Design and Implementation of A Wearable Monitoring System for Alzheimer's Patient and Elders

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***Abstract*—Advancing digital networking and improving technology offers an opportunity for the health sector to play a crucial role. The technology for interactive and remote patient care is now much more available and affordable. A patient with a severe disease like Alzheimer's should be checked for wellbeing. In terms of a critical patient, the major problem is to go to the hospital for the routine checkup. In regards to vital care, the main challenge is regular screening in the hospital. Based on the capabilities of IoT based technology, a frequent medically impaired patient may resolve their difficulties in consulting a doctor in a regular basis. A wearable device that allows people to get their real-time pulse rate, temperature, ECG and orientation is what this project suggested. This project led to the creation of a prototype health monitoring device. Four health sensors are part of this prototype: MAX30100, LM35, MPU6050, AD8232. All these sensors were integrated into one system using Arduino Nano. In real-time, cloud storage is continuously updated. An android application was created, where the database was accessed and the health parameters were graphically represented. This wearable health monitoring device will resolve the need for hospital admission or routine checkup in case of minor health issues. In order to clarify the functionality of the sensors used, a thorough study of the signal to respond to variability in physical and environmental behaviours was carried out.**

Keywords—Alzheimer, Arduino Nano, Health Monitoring Device, Android application

I. Introduction

The Wearable Health Monitoring System is a focal point for both academics and industry due to the fast-growing ageing population and resulting health and difficulties. Government priorities include such a need to minimize or reduce healthcare costs and also to improve service quality. While technology plays a major role in achieving these goals, any approach must use sufficient domain knowledge, Planning, application and validation. Therefore, more real-time health monitoring can be used to detect relapses under circumstances that require early intervention to address these challenges. Therefore, the creation of a Wearable Health Monitoring System capable of remotely monitoring elderly patients was achieved. [1]

In the field of healthcare, cloud-based technology enabling better collaboration has grown. When the wearable equipment is paired with cloud-based technology, it is much more efficient, and it will significantly attract more customers.

Wearing tools include a range of benefits, including economic, organizational and practical benefits contrasted with housekeeping. The following list of the advantages of using Wearable Health Monitoring System in health care:

- Monitors Vulnerable Patients: An exclusive use of wearable technology is that it can be used from a distance to track vulnerable patients. While many people use wearable devices for their health, And people continue to use them to protect the health of their family's elderly members.
- Encourages Proactive Healthcare: Many citizens are responsive when dealing with any potential health risks. When they begin to feel ill, uncomfortable or anything else, they go to see a doctor. They have a health problem and respond by testing it out. The prospect of a more proactive approach to wellness is offered by wearable technology. Wearable devices can be used to take action at an early stage rather than to respond to health issues when they start causing problems.
- Communication with caregivers: In case the patient faces any difficulties, the wearable Device will let the caregiver know that his/her patient is facing problems.

- Communication with physicians: In the situation when patients experience trouble or discomfort, the wearable Device can allow the doctor to track the vital parameters of the body, and can, therefore, enable automated monitoring.

A. *Principle of photoplethysmography (PPG)*

Photoplethysmography (PPG) is a simple optical technique used to detect volumetric changes in blood in the peripheral circulation. The surface calculation process is cost-efficient and non-invasive. The system provides valuable information about our cardiovascular system. This method, which is commonly used for clinical physiological measurements and monitoring, has revived recent technological developments. [2]

PPG makes uses of low-intensity infrared (IR) light. As passing through biological tissues, the muscles, skin pigments absorb light and heat, both the veins and arteries. Because light is absorbed more intensely by blood than surrounding tissues, PPG sensors can identify changes in blood flow as differences in light intensity. The PPG voltage signal is proportional to the amount of blood passing through the vessels. This approach may even detect minor changes in blood volume, but blood quantification cannot be achieved. A PPG signal has several components, including arterial blood volumetric changes associated with a heart attack.

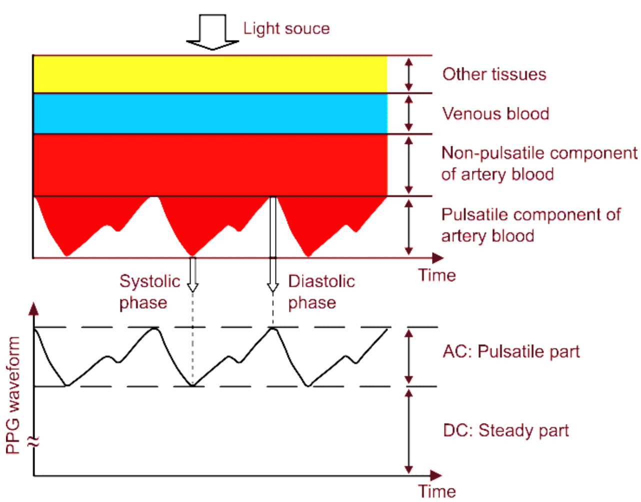

Fig. 1. Variation of light attenuation by tissue [3].

