Smart Computing and Intelligence

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Internet of Things Based Smart Healthcare

Intelligent and Secure Solutions Applying Machine Learning Techniques

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Smart Computing and Intelligence

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Biswaranjan Acharya · Chuan-Ming Liu
Editors

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Contents

IoT Based Smart Healthcare

Wearable Sensors and Machine Intelligence for Smart Healthcare

Samaleswari Pr. Nayak, Sarat Ch. Nayak, S. C. Rai, and Bimal Pr. Kar

Abstract Continuous growth in global population and the demand of healthcare, particularly for the elderly and physically disabled people, is a challenge in the current era. The growth in ageing population led to complex health issues and rise in healthcare expenditures. Conventional health monitoring system for these people is time consuming, inconvenient, and insufficient most of the times. However, there has been a demand for developing efficient healthcare solutions for these people for an improved lifestyle. Advances in artificial intelligence (AI) technologies and Internet of Things (IoT) have opened up a new revolution in the healthcare domain. The response time in diagnosis and treatment of elderly and disabled patient can be reduced through Internet of Things and wearable body sensors. Using low-cost and lightweight body sensors placed very close to the body of the patient, the lifestyle data can be collected, and the information, in turn, could be shared with the doctors and health caretakers remotely. Machine intelligence is another aspect to remote healthcare system in analyzing the huge and heterogeneous data collected by the sensors. The promising technological area of wearable sensors, IoT, and machine intelligence seems to afford a smart and intelligent means for an automated health monitoring system for elderly and disabled patients staying remotely. The intension of this chapter is to explore the advancement, modality, specification, and applications of wearable body sensors for acumination of body symptoms from remote patients. Then, the importance and necessity of machine intelligence for analysis of healthcare data will be discussed. Finally, a conceptual model integrating wearable body sensors, IoT, and machine intelligence for remote healthcare will be presented. The model

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may be helpful in reducing the complexities and healthcare expenditure faced by aging, physical disabilities and remote population.

Keywords Internet of Things · Wearable sensors · Remote healthcare · Artificial intelligence · Machine intelligence · Smart healthcare

1 Introduction

Living with good health is the most important activity in human life. Healthcare demand has been growing with the rapid growth of world population while the resources are limited. Satisfying the high demand in healthcare resources starting from manpower to modern hospital infrastructure is creating significant challenges in the current era (Australian Institute of Health & Welfare, 2014; Perrier, 2015). Particularly, the growth in ageing population and patients staying in remote areas led to complex health issues and rise in healthcare expenditures. Conventional health monitoring system for these people is time consuming, inconvenient, and insufficient most of the times. However, there has been a demand for developing efficient healthcare solutions for these people for an improved lifestyle. Health of non-critical patients could be monitored remotely at their residence rather than in hospitals, which can reduce the pressure on hospital resources. It could be helpful in providing better access to healthcare for patients living in rural areas, aged people to live independently at home or physically disabled persons as self-assistance. More specifically, it can progress admittance to healthcare assets at the same time as dropping excess load on healthcare systems. Also, it can give people be in charge of over their own health at all times.

IoT has been emerging as an alternative to abridged pressures on the current healthcare systems in the form of remote monitoring of patients with certain criteria, aiding rehabilitation through continuous monitoring the patient's progress etc. (Fan et al., 2014; Gope & Hwang, 2016; Zhu et al., 2015). IoT has opened up a new revolution in the healthcare sphere of influence. The response time in diagnosis and treatment of elderly, remotely and disabled patient can be reduced through Internet of Things and wearable body sensors. IoT is a relatively new research area and its adequate applications in healthcare are still under exploration. Several IoT healthcare-related technologies such as accessible solutions, possible applications, as well as challenges are surveyed in literature (Baker et al., 2017; Islam et al., 2015). The possibilities and potential of IoT as a solution for remote healthcare have been identified by many researchers recently. A system to generate a rehabilitation plan using IoT based on the symptoms is suggested by different authors (Fan et al., 2014). The system is proved successful in almost 87.9% cases where IoT is used for monitoring patients suffering from Parkinson's disease (Pasluosta et al., 2015). An IoT-based system for monitoring the glucose level in blood of diabetic person is suggested in Chang et al. (2016) by researchers. The system is claimed to be practical in analyzing the abnormalities in the glucose level and notifying the healthcare personnel. The easy availability of low-cost wearable sensors improved the style of remote healthcare system. These are used to extract and measure the physiological conditions of a patient. Using low-cost and lightweight body sensors placed very close to the body of the patient, the lifestyle data can be collected and the information in turn could be shared with the doctors and health caretakers remotely. More applications of wearable sensors to identify chronic heart diseases are elaborated in Sect. 2.

Major challenges in IoT-based healthcare system are security and big data management and analysis. The volume and varieties in sensor data collected from remote patients can be huge and need to be managed and analyzed in a systematic way to extract meaningful insights, which can be then used by the healthcare experts. Cloud-based data storage models are suggested in this regard (Ghanavati et al., 2016; Xu et al., 2014). For analysis and inference drawing from these huge data stored in cloud, machine intelligence could be used (Abawajy & Hassan, 2017; Sahoo et al., 2016). Few researchers suggested and compared the performance of machine learning methods such as deep learning, multilayer perceptron, support vector machine etc. for processing and analysis of cloud-based healthcare data (Hung et al., 2017; Park et al., 2014).

