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IoT Based Smart Wheelchair for HealthCare

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Abstract*: People suffering from certain permanent disabilities due to accidents, paralysis or old age often depend on others for help with respect to movement. Providing an access to the remote health services using a health monitoring system enhances their independence, since their health is regularly recorded and monitored by the doctor without any efforts. By accessing the services online, they can directly communicate with their doctors only in case of an emergency. Since disabled patients cannot afford to travel, smart healthcare systems help them gain access to healthcare systems. A possible solution to monitor their health status is by developing a health monitoring system based on a smart wheelchair since it is adequate for a wider range of audiences and it does not require a lot of maintenance unlike the wearable systems. Smart wheelchairs not only focus on the mobility of the device but also on health monitoring of the patient. The objective of the present work is to develop a smart sensing wheelchair by implementing sensors within its structures. The technology adopted is Internet of Things wherein the heart rate and blood oxygen levels are detected by sensors, processed by embedded systems and sent to the cloud that initiates a trigger in case of any abnormality. The trigger produced can be in the form of an SMS or an e-mail.

***Index Terms*: Smart wheelchair, Internet of Things, Microcontroller Unit, PPG Sensors, Cloud.**

I. INTRODUCTION

Since people suffering from disabilities cannot afford to move, smart devices enable them to gain access to healthcare systems. A possible solution to monitor the patient's health status is by developing a health monitoring system. The objective of the present work is to develop an inexpensive smart wheel chair by integrating a microcontroller based health monitoring system to a regular wheel chair, to detect any cardiovascular abnormality using heart rate and breath rate and alert designated cell phone users by sending the alert signal over the cellular network.

A. *IOT:* The evolution of multiple technologies has led to the definition of the Internet of Things as an extension of Internet connectivity into physical devices and everyday objects. The technologies such as traditional fields of embedded systems wireless sensor networks, control systems and automation including building and home automation enable the Internet of Things. Web enabled smart devices that are embedded with sensors, processors and hardware that collect; share and act upon data acquired from their environments form the IOT ecosystem. Although people can interact with these devices, most of them work without human intervention – for example, gaining access to data by giving them instructions. The protocols used for networking, connectivity and communication in the web enabled devices are dependent on the IoT applications deployed. Before the IoT came into picture, the patients were restricted to communicating with their doctors via visits and tele communications. The doctors were not able to maintain a track of the patient's health records and monitor them on a regular basis. Through IoT, remote monitoring in the healthcare sector is possible with the help of the IoT enabled devices, thereby empowering the doctors to deliver superlative care.By enabling constant tracking of health conditions, IOT has changed people's lives, especially elderly patients, by enabling constant tracking of health conditions. This in turn impacts the patient as well as the concerned family members.

B. *Embedded Systems:* A computing system that is programmed and controlled by a real-time operating system to fulfil a function in an embedded environment is called an embedded system. The design of an embedded system is uniquely constructed to meet the requirements and specifications of the user. A computer board is incorporated and is associated with an input/output. The embedded operating system allows the application software to utilise the features to provide the required functionality. For example, a fire alarm that senses smoke is an embedded system. The hardware, the application software and the real-time operating system that provides the mechanism for the processor to run the process forms the three major components of an embedded system. The real-time operating system defines a set of rules for the execution of the application program. An embedded system is therefore a microcontroller system driven by software that is reliable and controlled by a realtime control system.The main advantage of using the embedded systems is the enhanced performance that is available at a low cost with low power consumption that can be easily customized. However, the embedded systems require a larger time to market and expect a high development effort. The embedded systems have been adopted in the medical field and are used in many ways by the doctors. They can be used for preventative medicine by enabling the patients to treat themselves. Embedded systems have also led to enhanced prosthetics by providing the prosthetic technicians with advancements. With the Internet of Things, through an extended inter network, doctors can keep a track by remotely monitoring their patients. The smart technology-based embedded medical devices have made the users proactive about their personal health.

