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Smart Health Monitoring Device

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Abstract - *This paper is based on a project that aims to integrate the monitoring of important health parameters like body temperature, heart rate, and oxygen level in the human body. The project includes the MAX30102 oxygen level and heart-rate sensor, and a temperature sensor. The microcontroller Arduino Lilypad is used to integrate the data collected from the sensors into the monitoring device. This device will allow a person to measure their Mean Arterial Pressure (MAP) in about one minute, oxygen levels up to 100, and the precise body temperature. With the onset of a global pandemic, humanity has realized the need to monitor these parameters in order to ensure an efficient diagnosis of SARS Covid-19 Virus, as well as any underlying disease in the body. The working prototype of this project is aimed to be integrated with a Machine Learning algorithm that enables the monitoring of these parameters; along with the opportunity to analyze real-time data in order to diagnose an underlying condition. The instrumentation in the bio-medical industry already has devices that monitor these parameters individually, but this project aims to amalgamate them into a single device for ease of use and systematic data storage. This paper discusses major aspects of the project like objectives, methodology, circuit diagram, social relevance, and scope for development.*

Key Words: *Health monitoring device, Instrumentation, Data Storage, Body Temperature, Oxygen Saturation*

1. INTRODUCTION

Fever is one of the first reactions of the human body to an infection and is a common symptom of illnesses like influenza and COVID-19. Part of the human brain called the hypothalamus constantly adjusts the body temperature in order to maintain a suitable environment for the body to carry out its functions effectively. A fever is produced when the hypothalamus receives a signal from the immune system directing it to raise body temperature in reaction to the presence of an unwanted foreign particle in the body. This creates a heated, hostile environment that weakens the virus and triggers an immunological response.

A temperature greater than 100°F can indicate that the body is fighting an infection. By regularly monitoring body temperature and analyzing the normal range for an individual, subtly higher temperatures can be detected easily.

The normal resting heart rate in an adult ranges from 60 to 100 beats per minute. A lower resting heart rate usually implies efficient heart functioning and better cardiovascular fitness. A well-trained athlete, for instance, might have a typical resting heart rate of close to 40 beats per minute. A heart rate that is extremely high or low could point to a problem even if everyone's typical range varies. A condition known as tachycardia may be present if the heart rate is continuously over 100 beats per minute. On the other hand, Bradycardia, a disorder that affects non-athletic people, might be indicated by a resting heart rate below 60 beats per minute. Monitoring heart rate helps diagnose any underlying condition in individuals with abnormal readings and helps take preventive measures before it's too late.

Oxygen saturation, also known as SpO_2, is the ratio of the amount of oxygen-carrying haemoglobin in the blood to the amount of haemoglobin that does not carry oxygen. In order for the body to operate properly, it needs a certain level of oxygen to be present in the blood. Very dangerous illnesses like hypoxemia can be caused by extremely low SpO2 values. As a result of this condition, there is a visible effect on the skin, known as cyanosis (spots of blue tint) due to the lack of oxygen in the blood circulating throughout the body. Low oxygen levels in the blood can develop into hypoxia (low oxygen levels in the tissue), which can worsen the condition of organs connected to the tissue. When a person has a condition that lowers blood oxygen levels, such as a heart attack, heart failure, COPD, anaemia, lung cancer, asthma, or pneumonia, monitoring SpO2 levels is essential to determine their heart health as well as overall health.

A health monitoring such as the one proposed in this paper is required in order to track these vital health parameters from time to time. This real-time approach towards monitoring has the potential to eliminate occurrences of emergency and unforeseen casualties among the young and old alike.