The overall contributions of this chapter are as follows:

- Presents healthcare issues and challenges for remote patients, particularly elderly and physically disable people.
- The possibilities of IoT as an alternate to conventional healthcare system.
- The state of the art and advances in Wearable sensors, specifications, and applications to IoT enabled healthcare system
- The necessitate and significance of machine intelligence for analysis and extraction of noteworthy insights from large and heterogeneous data collected by sensors.
- Designing a conceptual IoT-enabled autonomous healthcare model for remotely staying elderly and physically challenged people.

The remaining of the chapter is structured into four sections. Section 2 discusses present healthcare scenarios and challenges faced by remote patients. The possibilities of IoT as a suitable solution to the current healthcare system are discussed in Sect. 3. Section 4 presents our conceptual IoT-based model for remote healthcare monitoring. Section 5 concludes the chapter.

2 Presents Healthcare Issues and Challenges for Remote Patients

For every human being, heart is considered to be the most vital organ and assumed to be most affected in human body due to surrounding parameters. Different types of heart diseases are creating panic among all human beings of the world out of which coronary heart disease named as CHD is accepted as the greatest enemy to old age patients, due to which the death rate is increasing in most of the developing countries rather in developed. “The Registrar General of India” announced that CHD has caused 17% of total mishap and 26% of mature mishaps in 2001–2003, which is now expanded to 23% of total and 32% of mature mishaps in 2010–2013 (Perrier, 2015). In US about one in every three deaths are caused by cardiovascular disease, which leads to nearly 801,000 deaths with an average of 1 death in every 40 s as per 2017 survey (Australian Institute of Health & Welfare, 2014). CHDs take more life compared to cancer and another disease related to respiratory jointly in every year. So, the monitoring of heart condition is very much essential for each and every person, especially for the old age people. But with the increasing population, it is very difficult to continuously monitor each and every patient by a medical expert. Also, there are several critical situations need to be monitored where the patient lives in a rural area or far away from the hospital and suffering from different diseases, also the aged people who are suffering from a physical disorder with some cardiac issues.

Real-time monitoring during game is necessary as few players seem as invincible due to sudden demise and unaware of their health issues during game. Balers performing phenomenal feats in the playground can sometimes make us forget that they are even mortal. Due to previous cardiovascular diseases, sudden mishap may occur for athlete. An athlete’s heart is normally considered as a benevolent development in cardiac mass, with specific circulatory and cardiac morphological alterations, that defines a functional variation to procedural training, Boston Celtic.

From the history, it is found that at the age of 27 after collapsing Reggie Lewis faced death in an open session game (Naik & Sudarshan, 2019). Sudden mishap forced people to think seriously about the other star athletes those who had faced sudden mishap while performing in the sports they interested in and it is considered to be common that players will die during their game through severe cardiac stroke and other health issues. Many players had already faced the same situation and followers are losing their favorite sports down the memory lane. Thus, the great loss of all modest players had put a great challenge over healthcare communities to overcome the situation. Day by day, the medical profile of all athletes is becoming getting better due to availability of ECG, echocardiography, cardiac magnetic resonance and health training, due to which they are being recognized by a wide variety of population and are accessible by number of people (Al-Makhadmeh & Tolba, 2019). On a serious note, the cardiac change depends on the extended recognition conditioning, which is impacting on several athlete health situations. This may create some situation due to which sudden mishap or development in stages of disease may arise for athletes, which needs to be restricted but not completely avoided. So, the monitoring of real-time heart condition is very much essential for each and every person, especially for the old age people as well as sports persons during the game.

It has been considered that body temperature along with heartbeat and patient’s surrounding parameters need to be monitored for providing status. 72 BPM is considered as the natural heart rate of any adult where babies have 120 BPM and others are of 90 BPM (Fan et al., 2014). Between 97°F to 99°F the body temperature ranges for a person and in average it is 98.6°F. Considering these facts about the human being,

Table 1 Normal BPM at different ages (Zhu et al., 2015)

Age	BPM values for normal heart rate
Till month 1	70 >= BPM <= 190
1 >= month <= 11	80 >= BPM <= 160
1 >= month <= 2	80 >= BPM <= 130
3 >= years <= 4	80 >= BPM <= 120
5 >= years <= 6	75 >= BPM <= 115
7 >= years <= 9	70 >= BPM <= 110
Years >= 10	60 >= BPM <= 110

the healthcare model needs to detect the patient temperature and heart rate along with the room temperature and the humidity. To accurately measure the patient's objective, different sensors need to be used with the microcontroller in every healthcare model. The model should be designed in such a way that it should accumulate the real-time patient data and can forward to the destination server for storage. So, the model has to include a major area in network of sensors and communication-enabled things in IoT to achieve remote health care (Table 1).

