COMMUNITY HEALTH MONITORING SYSTEMS BY USING SOLAR ENERGY

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ABSTRACT:

The development of matured individuals or physically disabled individuals and the individuals enduring from a few genuine illnesses are ordinarily kept Many individuals endure persistent health conditions that limit their ability to stay active or participate in everyday activities outside their homes. This often leaves them feeling helpless and dependent, restricting their social interactions and preventing them from handling even minor tasks. This paper presents the design and development of an Arduino-based microcontroller system integrated with an embedded system powered by solar energy. The proposed solution is designed for monitoring vital health parameters such as blood pressure, heart rate, body temperature, body weight, and height. Additionally, it includes a body balance and flexing system along with ECG signal monitoring to provide comprehensive health tracking. Is designed to function without a mobile connection using solar energy as a power source i.e, Reflectance Method. The system integrates a weighing unit (5–200 kg), height-measuring unit (0.02–2 m), temperature-sensing unit, body fat measurement unit, SpO2 sensor, and heart rate sensor, all controlled by an Arduino Mega microcontroller. The device uses sensors such as an ultrasonic sensor for height, the MLX90614 EFS for temperature, and the MAX30102 for SpO2 and pulse rate, with data displayed on an LCD. Validation against standard methods shows high correlations for weight (0.99) and height (0.97), affirming its accuracy and potential for reliable medical use.

Keywords - Button cell battery, load cell amplifier, ultrasonic sensor, body mass index (BMI) module, and Arduino Uno.

1. INTRODUCTION:

This study emphasizes the creation of a photovoltaic (PV)-powered automated system designed to measure Body Mass Index (BMI), body temperature, body fat percentage, SpO2, and pulse rate. The device incorporates various sensors, including load cells for weight, ultrasonic sensors for height, infrared sensors for temperature, and optical sensors for SpO2 and pulse rate, all controlled by an Arduino microcontroller [1]. Utilizing solar energy, the system ensures sustainability while delivering accurate health metrics on an LCD display. Calibration and validation against standard medical equipment confirm its accuracy and cost-efficiency, making it ideal for portable and dependable health monitoring across diverse environments.

Any abnormal fluctuations in these parameters are detected instantly, prompting immediate attention from nearby family members or healthcare providers. The increasing prevalence of cardiovascular diseases (CVDs) and related health concerns has emerged as a significant global issue, requiring urgent intervention by healthcare professionals. Non-communicable diseases (NCDs), including obesity and type II diabetes[2], have now surpassed communicable diseases as primary causes of premature deaths worldwide. Overweight and obesity, characterized by a Body Mass Index (BMI) of 25 or above, are major contributors to these concerns, with the World Health Organization (WHO) reporting millions of fatalities annually due to these conditions.

BMI remains a crucial indicator for evaluating body composition and identifying potential health risks. Alongside BMI, other vital signs such as body temperature, body fat percentage, SpO2, and pulse rate provide meaningful insights into an individual's overall well-being. Imbalances in these measurements are associated with conditions such as ischemic heart disease, hypertension, and stroke, underscoring the need for precise and accessible health monitoring systems.

Obesity's impact extends beyond physical health, influencing lung function, cardiovascular efficiency, and body temperature regulation. These physiological effects heighten the risk of chronic illnesses, further intensifying the global burden of CVDs. Additionally, rising obesity rates among children and adolescents pose a growing concern, increasing the likelihood of long-term health complications and continuing the obesity cycle into adulthood [6]..

Incorporating renewable energy, particularly solar power, into health monitoring systems has become a crucial step in enhancing their sustainability and accessibility. Solar cells, which convert sunlight into electrical energy, provide a reliable and eco-friendly power source, especially in remote or underdeveloped areas where conventional electricity may be limited [7]. The integration of photovoltaic (PV) systems in automated BMI measurement devices enables them to operate independently of traditional power grids, ensuring uninterrupted functionality in resource-constrained environments.

Relying on solar energy not only fosters environmental sustainability but also minimizes operational expenses, making the devices more viable for use in off-grid locations. Solar-powered systems facilitate continuous tracking of key health metrics, including body temperature, SpO2, and pulse rate, empowering healthcare providers and individuals to manage obesity-related risks more effectively [5]. The combination of solar energy with advanced health monitoring technologies enhances the reliability of these systems while contributing to global efforts toward sustainable development.

To confront these challenges, cutting-edge technologies are being introduced to improve the precision and accessibility of health monitoring tools. Automated BMI measurement systems powered by photovoltaic (PV) systems provide sustainable solutions by incorporating additional metrics such as body temperature, SpO2, and pulse rate. These advancements aim to support healthcare professionals and individuals in recognizing and managing obesity-related health risks effectively, fostering improved health outcomes worldwide [4].

