IoT and Healthcare: A Review

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Abstract

Healthcare is one of the most critical area which is simplified by Internet of Things (IoT) these days. The miniaturization of sensors is able to gather the data and analyze this big data. The medical devices and resources can be connected to collect the data and process using IoT sensors. Medical requirements fulfillment seems to be a major challenge. The current conditions in the countries are calling for the remote healthcare solutions. People are preferring personal activity trackers and healthcare monitoring devices or wearables. The patient or person's data is being recorded and saved for continuous monitoring purposes. The data can be monitored remotely by the healthcare professionals to guide the patients or sometimes to save them from future health problems. The paper mentions that there is need to change the healthcare scenario from reactive to proactive and preventive. Benefits of using IoT in healthcare are also highlighted. IoT and Healthcare (IoHT) architecture is discussed with the three layers, Device layer, Fog layer and the Cloud layer. Also, the challenges in IoT healthcare ecosystem are mentioned in the paper which are to be resolved for the remote ubiquitous and pervasive patient monitoring supported by IoT.

Keywords

IoT, Healthcare, Heterogeneity, Blockchain

1. Introduction

There is an urgent need to change the healthcare scenario from reactive to proactive and preventive. Also, it should follow patient centric approach rather than hospital centric [1]. The smart healthcare is needed and expected to achieve better growth in this healthcare sector. It is only possible through the use of Internet of Things (IoT), which is giving new direction in this area. Still many issues exist but we are heading in the right direction, soon we will be able to resolve the issues. Researchers are working continuously to improve the results. Machine learning, Artificial Intelligence are also used along with IoT to analyze data and predicting the future diseases for the patients without any intervention by the humans.

The use of IoT for health monitoring include various sensors or devices, primarily wearable devices. These are worn by the humans or the patients for the continuous health monitoring. These may include smart watches, health bands, sensor-based shoes or clothes etc. (Fig 1) as mentioned in [2]. These are helpful in easy monitoring of blood pressure, heart rate/pulse rate, number of steps or hand/feet movement, sleep/deep sleep duration, breathing patterns etc. This collected data may be captured by the application installed on the device such as mobile phone or sent to the website or the

International Conference on Emerging Technologies: AI, IoT, and CPS for Science & Technology Applications, September 06–07, 2021, NITTTR Chandigarh, India
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cloud for the analysis purposes. Also, there is provision for the data to be analyzed for some weeks or months. The targets can be set and reward points are given to motivate the patient or the person wearing such devices. So many big companies are providing these products such as Apple, Amazon, Samsung, Boat etc.

Figure 1. Variety of wearables for monitoring patients' health data

Some benefits of using IoT in healthcare are listed [3]:

- Patient's Comfort: It is the maximum when a patient is monitored remotely without going frequently to the hospitals to meet the doctors for the emergency and the routine checkups. The connected devices are storing and analyzing the data for the proactive treatment. This type of treatment leads to early detection of diseases and the timely intervention and the treatment by the doctor.
- Low Cost: As there is no need for the patient to go to the hospital for the diagnosis or get admitted, sometimes in the emergency situations, the cost of home treatment is certainly low.
- Accuracy: The data which is collected by the different sensors (BAN-Body Area Network) has more accuracy as compared to going and visiting the hospitals and getting tested there. Also, the data is processed frequently and can be analyzed properly, errors are also reduced because of the accuracy.
- Timely Treatment: Because the proactive treatment is given to the patients with the help of the sensors using IoT, the timely and more accurate treatment may be given to the patients before the disease become serious and life taking.
- Easy management: The huge amount of data is stored, collected and analyzed by the sensors. The sensed data is managed by the devices and it is the patient's choice to share the particular data to the hospital staff.
- Automation: Without or with minimal human intervention, the data is being sensed, recorded and analyzed. With the automation of all the processes in health monitoring and diagnosis, improves the patients' experience of using the technology.

2. IoT and Healthcare Architecture

The data from the wearables can be collected from so many heterogeneous devices and communicated using various heterogeneous technologies such as wi-fi, Bluetooth etc. The volume and velocity of such huge data come up with big data issues. This data should be processed in such a way that we will be getting benefits more than the overhead it is generating on the healthcare and IoT ecosystem. The architecture mentioned in paper [4] outlines the three layers which are required from sensing this data from the patients' wearables devices to the final analysis stage. Three layers are mentioned namely (i) Device layer (ii) Fog Layer and (iii) Cloud layer.

(i) Device layer – It is responsible for sensing the data of the patient. It mainly deals sensor monitored data such as blood pressure, spo2, temperature or any other vital health signs of the patients. It may also be context aware involving in collecting location or other environmental factors of the wearable devices. The data using any communication protocol is sent to the cloud layer for processing, where the layer in the middle of the communication is Fog layer.

(ii) Fog layer – It is responsible for communicating the collected data from the Device layer to the Cloud layer. It works as a gateway for the sensed data to reach its final destination for the analysis. It involves the preprocessing, the filtering and cleaning of the data to get the required and only valuable attributes to be transferred from the big data coming from various heterogeneous devices collected at the Device layer. Also, there is variety of communication protocols available, heterogeneity of communication protocols and heterogeneity of devices, so this layer is also focusing on the conversion of one protocol to the other protocol.