The standard procedure for the calculation of blood pressure and glucose along with heart beat level was carried out through physical healthcare centers with various kinds of tests. But to overcome these lengthy processes, the technological advancement in wireless connectivity along with sensors like glucometer, blood pressure, and temperature is used to get the vital symptoms on regular basis instead of going to hospital (Fan et al., 2014). Through this IoT-based mechanism, different categories of people are getting benefitted like people who are staying in remote areas and patients with physical disabilities. Lots of opportunities are being created through this technology so that people with manageable heath issues should not come to be admitted to the hospital as they can be monitored remotely by the concerned person. IoT in healthcare provides the early symbols through continuous check up and make the patient know about the deteriorating signs of health and involves other healthcare attention to get rid of it. Statistics says people used to feel more comfortable at home rather at hospital, which provides machine to human communication (Pasluosta et al., 2015). The treatment and monitoring of the patient at a hospital including shifting physically consume huge amount of money and time. Also once admitted in hospital, no one related to patient can monitor the status of the patient. With the help of remote patient monitoring, these problems can be solved and some solutions can be provided to monitor the patient from anywhere at any time by anybody no matter where the patient lies.

3 The Possibilities of IoT as an Alternate to Conventional Healthcare System

Internet of Things combines cloud computing along with wireless network using wearable sensors to revolutionize remote healthcare for different kinds of patients. IoT for healthcare is determined as HealthIoT (Chang et al., 2016), which can be differentiated into three different stages (Xu et al., 2014). Out of that in first stage hardware uses sensors and devices for communication, where as in stage 2 keeps place for data storage and uses analytical tool for data analysis. The last stage is to provide virtualization through which the user can get all relevant data to visualize the current status of the patient. Based upon the mentioned stages, patient health can be effectively monitored and handled with negligible error (Ghanavati et al., 2016). The procedure is followed to collect the patient data by using wearable devices or sensors and communication is built among the devices and sensors to communicate with themselves and lastly the transmitted data need to be kept at a place to be analyzed by some applications. With respect to context awareness, computational intelligence and data storage using IoT along with cloud computing known as CloudIoT (Sahoo et al., 2016), plays a vital role in real-time healthcare (Abawajy & Hassan, 2017). The advanced network generations make the patient monitoring easier for anyone from anywhere at any time (Hung et al., 2017). Not only the alert system but also a display device needs to be attached for logical as well as physical monitoring of patient by reading the data through sensors before communicating to the authenticated and connected users.

Transmitter and receiver are the two basic components used in the article Heartbeat and temperature Monitoring System for Remote Patients using Arduino (Park et al., 2014) by the authors. Along with ATMEGA328, a radio frequency module is attached in both sections. Transmitters like LM35 and LM358 are used to collect the relevant record from the patient in real time and transmit to the receiver using module RF. The LCD is associated with the receiver section, which is responsible to display the values collected by the RF module. In few models, ESP8266 Wi-Fi module along with Message Queuing Telemetry Transmission (MQTT) protocol (Gupta et al., 2016) is used for achieving the goal of real-time healthcare of any patient. The Raspberry pi in the model is used like a broker for establishing the connection between sensors and client. The value of BPM is collected from the patient body by pulse sensor collectively with the Arduino and forwards to the broker protocol MQTT, which transmits the same by creating new session to the client when required instead of creating new session for every data transfer. The error rate between manual and sensor module can be enhanced through the use of multiple sensors. From number of researches on these healthcare models, one model (Heart Disease & Stroke Statistics, 2017) uses PIC16F73 as an embedded system along with different sensors, filter, GSM module, LED sensor, and one IR receiver for detecting the photo. All are associated to capture the heart rate and to calculate temperature of patient body LM35 is used. In another study (Mallick & Patro, 2016), PIC16F877, A Peripheral Interface Controller RISC processor is used to monitor the heart rate and body temperature parameter. Here also a heart rate sensor with digital output along with LM35 is used to gather the real-time patient temperature and heart rate accordingly. GSM module along with LCD is also used in the embedded system to clarify the status of patient healthcare in real-time. Nagaravali et al (Yick et al., 2008) have provided some light on the heart rate and different activities to monitor using microcontroller Arduino Uno in connection with CPR and pulse sensor to control emotional activities as well as heat rate, respectively. GSM module is responsible to send the status of patient as per requirement to the respective users.

One more model on healthcare using microcontroller AT89s51 (Kevin, 2009) is being described where a photo resistance sensor along with a LED are working on behalf of heartbeat sensor to provide readings of patient heart rate. But the analog signal produced by the mentioned integration is processed through LM358 and forwards the result to the microcontroller. Also, LM35 is used to collect body temperature, and ZigBee module is attached for wireless communication between sender and receiver. Schlessinger has proposed (Logvinov, 2016) an OOP, full-time, continuous modeling for providing a vast area of clinical, technical, organizational, and economical choices related to patient health. The model consists of physiological as well as care process. The care process model is mathematically designed to provide a detailed procedure to generate a complete healthcare application. Nisha et al. uses PIC16F877 as the microcontroller for the microcontroller-based wireless temperature and heart beat read-out (Gómeza et al., 2016). LED and LDR have been placed side by side of a finger to detect the heart beat and LM35DZ is used to measure the body temperature. IEEE 802.25.4 (ZigBee) is used for wireless communication. CC2500 wireless transceiver module is integrated with the PIC controller to receive the data from the sensor nodes. A JHD162A series LCD is attached with the PIC controller to display the data locally. In a study of "Heart beat and Temperature Monitoring system per Minute rate" (Ahmed et al. 2015), ARM microcontroller-based unit is used as the controller of the system. Infrared LED, OP-AMP and photodiode sensors are combined together for supporting the working mechanism of the model to calculate the heartbeat. The most common LM35 is used as the temperature sensor. The data collected by the sensors are passed to the controller and in critical situations, the data are being sent to the concerned authority via SMS with the help of GSM module, which is integrated with the microcontroller.

