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Systematic review of smart health monitoring using deep learning and Artificial intelligence

A.V.L.N. Sujith^a, Guna Sekhar Sajja^{b,*}, V. Mahalakshmi^c, Shibili Nuhmani^d,
B. Prasanalakshmi^e

^a Department of Computer Science and Engineering, Anantha Lakshmi Institute of Technology and Sciences, Ananthapuramu, AP, India

^b Information Technology Department, University of the Cumberlands, Williamsburg, KY 40769, United States of America

^c Department of Computer Science, College of Computer Science & Information Technology, Jazan University, Saudi Arabia

^d Department of Physical Therapy, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

^e Center for Artificial Intelligence, King Khalid University, Saudi Arabia

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ABSTRACT

In the rapidly growing world of technology and evolution, the outbreak and emergences diseases have become a critical issue. Precaution, prevention and controlling the diseases by technology has become the major challenge for healthcare professionals and health care industries. Maintaining a healthy lifestyle has become impossible in the busy work schedules. Smart health monitoring system is the solution to the above poses challenges. The recent revolution of industry 5.0 and 5G has led to development of smart cum cost effective sensors which help in real time health monitoring or individuals. The SHM has led to fast, cost effective, and reliable health monitoring services from remote locations which was not possible with traditional health care systems. The integration of blockchain framework improved data security and data privacy of confidential data of patient to prevent the data misuse against patients. Involvement of Deep Learning and Machine learning to analyze health data to achieve multiple targets has helped attain preventive healthcare and fatality management in patients. This has helped in the early detection of chronic diseases which was not possible recently. To make the services more cost effective and real time, the integration of cloud computing and cloud storage has been implemented. The work presents the systematic review of SHM along with recent advancements in SHM with existing challenges.

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1. Introduction

The old saying of “Health is Wealth” found to be correct in the present time too. The busy lifestyle, increasing pollution and outbreak of epidemic and pandemic diseases has led to poor and unhealthy life quality of the human being. As per the recent data, more than 90% of population has been exposed to polluted environment [1]. The industry revolution and population explosion has led to poor lifestyle of the majority of the population. Thus, it become necessary to monitor and enhance and promote healthy lifestyle. Thanks to the industry 5.0 and 5G telecommunication technology which has led to the emergence of cost-effective sensors and devices for real time monitoring and capturing of the data [2]. The applications of SHM have been shown in the Fig. 1.

In the world of internet of things (IoT), the internet of medical things (IoMT) plays a major role in Smart health Monitoring. (SHM) [3]. Internet of thing originates with the concept of inter connection of electronic devices on a network to allow the data exchange for a specific domain of application. Internet of medical things are the network of interconnected electronic devices specially dedicated to the medical services such as medical nursing and rehabilitation system, diseases, anomalies detection system, patient monitoring, conditioning and screening system, remote and telemedicine care system are to name a few. IoT and SHM (smart health monitoring) are the extensions of medical systems in hospitals by which the patients can take under the interpretation without any negligence nothing like traditional methods. Since last decades, our technologies give priorities towards life safety and to reduce inspection costs. There are many types of emerging methods such as SHM, General smart monitoring (GSM) in which IoMT are helpful in various streams to minimize direct, indirect costs and non-distinctive evolution such as electrical resistivity, ultrasonic surface waves, ground penetrating radar techniques are to name a few.

* Corresponding author.

E-mail addresses: sujeeth.avln@gmail.com (A.V.L.N. Sujith), Gsajja1524@cumberlands.edu (G.S. Sajja), mahabecs@gmail.com (V. Mahalakshmi), snuhmani@iau.edu.sa (S. Nuhmani), prengaraj@kku.edu.sa (B. Prasanalakshmi).



Fig. 1. Benefits and applications of SHM.

IoT's are the cascade of various types of electrical and wireless devices, all are inter connected and share their patient data for the diagnosis and analysis and also used for saving the data of patients [4]. In wireless communications there are various sensors and devices which collect the patient data. In the epicenter of these, SHM is advancement in medical stream for monitoring conditions of patients (specially comma patients), to recognize their body movements by using IoT's accelerometer (body movement measuring device and sensors), eye blinker, temperature measuring devices, etc. These remote monitoring devices are useful for elder and chronically ill patients [5]. There is rapid increase in the elder patient and chronic patients in past few decades who requires the remote-control health monitoring system. With the advent of increase in number of patients, the hospitalization and patient cares rises worldwide. According to survey the mortality rate in US rises day to day i.e., 770,000 peoples are dies per year [6]. The reason behind this is the delayed treatment, incorrect medications, inaccurate dosage etc. SHM models helps in these cases and reduces the burden of staff and other medical professionals [7–9].