2. LITERATURE SURVEY

Table -1: Literature Survey: Key Findings

Author/Topic/Publisher/Year	Key Findings
SHATHIYS, L VERAVIJAYAN Heartbeat and Temperature Sensor Using Arduino (Heart Rate Monitor) & Internet of Things Politenik	The heartbeat sensor was initially designed to measure internal temperature and heartbeat of human body which is highly related to heart stroke and heart attack cases. The most serious form of heat injury is heatstroke and it can occur if the body temperature rises to 104 F or higher.[4]
Mr. Amar Saraswat Sensing Heartbeat and Body Temperature Digitally Using Arduino SCOPES 2016	An embedded system which can measure the heart rate and body temperature and store the data for the doctor to know the condition of the patient can help for this purpose.[5]
Vikram Singh R. Parihar Heartbeat and Temperature Monitoring System for Remote Patients Using Arduino IJAERS 2017	The temperature sensor produces analog output voltage which is proportional to the temperature. The temperature sensor required analog to digital converter (ADC) so that the analog output voltage can be converted to digital form.[6]
Samik Basu, Sinjoy Saha, Soumya Pandit and Soma Barman Smart Health Monitoring System for Temperature, Blood Oxygen Saturation, and Heart Rate Sensing with Embedded Processing and Transmission Using IoT Platform 2020	MAX3010x family sensors are used to measure both blood oxygen saturation and heart rate in comparison to the previously selected sensor which measures only the heart rate.[7]
Real-time pulse oximetry extraction using a lightweight algorithm and a task pipeline scheme John Vourvoulakis, Leonardos Bilalis IEEE 2021	The photoplethysmographic signal (PPG) is used to estimate SpO_2 and HR. It indicates the light absorption of oxygenated and deoxygenated hemoglobin at a certain wavelength. Red and IR wavelengths are often used to extract PPG signals. Subsequently, various algorithms can be applied to the PPG signals in order to obtain SpO_2 and HR.[8]
Design and Implementation of an SPO_2 Based Sensor for Heart Monitoring Using an Android Application Radwa Sameh, M Genedy 2020	The pulse oximeter's measurements are based on the PPG signal acquired. PPG is a non-invasive measurement technique which uses a light source and a light detector to measure the variation in the volume of blood flowing to and from the given region. [9]

3. SOCIAL RELEVANCE

With the onset of new viral diseases and deteriorating human immunity, monitoring of vital health parameters becomes all the more important. Annual health check-ups do not suffice anymore, and day-to-day updates on these parameters are becoming more important than ever before. Integration of this project with Machine Learning will enable regular monitoring of patients' parameters.

The real-time data from this device can be used by medical professionals for easier diagnosis of chronic diseases based on the patient's medical history. Studying these parameters and the response of the body to a change in them helps scientists and researchers understand the connection between these health parameters and complications of infectious diseases like Covid-19 better with time. Integration of the prototype with IoT is aimed at providing alert signals on gadgets via e-mail/messaging notifications.

When fully developed, this device can also be used effectively in hospitals/dispensaries. The Arduino Lilypad Microcontroller can be easily sewn into clothes. Due to its size and portability, the prototype can be easily used by individuals regularly.

4. METHODOLOGY

When the microcontroller is turned on, the circuit begins to read the heart rate, SpO2, and ambient temperature from the LM-35 temperature sensor and the MAX30102 sensor. The IR LED of the pulse sensor glows whenever a pulse is found. The phototransistor detects the flash of the IR LEDs and modifies the resistance. An interrupt of 2 milliseconds is established to count the beats per minute (BPM). For wireless connection, the HC05 Bluetooth module is included.

The gadget attached to it receives the data from the sensors and transmits it to the microcontroller Arduino Lilypad, which stores the information. Additionally, the collected data is transferred to the server where it will be kept and trends will be analysed to help with disease diagnosis or just to keep track of various health markers.

4.1 HC05 Bluetooth Module:

The HC-05 Bluetooth module was created for wireless communication. Both master and slave configurations are compatible with the module. It can operate up to 100 metres distance. However, this is dependent on the geographic, atmospheric, and other environmental factors, as well as the transmitter and receiver calibrations.