4 IoT-Enabled Healthcare System

The revolution in the Internet of Things provides facility to track and monitor everything throughout the globe at any instant of time to achieve remote healthcare. The noble cause of this chapter is to provide an overall idea for the development of a real-time model to monitor the health status of every patient in different modes like offline or online. For communication between the source and destination, different network layers are necessary for end-to-end data delivery. The required layers need to be interconnected due to the composition of forwarding followed by acquisition and extraction of information from the body of the patient to the expert of healthcare.

4.1 General Architecture

To fulfill the requirements, the proposed design architecture consists of five layers like application, storage, network, data gathering with preprocessing and data acquisition layer. Figure 1 describes the layered architecture of the healthcare IoT model.

In the first layer of model, i.e. data acquisition layer, patient data are collected through the use of various wearable sensors including environmental parameters to perform various operations. Also, the patients are attached with few implant sensors

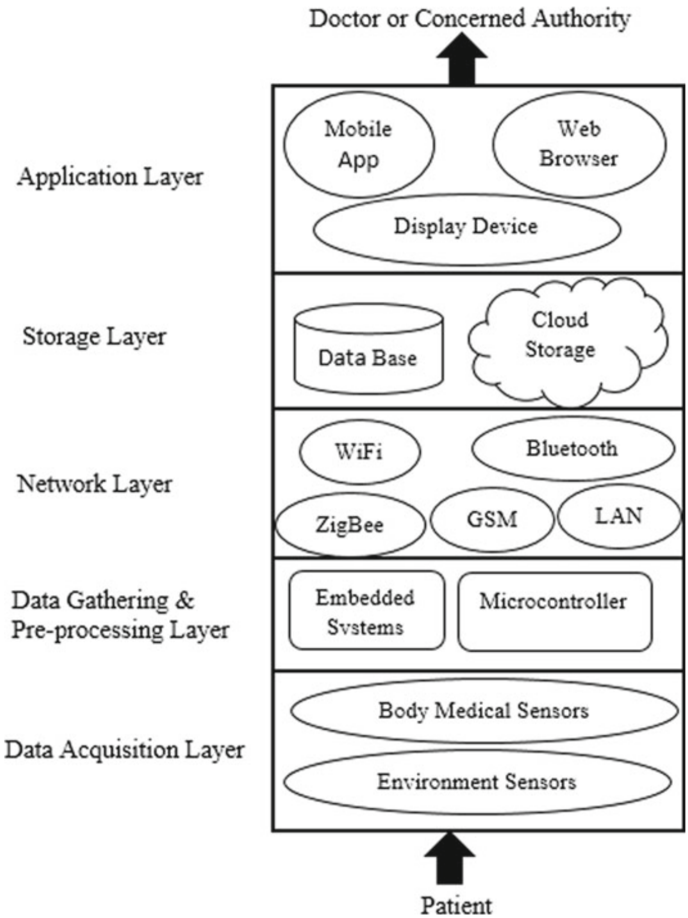

Fig. 1 General architecture for the IoT-based remote patient monitoring system

for clinical observation (Hossaina & Muhammadb, 2016) and are hidden inside the patient body whereas the surface of body is implanted with different sensors known as wearable devices. After collecting the parameters as per the characteristics of sensors, the data are forwarded to the next layer for rest of the operations. To identify a patient in a remote healthcare, RFID tag can be used (Gubb et al., 2013). To map the patient data with corresponding patient, the RFID tag plays a very vital role. Data acquisition is achieved through the first layer of the model.

For data gathering and preprocessing, several categories of embedded systems (ES) or microcontrollers are used. These devices are consisting of small memory unit with limited processing capacity along with provision for data collection and storage from the connected sensors and perform different operations on the gathered data (Liu et al. 2016). For internet connectivity and data forwarding, NODEMCU microcontroller can be used and automated to gather appropriate data for processing. The collected data processed by NODEMCU are forwarded to the application layer directly or through the storage layer passing via different wireless or wired networks. Different patient data are important in terms of monitoring and analyzing, so tracking of the same record is possible by storing these in a convenient place. To accommodate a large number of patient's data, cloud storage can be considered as the best possible option to implement any kind of healthcare application using IoT. Global as well as local servers can be used for more effectiveness of model, which provides service to online and offline users. Different users like healthcare authority, doctor, and concerned people will get an interface to be connected with the patient virtually through application layer for monitoring, analyzing, and visualizing the status of patient. Virtualization of status can be provided through web as well as mobile application to the online users and through display device near the patient will meet the objective of offline users.