2. DESIGN AND METHODOLOGY

2.1Methodology:
The system comprises an Arduino microcontroller, various sensors, a power supply, buzzer, keypad, ECG signal sensor, and a Liquid Crystal Display (LCD). The system is designed to measure and display health parameters directly without the need for mobile communication. The device integrates sensors to measure body temperature, body weight, height, SpO2, pulse rate, and ECG signals [12]. These sensors are interfaced with the Arduino microcontroller, The system processes the collected data and presents the results on an LCD screen for instant viewing. If abnormal readings or emergency situations are detected, a buzzer is activated to alert nearby individuals or caregivers. Each patient is equipped with this device to continuously monitor and display their health status. Any deviation from normal values is instantly detected, and the updated data is shown directly on the LCD screen for immediate attention. This sensor-based direct measurement system eliminates the need for mobile, GSM networks, or Bluetooth communication, ensuring reliable monitoring without dependence on external communication services.

Proposed Method Block Diagram:

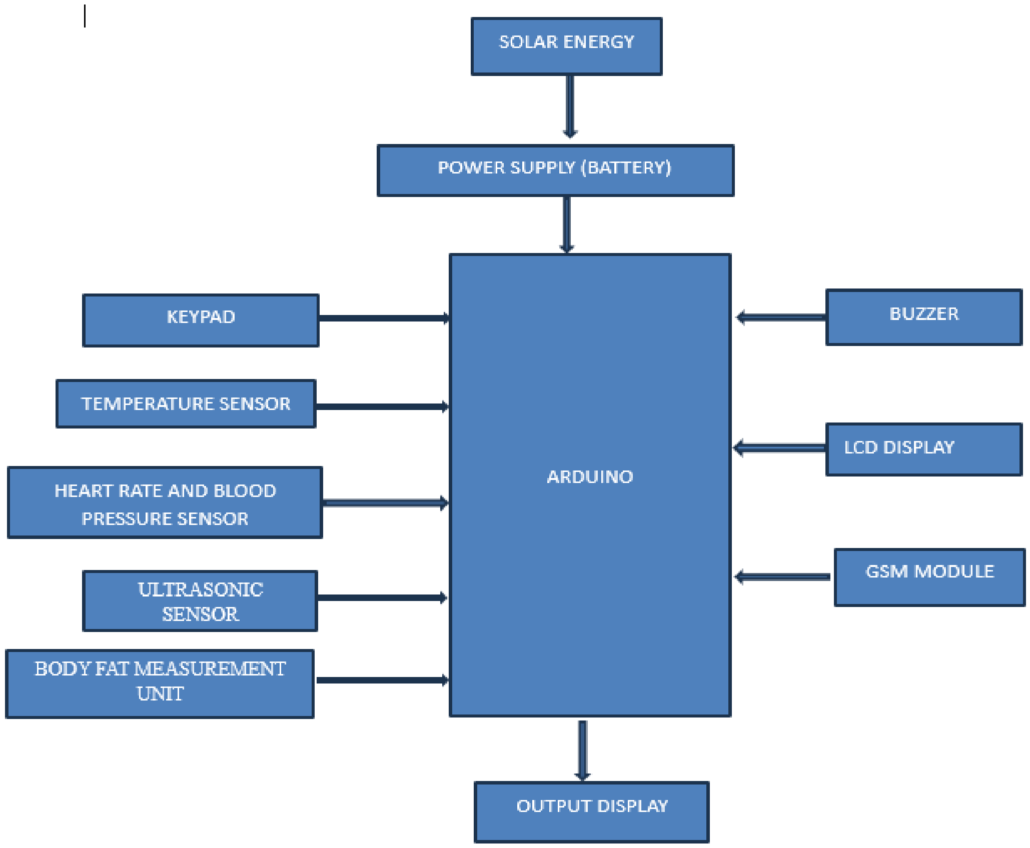

Figure 1: Complete proposed method Block diagram

1. TOOLS AND TECHNOLOGIES:

Tools used for this paper are listed below; 1. Arduino-Uno, 2. LM35 temperature sensor, 3. Pulse sensor, 4. Keypad 4x3, 5. Buzzer, 6. LCD display 16x2, 7. Bluetooth module RS232HC-05/06, 8. GSM (global system for mobile) module, 9. Mobile, 10. LED, 11. Oscilloscope.

Technologies The technologies that we used is embedded system technology interfacing Arduino-Uno with GSM, Bluetooth module and pulse sensor and other different sensors with specific function to get all the patient status (heart rate, body temperature, blood pressure, his sleeping position) and to monitor it, in addition to the technologies and tools listed above, the software's we use are Arduino-Uno and Proteus and hardware installation It shows in Fig 5 & 10 and 11.

example 1: BMI-for-age

Name: Sam
Age: 9 years
Sex: boy
Height: 105.4 cm
Weight: 16.9 kg

Calculate BMI metrics

By-Hand Calculation: (16.9 kg / 105.4 cm / 105.4 cm) x 10,000 = 15.2
BMI: 15.2
BMI-for-age Percentile: 28th

