Remote Health Care Monitoring System Based on Arduino Nano33 IOt and Raspberry Pi

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INTRODUCTION:

- **IoT Transformation in Healthcare:** Revolutionizing healthcare with continuous monitoring and proactive care.
- **Project Overview:** Integration of Arduino Nano 33 IoT and Raspberry Pi for comprehensive health monitoring.
- **Key Features:** Real-time monitoring, user-friendly interface, and empowerment for patients.
- **Challenges and Solutions:** Data accuracy, secure transmission, and intuitive UI design addressed.
- **Potential Impact:** Early detection, large-scale health studies, and improved healthcare efficiency.
- **Conclusion:** IoT integration for efficient, effective, and patient-friendly health monitoring.

ARDUINO NANO 33 IOT :

The Arduino Nano 33 IoT is a compact and versatile microcontroller board that combines the ease of use of Arduino with integrated IoT (Internet of Things) capabilities. It is designed for makers, developers, and hobbyists to create connected devices and smart applications easily.

Key Features:

- Microcontroller: SAMD21 Cortex-M0+ 32-bit low power ARM MCU
- It is designed for low-power, high-performance applications

Connectivity:

- WiFi and Bluetooth via u-blox NINA-W102 module
- Secure communication with ECC608 crypto chip

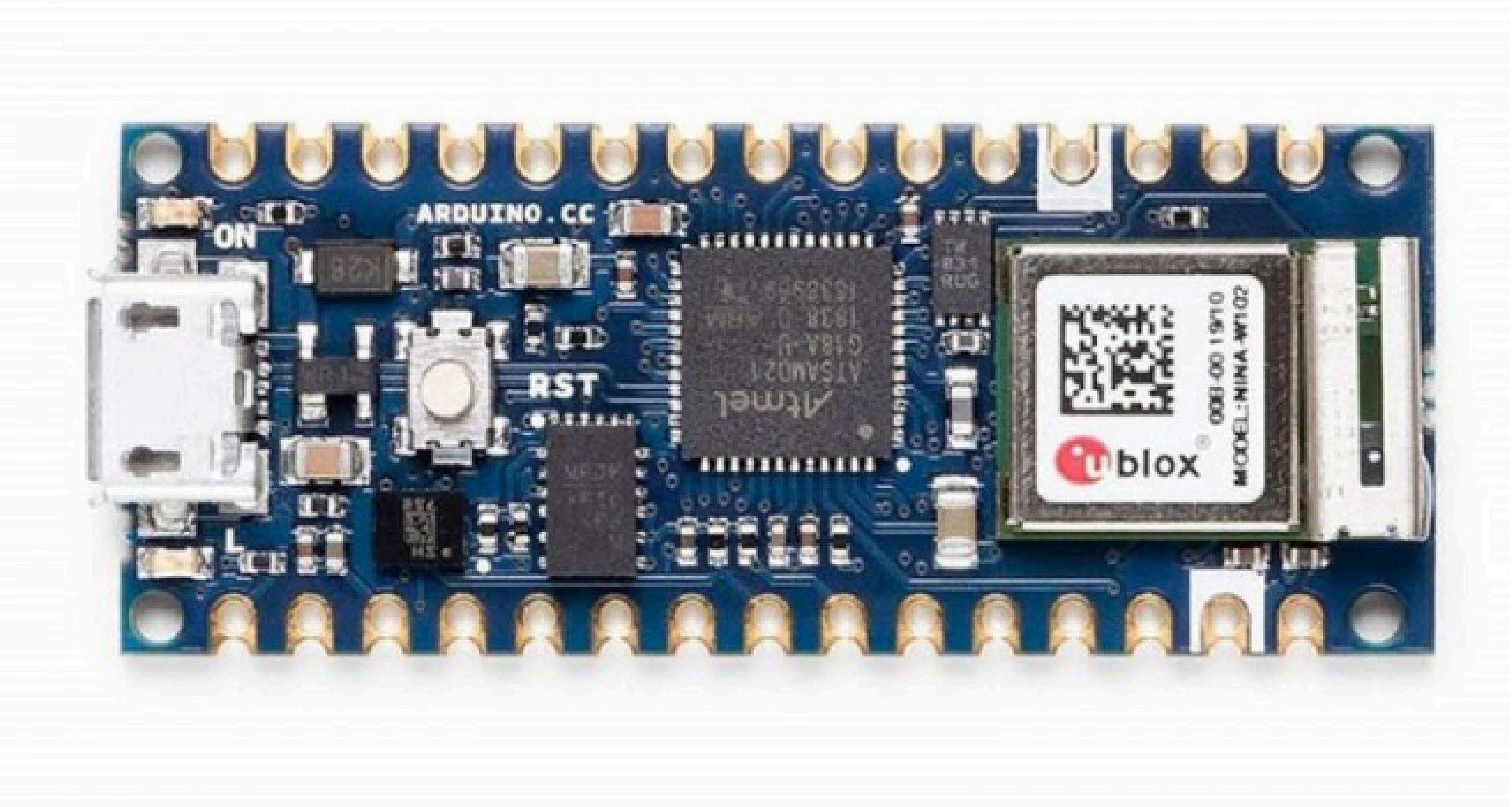
Power: Operates at 3.3V with a recommended input voltage of 7-12V

Memory:

