Wearable Patient Care System: A Compact Multipurpose Medical Monitoring device

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Abstract- A brief description of the prototype of a compact medical device based on ESP8266 NodeMCUboard is detailed in here which is capable of tracking multiple health parameters in real time and has the potential to improve the patient care and remote assistance capability of existing Hospital frameworks. Cloud applications already available in market are used to implement Cloud interfacing with an IoT Node. Prospective development opportunities exist in adapting this model and converting it to a fully secure and customised platform.

Keywords- Node MCU, ESP 8266,Gyro Sensor, Temperature sensor, Pulse Sensor,IoT, Cloud

I. INTRODUCTION

Wearable devices are very popular in consumer market due to the latest improved and secured technologies employed in tracking personal health data. It is designed to be highly precise and comfortable to wear, commonly available as smart watches or wrist bands. In general, the use is common among people indulging more in fitness or sporting activities . A wide range of health parameters are monitored by these devices like number of steps covered , amount of Calorie burnt, Heart rate , body temperature, VO2 max (maximum oxygen uptake) etc using which the extent of workout performed by an individual can easily be analysed. But the level of acceptance or application of the same wearable devices are comparatively low in medical field , May be because of Data Security concerns or less confidence over such newer devices in comparison to fully tested and long proven precise medical equipments which are currently dominating healthcare industry. Also many innovations and advancements in this wearable field has to go through extensive evaluation before it can actually be approved for deployment in real world medical scenarios. Many research groups are already making effort to locally produce such high end medical wearable devices, so that it can be easily and economically be accessible to public. In this paper, the Proof of concept (PoC) of a viable compact wearable prototype based on IoT (Internet of Things) developed using low cost sensors, Microcontrollers and open source applications is described .The device is designed to act as a central hub thereby integrating multiple sensors into it and is also able to seamlessly transmit the collated sensor data to cloud platform. Main intention is to slowly move away from traditional heavy and expensive Medical equipments and embrace innovative electronic sensors andintegrated IoT wearable devices to make effective use of Hospital resources,Emergency care facilities and tobe accurate in medical diagnosis. This design can further be miniaturised and upgraded into a medical grade equipment to handle various real time health scenarios and should be able to reduce the overall implementation cost of similar facilities using low cost, low power, high precision digital wireless patient care systems. While hospital visits cannot be avoided at many occasions, a majority of the patients undergoing preventive and long term treatments can benefit out of such wearable medical devices which can improve the overall individual experience by providing remote patient assistance and access to real time health records, thereby ensuring better diagnosis and treatment of conditions.Eventually, Machine learning and Artificial intelligence will be able to enhance its ability to handle complex analytics by making use of such huge discrete medical data from numerous IoT nodes inorder to sharpen our predictive diagnostic capabilities.

Advantages and outcomes expected from this product design are as follows :

i. Continuous real-time health data collection from wide range of sensors(Temperature, Fall Detection ,Heart Rate) using a compact central monitoring device and Cloud Services.
ii. Globally accessible methods with Visually impressive depiction of gathered data.
iii. Reusing and redesigning locally available components that can be converted into medical grade devices.
iv. Aim to reduce the amount of traditional Medical Equipment'sin use , drive profitability through simplification and also efficient use of hospital resources.
v. Enhancement of advanced remote systemswhich can be deployed at patient locations in a hassle free manner.
vi. Future prospects exists in advancing the emerging technologieslike Artificial Intelligence, Deep learning etc.by interfacing it with IoT nodes and incorporating it's immense potential in early diagnosis of chronic and complex diseases.

II. HARDWARE DESCRIPTION

Central part of the device , The NodeMCU Development board based on ESP8266 microcontroller handles the sensor data processing and transmission to cloud application. I have only considered Temperature,Pulse rate and Fall detection valuesto be gathered using the device. DHT11 Temperature sensor , LDR based Pulse sensor , MPU6050 Gyro Sensors respectively enables capturing of readings. DHT11 works on the principle of Negative temperature coefficient , which means that the resistance decreases with increase of temperature .From the MPU6050 sensor accelerometer feature is used to detect a free fall. The pulse rate sensor uses a Light emitting diode(LED) and a photo diode combination which is capable of producing electrical signals proportional to the blood volume variations in a particular tissue caused by heart beat pulses .This compact device can stay functional for long hours using a 3.3v battery supply .Fig.1 shows the operational components and wiring details of the device.