Smart healthcare system is made up of various types of stakeholders like clinicians, patients, doctors along with other organizations. Even some hospitals started the use of smart beds which recognize the actual condition of patients without any nurse. These beds are much effective for the comma and chronically ill patients to detects, monitor, analyses and respond accordingly to their activities [10]. IoMT plays an important role in making healthy environment to achieve healthy life style and real time monitoring of general and special medical activities.

SHM and IoT's has proved its essentiality in the breakout of covid-19 pandemic. Two years ago, when WHO declared covid –19 as a pandemic where the social distancing became necessary condition and the cases of covid –19 are burst out, various SHM models and smart devices had important role in controlling the covid spread by preventing social gathering and rust at the hospitals [11,12]. This also helped in managing the patients suffering from other diseases. The smartphones are most helpful tool in such situation and in other fields for example, in schools, offices, banks and other government and non-government services. SHM has vital role in hospitals such as the doctors providing home treatment

for covid patients. Patient and doctor exchange reports and medical prescriptions, by smartphones, laptops and tablets over the wireless telecommunication network [13]. The medicines were ordered online from the rural areas and delivered with the help of drones and guided vehicles, where the connectivity to the medical facilities by road or rail is near to impossible.

SHM is able to monitor the real time condition of covid patients remotely. Now in the present days after the covid 19 pandemic has been controlled to an extent in most of the countries, everyone prefers teleconsultation and online appointment to avoid hospital visits, medical stores and public gathering programs where the chances of communication with each other are more [11]. The present review work discusses about the new emerging technology i.e. SHM. The present work entails the details of various components of SHM, sub classes of SHM, role of deep learning and Artificial intelligence in handling the healthcare data generated in SHM.

The essential technologies integrated in SHM for security and privacy of patient, doctor confidential data followed by some special case study analysis where SHM had a significant role with concluding remarks and futures scope of SHM technologies in the society and human life.

2. Features of SHM and IoMT

Smart health monitoring health devices poses many significant features such as: prevention of unnecessary visits of hospitals, doctors can remotely check the real time condition of the patients. The data generated from these devices is secure from hackers. Healthcare services are costly today's and these devices helps to solve this problem which is a great evolution in medical field. By increasing the demands and belief of peoples on the smartness of devices and digitalization, the role of IoMT's and SHM will have continuous role in the overall evolution and growth. SHM as a advanced technology in medical stream can be used to Remotely controlled medical facilities to save the life of critical patients of heart attack, asthma attack, diabetic patients etc. The data generated by SHM network and IoMT devices need regressive analysis and computation for convergence of multiple inferences. Theses data analysis and computation help to achieve multiple goals such as controlling the outbreak of certain diseases, predictive health monitoring, prevention of chronic diseases and fatality in patients. Deep learning and Artificial intelligence play a critical role in analysis of health care data [14]. Many frameworks and proposed architect are available in public domain for the analysis of healthcare data in SHM network [15–17].

3. Role of Deep Learning (DL) and Artificial Intelligence (AI) in SHM

DL and transfer learning (TL) are subdivisions of machine learning (ML) in which the multiple layers are used to collect effective data which progressively extract higher level information from previous data followed by its applications dealing with large amount of data that have been effectively verified at any platforms. DL provides fruitful information by collecting hidden data with the help of staked block of layers of the DL skeleton. DL models are used in wide range of area i.e. in research area, SHM, telemedicine etc [18]. While the TL is an integral part of learning machine that is applies by peoples when they have learned from previous situations, but TL creates problems in researches for researchers and engineers. The correlation of DL ML and TL has been shown in the Fig. 2.