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C. *Pulse and Heart Rate:* A pulse refers to the number of heart beats per minute and represents a tactile arterial palpation of the heartbeat by the fingertips. For an average adult, the resting pulse rate lies between 60 and 80 beats per minute. The pulse rates vary from person to person. The changes in the rate and regularity of the pulse can change upon ageing of an individual. The wrist, the side of the neck, the inside of the elbow and back of the knee are the best places to check the pulse using the index and the middle fingers. Studies show that the pulse rate for women is slightly higher than that of men. This is due to the fact that the male heart muscle is stronger. Age, body size, heart conditions and fitness level are a few factors that affect the resting heart rate. It also depends on activities such as sitting or standing, medication, emotions and even air temperature. Generally, those with a good cardiovascular fitness, such as athletes, experience a lower resting heart rate.

The National Institutes of Health recommends the following guidelines for a healthy heart rate:

- New borns up to 1 month old - 70 to 190 bpm
- Infants 1 to 11 months old - 80 to 160 bpm
- Children 1 to 2 years old – 80 to 130 bpm
- Children 3 to 4 years old – 80 to 130 bpm
- Children 5 to 6 years old – 75 to 115 bpm
- Children 7 to 9 years old – 70 to 110 bpm
- Children 10 years and older (including adults) – 60 to 100 bpm
- Well trained athletes: 40 to 60 bpm

The rate of blood flow controlled by the heart's pumping action can be sensed using a light based technology by the PPG sensors. An abnormal heart beat arises when the heart beats too fast, slow or irregularly. The heart is a complex system comprising valves, nodes and chambers that control the flow of blood. When the functions of this system are damaged or disrupted, the pattern of the heart beats start varying. This can lead to discomfort, pain or a pounding in the chest. The most common type of abnormal heart rhythm is the Tachycardia, when the heart beats too fast with a resting heart rate beyond 100 beats per minute. When the heart rate slows down and falls below 60 beats per minute, it is referred to Bradycardia. Most athletes have a slow heart rate, but that may not be an abnormality since they are in excellent physical condition. The main objective of this project is to develop an inexpensive wheelchair that can detect the heart rate and blood oxygen levels of the patient and notify the concerned patient party or the doctor in case of any abnormality. This proves to be beneficial for the handicapped patients who wish to be independent, while having their health monitored through the sensors. The pulse and blood oxygen level values are processed and sent to the cloud. While the client side uses the Arduino platform to detect and obtain the pulse as well as blood oxygen level input values, the server side uses the cloud platform to produce a trigger whenever an abnormality arises in the obtained data. The trigger produced can be in the form of an SMS or an e-mail. The graph of the PPG values can be obtained on the OLED display, while the data values are stored in .csv files. Thus, the health condition of the patient is monitored on a regular basis using the concept of Internet of Things. There have been devices that are constructed to make the wheelchairs "Smart" in terms of motion wherein the wheelchair movements are controlled by the patient.

Since people suffering from disabilities cannot afford to move, smart devices enable them to gain access to healthcare systems. The purpose of the proposed Smart Sensing Wheelchair is to detect any cardiovascular abnormality of the patient on a regular basis and notify the concerned person through a message. This proves to be beneficial for the handicapped patients who wish to be independent, while having their health monitored through the sensors. A possible solution to monitor the patient's health status is by developing a health monitoring system. The objective of the present work is to develop an inexpensive smart wheel chair by integrating a microcontroller-based health monitoring system to a regular wheel chair, to detect any cardiovascular abnormality using heart rate and breath rate and alert designated cell phone users by sending the alert signal over the cellular network.

