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Health Emergency Alarm for Rigorous Treatment (HEART)

[1] S Chandra Sekhar, [2] Pudigi Bhargav Ram Charan
[1] Assistant Professor, [2] M.Tech Student.
[1][2] J.N.T.U.Kakinada, AP

Abstract: The improvement of smart technology in healthcare applications have made patient monitoring more feasible. The potential health applications will save lives and they cut the cost of medical services. The development of Health Care Monitoring with the Internet of Things is an ultimate solution to achieve the goal of universal health care for everybody due to accidents and various diseases. The objective is to monitor a person's health in a real-time environment by tracking vital human health parameters which will provide instant health condition of a patient. By using Global Positioning System (GPS) we will track the patient location, with Global System for Mobile communication (GSM) we can transfer the data through messages to the emergency services and by using wifi module we will continuously log patient vital information in cloud storage. This will ultimately useful to analyze a patient health condition in a given time interval.

Index Terms— IoT, Emergency Health Monitoring, Patient Tracking, Vital Sign Tracking, Smart Health Alarm.

I. INTRODUCTION

The immense use of wireless technologies in daily life caused a gigantic increase in the adoption of smart technologies in work environment. Health care deserves more attention in smart technology. This area has experienced changes in treatment, exam manipulation and also in the development of studies in regions of difficult access. This evolution led to the development Smart Healthcare and monitoring. According to the World Health Organization, medical practice with support of smart devices, like wireless devices, including the use of cell phones for messages, Bluetooth and other services, the use of smart devices is becoming more frequent in medical area as such devices help doctors in an efficient way to examine patient data records and life signs monitoring. They create valuable data for medical research. It revolutionizes the capture, compare and communication of critical data for use by medical services.

II. RELATED WORK

The increased use of wireless networks and the constant miniaturization of electrical devices have empowered the development of smart systems. In it, various sensors are attached to the body or implanted under the skin. Their power and size make it feasible to embed them into wearable vital sign monitors, location-tracking tags in buildings. These wireless systems and sensors offer numerous innovative applications to improve health care and the Quality of Life.

A. CodeBlue

CodeBlue is developed at the Harvard Sensor Network Lab, based on the medical sensor network. It is a wireless infrastructure deployment in emergency medical care, integrating low-power wireless sensors, PDAs, and PCs. It is a fully constructed environment placed in a selected field to monitor the patients' health condition. It is intended to scale to very dense networks with thousands of devices and extremely volatile network conditions. This infrastructure will support reliable ad-hoc data delivery, flexible naming and discovery scheme. Facilitates RF-based localization, which is accurate enough to locate a patient or medical professional position.

B. Alarm-Net

A heterogeneous network architecture named Alarm-Net was designed at the University of Virginia. The research is designed for patient health monitoring in the assisted-living environment. Alarm-net consists of body sensor networks and environmental sensor networks. It uses gateways in wireless networks to transfer the data. Any authenticated user can access data by connecting to that network.

C. UbiMon

It is a Body Sensor Network environment architecture composed of wearable and implantable sensors using an ad hoc network. The aim of the project is to provide

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continuous monitoring of an individual's physiological states and capture transient as well as life-threatening abnormalities that can be detected and predicted.

D. MEDiSN

MEDiSN is designed at Johns Hopkins University. It specially designed for patients monitoring in hospital and during disaster event was reported. In MEDiSN sensors store collected data temporarily with them and transmit whenever they connect to relay points to store it in the database. It comprises multiple physiological monitors (PMs), which are battery-powered motes and equipped with medical sensors for collecting patient's physiological health information. The PMs are mobile, temporarily storing sensed data and transmitting it to the relay points (RPs).The RPs uses a collection tree routing protocol (CTP) to forward their measurements to the gateway. MEDiSN is connected to a back-end database that constantly stores medical data and presents them to authenticated GUI clients.

E. SATIRE

SATIRE is a wearable personal monitoring service, designed by the collaboration of the University of Illinois and the University of Virginia. SATIRE allows users to maintain a private searchable record of their daily routine activities. When the person comes into the vicinity of an access mote (connected to a computer) the logged data is uploaded to a private repository.

F. MobiCare

MobiCare is a remote wireless patient monitoring system that efficiently exploits the recent advances in clinical sensor systems and wide area wireless networks to provide better medical services to patients. In which medical devices and sensors to be remotely installed, reconfigured. It enables remote registration and configuration of body sensors.

G. Noncontact ECG Monitoring

A non-contact ECG measurement system aims to continuously measure the biological signal on chairs. This approach can be applied to different chairs at multiple locations to continuously keep track of the health status of a patient. The proposed system is mainly used for ECG monitoring with a mobile healthcare system and cloud-based service. The data is displayed in real time on the mobile device. Cloud computing system is implemented into the healthcare service to ensure a seamless continuous health tracking system.