There are many advantages of using DL in SHM network. DL models gives the accurate and efficient information which is also helpful in collecting of bulk of data. Minimize the delay in reporting of critical cases, easy and fast diagnosis. Computational

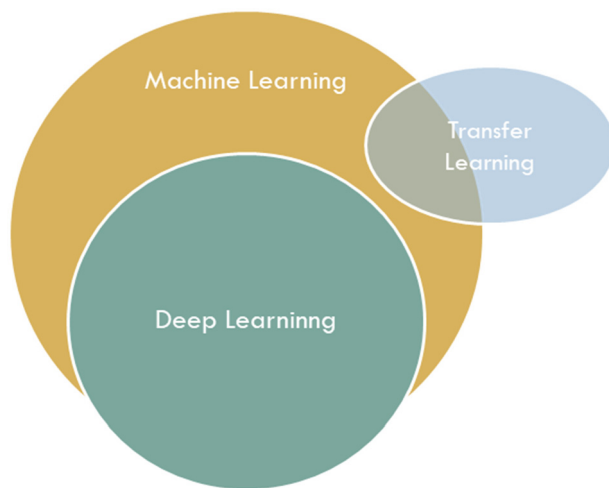


Fig. 2. Relation of deep learning, machine learning and transfer learning.

learning system, SHM, IoTs, and knowledgeable doctors who have the capability to detect the real time condition of the patients and have the proper information or prediction of future condition and anomalies of diabetes, Alzheimer's diseases generic diseases, cancer, respiratory malady etc.

In mental health SHM helpful to detect online mental conditions by using certain apps such as Happify, moodkit, wysa are to name a few which are helpful in early detection of covid-19, Alzheimer's diseases and other critical diseases [19,20]. In addition, DL has been improvised in other cases i.e. data integration and data security etc. Artificial intelligence is applied for the uses of machine learning algorithm and software in healthcare system the results of artificial intelligence is based on the data used in machine learning. Basically, this is discovered for the games. The working of deep learning models is based on the convolutional neural network (CNN) learning it is a type of artificial neural network (ANN) which is applied for the visualization of images such as ultrasound, MRI CT scan Xray are to name a few. With the help of deep learning the detection of generic diseases such as turner's syndrome, hemophilia, sickle cell anemia and so on can be easily detected by the study of the genes and the doctors are able to find the treatments for the future as well as future medication. The deep learning and machine learning are able to find the normal as well as abnormal data of the patients, by which the doctors can detect the condition of patients.

Advancement in IoMT hardware and software, use of GPU (graphical processor unit) for training deep neural network and minimize time exploitation. DL is useful for collection of deep information of many critical patients specially coma sufferers by using multiple IoT, GSM and SHM modules. DL is also used for analysis of medical data obtained from wearable devices and medical devices such as smart watches, pulse oximeter, blood pressure monitoring devices, temperature and eye blinker, computed tomography (CT) scan, X-Ray images, Magnetic Image Resonance (MRI) ultrasound images, etc. The main purpose of monitoring real time health data is to prevent chronic diseases, trauma cases, prevention of disease outbreak in certain state and countries as well as maintaining healthy lifestyle. In recent study has shown that DL based framework was able to capture real time data of coma patient. The IoMT and medical equipment are the way of wireless communication with which the patients unlike the traditional methods saves power and time-consuming methods. Various components of SHM and subclasses of SHM has been discussed in the next section

4. Structural of IoTM and SHM

These devices may be divides into several subparts on the basis of different parameters such as;

1. On the basis of transfer of health-related data or information from phone to phone i.e. from patients to the doctors.
2. Publisher
3. Broker and
4. Subscriber

Publishers arrangement of connected sensors and patients record includes blood pressure, Eco elegance, blood sugar level etc. The broker is able to store the data in clouds and broker receives the data or information from publisher. The last is subscriber which is used for continuously monitoring data extracted from publisher which can be visualized or recognize by the smart gadget like android smartphones, laptops, tablets, wearable devices etc. The classification of IoMT has been presented in the Fig. 3.

SHM on the basis of ranges single or multiple parameters can be classified into the following sub categories

- RHMS (remote health monitoring system)
- MHMS (mobile health monitoring system)
- WHMS (wearable health monitoring system)
- GHMS (general health monitoring system)

The classification of SHM has been shown in the Fig. 4.