II. LITERATURE SURVEY

Most of the papers reviewed presents discussion on control of smart wheelchair in terms of driving and steering. Control of wheelchair using different techniques such as Brain waves, Tongue Driven Systems, Face Movement Control, Hand Gesture Control etc. is discussed. Very few papers discussed the possibilities of Health Monitoring System using various sensors that can be integrated into the wheel chair. The availability of inexpensive sensors and the lack of extensive work done in health monitoring smart wheel chairs provides a scope for research. The choice of a wheelchair is rather complicated and depends on many criteria, such as the user's pathology, morphology, his/her rate of evolution, his/her environment(at home, in the office, etc.). Accordingly, there is not a "model" wheelchair. Thus, the wheelchair is selected according with economic and technical criteria. The position of each force sensor is identified where one force sensor is positioned in each pressure zone. Temperature sensors are integrated following the same procedure of force sensors, where a temperature sensor is placed just in front of each pressure sensor [1]. Many research study show how smart wheelchair can be of maximum assistance to its user. Navigation methods are divided to three categories according to levels of assistance. The three main categories are: Shared control, semi-autonomous control and completely autonomous control [3]. In the research work carried by Sibai & Manap,[1] a survey of the different type of smart wheel chairs is available. They also discuss on the HMI- Joystick Steering, Head/Chin/ Tongue Movement, Gaze/Face Direction. The paper also contains discussion on Sip & Puff Technology, EEG (Brain Signals), Voice Input, Hand Gesture Control , Discussion on Navigation Methods & Devices, Discussion on Future work on Health Monitoring Add-Ons. Kim et al.,[2] discusses a Smart Wheel Chair with a Tongue Driven System(TDS) for people with severe disabilities.

Purnomo et al.[3] discusses emerging technologies & recent development on Pervasive Biomedical Engineering. Also mentions the following Technologies :

- MC10 –Stretchable Electronic Tattoo for monitoring bio-signals
- Vein Viewer – Helps locate veins
- Vital Signs & Daily Activity Monitoring-PPG,BCG, ccECG, contact ECG, eTextile Electrodes

Upase [4] discusses Speech Recognition technology for Steering and Driving a Smart Wheel Chair. Commands are given through Android Meets Robot app, Speech to text is performed. The text is processed to identify the instruction input to the system. The necessary control action is performed after processing the instruction

Bansal & Gandhi, [5] reviews domains where continuous and long-term supervision of heart-rate is essential. The areas include elderly and differently-abled people, fetal ECG monitoring, infant monitoring, monitoring for automobile drivers, etc. Paper focuses mainly on the need for the above discussion to face the challenge of Cardio Vascular Diseases (CVD) affecting the population. Gassara et al. [6] focuses on placement of sensors when developing a Smart Wheel chair by integrating sensors to a traditional wheelchair. Selection of Wheel chair- Based on users pathology, Morphology, environment, activities etc. Economic & Technical Criteria, Sensors used- Plug & Play Optical Pulse Sensor,Flexi Force Force Sensor, Temperature SensorThe proposed system aims at developing a simulation of smart wheelchair which consists of a ppg sensor which senses the pulse rate of the patient on thewheelchair. The collected data is converted into signals and processed by NodeMCU. The processed signals are then sent to cloud .The cloud then analyze theinformation and sends a notification to a concerned person if the pulse rate goesabove or below a certain threshold value.

III. PROPOSED WORK

A. ***Arduino Platform****:* The arduino is a platform for building the devices that can sense and control the physical world. The main feature that comes under this is the IOT cloud platform.

B. ***IOT cloud platform:*** IOT cloud platforms are specialized cloud-based private or public infrastructure, which in itself is an extensive topic. The IOT cloud platforms are carefully designed for use by edge devices. The IOT platforms usually provide the following fundamental services:

- Web-based administrative console for managing the connection details of edge devices. Device-specific connection points are also known known as channels, while there are also generalized messaging queues to which any device can post data.
- Cloud-based backend databases for storing the incoming device data.
- Cloud based analytics services to operate upon the incoming data and transform the data into more meaningful desirable forms.

The following are the features of the proposed system:

- Developing an smart wheelchair which monitors the health and to detect any cardiovascular abnormality using the heart rate and it also checks the blood oxygen level using pulse oximetry sensors.
- The data is updated on the server and if any abnormality is found then it will notify to the concerned person through emails/sms. The user objective is to have the system in a regular wheelchair and alert caretakers in case of abnormality.