H.Driver Safety by Data Fusion

It is a smartphone based driver safety monitoring system works by the concept of data fusion. It predicts the driver's alertness state through a series of computations and displays the computed results on the smartphone's screen. The smartphone device receives data from biomedical sensors that are attached on the steering wheel and the driver's facial images from the smartphones front camera and acceleration taken from accelerometer sensor which will give speed of the vehicle. Temperature data can be obtained from the humidity sensor, which is placed on the steering wheel. An extraction process is performed to extract meaningful features from the received data. These features then serve as input models to an inference network to analyze the driver's vigilance level.

Whenever the driver's vigilance level is low it will trigger the alert module which gives the warning signal as well as a fake call.

I. Mikhail St-Denis-Life line

It will get heart rate, blood sugar levels, and human body temperature with body sensors. By using a wireless communication technology it synchronizes and displays this information into a standard computer. Such device gathers data from the user and displays some related graphs in order to encourage users to remain aware of their health conditions by providing a week to week feedback.

J. Eli wristband

Eli Hariton designed Gluco (M) wristband monitors the blood glucose levels. Patients body glucose levels are continuously monitored by wearing the wristband.

K. LUMO BodyTech

It created a platform for tracking human biomechanics, starting with a unique sensor-based solution for posture and back pain. It will analyze the sitting and standing posture of a person and estimates the probability of back pain.

L. Mobisante

In 2009 Dr. SaileshChutani founded Mobisante for ultrasound imaging. Health care workers in remote locations can check pregnant women and monitor baby's health and examine patients for heart and lung problems. Their phone can then transmit the images to a hospital for consultation. It is an ultrasound imaging technique which enables scanning of a person and developing the scanned results into images and transfers through mobiles.

M. NoninGO2

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Nonin and Numed have developed wireless vital sign sensor based on Bluetooth technology. Nonin GO2 tracks oxygen levels and pulse of a person through oximeter and transfers the data through Bluetooth technology

N. Radianse-RFID

Radianse has developed an RF-based location-tracking system for use in hospitals. Patients wear the Radianse active-RFID tags from admission to discharge. The tags send continuous RF signals to Radianse receivers plugged into a hospital's wired or wireless network. From there the signals are analyzed by Radianse location software and the results are available in a variety of ways as part of a workflow application's data; by querying a web-based application; or as alerts to a cell phone or pager. By tracking the patient, the Radianse IPS can also automatically record clinical events.

III. SYSTEM DESIGN

It is comprised of several embedded devices which need to be configured and programmed individually and work in a serial environment they collaborate one another to perform their tasks in order to give the efficient outcome of the monitoring system.

A. Architecture

HEART is a three-layered system in which each layer feeds from the preexisted layers outcome. The layers are divided mainly based on their functionality. CAPTURE is the first layer in which the human vital signs were monitored by using different biosensors like the temperature sensor which senses the temperature differences and the pulse sensor which continuously monitors the pulse fluctuations.

COMPARE is the second layer in which the sensed data from different body sensors will be grabbed and compared with the threshold limits which are predefined. This layer is responsible for enabling actuator modules like GPS, which attains the location of the patient in the emergency situation. It plays a key role in information gathering and processing. The third layer is for the communication (COMMUNICATE). In which the processed information made available to the users in different platforms like stored data in web clouds and message alerts by GSM module.

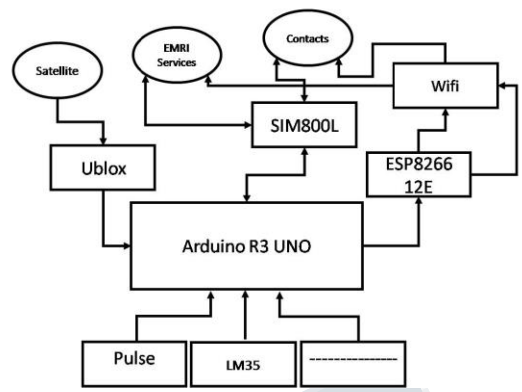

Figure 1 System Design

B. Algorithm

Algorithm 1: Heart (Health Emergency Alarm for Rigorous Treatment)

input : Pulse, LM35 sensor inputs *pulse* and *temp*
output : Outputs *msgalert* and *Datalog*
initialization : *count* ←0
hp ←74
tp ←99

```
Loop
    Read WiFi Status
    Read GPS Status
    if pulse >=hp then
        count++;
    end
    if temp >=tp then
        count++;
    end
    if count >0 then
        msgalert ← {hp, tp,GPS Location};
        count = 0 ;
    end
    Datalog ← {hp, tp,GPS Location};
EndLoop
```

Figure 2 Algorithm

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C. Embedded Devices

There are several sensors and embedded devices used in this project, like pulse and temperature sensors, Arduino microcontroller, GPS, GSM and wifi modules. As well as some other electronic components also used to solve power and data sharing problems such as regulator, switching circuits to switch between Tx of both GSM and GPS modules, 16x2 display, resistors, regulators and capacitors for regulated power supply.