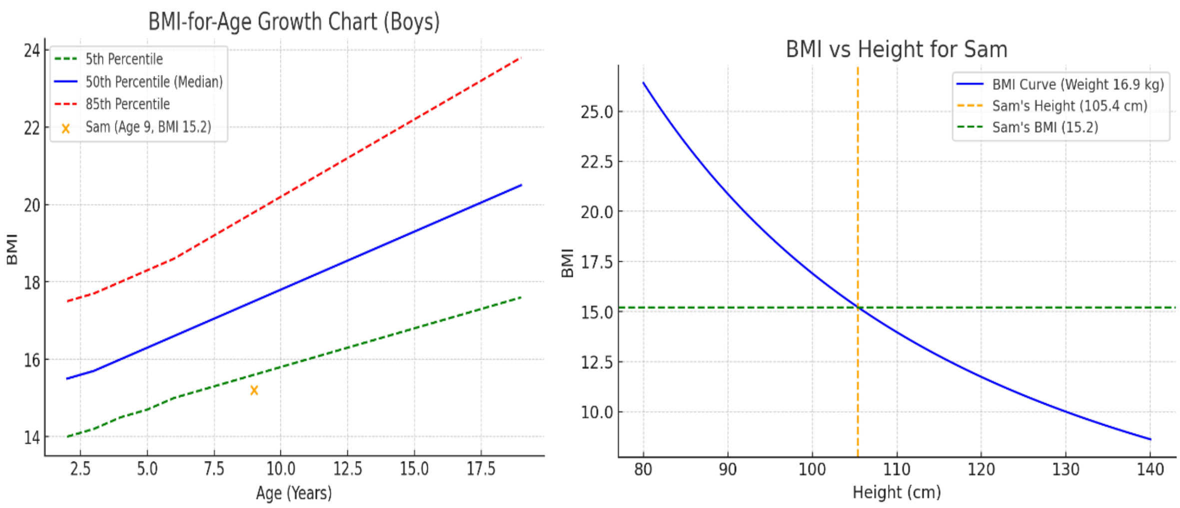

Figure 2: BMI Comparison with Age and Height

2. SOLAR PANEL CONFIGURATION:

BATTERY; The AJC Interstate 12V and 1.3Ah Sealed Lead Acid (SLA) Battery is a maintenance-free, Absorbent Glass Mat (AGM) technology battery.

Electrical Specifications;

- Nominal Voltage: 12 Volts
- Capacity: 1.3 Ampere-hours (Ah)
- Chemistry: Sealed Lead Acid (AGM)

Table 1: showing the battery's voltage and remaining capacity over time

Time (Hours)	Voltage (V)	Remaining Capacity (Ah)
0.00	12.00	1.30
0.05	11.77	1.27
0.10	11.53	1.25
0.15	11.30	1.22
0.20	11.07	1.20
0.25	10.83	1.17
0.30	10.60	1.15
0.35	10.37	1.12
0.40	10.14	1.10
0.45	9.90	1.07