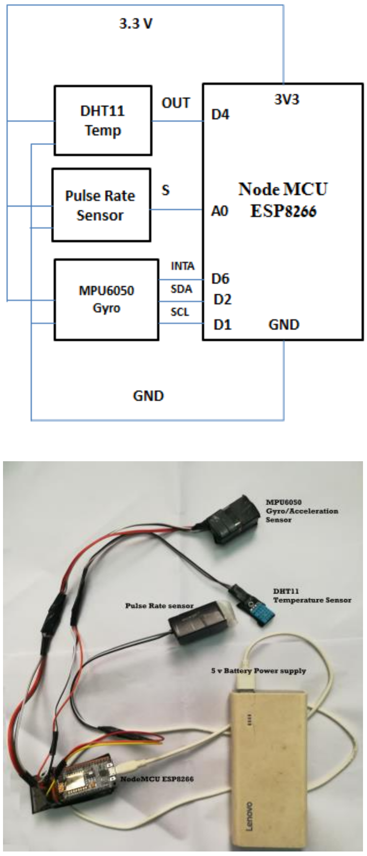

Fig.1: Wiring and Components of Patient Care System

III. SOFTWARE DESCRIPTION

Main part of the ESP8266 program is written in ARDUINO IDE which is basically using C++ language. The Open source Cloud IoT platform - "CAYENNE" is used here as a common service provider to interface theIoT node and publlish sensor readings . The available API's are adopted in NodeMCU ESP8266 coding to do the publish or transmit of the real-time sensor values through MQTT (MQ Telemetry Transport) protocol,(Ensure the MQTT protocol TCP/IP port 8883 is not blocked by local Router/ Firewall) .Fig.3depicts a visualisation of Real-time readings transmitted by the device from Cayenne Dash board. We need to add required header libraries specific to each sensors used , to initialise and process the respective digital or analog signals.Cayenne header library for ESP8266 provides an option to connect to the Cayenne IoT platform using local Wi Fi. As per the code design, the NodeMCU device keep an open execution loop which constantly captures the readings from all attachedsensors.

Main two problems envisaged in carrying out the project work were:

•Collating the data collected by various sensors in real time and publishing this information through different channels to the cloud application with minimal packet loss was a challenge in early stages of the project. This problem was resolved by restructuring the program loop .

•Certain configurations (for eg: WiFi to Cloud app interfacing) were borrowed from literature survey and GITHUB as it was required to learn Arduino/Sensor specific code syntax to develop the prototype.

As per the Code design , First of all the code will initialize all Sensors and get connected to the WiFi network. Incase of unavailability of the WiFi connection or the sensor wirings different to what is defined in the code , it will go on to run in an indefinite loop until the necessary rectifications are made in the WiFi router credentials, Cayenne connectivity parameters or Sensor wirings . Then, it will calculate the MPU 6050 Gyro sensor initial positioning data and keep it as a reference . Then the process loop starts immediately to read the data from the DHT11 temperature sensor, Pulse sensor , Gyro sensor and calculate the values based on that data.Incase of pulse rate sensor , every 2ms a timer takes a sample from ADC(pulse sensor) and calculate BPM(Beats per minute) and average BPM value is chosen for the send .Intermittent noise can be noticed which can result in getting wrong pulse values. From cayenne cloud application we have to define channels to receive the discrete sensor data and same is used as variables within the code . The values like temperature, Beats Per Minute and Position changes are captured at specific intervals , the NodeMCU will start publishing these value via the designated channels to the Cayenne Cloud data base . Cayenne services make use of MQTT protocol to receive and publish data using the port '8883'. The program will continue to run in a loop reading and publishing sensor data over WiFi. Patient fall detection is one of the prime factor identified by this wearable, as per the code design only free fall is considered to be a real incident of patient falling.Several fall-feature parameters and possible falls are calibrated through an algorithm. The implementation of program built to read an analogue variable from MPU6050 port as an additional adjustment.The total sum acceleration vector to distinguish between falling and activities of daily Living. However, we use gyro axis positions and accelerometers to isolate falls from activities of daily living .The overall function of the code can be tested using the Serial Monitor feature of Arduino IDE. Now, if you open the Serial Monitor and set the baud rate to 115200 and also select "Both NL & CR" option, you can see the progress of the ESP8266 Module. Below figures are the output Serial window for the NodeMCU sketch which describes what the output results are at each step of the code execution. All success factors and errors encountered are alsoclearly displayed during process run. Flowchart of execution is given in Fig 2.

