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Remote Health Monitoring Based On IOT and Environment Detection

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***Abstract*— Remote Health Monitoring is an advance way to keep track of the physical condition of a person who has a health problem, the use of IoT makes it more effective. The advantage of continuous tracking and recording the physiological conditions of the patient is that, a medical practitioner can well in advance identify any variations and prescribe necessary treatment for the wellbeing of the patient.**

The system also makes it easy to store and manage medical data received from the patient, irrespective of the activities each one may get engaged in like, resting, sleeping, or exercising. Thus it will help to monitor even the minute changes in the body and identify problems even before the condition turns out to be critical. Also it saves lots of the patient's and doctor's time. All the information collected from the patient could be stored in the cloud and thereby it is available for reviewing at anytime.

Keywords: Remote health monitoring, IoT, vital parameters, cloud, physical condition.

I. INTRODUCTION

Remote health monitoring is a field of great advancement in the past few decades. Introducing IoT (Internet of Things) into remote health monitoring greatly increases the efficiency of the system. IoT is a promising area which is bringing in a lot of new technologies in the healthcare field, integrating the generation and exchange of huge amounts of data over the internet. IoT-based health care include new services and applications, interoperability, and security, to the existing remote monitoring systems. The use of IoT in health care sector for continuous monitoring of health status of patients make it more reliable, as it enables a real time recording and monitoring of data by authorized medical experts. It also provides a medical data base of each patient in the cloud storage which helps the hospital in easy data management and understanding of the patient's medical history.

The remote health care system based on IoT is a great leap in the health care field as it supports the life of persons affected with long term diseases, older citizens and others concerned about their personal health care. An interactive mobile healthcare service is a technology which can greatly revolutionize the health care field by maintaining a continuous and real time interaction between the patient and the doctor or hospital authorities. Man is always concerned of a sound body, understanding the body parameters are always important for this. With the objective of supporting a personalized and preventive healthcare aspect, a wrist band which is a wearable sensor device have been designed incorporating various sensors needed for learning the health status of a patient. The health condition of a person is basically evaluated from the vital signs obtained from the body. The wearable device is designed so that any variations in these can be identified and notified to the physician and caretaker at an early stage.

II. OVERVIEW

A. Remote Health Monitoring

Remote health monitoring of patients is a technology to enable monitoring of patients outside the conventional clinical settings (in the home or working environment) which may increase access to care and decrease healthcare delivery cost. Remote monitoring of a person's health status can significantly improve an individual's quality of life. It allows patients to maintain independence, prevent complications and minimize personal costs. In addition the person and the family members feel comfort knowing that they are being monitored and will be supported if any problem arises.

The main objective of remote health monitoring is to provide the necessary health support for patients in remote locations, on a real-time basis. There are situations where the patient's health parameter needs to be continuously monitored in order to keep track of the vital signs to avoid emergency situations. A wearable device which can be used to sense the vital signs of a person is designed so that we can continuously track the health status and provide the necessary medical support in prior thus avoiding emergency.

B. Motivation for the project

In India the healthcare field is in a stage of advancement, but there are still many rural areas which lack good medical facilities or experts. The patients in such remote locations travel a long way for their medical needs. A wearable device that continuously monitors their vital signs and sends an alert signal to the medical expert in prior will be of great help to such patients.

Studies show that in most of the cases of heart attack and strokes the symptoms occur at a very early stage. But by manual observation these variations in vital signs are not identified. Continuous and accurate monitoring of one's vital signs with the help of a wearable sensor device provides a better idea of any health deterioration. It can avoid emergency situation and in the worst can help to make necessary preparation for immediate treatment of the patient.

C. Existing system

There are many systems being designed for remote health monitoring in the recent days which are based on IoT. Most of them are designed for different applications like assisted living, for patients suffering from chronic diseases or for supporting the life of elderly people etc. So they are designed particularly depending upon the application. Many of them are bulky and sometimes involve more than a single hardware device, like in case of having a wearable device and a gateway supporting it for IoT. In most of the cases the only a single health issue like cardiac attacks or brain functioning etc is focused. As the number of parameters being monitored increases the size of the system also increases making them less usable and wearable. The ease of use is another main factor which makes the existing systems less favourable. One important fact that needs attention is that the system has the capability of enhancing the patient's health status storage and management at any time but this is not utilized to a wide extent. In India such remote health monitoring systems are not in use extensively, and the ones available are not cost and power efficient.