With the help of a bar or a graph, PPG displays the changes in blood supply as a waveform. The waveform has a portion of alternating current (AC) and a component of direct current (DC). In a rhythm of the pulse, the AC elements reflect changes in the blood volume. The DC portion is extracted from the absorbed or transmitted optical signals of the tissue and is calculated by both the tissue composition and the blood volume of the vein and arteries. The DC component shows minor changes with respiration. [2] The AC component's specific frequency relies on the heart rate and is superposed on the DC standard.

B. *Principle of Galvanic Skin Response (GSR)*

The Galvanic Skin Response (GSR), also named Electrodermal Activity (EDA) and Skin Conductance (SC), is the measure of the continuous variations in the electrical characteristics of the skin, i.e., for instance, the conductance, caused by the variation of the human body sweating. [8] The standard hypothesis of GSR analysis is that the resistance of skin differs from the condition of the sweat glands in the body. The Autonomous Nervous System (ANS) regulates the sweating of human bodies. If the autonomous nervous system's sympathetic branch (SNS) becomes extremely aroused, sweat gland activation often increases, growing skin actions and vice versa. Skin activity can thus test the reactions of the human Sympathetic Nervous System. Such a device is directly associated with human emotional actions.
Further research has demonstrated the correlation between GSR and certain mental conditions, such as distress, sleepiness, and engagement. [4]

The GSR signal is easy to capture: usually, it only requires two electrodes on one hand's second and third fingers. The difference of the low-voltage applied current is used as the EDA indicator between the two electrodes. New commercial medical devices like bracelets, watches have lately been developed, and are gradually portable and advanced. This test is, therefore, also can be done in non-laboratory conditions.

II. Hardware and Software Architecture

A. *Hardware Architecture*

The hardware architecture of this project is straightforward with Arduino Nano as a microcontroller along with the other sensors. The block diagram for the execution of the project is seen in the following diagram.

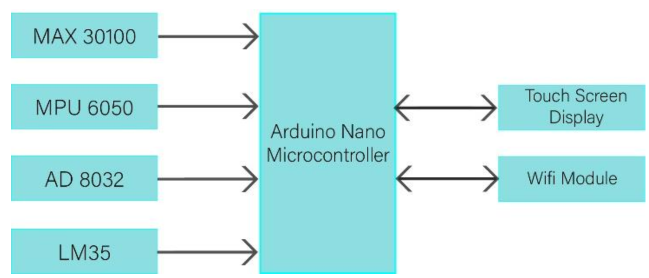

Fig. 2. Block diagram of the system architecture.

To execute the project without a functional error, each part was previously measured individually from each other. Eventually, the individual sensors were merged to work together to accomplish the main objective of the project. Sensor data is transferred through wireless communication to the Arduino Nano. Physiological information about blood pressure pulse rates and the oxygen flow can be given by the MAX30100. In addition to the MPU, data from sensors are obtained and important signals including heartbeat, temperature and more are measured.

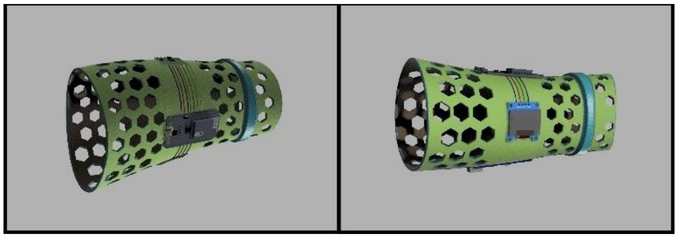

Fig. 3. 3-Dimentional modeling of electrical exposed parts.

The hardware implementation was simulated first in order to keep the measurement more precise for 3-Dimensional printing. A wearable device designed to keep in mind about elderly patients. The Device has a diameter of 181 mm to 252 mm and weight of 917 grams, and the 18650 rechargeable lithium ion battery is 3.7V. The standby time for the watch is seven days.

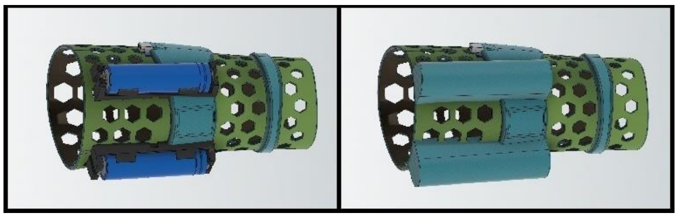

Fig. 4. 3-Dimentional modeling of battery holder with and without cover.