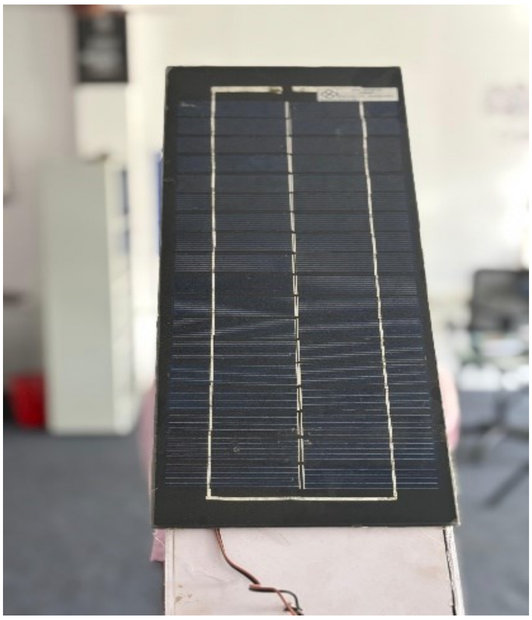

Figure 3: Solar cell

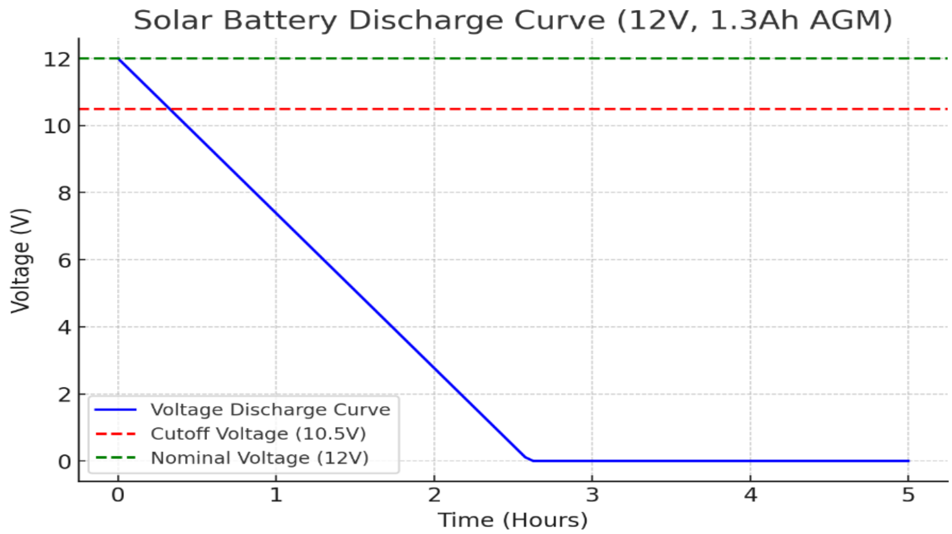

Figure 4: Solar battery performance

3. SOFTWARE DEVELOPMENT AND DISCUSSSION:

The software design involves developing, writing, and debugging the control program using the Arduino C language, which generates an optimized and compact hex code for the Arduino microcontroller. Upon powering the system, the microcontroller enters a RESET state to initiate the system's configurations. The Arduino first initializes its ports for communication with various sensors, the LCD display, and the buzzer. The LCD is then initialized to display a welcome message, indicating system readiness[13]. The system continuously scans multiple sensors to monitor key biomedical parameters, including blood pressure, heart rate, body temperature, body weight, and height. These values are processed through the Arduino's ADC (Analog-to-Digital Converter) and displayed directly on the LCD screen it shows in Fig 10.

The system compares the monitored readings with pre-defined threshold values to determine whether the values are within a safe range. If any parameter deviates from normal limits, a warning message appears on the LCD screen, and a buzzer is activated to alert caregivers or nearby individuals. To manage emergency alerts efficiently, a DISABLE button is integrated. If pressed within a designated time frame, the alert is turned off, and the system resumes monitoring. If no response occurs within the allotted time, the buzzer continues to sound until assistance arrives.

Additionally, a flex sensor (FS-L-0055) is incorporated to detect intentional patient movements. This sensor allows patients to request assistance or indicate needs such as water through specific hand gestures. Upon detecting such movements, the system displays a corresponding message on the LCD and activates the buzzer to alert caregivers. The system follows a continuous monitoring loop to ensure real-time health data is consistently updated on the LCD display. Error detection mechanisms are implemented to manage potential issues such as sensor malfunctions or power interruptions. In case of sensor failure, an error message is displayed, while power recovery triggers the system to automatically restart the initialization sequence [10].