4.2 Proposed Architecture for the Healthcare System

By following the common IoT architecture, the model has been designed using architecture and divided into five different layers. The patient with the wearable body sensor stays in the data acquisition layer. Sensors detect the vital signs from the body of the patients and pass it to the next layer. NODEMCU-12e is the microcontroller integrated with Wi-Fi module, used collect information from all the sensors and converts the analog data of the sensors in a human-readable format. Wi-Fi connectivity is used in the network layer to transmit the data from the microcontroller to the database. MySQL database server can be used as the database in the Storage layer. Finally, in the application layer, the view of the collected information has been displayed. A 16×2 display LCD can be directly associated to the NODEMCU-12e helps to monitor the patient locally. Different mobile applications and web applications have been designed to analyze the collected information and give the status of the patient. For mobile applications Blynk, a third-party application has been used

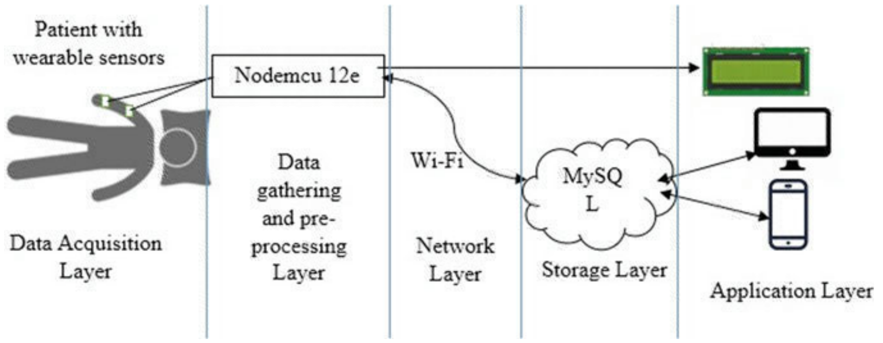

Fig. 2 Architecture for the IoT-based remote healthcare system

to display the results. Data have been sent to the Blynk server as well and the user with proper authorization to monitor the patient (Fig. 2).

4.3 Proposed Model

For monitoring the patient heart bit rate (BPM) and body temperature, Pulse Sensor and LM35 as body medical sensors can be used whereas to measure the patient's environment temperature and humidity, DHT11 is used. To keep updated records, date-wise DS3231 along with RTC modules can be attached with sensors in the ES to facilitate rigorous analysis on the collected record of the patients. The development board NODEMCU-12e is a microcontroller and can work like an interface where all the components are attached, through which it can collect all relevant data as per requirement and can able to transmit through Wi-Fi network to the storage server. MySQL server can be used as a storage device for the online users to get all the information as per their wish throughout the globe and similarly the LCD can be used to display the relevant contents like environment parameters along with patient's heart rate and temperature to the offline users all the time. Also, one buzzer can be attached to provide any kind of alert messages related to the patient during the critical situation.

4.4 Component Description

4.4.1 Pulse Sensor

For scheduling an activity, anticipating the movement or uneasiness levels, heart rate information can be extremely valuable in our day to day life (Botta et al., 2016). The problem associated with real-time model is that it is very difficult to measure heart

Fig. 3 Pulse sensor

rate manually. So, the pulse sensor can be attached to solve this issue and provides solution for the patients. The use of sensor is so simple that any layman can use and get the values as per requirement effortlessly. Generally, it consists of heart rate sensor with optical output including enrichment and cancelation of noise from the hardware, used for capturing raw facts about the heart rate in a simple and efficient way. It can work with 4 mA current draw at 5 V, which is considered as efficient for portable device designing. The sensor is attached with patient fingertip and can be connected to the 3- or 5-V power supply, ground and analog pin of the ES. The wire connected to the heartbeat sensor is ended with normalized male header so there's no closure required (Fig. 3).

4.4.2 LM35

Temperature is the most common and important characteristics of the patient body measured by the doctor. These sensors basically generate some output voltage after detecting heat/cold from the object to which it is connected. These sensors are classified into two classes, non-contact temperature sensor, and contact temperature sensor. Non-contact temperature sensors are used to measure the weather temperature and the other sensors are attached with the object to collect the temperature information. The contact temperature sensors are furthermore classified into three categories, electro-mechanical, resistive resistance temperature detector, and semiconductor-based temperature sensors (Stergiou et al., 2018).

LM35 is a semiconductor-based contact temperature sensor, which is incorporated simple body temperature sensor with output as electrical signal is relative to centigrade in degree. This does not need any outside adjustment or trimming to give average accuracy. The output with low resistance, direct output, and exact natural for making the alignment as interface to get or control hardware particularly simple (Fig. 4).

For effective calculation of patient health temperature, this sensor can be utilized as body temperature wearable sensor device, which can provide output per degree Celsius as 10 mv.

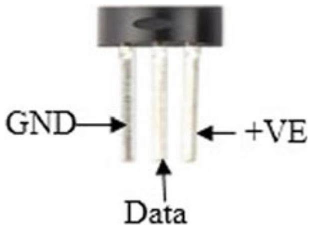

Fig. 4 Pin configuration of LM35 temperature sensor

4.4.3 DS3231

This sensor is merged with temperature-compensated crystal oscillator (TCXO) along with I2C real-time clock (RTC) having a maximum accuracy and low cost to implement. This electronics sensor needs a battery input and records the exact time while this gets principle energy (Silva et al., 2015). It combines the stone resonator with the long-haul precision while decreasing piece part in assembling line. Specifically, the DS3231 is used in business and mechanical devices that provide a 16-stick, 300-mil SO bundle. The RTC looks after seconds, minutes, hours, day, date, month, and year data. The date toward the finish of the month is consequently balanced for quite a long time with less than 31 days, counting alterations for next year. The adjustment of time slot related to 12-h or 24-h can be dynamically managed with AM/PM notations. Two programmable time-of-day alerts and a programmable square-wave yield are given. Using the I2C, bidirectional transport information and addresses can be interchanged serially. Correctness of temperature-remunerated voltage orientation and comparator circuit screens the status of VCC to differentiate control dissatisfactions, to give a reorganized vintage, and to subsequently change to the strengthening supply when necessary (Fig. 5).