The input is the pulse which is sensed by the PPG sensors and the SPO2 (peripheral capillary oxygen saturation) sensors. The output of the PPG graph is displayed on the OLED screen while Cayenne displays the output of the beats per minute.

C. *General Constraints*

- The sensors shouldn't move a lot and they should be positioned properly in order to get the accurate values.
- A strong Wi-Fi connection should be available since the processed data is sent to cloud and a trigger is generated for email/sms.
- PC should be available to user to switch on/off the trigger conditions

D. *Software and Harware Requirements*

The software requirements are:

- Arduino
- Window PC/OS
- Arduino IDE
- MQTT Library
- Max30100 library

The hardware requirements are:

- Arduino Nano
- Laptop Configuration
- Node MCU
- SpO2 Sensor
- PPG sensor
- 4.7k ohm resistance
- SSD 1306 OLED display-128*64

E. *Non-Functional Requirements*

- Performance Requirements: The system requires stable internet access.
- Reliability: The system can be used from any place at any time
- Maintainability: Arduino sketch is used to support the client side, maintenance is very easy and economical.

· Portability: Server side of the project may be ported to other cloud platforms to which the IOT edge devices can easily adapt.

· Security: Secure as server side application requires user credentials for logging in.

This diagrammatic representation illustrates a solution model to a given problem is shown in Fig 1.

The processing is shown in a diamond.

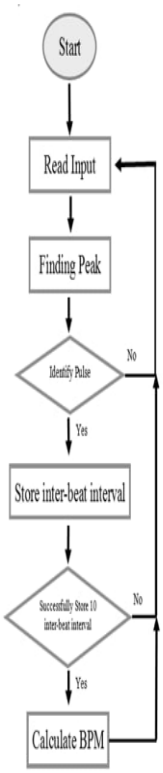

Fig 1. Flow chart for PPG sensor

The proposed system intends to be a low cost smart wheel chair.

- It is smart in terms of health monitoring and alerting in case of abnormality in heart rate & respiratory rate.
- The health monitoring will be done by assessing Heart Rate & respiratory rate.
- Normal Heart Rate (adult)- 60-100 bpm
- Normal Respiratory Rate(adult) – 12- 20 breaths per minute
- Any gross deviation from this range would be an indication of an underlying pathology.
- PPG Sensors detect the heart rate.
- The output of the PPG Sensor is given to the microcontroller unit for processing.
- The heart rate signal is processed in the microcontroller.
- The Heart rate for normal conditions are within fixed thresholds for that age group.
- The signal is processed to detect any abnormality in Heart Rate such as Tachycardia(resting heart rate >100bpm for adults above 15 years)
- A higher or lower than normal resting heart rate could be considered an abnormality.
- Thermistor is used as a breath sensors to detect the respiratory rate.
- The output of the breath sensor is given to the microcontroller unit for processing.
- The signal is processed for detecting deviations from normal.
- Cell numbers are programmed in the microcontroller to be recipients of the alert message.
- When any abnormality is detected, a pre-set alert message is sent to the designated cell numbers via the GSM Module which is attached to the microcontroller unit.
- The Message is sent over the GSM network as an SMS to the recipients thus alerting them to check on the patient.
- The system may be programmed to have multiple recipients for the message.

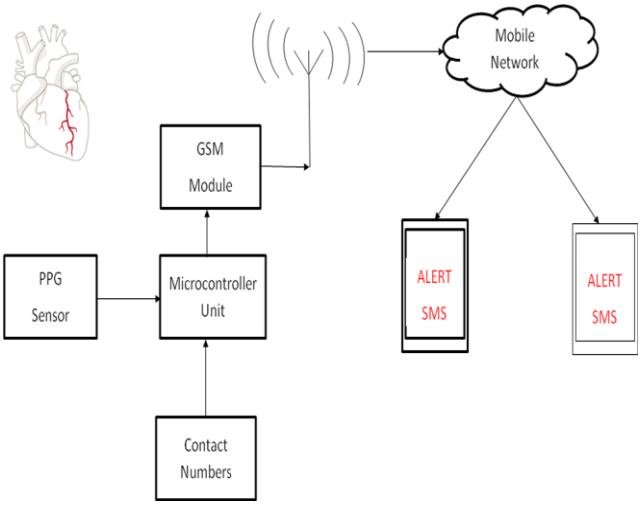

Fig 2. System Design

IV. RESULTS AND FUTURE WORK

Below tables show the test cases used in the process.

