International Journal of Engineering Sciences 2022 15(3)105-110

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES

Applications of IoT in Healthcare

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(Received 28 July, 2022; Accepted 2 September, 2022)

DOI: https://doi.org/10.36224/ijes.150303

Abstract

One of the essential functions in the survival of human beings is healthcare. The fraction of total of doctors to inhabitants in established countries is around 1:40, establishing countries 1:1000, however in under-established countries is 0.6 per 1000 inhabitants according to a lot of reviews. IoT is enormously identified as a probable prospect in case of smart healthcare system. A smart manner for decreasing pressure on infrastructure of hospital is monitoring health remotely. This can supervise patients who are non-critical at their home instead of hospitals and healthcare centers. It decreases the pressure on resources of healthcare like doctors and beds for patients. The advantages of remote health monitoring are to give more appropriate medical facil- ity to the people of semi-urban and rural areas and the elderly citizens. But, the ultimatum of the remote healthcare monitoring is the threat of data protection as the sensitive data is stored in a single database, individual sensors adaptation for verifying their correct supervision, correct connectivity link among the patients and the hospital and the device power capability problems. Providentially, these problems are mostly resolvable because of the betterment in the techniques of technology and encryption. Thus, remote health supervision on the basis of IoT have favorable characteristics which can obtain answers to these problems of the system of healthcare. IoT healthcare systems are established for some of the medical context like management of diabetes, rehabilitation, assisted ambient living (AAL) for elderly persons and others. The main aim of this topic is to explain the working of various applications of monitoring of health and types of healthcare sensing elements utilized on IoT healthcare.

Keywords: Healthcare, IoT, sensors

1. Introduction

1.1 Health and fitness monitoring

Wearable IoT gadgets which can permit inviolable and continuous monitoring of functional factors help in supervision of continual well-being and strength. These comfort- able gadgets can be in many types like straps and wristlets. The comfortable gadgets device a kind of wireless sensing elements networks known as body area networks where the values from a lot of comfortable gadgets are continually sent to a master node (like smart phone) which then transfer the data to a server or a back-end on cloud basis to analyze and log. Health-care issuers can analyze the composed data on health-care for determining any health states or abnormalities. Regularly utilized body sensing el- ements incorporate: temperature of body, pulse rate, pulse oximeter oxygen saturation (SPo2), blood

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ISSN 0976 – 6693.

pressure, electro-cardiogram (ECG), activity (using acceleration sensing elements), and electro-encephalogram (EEG).

1.2 Wearable Electronics:
Wearable electronics like comfortable instruments (smart watches, smart glasses, wristlets, etc.) and fancy electronics (with electronics combined in clothes and add- ons (e.g., Google Glass or Moto 360 smart watch) issue many purposes and characteristics for assisting us in our everyday actions and making us lead healthful situations. Smart watches that run mobile operating systems (such as Android) issue improved serviceability over just time-keeping. The users are able to do Internet search, play audio/video files, make calls (with or without paired mobile phones), play games and utilize many types of mobile applications utilizing smart watches. Smart glasses permit users for taking pictures and recording videos, obtain directions of map, verify status of flight, and do Internet search by utilizing voice commands. Smart shoes supervise the strolling or jogging rates and jumps with the assistance of embedded sensing elements and be coupled with smart-phones for visualizing the data. Smart wristlets can follow the everyday exertion and calories burnt.

2. Applications: Healthcare monitoring applications involve supervision of persistent disease, individual fitness supervision, and individual wellness. Incurable diseases involve diabetes, asthma, diseases related to heart and disturbances in sleep. Incurable disease monitoring comprises the following:
i. Occasional supervision of patients: This is utilized in non-critical pa- tients for tracking particular measures and determine the progression of the disease or recovery. Here, essential indications of patient like heart rate, temperature and disease-particular measures like BP, blood glucose level are supervised for determining abnormalities and identifying direc- tions. The supervision is done occasionally and every information which the medical sensing elements collect is time stamping and then safely re- directed to a centralized hub which works as a system to supervise pa- tient. Moreover, the centralized hub redirects the consolidated infor- mation in a safe way to a data server. Medical staff and family health care issuers will be able to acquire the information saved in the data server for supervising the disease progression.
ii. Continual supervision of patients: This is related with critical conditions that need continual or recurring estimation of health status. Here, the essential indications like heart rate, temperature, pulse oximeter are supervised on a continual basis for permitting continual estimation of health condition of patient at rest or at the time of moderate exertion for the goal of treatment adaptation, improvement or detection. The essential indications' measurements waveforms like heart rate are safely streamed to an on-body data gathering division to an off-body central- ized hub like PC/laptop, PDA or cellular phone for analysis of store- house and data. Alternately, the data can be transmitted right away to a mobile terminal. The patient or the care issuer remotely operates the on-

body sensing elements with the help of the off-body unit; the estimated data from the body sensing elements is safely broadcasted consistently to the on-body unit, where it is saved for the time being. In due course, the registered estimation data are sent safely to the off-body unit through batch transmission for storing persistently and further analysis by the healthcare issuer. Voluntarily, an off-body division can also be utilized for safe waveform scrutinizing at the time of estimation. The healthcare expert utilizes the recorded data for providing the proper diagnosis or for adjusting the level of treatment.