4.4.4 DHT11

It is a simple, extremely cost-effective digital humidity and temperature sensor (Parihar et al., 2017). It uses a generalized moistness sensor and a different thermistor to calculate the surrounding parameters and modifies an advanced flag on the data stick. It is easy to use, however, needs watchful planning to get information. The main feature of this sensor is that the user can find updated data from it every 2 s intervals (Fig. 6).

Fig. 5 DS3231 pin configuration

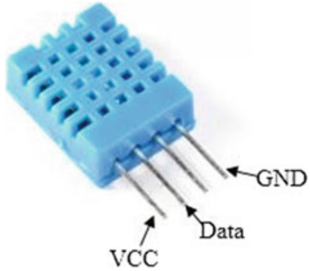

Fig. 6 DHT11 pin out

Fig. 7 16 × 2 LCD

4.4.5 16 x 2 LCD

In general fluid, gem is used in the electronic device, i.e. LCD module for display purpose to provide a clear picture of the result.

As a fundamental device, the LCD with 16 × 2 usually operated in different kind of circuit designs. It is a combination of 16-character length for total number of lines, i.e. 2 to display varieties of results as per the requirements where each character occupies matrix of 5 × 7 pixel of the LCD (Chooruanga & Mangkalakeeree, 2016). Different properties are associated with the LCD to make it a convenient one like the working voltage is being set between a range of values 4.7–5.3 V and without backup it can consume electricity around 1 mA. Regardless of use, the LCD can be designed for alphanumeric values where any kind of formatted result can be displayed. Also, each line of LCD can display 16 characters using two columns of the device with 4 as well as 8 bit mode compatibility and this is accessible with green and backlight (Fig. 7).

4.4.6 I2C Adapter

This connector changes over 16 × 2 parallel display data format into serial in LCD using I2C measured by four different wires (Alam et al., 2016). Connector utilizes PCF8574 chip because it communicates with different kinds of microcontroller using the format of I2C with I/O enlargement. An aggregate of several LCD displays such as 8 can be associated with a similar 2 wires of I2C transport of respective board containing an alternate location (Kale et al., 2015). Features of I2C adapter consist of properties like each connector incorporates 16 different PIN with male header connector to fasten the display device LCD. Complexity is balanced through installed

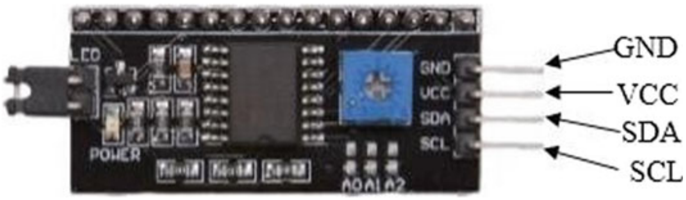

Fig. 8 Pin configuration of I2CAdapter

potentiometer. Backdrop illumination might be switched on/off by means of jumper with 5 V supply of voltage (Fig. 8).

4.4.7 CD4051B

CD4051B is a single 8-channel multiplexer with three binary control input S0, S1, and S2 and an inhibit input. One of the eight input channels is selected based on the values of the three select lines. It has an active low input circuit. So, whenever the inhibit input is low then only one of the eight input signals can work else no input channel will work. The value of the selected channel will be passed through the common output line. The working voltage for CD4051 is 4.5–20 V (Turlapati et al., xxxx) (Fig. 9 and Table 2).

4.4.8 Push Button Switch

Push button switches are two-state switches that have two states as ON and OFF. These are called push button switches as user will push to on or push to off. This mechanism is also called as push-to-make or push-to-break mechanism (Singh & Mishra, 2013; Schlessinger and Eddy, 2002; Shelar et al., 2013).

Fig. 9 Pin diagram of CD4051B

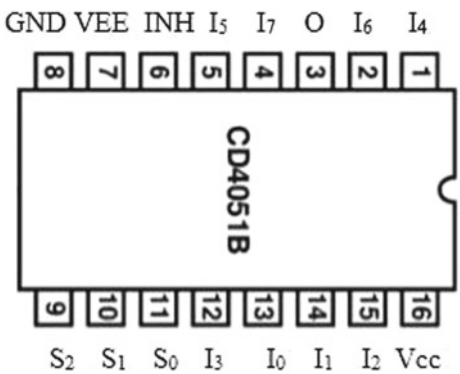

Table 2 Pin description of CD4051

Pin no.	Pin name	Description
13, 14, 15, 12, 1, 5, 2, 4	I0–I7	Independent input channels
3	O	Common output channel
6	INH	Enable input (active low)
11, 10, 9	S0, S1, S2	Select line
7	VEE	Negative supply voltage connected to ground
16	VCC	Positive supply voltage
8	GND	Ground

4.4.9 Piezo Buzzer

This is the device used for generating alarming signal as per requirement. Due to its simple characteristics like easy for deployment, lightweight and cheap in value it is used in wide spread applications like vehicles, computers and call doorbells. The prodigies of generating power during mechanical measurement are bind to particular properties and the alternative route is likewise valid. These buzzer substantial are either accessible or artificial planned. This is a group of artificial material, which carriages piezo electric influence and is approximately used to make different plates, which are considered to be the core part of buzzer (Sandeep et al., 2016). As per the recurrence of the flag for delivering sound, the substituting electric field can be extended.