Temperature and Heart beat information is published to Cayenne in real time where in the fall detection information will only be published when the sensor reports a free fall occurance. The published information is instantaneously displayed in Cayenne dash board which we need to customise as a preliminary step during initial configurations like user account setup , NodeMCU device interfacing etc.We have a facility in Cayenne to create trigger conditions based on a sensor reference value to take an action like sending an email message or mobile alerts whenever a critical threshold value is reached .

Cayenne Software also has an Android mobile version which has a user friendly interface which makes the readings easily accessible on the go.

URL to access the Cayenne dash board for this project: https://cayenne.mydevices.com/cayenne/dashboard/device/bd199b20-852b-11e8-9c05-61f9e9bc1eea

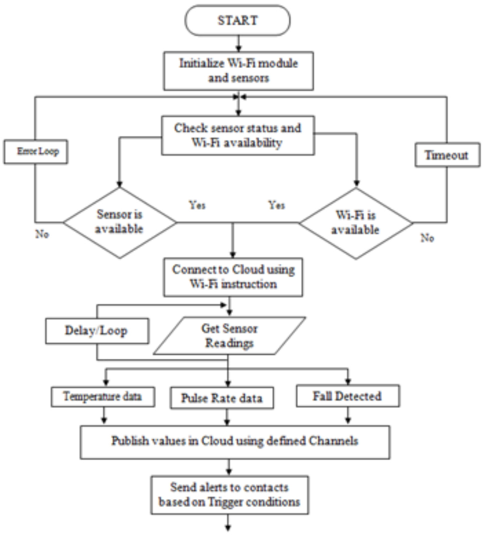

Fig.2:Flowchart of theNodeMCUCode

Fig.3: Temperature, Pulse Rate, Fall Detection readings as displayed in Cayenne Cloud

For easy visualization purpose, Device widgets or graphs should manually be created and customized by us. Cayenne is also available as an Android app which is easy to setup.Fig 4 Shows the dash board reading taken from the Mobile app alongside with the details of facility to sent alerts to a configured email address or Phone number notifying an authority like Emergency Care, Hospital or a doctor at any point the readings goes above a defined threshold value.

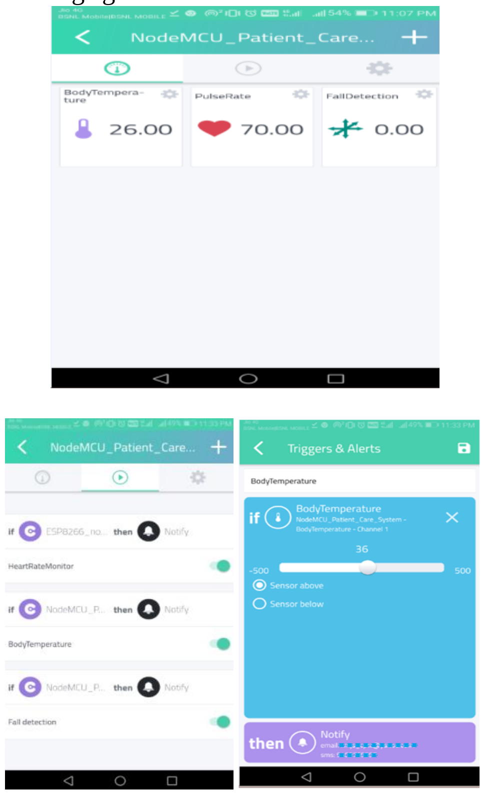

Fig.4: Cayenne Android App

IV. SYSTEM ARCHITECTURE

Interfaced Sensors continuously register its readings with theNodeMCUBoard which inturn acts a mediator-Node toreceive and transmit real time data over to the cloud. Within Cayenne cloud database the readings are stored for the purpose of anywhere - anytime data access .The inbuilt IFTT (If This Then That) logic can sentnotifications based on the trigger conditions set against the threshold value. Overall architecture of the design is represented in a simplified manner through Fig 5.

