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Research paper

Internet of things (IoT) based health monitoring system and challenges

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Abstract

Among the applications that Internet of Things (IoT) facilitated to the world, Healthcare applications are most important. In general, IoT has been widely used to interconnect the advanced medical resources and to offer smart and effective healthcare services to the people. The advanced sensors can be either worn or be embedded into the body of the patients, so as to continously monitor their health. The information collected in such manner, can be analzed, aggregated and mined to do the early prediction of diseases. The processing algorithms assist the physicians for the personalization of treatment and it helps to make the health care economical, at the same time, with improved outcomes. Also, in this paper, we highlight the challenges in the implementation of IoT health monitoring system in real world.

Keywords: *Internet of Things (IoT), health monitoring, Medical Devices, Sensors*

1. Introduction

The world population is increasing tremendously. The cities accommodating more population face astounding pressure of urban living. Even though the medical resources and facilities in cities are expanded daily, still the suffice level is not attained. The massive pressure towards the management of healthcare in cities has triggered the advancement in technologies to come out with the proper solutions to the booming problems.

With the increased rate of medically challenged people, remote healthcare has become a part of our life. In recent years, we observe the increased interest in wearable sensors and such devices are available in market for cheaper rate for personal healthcare and activity awareness. Researchers considered implementation of such advanced devices for the medical applications for data recording, management and also to continuosly monitor the patient's health.

The Intenet of Things offers a rising technology to attain the next level of health services [2]. 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 analzed with the existing health records [1]. Using the available data records and decision support systems, the physician can do a better prognosis so that to suggest early treatment. Even when the doctor is not available, this analysis enables the today's machines to predict the health issues. Not only prediction, machines can also be able to come out with the medicines from the systematic study of the medicinal databases.

The progressive technology will have a transformative impact in every human's life and health monitoring; it will remarkably cut down the healthcare expenses and a step ahead in the accuracy of disease predictions. In this paper, we present a idea of a service model in technological and economic views for the comfort of patients and also the open challenges in implementing IoT in real world medical field.

2. Background

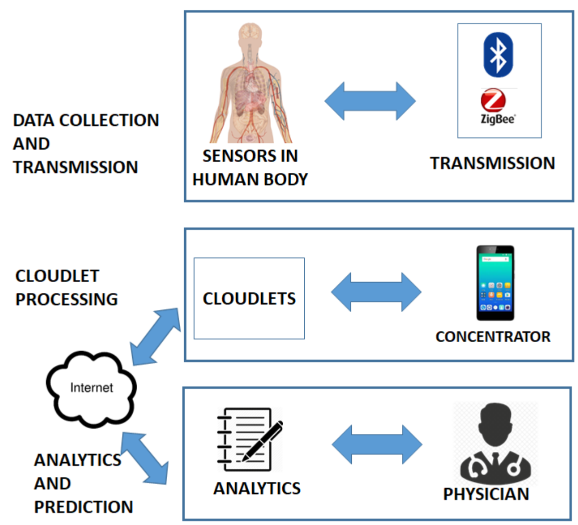
In recent days, various IoT systems were developed for health monitoring systems. Wang et al [6] designed a compatible IoT system for medical devices which was having multiple communication standard. A resource-based data retrieving method (UDA-IoT) was proposed by Xu et al [7] for information-intensive health applications.
Peer-to-Peer (P2P) and IoT technologies were combined in a medical system called as a smart box to keep the patients in control. Kolici et al [8] implemented that compared the experimental results for different scenarios. Web Real-Time Communication (WebRTC) was given by Sundholm et al [9] which focused mostly on the secured transmission of data multiple concurrent streams in an efficient manner.
By enabling the electronic sphygmomanometer to communicate via Bluetooth, an Android application [10] was developed to record the data such as SBP-Systolic Blood Pressure, DBP - Diastolic Blood Pressure and Heart Rate. That application made it easy to transmit the recorded data using any mobile device and such data is then be recorded, abnormality is found out and message is conveyed to the people.
A real-time application [11] was presented with distributed flow environment for the IoT healthcare. When the person under observation moves beyond range, data will be recorded in the local server and communicated later. A Galileo board [12] is a IoT-based device with embedded medical platform for the designed for electrocardiogram (ECG) signal analysis and based on an algorithm, heart function is monitored.
In market, few IoT Portable Medical Devices [13] were introduced which upgraded the patient's mobility. But the security threats and few drawbacks were also there while using Portable Medical Devices. When we started to consider light-weight IoT devices, using the existing databases, diseases were predicted. But while such predictions, issues were in storage of databases and analysis using those databases. A new cloud-based fine-grained health information access control framework [14] was introduced which addressed the security challenges and the cloud reciprocity issues.
A proxy-based approach for end-to-end communication between the IoT-enabled living systems [15] was proposed to challenge the real world applications. A portable electric aid device[16] was designed specifically for the blind people in which ultrasonic range finders are mounted on the belt to find the obstacles present in the users way and to direct the blind people through Bluetooth headphone. Another depth sensor based den avigation system [17] for the blind people with high accuracy and to alert user via vibrio tactile feedback in the hand gloves.
When the previous works are addressed, there is a limitation of database connectivity between the different cloud environment in monitoring the data in constant time intervals and to analyze data. Considering this limitation, in this paper, we present a cloud-based Internet of Things system that can be implemented in different health monitoring systems.