The remote health monitoring system (RHMS) the system can send the data to or send from the location, covers the variety of symptoms can be utilized in home as well as hospitals. The MHMS involves mobile phones, smartphones, laptops, pocket personal computers which are used as main processing station. Whereas the wearable devices like digital watches, digital bracelets eye blinker, oximeter, pulse tracker etc, collect the original health data and relevant information. By storing and analyzing the real time data. These are advanced technology in the medical field in last decade. GHMS monitor the general diseases and also plays important role in the modern days. This minimizes the visits to hospitals for normal diseases. Now in these days people are aware about their health and can treat their problems by using online medical services and other internet facilities. They can also find the relevant hospitals and doctor related information on internet by using various medical applications available on multiple platforms (such as mobile or smart watches.). For general architecting the required components of medical IoTs are

1. Data acquisition
2. Communication gateway and
3. Server

for collecting proper data, the IoTs bears three layers Device layer which includes body sensors and wearable devices, fog layer; in which the data is semi processed, and cloud layers which stores the whole data or information which high computational resources. The semi processed data by fog layer is processed into relevant information and achieve multiple targeted goals by using high computational resources. The cloud also act as on demand service which is very cost efficient solution to medical services. Data acquisition is the initial component used for collect the whole data of any patients by using various types of smart health devices which are basically are of two types namely wireless sensors and wearable devices. The wireless sensors are smart phones and smart cameras, microphones, raspberry pi with cameras are used are to name a few. These sensors are most beneficial for the chronic disease patients, coma patients, and newly born babies for smart

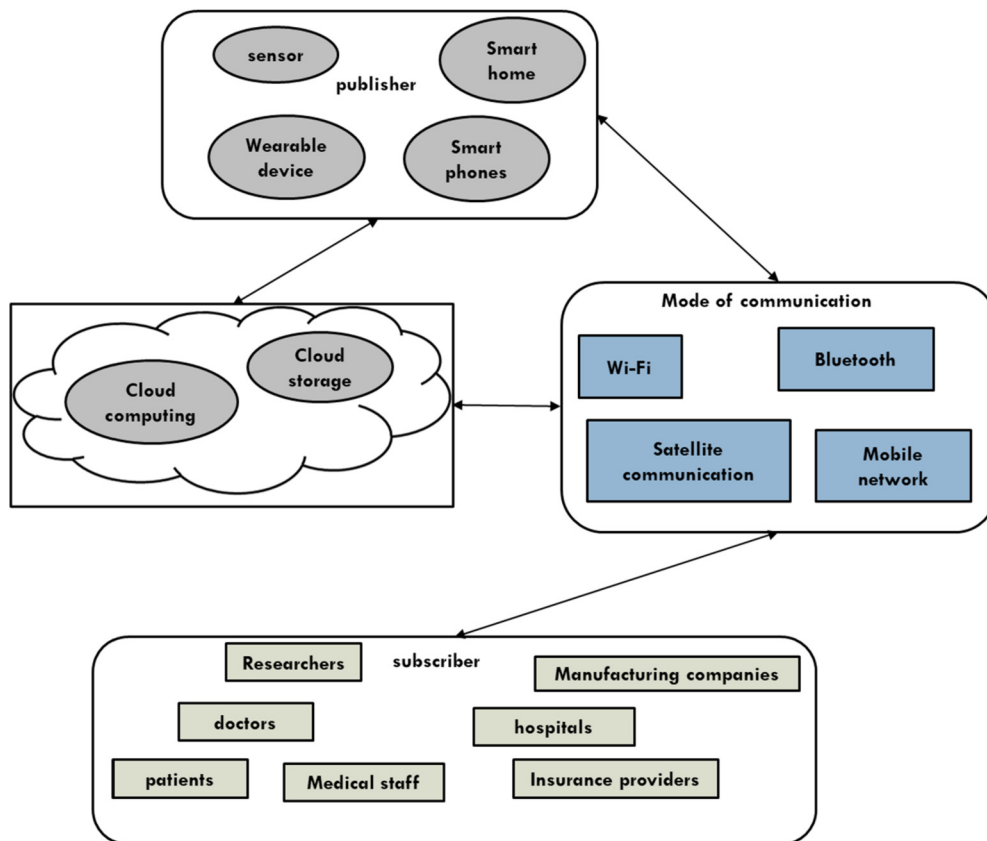


Fig. 3. Components of IoT based networks.