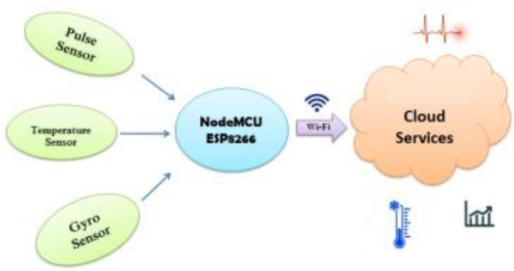

Fig.5: Block diagram

V. FINAL RESULTS

Successfully managed to develop a prototype of the wearable device which can easily be fitted to a patient and it was found to be extremely user friendly and cost effective. Since Patients are not wired to any fixed devices, comfort and freedom of movement is ensured. It is cost effective as in it will cost exactly as the project requires (optimum price). Fig 6 shows the finished prototype of the Wearable patient care system.

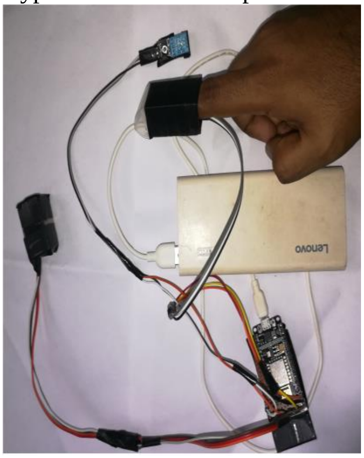

Fig.6: Final Design

VI. CONCLUSION

Our prime objective was to develop a wearable device that can provide information on heart rhythm, body temperature and fall detection to provide regular assistance during treatment. These devices carry incredible amounts of data and the collected data can start finding their way into electronic health records which can overall help to improve the healthcare industry. This project's base components include Cayenne Cloud and NodeMCU platform both of which are FOSS (Free Open Source Software). So the overall implementation cost is very cheap and it is affordable by a common person. Looking at the current scenario we have chosen wireless data transmission to cloud so that most of the health data can be remotely accessible and a wide group of medical personnel can take benefit of this quality data to be used to do prompt diagnose of various diseases or to deliver care remotely and can expect long term better health outcomes.

Future studies are further needed, in order to address the complex issues of flexibility and functionality of sensors in the literature survey, we designed and implemented a novel, standalone, flexible and low cost wearable patient care system. The promise of the data these wearable devices can pick up and transmit to providers could help transform healthcare from delivering reactionary care to preventive care. There is significant data from wearables and Data from wearables can be used in clinical trials. Digital technology is allowing investigators to reimagine clinical trials, in general. Wearables can be one source where trials can collect information, such as amount of sleep, heart rate, and physical activity. Wearables allow the data to be collected passively and can produce a more representative picture of what do with an experimental drug or device as they go about their everyday lives. However, there is a wide range of types of wearable devices, including implantable devices. As technology advances, healthcare has ever more access to data to understand patient behaviors and improve care. In particular, there has been a proliferation of wearables from consumer gadgets.

Wearables are being developed that combine sensors to unobtrusively monitor motion, biometric, and environmental data that translate into clinically meaningful parameters to incorporate into real world applications like :

- Remote monitoring of Blood Pressure, EMG, ECG, Air flow, Blood Glucose etc.
- Medical Drip controller
- Medical alert/Tele assistance especially to blind , elderly and disabled patients.
- Telemedicine
- Clinical mobility - use of mobile devices such as handheld mobile computers, tablets and mobile printersin hospitals to improve service delivery.
- Better long term care during their treatment to patients using Data analytics

They not only provide instant information to those people involved in a patient's care, they also generate large amounts of data over periods of time, which can then be analysed to identify trends.

The value of this data in terms of healthcare is starting to gain recognition. Big data is a term that describes incredibly large data sets. Making efficient and informed use of this data is thought to have the potential to positively affect health outcomes for patients and economic outcomes for the healthcare system.

With the ever advancing AI and Data analytics field , more reliable predictive algorithms in coming years can make use of the output from suchpatient care systems and map foreseeable complications for those patientswith chronic diseases, allowing proactive interventions that prevent rather than treat.

VII. ACKNOWLEDGMENT

This Project wasundergone as part of AMIE Section B – Electronics and Communication studies. I would like to thank Institution of Engineers (India) for giving this opportunity and alsoMr.K.PVarughese,FIEfor extending the kind guidance and support in completion of this work.

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