1) Pulse sensor

Pulse sensor works with PWM (Pulse Width Modulation) technique. In which the gap between the two pulses will be captured by using Light Emitting Diode (LED). It will give one output and feed with 5v input.

Figure 3 Pulse Sensor

2) Temperature Sensor

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C).It can measure temperature more accurately than a using a thermistor. The sensor circuitry is sealed and not subject to oxidation.The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage is amplified.The LM35 has an output voltage that is proportional to the Celsius temperature. In HEART We use the LM35 sensor to grab patient temperature. The changing temperature around the sensor affects the resistance in it. Each degree temperature change will affect the output voltage of the sensor. By analyzing the output voltage we can calculate the surrounding temperature of the sensor. It works under 5v supply.

Figure 4 Temperature Sensor

3) Arduino R3 UNO

The Arduino UNO microcontroller board.It is developed by Arduino. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.

In HEART we use Arduino R3 UNO with an ARM7 microcontroller. Arduino will be powered by a 5v power supply. It grabs the data from sensors and compares that data with the thresholds we had given. If the sensed data exceeds the threshold limits then it will get location information from GPS module. It will send all the sensed information and location to the emergency contact numbers by using the GSM module. It also continuously feed Wi-Fi module with sensed information in order to store it in the cloud platform, which results in having the entire patient data log available in the cloud platform.

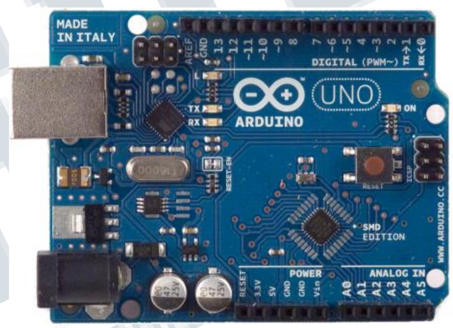

Figure 5 Arduino

4) GSM

SIM 800L is used as a GSM module in HEART. SIM800L works in 3.3v to 5v power supply but to avoid power drops we feed it with 3.8v power supply. In order to overcome the read and write pins scarcity in Arduino, GSM module shares a serial pin with GPS module as a Tx by using a switching circuit. Whenever the sensed data exceeds the threshold limits then the Arduino will attain AT commands which will send patient data to emergency contact numbers with GSM module.

Figure 6 GSM Module

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5) Wi-Fi Module

ESP8266-12E offers a complete and self-contained Wi-Fi networking solution; it can be used to host the application or to offload Wi-Fi networking functions from another application processor. In HEART we use ESP8266-12E as a Wi-Fi module. ESP8266 needs a 3.3v power supply. The Read and Write pins of ESP8266 are directly connected to the Rx and Tx pins of Arduino. This Wi-Fi module can be used both as a node and a host. We can use this module as a node to connect any other wifi network and transfer the data and even we can use it as a host to provide wifi network and by connecting to that network we can dump the sensed information to the connected devices. In HEART the wifi module is used to store the sensed data into a cloud platform and it provides a network by which we can collect the data in our devices just by directly connecting to it.

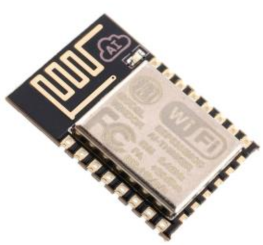

Figure 7 ESP8266-12E

6) GPS Module

We use Ublox GPS module in HEART, which will be powered by the 3.8v power supply to work efficiently. GPS module shares one of the serial ports in Arduino with GSM module as a Tx pin to overcome the need of read and write pins by using a switching circuit. It will continuously fetch location information of the patient by communicating with the satellites available in that region.

Figure 8 Wi-Fi Module

D. Implementation

We encounter two problems in designing the HEART the power and read and write operations. As each embedded device in the HEART needs a different power supply, we have to give regulated power supply. As the Pulse and Temperature sensors work with 5v power supply, GPS and GSM need to be feed with 3.8v voltage. The wifi module will work well in 3.3v power supply only. Arduino and 16x2 display module need 5v power and we have to feed the relay with 12v. The second problem is solved by using the switching circuit concept. As we all know that Arduino contains only one Tx and Rx, we need more Read and write pins to accommodate wifi, GPS, and GSM modules. For that, we use default read and write pins in Arduino to connect wifi module. By using serial pins in Arduino we convert them to Read and write pins and by using a switching circuit and a relay we are using a single serial pin in Arduino to toggle between GSM and GPS modules. It eventually solves the scarcity of the read and write pins in Arduino.