The IEEE 802.15.1 defined protocol is used by the HC-05 Bluetooth module to enable users to create wireless Personal Area Networks. For the purpose of transmitting data over the air, it uses radio technology known as frequency-hopping spread spectrum (FSSH). To communicate with other devices, it uses serial communication. USART is used for communication with the microcontroller.

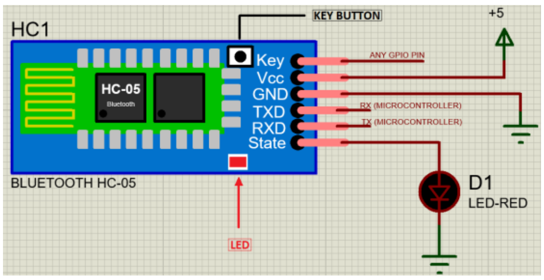

Fig -1: Pin Diagram for HC05 Bluetooth Module

4.2 HC05 Bluetooth Module:

Lilypad is a member of the Arduino family of boards and was created specifically for wearable applications. The Lilypad Arduino microcontroller runs on rechargeable batteries. This makes it possible to connect sensors and actuators effectively for simple incorporation into clothing and materials.

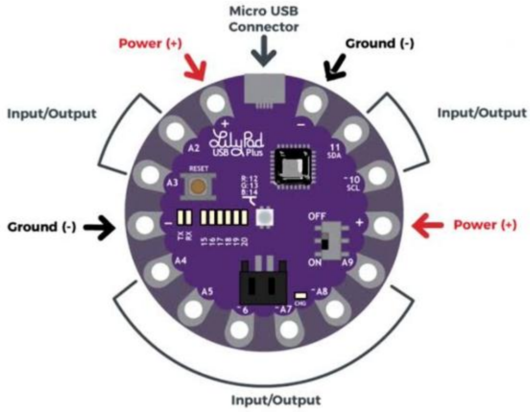

Fig -2: Pin Diagram for Arduino Lilypad Microcontroller

4.3 MAX30102 Sensor:

A heart-rate monitor module and a pulse oximetry sensor are combined in the MAX30102. To facilitate the rejection of ambient light, it has internal LEDs, optical components photodetectors, and low-noise electronics. To simplify the design-in process for wearable devices, the MAX30102 sensor offers a full system solution. It runs on a single 1.8V power source and the inside LEDs are powered by a separate 3.3V power source. A common I2C-compatible interface is used for communication. Software-based module shutdown requires zero standby current, allowing the power rails to run continuously.