III. SYSTEM ARCHITECTURE

A. Proposed system

The main aim of this system is to reduce the complexity and cost of the remote health monitoring so that it can be used by everyone easily. The design proposed here incorporates the sensors needed for monitoring the vital signs of a person accurately and continuously. A wrist band is designed such that it includes the sensors, the processing unit, Wi-Fi module for sending the data to the cloud and a display to represent the sensed values using a touch sensor.

The vital signs considered here are body temperature, pulse rate, and ECG. Fall detection is also included so that it is helpful in case of elderly patients to identify and notify the care taker in such situations. The sensor system consists of an ambient light and temperature sensor to obtain a better understanding of the subject's environment. The vital signs are continuously monitored and processed. If any variation in these values is observed, the hospital authorities, the concerned doctor and the care taker of the patient will be immediately informed by a message or call. It also has an emergency push button which can be used by the patient whenever there is a need for help or in case of any trouble. It alerts the people around him of an emergency so that the person can get the immediate attention.

The system is simple and can be easily handled by any person. It is designed such that it does not cause any inconvenience to the daily activities of the person wearing it. The system can be used as an independent health monitoring device or can be combined with the hospital server so that there can be data management and records available to the medical practitioner for understanding the stages of health condition of the patients at any time.

B. Block Diagram of Proposed System

The device is designed such that it includes: wearable sensor node, the processing unit, Wi-Fi module to connect to the cloud and send the sensed signals for storage purpose.

The figure1 shows the blocks of the wearable device designed as a wrist band which has a controller module, sensors and display in built into it. The Arduino module which is the controller used in the circuit is interfaced with temperature sensor, pulse sensor, ECG sensor module, and fall detection sensor to monitor the vital signs of the body and ambient light and temperature sensors to monitor the environment and activity of the person. The sensed data is processed by the controller and directly displayed on the OLED display screen one by one. The data displayed on the screen of the wrist band can be changed by a single touch on the touch sensor. The vital signs obtained from the sensors are compared with the values it should have normally to identify any health deterioration. Any variation in the vital signs beyond the expected level is alerted to the care taker first and then to the doctor or hospital authority. The device also incorporates an emergency button which can be used by the patient to alert the care taker or people nearby by ringing an alarm.

The figure 1, block diagram given below shows the various modules within the system.

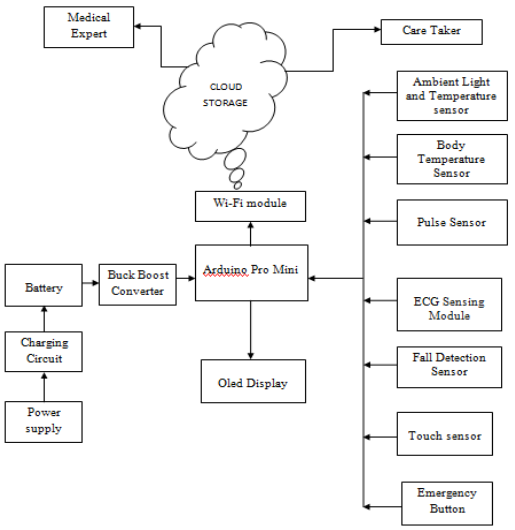

Fig.1 *Block diagram of the system*

IV. THE SMART BAND

A. Processing/controller unit

The controller block consists of the Arduino Pro Mini module. The reason for the selection of this controller is its small size, low cost and easy programmable nature. The board suits the requirement of being small in size so that the wrist band is compact. Most of the other controller modules are larger in size and have more power consumption. The program written in the Arduino IDE is uploaded to the board using the breakout board which is disconnected after uploading the code. The sensor modules are directly connected to the board using wires where the sensor data is processed. The values from the controller are then given to the OLED display so that it can be viewed by the user. The sensor data are processed and then uploaded to the cloud and other alert signals to the doctor and care taker are sent with the help of the gateway.