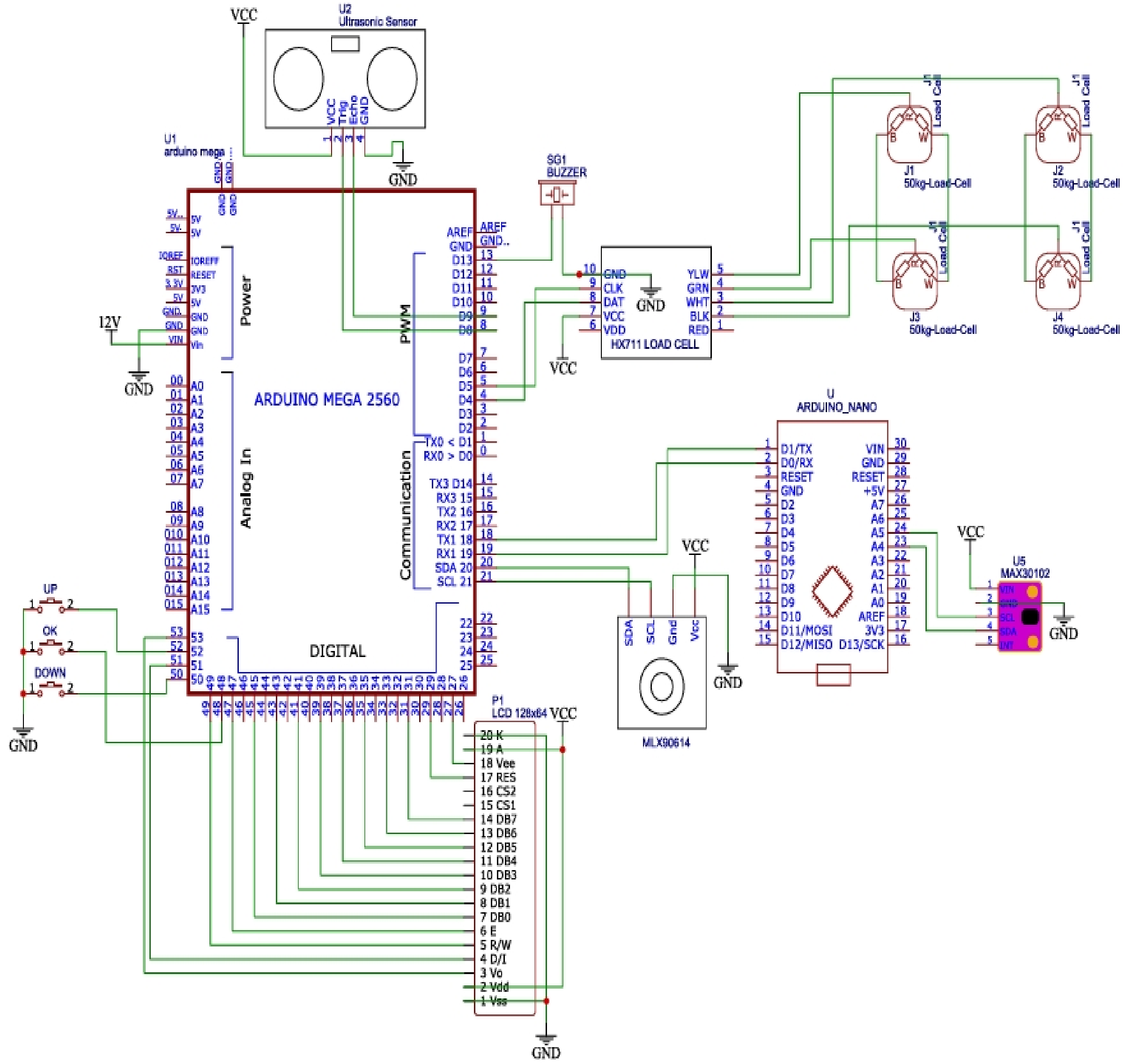

Figure 5: The overall software design of the system.

This streamlined design ensures accurate, reliable, and direct measurement of key health parameters without dependence on Bluetooth or mobile connectivity, improving practicality for healthcare applications.

4. SYSTEM MONITORING - "STARTS":

On software design system, when system runs or when set button is pressed it pups up well come to GSM based heartbeat, blood pressure and body temperature monitoring system and after some sating of time period it starts to receive mobile phone number of health care and doctors from the keypad and displays the phone number on LCD one after the other. The following Fig. 5 and 6 shows the respective programming execution on the LCD. When the user presses the set button the system starts saying welcome to GSM based heartbeat, blood pressure and body temperature monitoring system and after some time delay it goes to receive the user's phone number or the doctors and health care phone number respectively. Finally commands you to press the reset button to continuous for the next task or monitoring system.

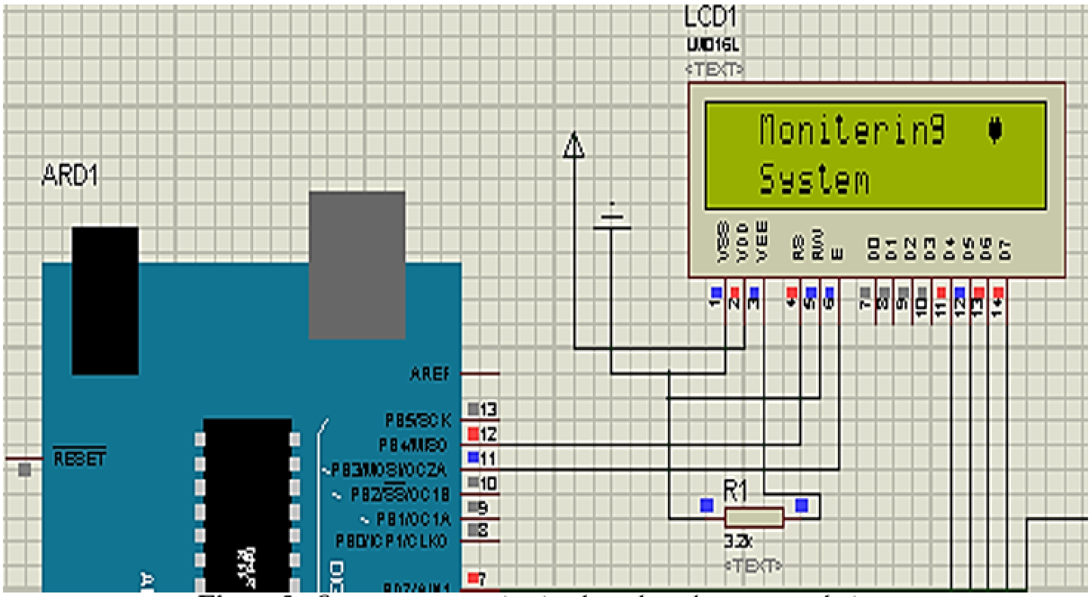

Figure 6: System starts monitoring based on the command given.

5. REFLECTANCE METHOD:

In the reflective method, both the LED and the photo-detector are positioned on the same side, placed next to each other. As shown in Figure 7, a fixed amount of light is reflected back to the sensor when a finger is present. With each heartbeat, the blood volume in the finger increases, causing a greater amount of light to reflect back to the sensor. If we observe the waveform of the reflected light signal, distinct peaks appear with each heartbeat. Between these peaks, there is a consistent low-value reading, which can be considered as the baseline reflection. The difference between this constant reflection value and the peak value represents the reflection change caused by blood flow during a heartbeat. In both scenarios, the peaks and troughs in the reflected light signal align with each heartbeat, and the time interval between two consecutive peaks can be used to determine the person's heart rate. Typically, a heartbeat sensor module comprises a single transmitter LED (commonly infrared) and one photo-detector.