(iii) Cloud Layer – Finally this layer is processing the data which is being sent by the fog layer and also which is filtered and valuable for the processing. It involves the data storage and analysis. Many machine learning algorithms are used to analyze and predict the patients' health. The crucial attributes related to the patients' health are analyzed and the treatment by the healthcare personnel, doctors is prescribed.

3. Literature Review

The development of sensors and IoT is leading to the great advancement in the personalized healthcare. Due to the pandemic situation, COVID19, the demand for the wearables is growing even more. We are already witnessing a very finest phase of growing technology. Some recent work by the researchers is discussed in this section.

In paper [5], the authors have developed a prototype of glasses for dietary monitoring. The glasses are used by person, intake activity is recorded, information collected by the sensors is analyzed for the disease diagnosis. The sensor used in the device is electromyography (EMG), Bluetooth radio, SD card and a microcontroller. The collected data is synced on the application on the mobile device. In authors in [6], mention that the EMG sensors are used for the prosthetics from past so many years, but the recent developments in this field have opened the scope for the devices which are now available for the general public. Specifically, the wearable armband is discussed with the EMG features. The paper clearly mentions the scope and application of sensor technology and IoT for the disabled persons. The wearable armband is useful for the recognition of the movement of the body parts. In Paper [7], the authors have used the term HIoT for healthcare applications of IoT. They have mentioned that in the recent years, due to the technological advancement, the healthcare system has been transformed from the hospital centric to patient centric. IoT has led to the growth of this global communication. They also mention that different sensors are used such as EEG, EMG, ECG etc. to monitor various health parameters such as Spo2, blood pressure, pulse rate etc. and also different protocols are used such as bluetooth, zigbee, wifietc to communicate the sensed data. Paper [8] mentions about mobile phones being the network gateway to send the sensed data from the wearables to ultimate destination i.e., to the data processing server. As the mobile phone usage is already increased in day-to-day life, sensing, collecting and communicating the personal health data of the patient is imposing more burden on the patient's mobile device. The authors have proposed a health monitoring system which directly sends the sensed data to the cloud to reduce the mobile usage. Paper [9], the authors have mentioned about Ambient Assisted living (AAL). AAL deals with lot many

types of heterogeneity. The various kinds mentioned in the paper are technology heterogeneity, services heterogeneity, sensors heterogeneity etc. Kitchenham methodology is applied, the vulnerable groups are identified, focus is on elderly population health monitoring. Paper [10], discusses that the evolving technology that can be in the area of mobile computing or if we consider wearable devices, will improve the individual and mass health. More attention should be given to Internet of Things and healthcare devices combination that is Internet of Health Things which is promising many benefits in the healthcare sector. The authors also analyze the effectiveness and quality of the system, data protection and wearables quality and safety. Paper [11] mentions about the future hospitals, which will be patient centric and working on the platform of IoT, and also which are able to meet all the patient needs, be it medical, social, psychological or economic. In the paper [12], the authors propose a secure and energy efficient IoT model for e-health. The work focuses on the transmission and the encryption of the biomedical images over the IoT network. The encryption and the decryption of the images done at the higher speed which is useful in secure communication in green IoT networks. Paper [13], mentions that most commonly used technology in IoT is RFID. To maintain the privacy and security of IoT data, the authors propose secure RFID tag using cryptography at device level and communication level. Paper [14], the integration of the semantics into sensor data for the IoT is highlighted. And the review of annotation techniques of the semantic solutions of adding semantic annotations of sensor data is presented by the authors. Paper [15], the authors mention that the volume of IoT data is very high. The wrong generation of the data can lead to wrong analysis of the collected data later. The paper focuses on the detection of such nodes which are producing wrong or erroneous data and further forensic analysis is required to locate such IoT nodes. Paper [16], mentions that there are three types of security which can be used IoT-IoT, IoT-Blockchain and the Hybrid approach that uses both. And the authors have implemented hybrid approach, where they are using public and private blockchain.

4. Future Work and Limitation

There is great need to resolve the various issues in IoT and Healthcare Ecosystem. The limitations in IoHT include various heterogeneity issues and privacy and security challenges. The future work may be done using blockchain in IoHT. The blockchain technology provides security and ensures that no one can change or alter the data available in once validated transactions and which is shared among untrusted parties. The smart contracts used in blockchain technology which are responsible of transferring the information between the parties further uses encryption on the information stored in the blocks to provide security. Blockchain, fog computing and cloud computing can be used in combination for better and secure connectivity and communication in the IoHT architecture [16].

5. Conclusion

There exist several types of heterogeneity – communication technology heterogeneity (wi-fi, Bluetooth, cellular etc.), wearables heterogeneity (smart watches, health bands, smart glasses, smart clothing etc.), hardware support heterogeneity (Arduino, Raspberry Pi etc.) and may be other types. Some standards are required to meet these heterogeneity issues and to deal with the security issues in IoT and Healthcare combination. The current hospitals will take time to evolve but for now we can put efforts to spread awareness for these future ecosystems among patients, healthcare workers and all the stakeholders. There will be great need to have patient centric processes as well as trained competent staff for the survival and the growth of future hospitals. As the technology is growing rapidly, the miniaturization of things is leading the way to provide more and more features and keeping the size of the devices smaller. In the current market situation if we compare the different wearables, these are offering many features but at the higher price and the devices which are offering less features are cheaper. So, we need a major transformation in the technology to grow, provide more features and that too at lowest cost.

6. References

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