4.4.10 NODEMCU

It is basically a LUA-based in-built firmware to express the utilization of Wi-Fi like ESP8266 and also it works like an open source apparatus board that needs to be connected with USB port for different programmable and troubleshooting purpose. It can be accommodated with breadboard and controlled by USB ports. This module is one of the least expensive accessible Wi-Fi modules in advertise. The most recent rendition of the discussed module that can be used for experimental purpose is V3 or Version3. This instructional exercise, however, will encourage you to interface every one of the forms of ESP8266 NODEMCU, i.e. V1, V2 or V3 (Naik & Sudarshan, 2019; Talpur, 2013; Zhao et al., 2011). Features of NODEMCU 12e are consisting of different occasion-driven API for arrange applications with 10 different GPIOs pins from D0-D10, usefulness of PWM, IIC and SPI communication, 1 for wire and ADC needs to be connected at A0 and so on across the board. The basic objective of using this to obtain Wi-Fi from different access point and from different stations along with webserver to get required information with input supply voltage ranging from is 5v to 19v (Fig. 10 and Table 3).

Fig. 10 NODEMCU 12E

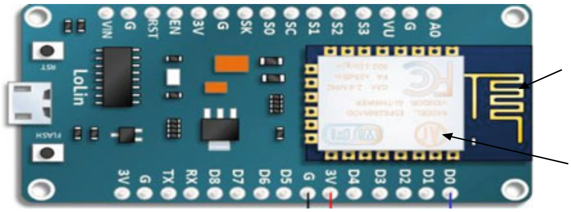

Table 3 Common pin description of NODEMCU-12e

Pin name	Pin mapping	Description
D0	GPIO16	General purpose input output pin is used to connect peripheral devices with the NODEMCU. Rx and Tx are used connect Bluetooth or other communicator devices with the NODEMCU. These pins are also known as Data Output pin
D1	GPIO05	
D2	GPIO4	
D3	GPIO0	
D4	GPIO2	
D5	GPIO14	
D6	GPIO12	
D7	GPIO12	
D8	GPIO12	
RX	GPIO3/Receiver	
TX	GPIO1/Transmitter	
A0	ADC pin	Only one analog input pin, takes analog signal as input and convert it to digital signal
Vin	–	+5 V output power supply
G	–	Ground
3 V	–	+3.3 V output power supply

4.5 *Working Procedure of Healthcare Model*

The desirable model can work on an open source development IoT board like NODEMCU-12e through integration of ESP8266, which will enable of using the stationary mode as well as an access point mode. This Wi-Fi module consists of a SPI controller, an ADC pin with multiple I2C and 10 GPIO pins. Each pin is capable of doing different tasks with using specified configuration of pin. Even if total pins are not required to design the healthcare model but the complete pin configuration can be proposed by connecting the required pins. But few things need to be taken care like both pulse and LM35 sensors provide output as analog signal, for which CD4501 module with 8:1 multiplexer needs to be attached to the ADC pin of NODEMCU-12e. By doing this, the output of both wearable sensors of patient healthcare can be collected in serial manner. The relevant data can be collected from the respective sensor modules using the combinations of the three selected pins of

CD4051. NODEMCU-12e can combine the data collected from the single output pin of CD4051 using ADC and forwards the same via the line of chip select conferring to the respective sensor's productivity signal. For offline users, a 16 × 2 LCD device can be used as a monitor for getting the status of patient locally. Although the embedded system has limited pins in it, to make compatible all 16 pins of the display device with NODEMCU-12e, I2C adapter can be used as an interface. A switch with 6-pin button push characteristics can be used as the mode selector for LCD device for display purposes. NODEMCU-12e supports the connectivity of DHT11 and DS3231 through the corresponding GPIO pins as digital output is provided by both the modules.

5 The Need and Importance of Machine Learning in Smart Healthcare

The recent development in IoT-based technologies helps in producing a large number of smart and wearable healthcare devices connected through internet. Huge amount of healthcare data are collected through these smart devices and need to be stored for future use. The amount of data may increase drastically with an increase in number of users of wearable sensors as well as kinds of sensor devices. Cloud storage is a suitable approach in this regard and has been suggested in the literature (Al-Makhadmeh & Tolba, 2019; Srivastava et al., 2019; Syed et al., 2019). These data need to be processed and analyzed in order to extract meaningful information that will be helpful for the medical practitioners. Analysis of this big data is a matter of concern. Machine learning (ML) algorithms can be adopted for the analysis of healthcare big data in the high-computing environment of the cloud. ML algorithms could be considered for.

- Mining through the healthcare big data,
- Discover the trend in previously unidentified disease, and
- Provide diagnostics and treatment strategy to the health worker.

The meaningful information thus extracted can be stored or forwarded to healthcare practitioners. ML applications can trim down human uncertainty and thus would help patients receive instant suitable care. Few ML methods such as logistic regression (LR), deep neural networks (DNN), gradient boosting decision tree (GBDT), and support vector machine (SVM) for predicting stroke is suggested in the literature where the DNN performed well. Meanwhile, ML algorithms such as generalized regression neural networks (GRNN), multi-layer perceptron (MLP), SVM, and k-nearest neighbor (kNN) were applied for determining a person's psychological wellness index, where SVM performed better. Artificial neural networks are usually data-driven model and can be considered as suitable model for fitting of large healthcare data. These studies suggested that there is still lack of best ML algorithms for healthcare and need to be explored. Hence, ML is going to play a vital role in IoT-based healthcare systems.