Flexible material for 3D printing was used to keeping in mind that it mainly will be used by the elderly peoples. Furthermore, the size was based on average hand size. Some dynamic style implemented to make in more user friendly by creating hexagonal holes which will facilitate the air and blood circulation standard once sporting this Device. A canopy was used to safeguard the electrical parts that increase the sturdiness of the wearable Device. By the essence of the raw material, the Device is slightly water-resistant.

B. *Software Architecture*

One of the most critical elements of a remote health control program is device convergence. This is the brain that leans to work flexibly according to the individual.

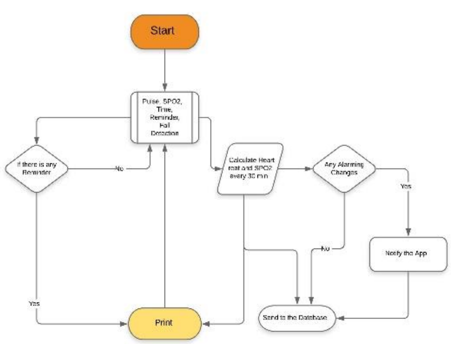

Fig. 5. Flowchart of the working principle of the software role.

The software architecture of the remote health monitoring system is based on the use of microcontroller Nano to use the Android Engineering tool. Arduino Nano IDE, an open-source program that helps to import the code into the development board conveniently, extracts the details. The Raspberry Pi consequently transfers data to the cloud. The cloud service is Google Firebase, a software framework built by Firebase for the development of a web application. The project software was created for the Android Studio, and can access the Google Firebase database directly, but allows the user to encrypt it. It guarantees no unauthorized staff to access the patient's records. The accompanying example illustrates measures taken to build the remote health management system's software architecture. [5]

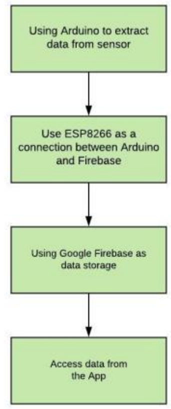

Fig. 6. Flowchart of the user interface.

III. Implementation and Review of the Result

A. *Measuring the heartbeat and SpO2*

Thissection collects important data from the patient. The theory is quite straightforward as the signal starts to drop, save a timestamp; since there are two timestamps, the distinction between them is which we can measure the BPM easily. We will measure the BPM after getting two timestamps. The following is the equation:

$$BPM = \frac{6000}{Currentbeattimestamp - Previousbeattimestamp}$$

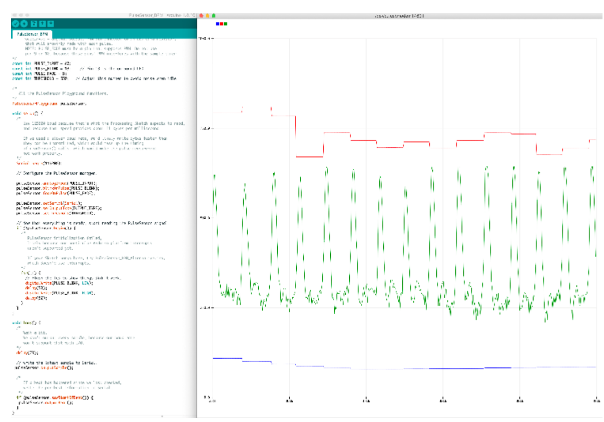

Fig. 7. PPG Signal displayed in Arduino Serial Plotter.

The oxygen concentration (SpO2) can be determined by the measurement of the ratio of absorbed light on the IR LED to the Red LED. Theoretically, the ratio of hemoglobin oxygenated to the overall hemoglobin amount may be measured [6]

OurDevice is a module that tracks the BPM, SpO2, and temperature of the patient continuously. It needs an exact value to ensure that patients can be well treated so that data from 4 people are taken with our Device using different sensors and similarly with a certified device from the government. Therefore, we found that the data was close. The table I indicates the difference.

TABLE I. SHOWING BPM AND SPO2 WITH OUR DEVICE AND CERTIFIED DEVICE

Our Device	**Result**		**Certified Device**	**Result**	
	BPM	*SpO2%*		*BPM*	*SpO2%*
Person (1)	114.32	89	Person (1)	93	95
Person (2)	103.65	91	Person (2)	90	94
Person (3)	88.33	98	Person (3)	82	96
Person (4)	93.11	93	Person (4)	72	97

Fig. 8. Data taken from a commercial device.