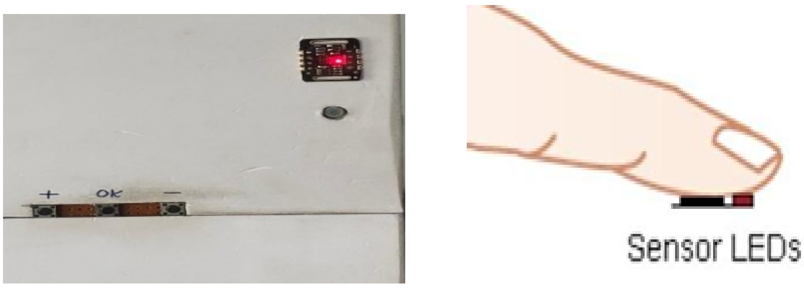

Figure 7: Reflective Method

6. SYSTEM RECONFIGURATION AND PROPOSED METHOD:

Arduino is an open-source electronics platform designed for developing various projects. It comprises a physical programmable circuit board (commonly referred to as a microcontroller) and an Integrated Development Environment (IDE) that runs on a computer for writing and uploading code to the board.Arduino has gained significant popularity, especially among beginners in electronics, due to its user-friendly design. Unlike traditional programmable circuit boards, Arduino does not require an additional hardware programmer to upload code. Instead, it allows direct programming through a USB cable, simplifying the process. The Arduino IDE utilizes a simplified version of C++, making it easier to learn programming concepts. Moreover, Arduino's standardized design makes microcontroller functions more accessible. The Arduino Uno, a popular model, is built around the ATmega8 microcontroller. It includes 14 digital input/output pins (6 of which support PWM output), 6 analog inputs, a 16 MHz ceramic resonator, a USB port, a power jack, an ICSP header, and a reset button. The board is equipped with all the essential components to support the microcontroller, requiring only a USB cable, AC-to-DC adapter, or battery for power. Unlike earlier Arduino models that relied on the FTDI USB-to-serial driver chip, the Uno employs the Atmega16U2 (or Atmega8U2 for version R2) programmed as a USB-to-serial converter. The second revision of the Uno board features a resistor that pulls the 8U2 HWB line to ground, simplifying the process of entering DFU mode.

Table 1: LCD Data

Parameters for Arduino UNO	Description
Microcontroller	ATmega2560
Operating voltage	5V
Input voltage	7-12V
Input voltage-limit	6-20V
Digital I/O	54
Analog Input pins	16
DC Current per I/O pin	40mA
DC Current for 3.3V Pin	50mA
Flash Memory	256KB 0F 8KB USED BY BOOTLOADER
SRAM	8KB
EEPROM	4KB
Clock Speed	16MHz
Length	68.6mm
Width	53.4mm
weight	25g
USB	Type-B
Communication Interface	UART, I2C, SPI

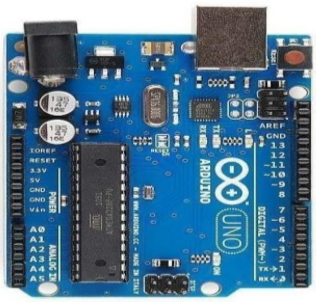

Figure 8: LCD Board

The monitoring system starts to measure each parameter with respect to each sensor to measure the required parameter and display on LCD and the virtual terminal shows the SMS sent in place of GSM. The Fig 8 below shows message displayed on LCD when Reseat button is pressed. After five second it displays the result on LCD and shows in Table 1 and Fig 8.

Principle The proposed system works on principle of fully-automated Heartbeat, blood pressure and body temperature checking framework to degree and show systolic and diastolic weights and beat rate and temperature and a patient need and feeling is read by flex sensor with that of position detector of MEM sensor to check normal position of a patient in the hospital and home care time then send the result to the healthcare or caregiver by SMS on GSM communication protocol [13]. When the gadget is begun the chip initializes the memory, I/O pins, LCD and GSM module and nourish SMS arrange into memory. "Blood Weight, Heart Rate and Body Temperature Checking System" is shown on the LCD to illuminate the client that the gadget is prepared. When the Set button of the monitoring system is pressed the system asks the user to enter phone number of the doctor and health care, and at that point show the result on nearby show connected to the module. The result is at that point communicated to the microcontroller by means of serial communication. The microcontroller appears same result on the LCD (crucial appear) and at the same time transmits same to GSM modem which at that point Visible to display board (healthcare and caregiver contact numbers) for remote monitoring of the patience health condition [17].

