed. Smartphone-controlled sensor devices and various hardware and software products are manufactured to make smart phones a versatile healthcare device [26].

V. CONTRIBUTIONS TOWARDS IOMT AND IOHT

Table 2 shows the recent contributions which are made through IoT technology.

Table 2: Recent Contributions in Healthcare via IoT.

Year	Author	Contribution
2021	Kora *et al.,*	Authors developed a ECG examination system for elder patients to detect heart related issues. The proposed system is empowered by IoT based wearable technology [22].
2018	Elhoseny *et al.,*	Secure and synchronized data transfer is key concern of life critical healthcare systems. The author proposed a secure data transmission scheme based on 2D discrete wavelet transform for IoT empowered healthcare systems [27].
2020	BKaaviya *et al.,*	As Covid-19 imposes greater threat on worldwide health. Author proposed an IoT based system for prevention of covid-19 in specifically work environments [28].
2016	Plageras *et al.,*	Authors proposed an IoT based approach for surveillance of ubiquitous healthcare systems. They secured the transmission line and compare their work with literature which shows their significant contribution [29].
2019	Saha *et al.,*	Author surveyed the Internet of Things in specifically in healthcare. They shows the significant impact of IoT in medical with their vital applications [24].
2019	Kaur *et al.,*	Authors proposed a healthcare monitoring systems which is empowered by IoT and intelligent by machine learning. They implemented random forest for prediction [30].
2012	Siva *et al.,*	They presented a real time patient management system for hospitals. RFID is used for patient tags to monitor the real time health stats [31].
2020	Rama *et al.,*	Authors proposed an efficient method for face detection and recognition for surveillance systems. This work is for post Covid era and highlight the persons as normal, missing and suspicious by mapping with predate set [32].
2018	Irfan *et al.,*	Authors discussed the internet of medical things in detailed and broader perspective. They shows the architectural model for internet of medical things applications as we as the factors which leads toward its adoption [33].
2020	Ettiyan *et al.,*	They surveyed the state of the art IoT based monitoring systems for maternity women. Corresponding healthcare perspectives are highlighted [34].
2016	David *et al.,*	Authors highlighted the IoT and wearable technologies in healthcare. As wearable devices promising the more efficient healthcare systems. They provide a detailed overview, prime findings with various use case[35].

2017	Chao *et al.,*	Authors presented an IoT based healthcare system for monitoring the heart disease on different parameters such as ECG, blood pressure, heart rate, SpO_2, blood fat and pulse rate. Furthermore, the current location of patient is also recorded in real time [36].
2019	Jahangir *et al.,*	Authors proposed a wearable system empowered by IoT for prediction of cardiac arrest. Energy consumption is main issue in wearable systems and they proposed an up to mark energy efficient system [37].
2017	Gulraiz *et al.,*	Authors discussed the role and impact of IoMT in healthcare sector. Further, they highlighted the IoMT applications along with their benefits. They also highlighted the challenges in healthcare domain [38].
2019	Dang *et al.,*	This research paper surveyed the IoT and cloud computing in depth for healthcare systems. They discussed the various diseases and their solutions with IoT and presented corresponding sensors. Further the highlight the various healthcare mobile applications and use cases of different countries against specific diseases [39].

CONCLUSION

Internet of things revolutionizing every field of life by providing automation. The impact of IoT in healthcare sector is very high and big space available for improvement. The IoT in healthcare is known as Internet of Medical Things and Internet of Healthcare Things. Medical, labs, hospitals and every aspect of healthcare is moving towards smart automations. Various supportive technologies providing help to IoT in healthcare sectors such as artificial intelligence, machine learning, cloud computing and wireless sensor networks. They are promising the intelligent and secure healthcare systems. We have presented healthcare sensors along with healthcare applications which are empowered by IoT. Further, we have tabularized the up to date IoT contributions in healthcare sectors which also shows open research directions. This work provides an introductory path towards IoT healthcare.

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