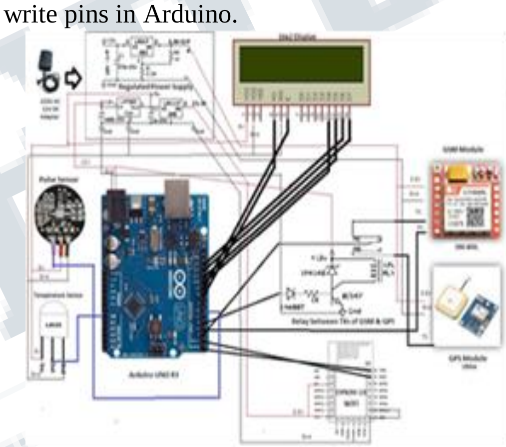

Figure 9 Implementation Design

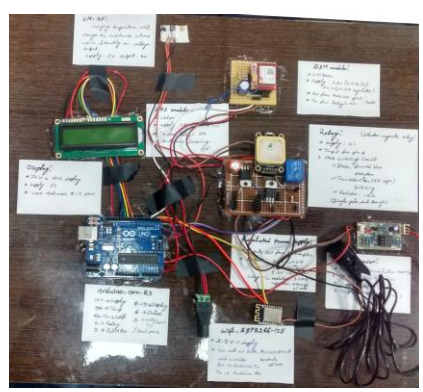

Figure 10 Implementation

IV.EXPERIMENTAL RESULTS

The implemented HEART results in a fully automated system which will give three different outputs.

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A. Intranet

In which the messages will be sent to the emergency contact numbers. The first given number will be the primary one, whenever the HEART initiate it will send the status to the primary number. Other numbers along with the primary number will be given alert messages when there is an emergency situation. Those alert messages contain the observed sensor values along with the location of the patient.

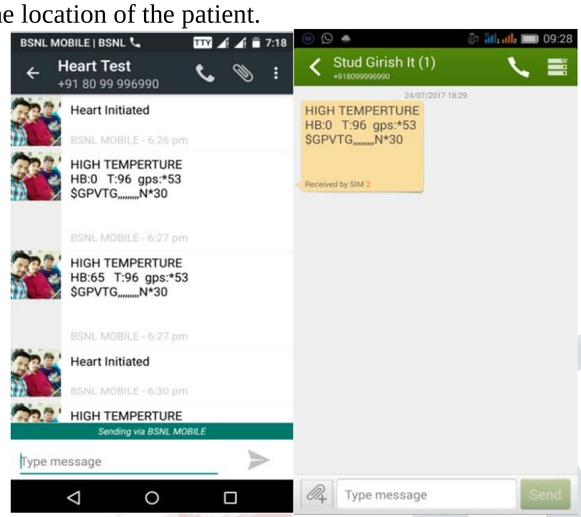

Figure 11 Message Output

B. On net

By using the wifi module we can establish a wireless network and by connecting our devices to that network we can access time to time updates from HEART. We can get the sensed values from HEART directly to our devices in that wireless network.

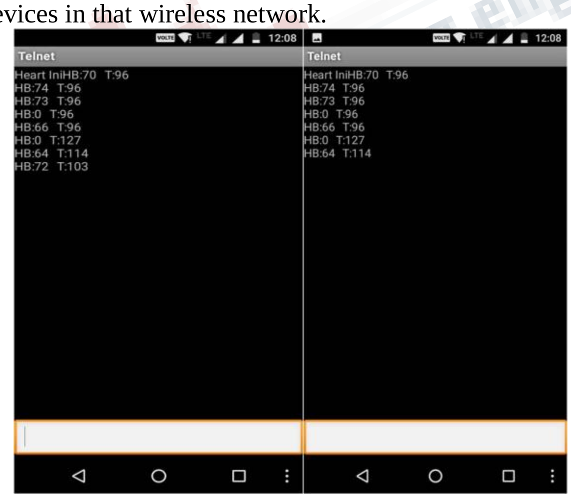

Figure 12 Telnet Output

C. Internet

Data from the HEART will be updated to the cloud with the help of ESP8266-12E wifi module. The data from the cloud can be accessed from different web applications and mobile apps.

Figure 13 Display Module

CONCLUSION

It is designed and implemented as a fully responsive automated alerting system which keeps track of the patient health position as well as his location. We can add RFID tagging to give a unique ID to each patient. We can add a privacy switch to protect user personal information.

Using a microcontroller with inbuilt Wi-Fi will reduce hardware complexity Prefer a board which can accommodate more than two read and write pins which will give us the ability to add more embedded devices. Using a high power and lightweight battery will give us flexibility.

Sensors which can be added:

SpO2, Sphygmomanometer, Galvanic skin response, Airflow, Glucometer, Accelerometer, and gyroscope.

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