3. System Architecture

This system consists of four-protocol layers such as the physical layer, network layer, middleware layer and application layer. First, the physical layer consists of devices embedded with sensors and transmitters. The network layer is responsible of transmitting signals from sensors to the Cloudlets whereas the Middleware layer do the work of storing the data into the cloud and make it available to the people who are concerned. Finally, in the application layer, analytics and diagnosis process are performed.

Data collection and Transmission:

Patients will be given with the necessary wearable sensors capable of measuring Electrocardiography (ECG), Temperature, Electromyography (EMG) muscle activity, respiratory rate, sweating and blood glucose level. Using these devices, diseases such as arrhythmia, fever, neuromuscular abnormality, blood pressure, obesity and diabetes. The sensors used nowadays can be easily placed in contact with the skin in mulitiple body parts are highly preferable so that to obtain accurate measures.
From the compact sensors embedded within the patients body, physiological data is collected consisting of various necessary physiological parameters. Then a small hardware capable of preprocessing the acquired data and a communication software to transmit that data. The sensors must be small, light-weight and not troubling the patient's mobility and movements. Those sensors must operate on small, energy efficient batteries. The batteries are expected to be working continuosly without charging and replcacement.



The system components responsible for data transmission must be able to convert recordings of the patient from any of their location to the health centre with accuracy and security. For transmission, short range low-power digital radio Zigbee or Bluetooth can be used. Further, the acquired data can be relayed to health center through Internet for storage. The sensors involved in the IoT system can be operated through the Internet via the concentrator which can even be a smart phone.

In the health monitoring system, the existing Wireless Sensor Networks(WSN) must be customized so as to remodify the sensing nodes based on relative distance between sensors and health center, also to acquire more physical information for long time by avoiding redundant tasks. [18]. When we focus on low energy consumption, threshold levels should be set so as to handle the emergency situations. At the same time, the other sensors can be powered off to save batter lifetime.
When energy consumption is limited, there increases the need of low power protocols for communication. When compared with IEEE 802.15.4, Zigbee is a low rate Wireless Personal Area Network (LR-WPAN) which operates even in the distance of 10m. Zigbee is implemented in mesh networking with reliability and extended battery life.
Another wireless communication preferred is Bluetooth low energy (BLE) which is for short range communication with low power consumption. It suits for particular requirements of applications such as health monitoring, home entertainment and also sports. Using BLE, the components can be put in sleep for long intervals and so the energy consumption will be highly reduced in terms of number of bytes sent per Joule of energy [19]. Further the protocol Low Power Wireless Personal Area Networks (6LoWPAN) can also be utilized in case of connecting energy constrained WPAN devices to the Internet [20].