B. *Detecting Orientation and Heart Rate*

First and foremost, the wire library was initialized and the sensor was reset via the power control register. Through the setup data, we have chosen a full set for the accelerometer and gyroscope. We had used the default scale +/- 2 for the gyroscope and 250 degrees for the accelerometer. The rest we commented on the section of the code.

Fig. 9. Reading of Gyro Sensor.

Nine connections from the IC breaks by the AD8232 Heart Rate Monitor. We used jumper wires to connect that with the Arduino. After all the connections were done, we snapped the sensor pads on the leads before applying that in the demo patients' body. We got better measurement after placing the pad as near as possible to the heart.

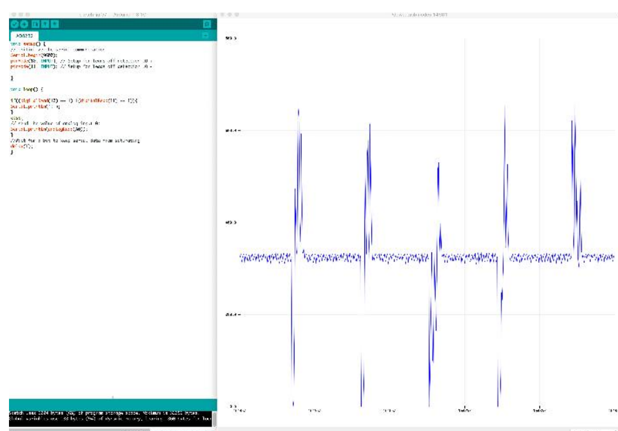

Fig. 10. ECG signal acquired from patient showing random variations.

C. *Measuring Body Temperature*

We use LM35 to detect the body temperature in our proposed project. This gives an exact temperature regardless of the constant relation of the output voltage to the temperature in Celsius. No proper calibration tests are required. The temperature scale is from -55 c to +150 c.

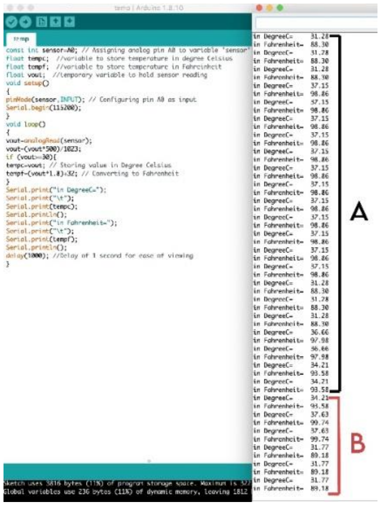

Fig. 11. Reading from body temperature sensing.

D. *Android Application of the Project*

Allthe sensor implementations were integrated into a single operating device after all the individual implementation. The data has been saved for access by an Android App on the Google Firebase Real-Time database.

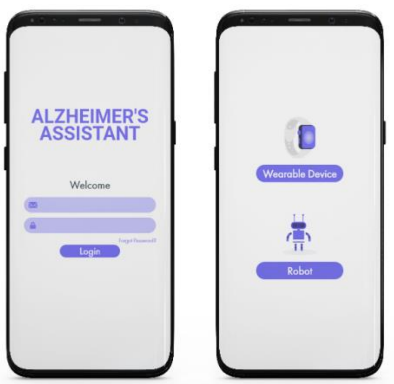

Fig. 12. Android Application titled Alzheimer's Assistant.

TheAndroid framework has been created with Android Studio. This has tools to monitor a patient's health status and enables personal supervision. Yet something in the cloud is likely to leak. To stop this, the code is encrypted for authentication purposes with login credentials. The user can also select the tracking types. The server has a special ID which a patient or caregiver can himself/herself only authorize. The figure above shows the function of this type.TheAndroid phone shows a screen of real-time details of body temperature, the heart rate and the SpO2, as seen in the figure above, once the caregiver monitoring the patient can access the patient's ID.Therefore, by actually tracking trends in the health condition, the caregiver will look after the patient by reviewing the previous data.

Fig. 13. Display of health parameter monitoring page.

IV. Conclusion and Future Plan

Themeasured values were obtained from a typical patient with the sensors during the experiment. However, these parameters vary accordingly and are co-related with each other with variations with their physical activities. Through the use of the app and the use of the database, the caregiver can access these data and take proper steps and give them the necessary care and medication. As this project is based on a microcontroller, the performance will be somewhat constant, and it will be easy to add updates to the code.We have also made a printed circuit unit for complex wiring to minimize the use of jumper cables so that there is a little chance of having loose connections and connection errors. In addition to that, the Device will meet its expectations in the long term and will have a significant impact on society in the future.

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