Table. 1 Sensor Unit Testing

Test Scenario	Test Case Description	Test Steps	Expected Result	Actual Result	Remark
Pulse Detection	Check for pulse using PPG sensor	1) Place the sensor gently on the fingertip	Each time a pulse is detected, the Arduino should blink and data is sent to the mcu to compute the bpm	Each time the pulse is detected, the Arduino blinks and data is sent to microcontroller	Pass
SPO_2 Detection	Check for the blood oxygen level using oximeter	1) Place the sensor gently on the fingertip	Each time a pulse is detected, the Arduino must blink and data is sent to the mcu to compute the bpm	Each time the pulse is detected, the Arduino blinks and data is sent to microcontroller	Pass

Table. 2 Micro – Controller Unit Test

Test Scenario	Test Case Description	Test Steps	Expected Result	Actual Result	Remark
Data processing	Obtains the pulse value from the processor and compares with the threshold value	1) Sending the input to the mcu through the sensors 2) Compute average and process the data	Processed data will be sent to the cloud	Processed data is sent to the cloud	Pass

Table 3. Cayenne Unit Testing

Test Scenario	Test Case Description	Test Steps	Expected Result	Actual Result	Remark
Trigger activation	Initiates a trigger if pulse value exceeds threshold value	1) Obtain input from the mcu 2) Enter email id/ contact number 3) Initiate trigger	User will be notified that an abnormality has occurred	User is notified about the occurrence of an abnormality	Pass

Table 4. Integration Unit Testing

Test Scenario	Test Case Description	Test Steps	Expected Result	Actual Result	Remark
Trigger activation upon detection	Detects pulse and Initiates a trigger if pulse value exceeds threshold value	1)Detect pulse value from sensor 2)Send value to the mcu 3)Process the data to compute bpm 4)Send processed data to cloud 6) Initiate trigger if value greater than threshold	User will be notified that an abnormality has occurred	User is notified about the occurrence of an abnormality	Pass