B. Sensor network

The sensor network senses the patients biomedical parameters and sends it to the processing unit. The sensors can be used as per the requirement of the patient, here the basic vital signs are considered. According to the requirement other physical parameters can also be measured by using the various sensors available. The sensors used are: body temperature sensor, pulse sensor, ECG sensor, ambient light detection sensor and temperature sensor, fall detection sensor, and a touch sensor for giving inputs to the display system.

The temperature sensor used for sensing the body temperature of the subject is LM-35. It is one of temperature sensor widely used. It is placed in close proximity of the subject's body so that it can sense the body temperature continuously with better accuracy. The analog output from the sensor is directly connected to the analog pin of the Arduino module. The sensor value is processed by the controller.

Another temperature sensor (LM35) is placed to in the band so as to sense the atmosphere temperature. This helps to understand the body temperature variation with respect to the atmospheric temperature change.

The pulse rate gives the number of heart beats per minute and is a representation of the heart activity. The sensor module consists of an optical sensor to detect the heart activity and a circuitry for noise cancellation. The output from the module is connected to the controller module by using wires.

The sensor module consists of an optical sensor to detect the heart activity and a circuitry for noise cancellation. The output from the module is connected to the controller module.

Fall detection sensor consists of an accelerometer and gyroscope with a circuitry for processing of the obtained signal. The module is connected to the Arduino module and the input is given directly to it. The sensor module shows the angle at which the sensor module is placed currently and if in case there is a sudden change in the angle that value is given as output from the sensor module. This helps us identify if there is any sudden acceleration of the body or change in its angle due to a fall.

It measures the electrical activity of the heart. There are three electrodes or leads which are connected to three points on the body mostly in the chest region or at RA (right arm), LA (left arm), and RL (right leg). The electrical potential is sensed consists of a high amount of noise and so it needs to be amplified and filtered. The waveform shows the duration of one cycle of heart's electrical activity. The variation in the shape or time duration of the waveform indicates the abnormality in heart functioning. The output from the controller gives the processed data which helps to identify any variation in activity of the heart.

A capacitive touch sensor is used to vary the details on the OLED display according to the touch input received from the sensor module. On the first touch the screen is awaken from sleep mode. Then if it is touched once it displays the time and date. By tapping on the touch sensor, the details displayed can be varied from pulse rate, body temperature, atmospheric temperature and lighting , ECG and battery level is displayed on the screen.

It is important to monitor the environmental condition were the patient is at. It influences the vital signs of the patient and so needs to be sensed continuously for understanding the patient activity.

For example the temperature, respiration rate, pulse rate, etc of a person is different while he is at rest, walking, running, during exercise or sleeping. Thus a good understanding of this is important for accurate monitoring of the patients health status. An LDR is used to measure the intensity of light so that we can decide if the subject is indoor or outdoor. The resistance of the light dependent resistor increases when the light intensity decreases, thus causing an increase in the voltage drop.

C. Display system

The OLED .96 inch display is used to display the sensor values on the wrist band so that the user can have a look at the vital signs to keep track of his/her health status. It is connected to Arduino module and programmed to display the vital signs with the help of a touch sensor. It also displays the time and battery charge so that device power failure can be avoided.

D. Gateway and data management

The data from the controller module is transmitted wirelessly to the cloud through a gateway. A Wi-Fi module is connected to the controller which is ESP8266. It acts as a gateway which connects the hardware part to the cloud storage. The mobile is connected to the internet and the data from the wrist band is continuously uploaded to the cloud server. This data can be viewed by the authorized doctor and the care taker. The alert signals when there is health deterioration is also send to the concern individuals over the network.

E. Power supply system

The power supply system for the wrist band consists of the battery, charging circuit and the buck boost converter. A Li- ion rechargeable battery of 3.7V 1400mAh is used for powering the device. The charging circuit (TP4056) is used for charging the battery from the supply line and provides over charge protection, and a buck –boost converter is used to provide a regulated supply for the Arduino controller module for its working.