iii. Patient alarm supervision: This necessitates the activating of alarms on the basis of agreed conditions which are particular for the patient and the disease. Here, the essential indications of patient like heart rate, temperature and disease-particular indicators like BP, EKG, EEG are supervised continuously. The data which the sensing elements collect are time-stamping and safely redirected to a centralized hub that functions as a supervision system for patient. The centralized hub safely redirects the consolidated information to a data server. In addition to this, at pre- decided settings, alarms are provided and responses/actions could be activated spontaneously. For example, at the time of monitoring the patient suffering from diabetic, the level of blood glucose drops down under a specific threshold, the patient, medical personnel and /or physician receives an alert. Enlarging the rate of sampling of a given monitor can also be activated once an alarm has been declared. The medical device or the gateway provides an alarm. Individual fitness supervision examines a person's activity and safety (especially for the elderly). Applications encompass but not restricted to smoke alarms, panic buttons, motion sensing elements, home sensing elements and other monitors for facilitated livelihood prerequisites. The information which these gadgets collect is safely transferred to a Centre position for decision-making, analysis, storage and trending.

iv. Senior activity monitoring scenario: This emphasizes to supervise everyday activities of elderly people. Apart from comfortable medical sensing elements/gadgets that supervise the essential indications like heartbeat, body temperature etc., this application encompasses supervising other non-medical sensing elements like sensing elements for surroundings. If an elderly person needs to observe a definite everyday agenda, like, checking weight in the morning, getting readings of glucose level readings twice in a day etc., the caretaker can supervise the everyday activity status of the person. The person can be sent a prompt if he doesn't finish the routine activities.

v. Scenario of safety supervision: This manages with supervising the security of the home surroundings. The surrounding at home is supervised for safety dangers involving poisonous gases, water and fire. Further- more, the essential indications like heartbeat, temperature of the people at home are supervised. Supervision of individual healthiness involves:

(i) observing and following and fitness level and (ii) individualized healthiness agenda situation.

3. Healthcare Sensors: Certain broad-spectrum and unnoticeable sensors play a significant part in smart healthcare systems on the basis of IoT. The essential sensors are:

i. Pulse sensors: They are utilized for detecting substantial parameters of conditions of emergency such as clot in the lungs, cardiovascular disease and consciousness because of vasovagal reflex. Looking at rate of pulse through fingertips as well as earlobe issue correct readings. Wrist sensors and chest- worn system are utilized for measuring the pulse. Type of sensor utilized to send the pulse are Photoplethysmography (PPG), radio frequency sensors, pressure sensors and ultrasonic sensors.

ii. Respiratory rate sensor: Respiratory measures the number of breaths a hu- man taker per minute. Respiratory rate monitoring is critical information for the asthma patients, lung cancer, hyperventilation, tuberculosis, apnea episodes etc. Certain respiratory rate sensors are nasal sensor on the basis if thermistor, echo cardiogram (ECG)-derived respiration (EDR), respiration diagnosis on the basis of microphone, fiber optic sensor in an elastic substrate, pressure type sensor, stretch sensor, respiratory sensor on the basis of resistance etc.

iii. Body temperature sensor: Body temperature is utilized for detecting heat stroke, hypothermia, fever etc. Thermistor type sensing elements, negative temperature coefficient (NTC) type temperature sensor, positive temperature coefficient (PTC) type temperature sensor is utilized for detecting temperature in the body.

iv. Blood pressure sensor: A significant measurement in the system of healthcare is the blood pressure. Certain systems are designed for the correct measurement of the blood pressure by calculating the pulse transmit time (PTT).

v. Pulse oximetry sensor: Pulse oximetry is utilized for measuring oxygen level in the blood. This is done by finding PPG.

4. Components of Healthcare IoT:

i. Sensors: They feel the value of functional variable through the body of pa- tient.

ii. Wireless connectivity: In the absence of accurate connectedness and trans- mission, the data felt by the functional sensing elements have no utilization in a system of healthcare on the basis of IoT. Usually, the transmission among the comfortable sensing elements and local processing unit (LPU) is via either wired or wireless connectedness. The wireless transmission among functional sensing elements and LPU happens using Zigbee and Bluetooth. Alternately, the transmission among LPU and cloud or server happens using Internet connection like Wi-Fi and wireless local area network.