7. Temperature Reading:

Temperature is measured based LM35 on Proteus by using it we can vary the temperature of the body like a potentiometer in voltage format for the experiment purpose on software and also the given data below shows sample software result of a temperature sensor. The Fig. 9 given below shows the temperature result on LCD and virtual terminal.

The Community Health Monitoring System using fingerprint identification and solar energy is designed to enhance healthcare accessibility in rural and underserved areas. This system integrates a fingerprint scanner for secure and unique identification of individuals, a display module to show critical health data like temperature, blood pressure, and oxygen levels, and a solar power unit to ensure uninterrupted operation in remote or off-grid areas. The biometric identification feature ensures accurate user identification, while the data display interface presents real-time health parameters without requiring a smartphone or internet connectivity. Solar energy utilization ensures reliability in areas with limited access to electrical grids, and the system's low power design optimizes energy efficiency.

The system functions by identifying users through the fingerprint scanner, which retrieves records from a pre-stored database. Integrated sensors then collect vital health data, which is processed by a microcontroller and displayed on the screen for immediate visibility. The solar power supply uses a photovoltaic cell to charge a battery, ensuring continuous operation. This system is particularly suited for rural healthcare centers, community health camps, and emergency response systems, where reliable health monitoring is crucial.

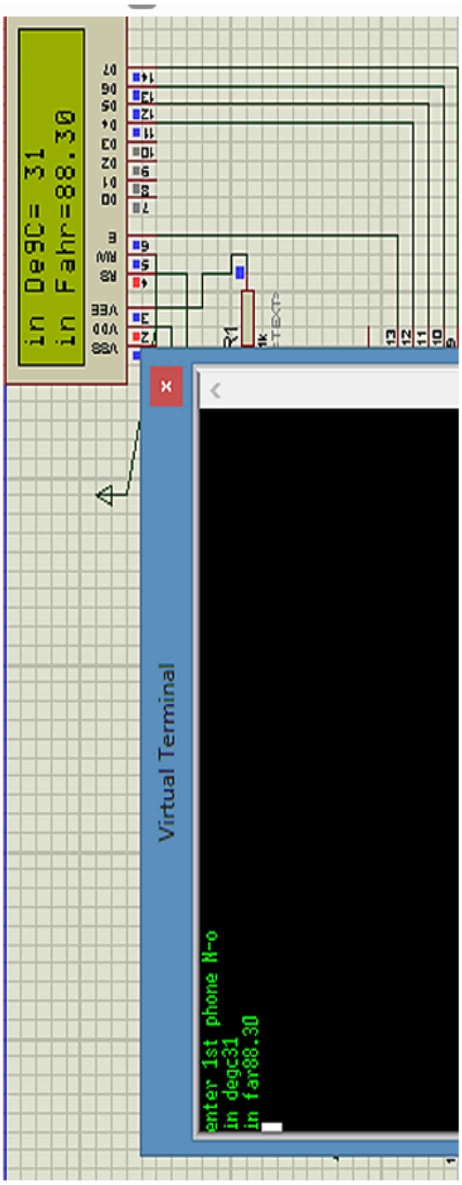

Figure 9: Temperature result.

Figure 10: Health Monitoring system.

The proposed solution offers multiple advantages such as eco-friendliness through solar power, enhanced accessibility by eliminating mobile phone dependence, and cost-effectiveness, making it ideal for large-scale implementation. Future enhancements could include integration with cloud-based systems for data storage, voice guidance for visually impaired users, and additional biometric features for improved security. This system presents a robust and sustainable solution for improving community healthcare monitoring, especially in resource-limited regions.