Cloudlet Processing:

Nowadays, the smart phones are coming with much and more advanced facilities so that it can be used as both LTE and WiFi. Such smart phones can act as concentrators in this system. Data collected by the concentrator will be transmitted to the cloud to storage. Such data, if stored, it will be much helpful to access on demand by the physicians or for analytics.
A small processing unit called cloudlet which is used for both storing and processing locally when the local resources are not suffice to fulfill the requirements. It also helpts to run time-critical tasks on the patients medical data. When data is stored in cloudlet, it enables all time access for data analytics to produce better diagnostic details.
Cloudlet Computing has been proposed as a better solution for the health applications through PAN as they often deal with offline data. The concenter and cloudlet are allowed to communicate through WiFi interface in order to reduce the data transfer latency for critical tasks on the collected data. At last, the data in the cloudlet will be saved in the cloud for reliable storage and distributed access of data. The data aggregation performed between cloud and cloudlet can be differentiated by context aware concentration where context is nothing but the current and expected status of the patient.
It has become highly essential to keep the patient's electronic medical records secure while storing in cloud. In order to prevent unauthorized access, appropriate privacy preserving measures should be taken when we transfer offline data to the cloud. Therefore, secure cloud storage frameworks were introduced to deal with the sensitive medical information [21], but it is still a challenge.

Analytics and Prediction:
As the medical datasets are rich in quantity, the data analytics is also big task. The machine learning algorithms do this work of correlating sensor parameters and clinical data. By analyzing this for longer duration, accuracy in the medical diagnostics can be better improved.
Data from the wearable sensors will undergo the process of pattern recognition and machine learning techniques [22]. In order to handle with more heterogenous and constantly changing sensor data, machine learning must be developed further. Also, those algorithms must be capable of dealing with inevitably missing data values, streaming data and information of varying dimensionality and semantics as the design of sensors often change.
There are three main challenges while we do the analytics process in the implementation of IoT in medical fields. Firstly, in the field of medicine, almost every day new measuring devices and equipment's will be introduced. And so, they need periodic updating of the IoT devices and the sensor data will also be different.
Obviously, it will make a huge impact in the database design and the IoT devices must be capable of managing all those. The machine learning algorithms are expected to be developed further to handle the constantly changing sensory information.
Secondly, everytime depending upon the condition of the patient, the data to be collected will differ as directed by the physician. Hence it is somewhat infeasible to additional input changing over time. It is possible to match the prior sensor data with the clinical records, still it is challenging because of the rare patient conditions. The concept of classification and regression methods can be helpful to prepare the common training data for providing machine learning algorithms, but again it will be the additional burden to the physicians.
Finally, as we take input from different sources, the sensory data will produce heterogenous modalities. This heterogeneity remains as a challenge for the machine learning approaches as it handles homogenous data. Graphical models may be helpful to combine different input data in a centered framework with significant customization.
Even though the sensor data are numerical; the medical data are plotted graphically to continuously monitor the patient's health. The concept of visualization plays a vital in health monitoring. The data from IoT warble sensors are spanned using different visualization methodologies for the effective prediction. The visualization tools must be always ready to interact with the heterogenous data to quick and accurate prediction in emergency cases. The visualization must be capable of handling the static images for comparing the medical reports of patients.

4. Conclusion & Future Work

In this paper, we found the importance and fruitful benefits of implementation of IoT in remote health monitoring systems. The compact sensors with IoT will make a huge impact on every patient's life, that even though they are away from home and physician, this helps them to reduce the fear of danger. The sensory data can be acquired in home or work environments. Also, the challenges in sensing, analytics and prediction of the disease are also highlighted and those can be addressed to provide a seamless integraton into the medical field.

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