iii. Protection and secrecy: The secrecy and protection of health data is a crucial task in services of healthcare IoT. In an architecture of healthcare IoT, a lot of gadgets link through outside circle. Furthermore, among LPU and the server/cloud, dissimilar networking device's function using logical distance between networks based on number of routers (through one associated gadget to another) to transmit the data. In case, any gadgets are weakened, it can cause stealing of patient's health data, which can lead to consequential protection violation and resulting legal actions. For enhancing protection of the healthcare data, discrete service issuers of healthcare and companies exe- cute procedures of healthcare data encryption and security.

iv. Analytics: To convert the primary data into information, analytics plays a significant part in healthcare IoT. A lot of actors, like patients, nurses and doctors, acquire the information related to healthcare in a dissimilar custom- built arrangement. This adjustment permits every actor in the system for accessing only the information relevant to their work. In those schemes, analytics plays an essential part in issuing dissimilar actors in the system accessing significant data pulled out through primary healthcare data. Analytics is also utilized to diagnose a disease through primary functional information obtain- able.

v. Cloud and Fog computing: A lot of functional sensing elements are affixed to the body of patient in healthcare IoT system. The sensing elements regularly create a large quantity of diverse data. Well-organized storage space is required for storing those large quantities of diverse data. These data are utilized to check the past record of patient, present health condition, and prospects to diagnose dissimilar diseases and patient's signs. Normally, the storage space of cloud is adjustable, where payment is made according to space utilization. Therefore, for storing health data in a system of healthcare IoT, storage space for cloud is utilized. Analytics on the saved data in repository space of cloud is utilized to draw numerous conclusions. The important ultimatum in storage is protection and postponement to access the data. Furthermore, cloud and fog computing play a vital part in the storage of these enormous quantities of diverse data.

vi. Interface: The most significant element for users in a system of healthcare IoT is an interface. Healthcare IoT is a very critical and delicate application among applications of IoT. Therefore, the user interface needs to be created in a manner that it can portray all the essential information distinctly and, if required, reconstruct or portray it such that it can be understood easily. Furthermore, an interface should comprise all the beneficial information associated with services.

5. Case studies: AmbuSens system

In a lot of establishing countries, patients have to move from primary care to tertiary care hospitals for actual detection and remedies. At the time of movement, the hospitals at both ends- the mentioned one as well as the preferred one- do not have any information regarding the condition of patient's health at the time of movement. In those circumstances, the hospitals cannot propose any preventative means in the incident of crisis at the time of movement. Therefore, a lot of patients don't survive at the time of transit because of insufficient applicable evocative care by medical experts. For over- coming these limitations, at the Indian Institute of Technology, Kharagpur, the Smart Wireless Applications and Networking (SWAN) laboratory established a system called AmbuSens. The Ministry of Human Resource and Development (MHRD) of the Government of India fundamentally funded the system. This product system is a very essential part of the healthcare IoT system.

The main aims of the AmbuSens system are:

- Digitizing and uniformity of the healthcare data, which the recorded hospital authorities can easily access.
- Real-time patients' supervision who are moving from a hospital to another hospital. Doctors can access health conditions of patients in both hospitals.
- Availability by which many doctors will be able to access the health data of patients simultaneously.
- Providing confidentiality to the patients' health data in the cloud.
- Wireless functional sensors are utilized in the AmbuSens system. These nodes of sensing elements make the system adaptable and uncomplicated to utilize.

5.1 Architecture of AmbuSens:

The AmbuSens system is supplied with dissimilar functional sensing elements to- gether with a local hub. These sensing elements feel the functional parameters through patient's body and transfer them to a local data processing unit (LPDU). The functional sensing elements and LPDU form a wireless body area network (WBAN). This local hub redirects the functional data to the cloud to store and analyse the parameters of health. Lastly, different users can access the data.

Layer 1: This layer comprises of many WBANs affixed with body of a patient. These WBANs get the functional data from the patient and transfer them to the upper layer. The functional sensing elements are diverse, that is, each of these sensing elements feels dissimilar measurable factors of the body. Furthermore, the physiological sensors need calibration to acquire accurate data from the body of patient. Layer 1 looks after of the adjustment of the functional sensing element nodes.

Layer 2: Cloud computing has a significant role in the AmbuSens system. Layer 2 handles functions related to cloud. WBANs affixed to the different patients deliver data to the end of cloud through Layer 1. The cloud is utilized for long-term analysis and

data repository in the AmbuSens system. Furthermore, the preceding health documentation of the patients is saved in the cloud for performing analysis on the basis of particular patients. WBANs produce an enormous quantity of health data. WBANs are handled by the cloud using big data analytics to issue real-time analysis,

Layer 3: The patient's identification persists unnamed in the AmbuSens system. An algorithm is planned for generating an effective hash value for every patient for keeping the identity of patient anonymous. Furthermore, a new hash value is produced for the patients at different time moments in the AmbuSens system. The whole process of hashing is carried out in this layer.

Layer 4: The end users submit into the system and utilize it according to the needs.

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