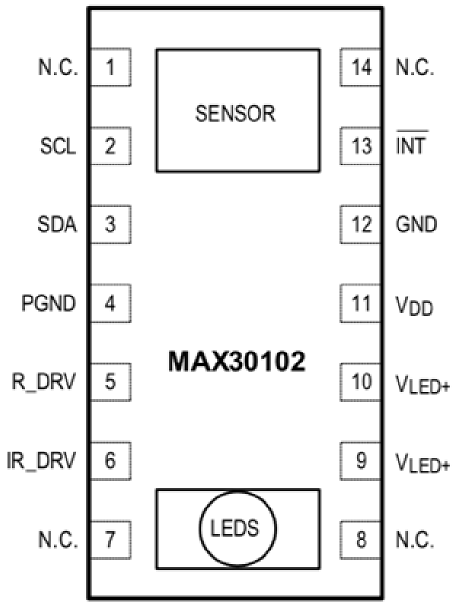

Fig -3: Pin Diagram of MAX30102 Sensor

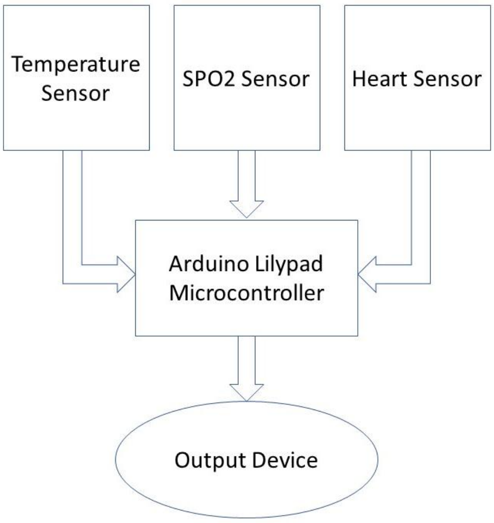

Fig -4: Block Diagram of the Prototype

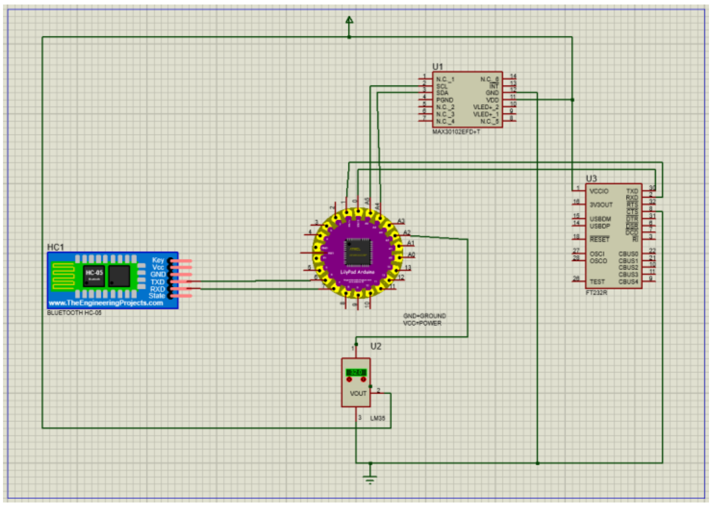

Fig -5: Project Circuit Diagram

5. RESULTS AND CONCLUSIONS

The following results were obtained by powering the prototype. The parameter readings are in the order of Heart Rate, Oxygen Level, and Body Temperature. The following are readings obtained on the serial monitor in Arduino IDE. When the prototype is integrated with LCD output, results can be obtained on the same.

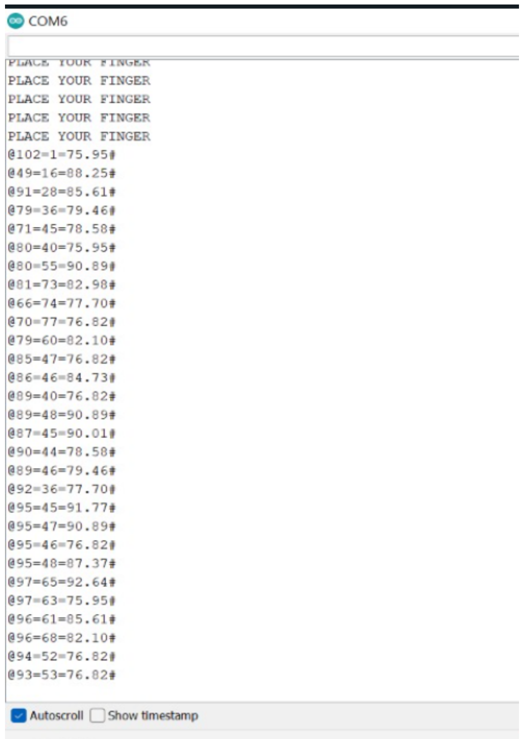

Fig -6: Serial Monitor Output (Heart-rate, Oxygen Level and Temperature readings)

When developed into a device that can be sewed into an individual's clothes or developed into a wearable watch, the device outputs more accurate values that can be monitored from time to time due to its close proximity with the individual's body. Integration of the project with Machine Learning Algorithm opens up a wide range of applications for the prototype, for both professional and personal use.

The objectives of the project are thus achieved, with enormous scope for development of the project into a real-time working model that can be used in the medical industry to ease the monitoring of these vital parameters by medical professionals.

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