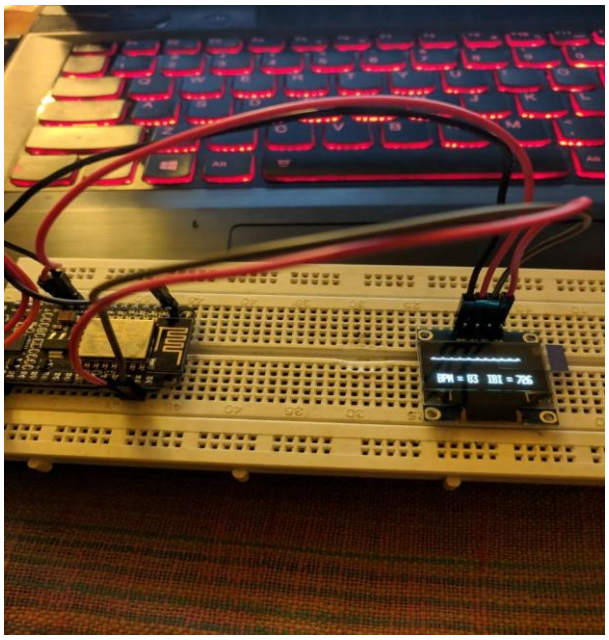

Fig 3. Circuit with OLED screen

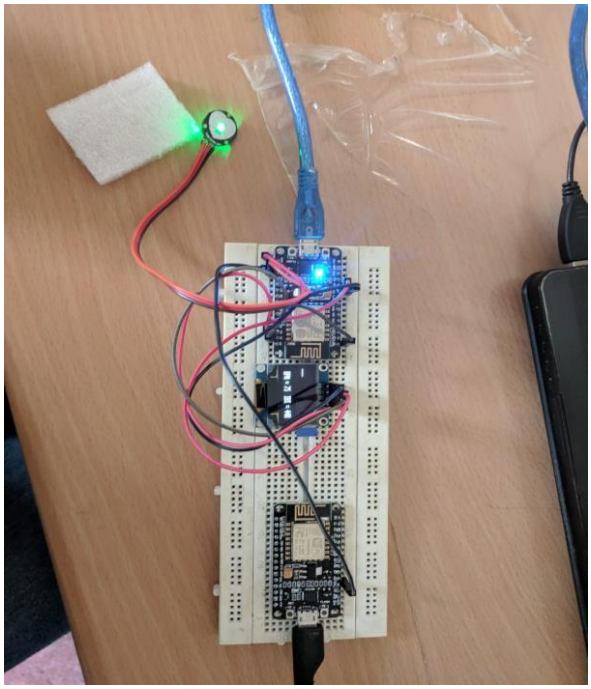

Fig 4. PPG sensor on Arduino Nano

V. CONCLUSION

This work aims at developing an inexpensive smart wheelchair by integrating a microcontroller-based health monitoring system to a regular wheelchair, to detect any cardio vascular abnormality using heart rate. Alerts to designated cell phones/email-id of users by sending the alert signal over the cellular network. This work is carried out to develop a smart wheelchair based on a traditional one by implementing sensors within its structure. The targeted sensors are pulse where the targeted integration structures is the armrest. The aim was to develop an inexpensive and easy use health monitoring wheelchair, which enables patients with disabilities to be in contact with the concerned person via sms updates. Thus, by sensing the heart rate, processing the data and sending the information to the cloud, the patient party can keep a track of the health of the patient.

REFERENCES

1. Alsibai, Mohammed Hayyan & Sibai, Al & Abdul Manap, Sulastri. (2015). A Study on Smart Wheelchair Systems. 4. 10.15282/ijets.4.2015.1.4.1033.
2. J. Kim et al., "Assessment of the Tongue-Drive System Using a Computer, a Smartphone, and a Powered-Wheelchair by People With Tetraplegia," in IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 24, no. 1, pp. 68-78, Jan. 2016. doi: 10.1109/TNSRE.2015.2405072
3. M. H. Purnomo, Y. Kristian, E. Setyati, U. Delfana Rosiani and E. I. Setiawan, "Limitless possibilities of pervasive biomedical engineering: Directing the implementation of affective computing on automatic health monitoring system," 2016 8th International Conference on Information Technology and Electrical Engineering (ICITEE), Yogyakarta, 2016, pp. 1-4. doi: 10.1109/ICITEED.2016.7863314
4. S. U. UPase, "Speech recognition based robotic system of wheelchair for disable people," 2016 International Conference on Communication and Electronics Systems (ICCES), Coimbatore, 2016, pp. 1-5.doi: 10.1109/CESYS.2016.7889851

5. M. Bansal and B. Gandhi, "The genre of applications requiring long-term and continuous monitoring of ECG signals," 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), Coimbatore, 2017, pp. 1-6. doi: 10.1109/ICIIECS.2017.8275919.
6. H. E. Gassara et al 2017 IOP Conference Series: Materials Science & Engineering. 254 072008 .
7. Divya Jennifer et al, IOT based Smart Sensing Wheelchair to Assist in Healthcare, International Research Journal of Engineering and Technology(IRJET), Vol6,Issue 6, June 2019.
8. A Study on Smart Wheelchair Systems; INTERNATIONAL JOURNAL OF ENGINEERING TECHNOLOGY AND SCIENCES (IJETS), Vol.4 (1) December 2015.
9. Smart Wheelchair: Integration of multiple Sensors; IOP Conf. Series: Materials Science and Engineering **254** (2017) 072008K

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