6 Conclusion

Health of non-critical patients could be monitored remotely at their residence rather than in hospitals, which can reduce the pressure on hospital resources. It could be helpful in providing better access to healthcare for patients living in rural areas, aged people to live independently at home or physically disabled persons as self-assistance. More specifically, it can progress admittance to healthcare assets at the same time as dropping excess load on healthcare systems. Also, it can give people be in charge of over their own health at all times. This chapter explored the advancement, modality, specification, and applications of IoT, wearable body sensors for acumination of body symptoms from remote patients. Then, the importance and necessity of machine intelligence for the analysis of healthcare data are discussed. A conceptual model integrating wearable body sensors, IoT, and machine intelligence for remote healthcare is then presented. The model may be supportive in dropping the complexities and expenditure in healthcare system faced by aging, physical disabilities and remote population.

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Architecture for Smart Healthcare: Cloud Versus Edge

Tumpa Pal, Ramesh Saha, Sayani Sen, Sohail Saif, and Suparna Biswas

Abstract Nowadays with the fast evolution of technology, smart healthcare plays a vital role to provide medical assistance to the patients from distant places, and checking large groups of people in a locale or country for detection and prevention of epidemics. Data handling of a critical patient is a challenging aspect for a smart healthcare system. Conventional healthcare systems can be divided into data collection layer, intermediate layer and analysis layer. Collected data by body sensor network are stored in the medical server through an intermediate layer and acted based on analysis. However, multi-modality of healthcare data causes failure of finding the hidden value of the collected data and increases the communication latency. Moreover, traditional smart healthcare systems are inflexible and heterogeneous network deployment in the lower layer causes degradation in Quality of Service (QoS). Hence, a more intelligent architecture is needed, with different QoS and Quality of Experience (QoE) parameters taken into account during the transmission of patient health data in order to obtain accurate information about a patient's health. Therefore, smart healthcare architecture, where sensing real-time data are accumulated in the cloud after analyzing them, feedback is sent to the caregiver. Due to emergency situations, the patient edge layer is introduced where decision taken promptly depends upon the patient's condition to reduce unwanted latency and delay. For future reference, data are sent and stored into the medical server through a network layer. In this chapter, cloud and edge-based smart healthcare architecture is described.

Keywords Healthcare · BAN · QoS · QoE · Edge · Cloud

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1 Introduction

Nowadays, IoT (Chen et al., 2018; Muhammed et al., 2018), an emerging technology, has connections with many smart sensor devices as a result of which exchange of data takes place between them. Hence, data storage platforms like cloud computing are needed. Healthcare (Muhammed et al., 2018; Tuli et al., 2020) is an application in the IoT domain, which helps towards the improvement of a patient. Tracking and constant monitoring of the health of the patient are very much essential for the healthcare system, and it is a major concern. It helps to overcome the drawbacks of conventional healthcare systems. In Healthcare service, the patient is mobile and is monitored continuously by using sensors as we may need patient data anytime using wireless networks. During any kind of emergency, the medical staff can be aware of the patient's health. Hence, there will be less delay for the treatment. Here, patient data are transferred to the service provider for healthcare keeping an eye on the state of the patient. The aim of a medical physician is to reach to a conclusion by diagnosis of the medical image of the patient. Here, diagnosis becomes easy as the clinicians interact for analyzing, and reach to a diagnosis based on the patient data and symptoms.

Smart healthcare architecture is shown in Fig. 1 (Failed, 2017; Tuli et al., 2020). Here, sensing real-time data are accumulated in the cloud. Then after analyzing them,

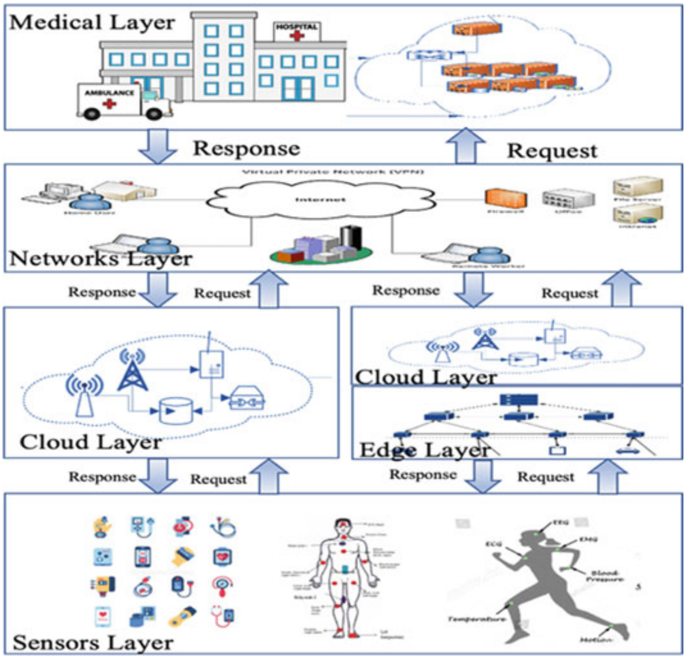

Fig. 1 Architecture of edge-cloud smart healthcare