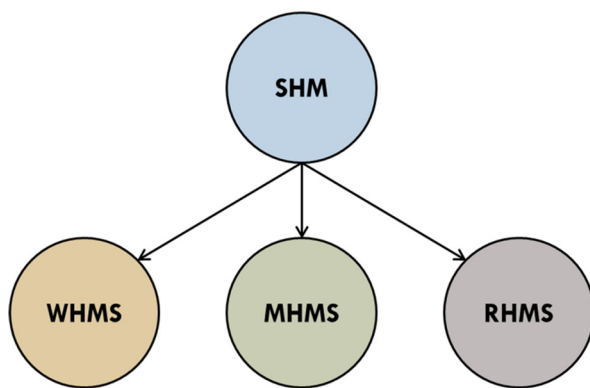


Fig. 4. Sub Classes of SHM.

caring, for smart homes for independent elders, respiratory rate and cardiac rate measurement by using air matter sensors, toilet seats integrated with the ECG monitor, cardiac, beat monitor, respiratory monitor, smart bed by using pillow with sensors, magnetic switches and many more. Wearable devices are such as digital watches, digital clothes, fitness tracker bands etc comes under the category of WHMS and GHMS and collects vast variety of data by connecting with other devices. In special cases, Smart vest is used for physiological monitoring such as ECG without using any gel on skin, galvanic skin response, body temperature, blood pressure, also helps in to find cardiac output by using eco-doppler to analyze and enhance the performance of athletes and disabled individuals [6].

SHM and IoTs are seen to be most effective for some common chronic diseases such as Parkinson's disease, Alzheimer's disease, dementia etc. Dementia is most common chronic disease and the

symptoms are seen in almost 25 million people are in the world. The common symptoms of dementia are memory losses, difficulty in problem solving and decision-making capabilities, depression, anxiety. Causes of dementia are not specify and triggered by several diseases. Alzheimer diseases and Parkinson's diseases are the most common cause of. In these cases the SHM plays vital role which is a great achievement in medical stream [21]. However, the data generated by IoMT can always be misused by individuals and organizations to fulfill their personal gains. The data security of SHM system poses a great challenge for the researchers

5. Data security in SHM

The data generated by SHM 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 SHM. 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 [22–25]. 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

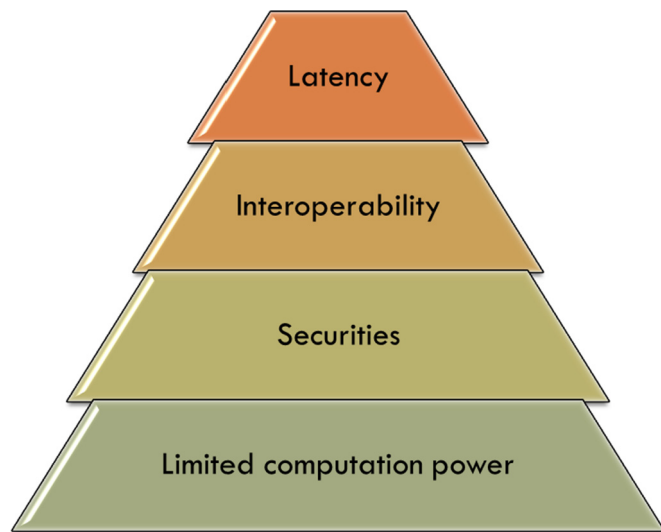


Fig. 5. Challenges in SHM.

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 SHM networks [26–28].

6. Limitations of SHM and IoMT

There are certain limitations of these SHM 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. IoMT 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.

The real time monitoring requires fast and reliable network connection which become difficult to achieve in low powered devices and in remote locations. These limitations are not constrained to the advancing technologies thus can be tamed with time and technology.

7. Conclusion and future scope

The SHM 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 SHM has gained the trust of medical care professionals as well as the patients in terms of data security and data privacy. SHM 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 SHM in sports and general care is limited and can be explored further with continuously evolving technologies. “The SHM poses several opportunities in the future for medical services which was earlier impossible to achieve. The present work presents the review of the smart health monitoring frameworks which successfully implemented the deep learning and machine learning approaches and algorithms for achieving

higher outputs. The similar review works on SHM lacks the reporting of ML, DL integrated SHM related works. The use of IoMT in SHM has led to fast and responsive remote and real time monitoring related medical services.”

Declaration of competing interest

We have no conflict of interest.

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