8. TESTING CONDITION and HARDWARE RESULTS:

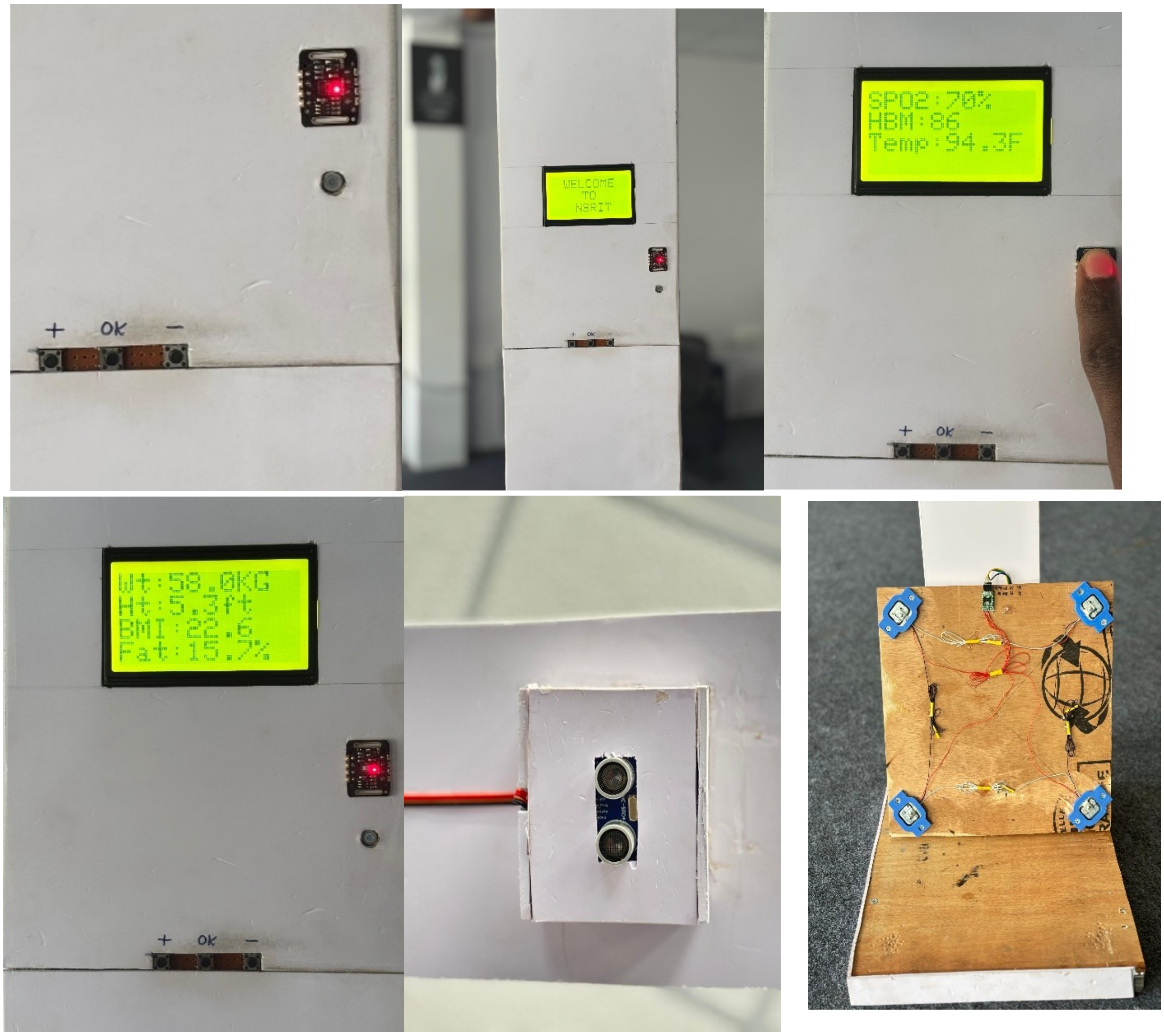

Figure 11: Please Press Reset Button command on LCD and virtual terminal

Table 2: Blood pressure classification for adults

Category	Systolic(mmHg)	Diastolic(mmHg)
Hypotension	< 90	or <60
Normal	90-119	and 60-79
Prehypertension	120-139	or 80-89
Stage 1 Hypertension	140-159	or 90-99
Stage 2 Hypertension	≥ 160	or ≥ 100

Table 3: Heart Beat rate in different age group

Heart rate range	
Age group	**Heart beat range**
Below 1 year	110 to 160 bpm
1 to 2 years	100 to 150 bpm
2 to 5 years	90 to 140 bpm
5 to 12 years	80 to 120 bpm
Above 12 years	60 to 100 bpm

Table 4: Characteristics of Arduino

Serial NO	**Pin**	**Character**
1	Microcontroller	ATmega328
2	Operating Voltage	5V
3	Input Voltage (recommended)	7-12V
4	Input Voltage (limits)	6-20V
5	Digital I/OPins	14 (of which 6 provide PWM output)
6	Analogy Input Pins	6
7	DC Current per I/O Pin	40 mA
9	DC Current for 3.3V Pin	50 mA
10	Flash Memory	32 KB (ATmega328) of which 0.5 KB used by boot loader
11	Width	53.4 mm
12	Length	68.6 mm
13	Clock Speed	16 MHz
14	EEPROM	1 KB (ATmega328)
15	SRAM	2 KB (ATmega328)

9. Working Models:

Figure 8- *Student working analysis*

CONCLUSION:

Blood Pressure, Heart Beat and Body Temperature Measurement by Using GSM and Low-Cost Microcontroller with Health Care Announcement are implemented in this paper. The system allows health personnel to monitor a patient's blood pressure, heart rate and body temperature from a farther area without requiring the doctor to be physically show to require the estimations. The framework is physically made and its execution has been tried. The framework works effectively. Subsequently, this proposed system can be practically used for remote monitoring of the patient blood pressure, heart rate and body temperature. The developed system can be used reliably by people suffering from variety of ailments. It is believed that, the different group of people such as aged, illiterate and Children greatly be benefited from this device. The current execution can be assist made strides. Future changes to the framework may incorporate; a genuine time clock so that the date and time of recording can be sent alongside the information, a web GSM-based web information-based framework, portable application-based ECG signal and database system, oxygen sugar level and glucose monitoring with blood pressure and heart beat with self-assisting system and human language-based alarm to alert the patient when an abnormality is found.

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