F. IoT for data storage and management

The internet of things is a global infrastructure which interconnects various physical and virtual things based on existing and evolving interoperable information and communication technologies. Here the health parameters of the person are continuously monitored using the sensors. The values obtained are processed using the Arduino controller. There is a Wi-Fi module which is incorporated into the board which acts as a gateway for uploading the data to the cloud. The data is directly uploaded from the device to the cloud. In the cloud the data is readily available for authorized persons anywhere around the world at any point of time.

V. RESULTS AND DISCUSSION

The vital signs are the essential body function parameters that give provide the basic details of health status of a person. The vital signs include body temperature, heart rate, respiration rate, blood pressure, etc. The vital signs can change with the age, gender, weight, exercise capacity, and health condition of the person. Deteriorating vital signs often precede disease conditions such as stroke, cardiac arrest, respiratory issues etc.

Some extra parameters like blood SpO2 level, sweat rate, ECG, EMG etc are some of the other parameters which are often measured to know the physical condition of the person.

In Table.1 the common vital signs and their normal range is shown. For the wrist band which is designed we have considered the body temperature, pulse rate, ECG and fall detection as the signs to understand the physical body functioning of the patient. Sudden and severe variation in the vital signs can even lead to death if left unnoticed. The normal vital sign ranges for a healthy adult is as follows:

TABLE 1

Sl.No.	Vital sign	Normal Range
1.	Pulse rate	60 - 100 beats per minute
2.	Body temperature	97.8°F - 99.1°F (36.5°C to 37.3°C)
3.	Blood pressure	90/60 mm Hg - 120/80 mm Hg
4.	Respiration rate	12 - 18 breaths per minute

A. Software implemented

Figure 2 shows the software tool used for programming the Arduino to receive the sensor values and process them. The Arduino Integrated Development Environment or Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with tabs for common functions and a series of menus. It connects through the Arduino breakout boards to the hardware to upload programs and communicate with them.

Fig.2 Arduino IDE

B. Hardware implementation

Figure 3 shows the device to be worn on the wrist and powered on. It starts sensing the body temperature, pulse rate and fall detection continuously. The ECG leads are to be placed at the three positions, right arm, left arm and right leg. Once the leads are connected the ECG sensor module also starts sensing. The values from the sensors can be viewed on the OLED display. Once the display turns ON, we can view the sensor results from the temperature, pulse, fall detection and ECG sensors on the display on after the other by giving a touch input.

The sensor values from the environment sensors are taken into consideration to identify the patient activity level. If the subject is observed to be out door on a sunny day it is obvious that his normal body temperature will be raised. So such conclusions are made by comparing the sensor values obtained from different sensors. Thus by proper analysis and processing of the data we are able to identify any critical variations in the vital signs. The emergency button used by the patient is aimed to send distress message to the care taker or family members. It also sounds a buzzer to notify that the patient is need of immediate help.

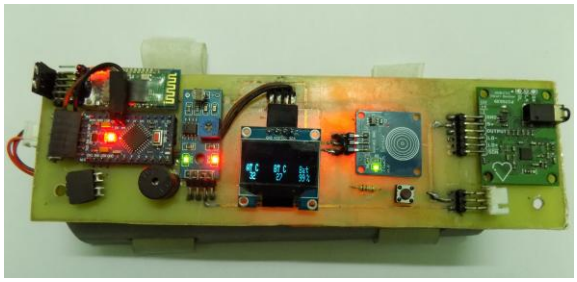

Fig.3 *Hardware board with display*

C. Mobile application

The processed data from the controller is displayed on the OLED screen for the patient's easy access. It is also uploaded to the cloud for future use and access by the doctor. The care taker should receive the continuous health status of the patient, for this a mobile application is designed. This app enables and easy access of patient's health details for the care taker.

The Figure 3 shows the screen shot of the mobile application displaying the vital signs of the patient.

Fig. 3 *Mobile application*

D. Future work

More health parameters can be added to the design such as respiration rate, blood pressure etc. The device can also be designed for specific applications, such as for patients suffering from cardiac problems, respiratory issues, stroke, or for sports persons.

The mobile application needed to display the data is created at a very basic level, this can be modified in such a way that the user can set some options or alert signals using the mobile application. Also the cloud server and data storage in the server is to be developed with greater security. Developing an energy harvesting system for the device is also a great advantage for the device.

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