- 32 KB SRAM
- 256 KB flash memory

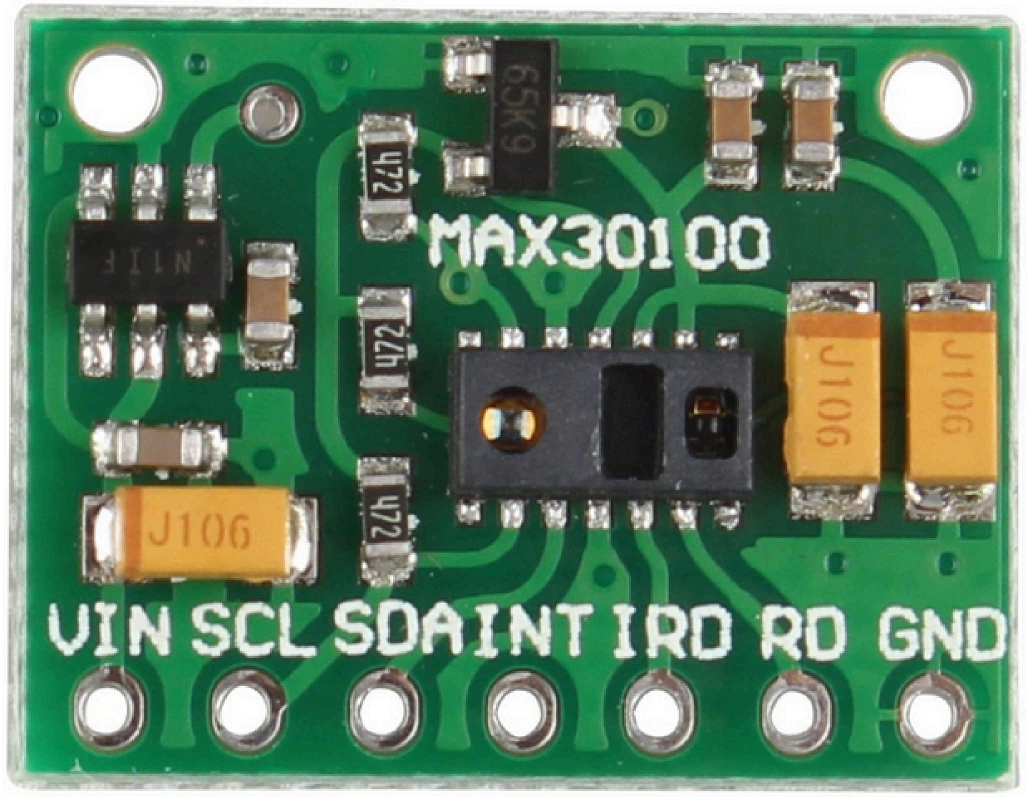
Interface:

- USB Type-C for programming and power
- 14 digital I/O pins (12 with PWM)
- 8 analog input pins



MAX30100 Pulse-Oximeter-Heart-Rate- Sensor:

The MAX30100 sensor module is an all-in-one solution specifically engineered for precise and reliable measurement of two critical physiological parameters: blood oxygen saturation (SpO2) and heart rate. Its integrated design incorporates advanced components and functionalities tailored for accuracy and efficiency in monitoring these vital signs.



- **Dual LEDs**: Includes red and infrared LEDs for light emission.
- **Photodetector**: Detects light intensity variations through the skin.
- **Optimized Optics**: Directs light onto the photodetector for precise readings.
- **Analog Signal Processing**: Low-noise circuits amplify and filter the received signals.
- **Light Absorption**: Measures light absorption by blood to calculate SpO2.
- **Pulsatile Blood Flow**: Analyzes changes in blood volume for heart rate calculation.

MLX90614 Temperature Sensor:

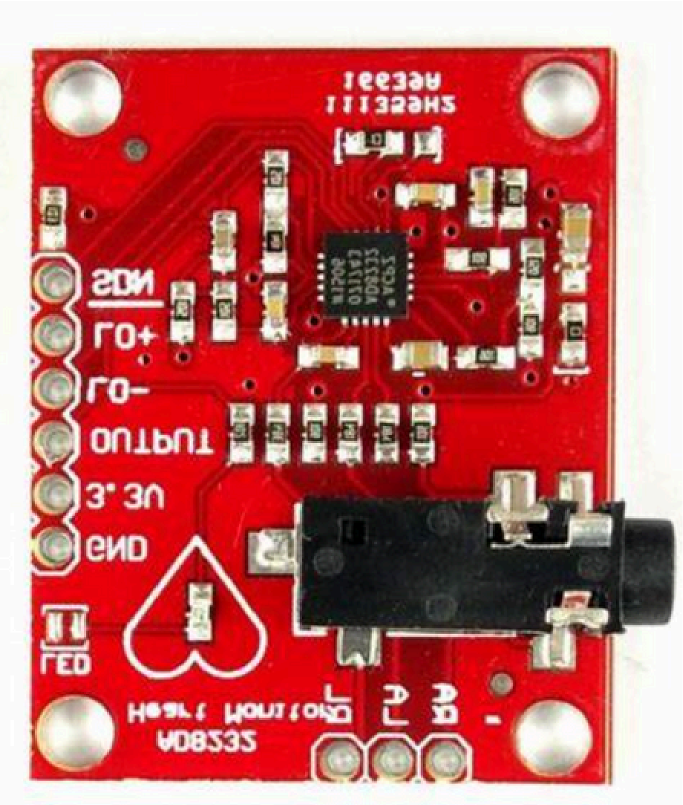
The MLX90614 is a non-contact infrared temperature sensor capable of accurately measuring object temperatures without physical contact.

- **Non-Contact Measurement**: Measures temperature without touching the object, ensuring non-invasive readings.
- **Infrared Technology**: Utilizes infrared radiation emitted by the object to determine its temperature.
- **Wide Temperature Range**: Capable of measuring temperatures from -70°C to +380°C (-94°F to +716°F).
- **High Accuracy**: Provides accurate temperature readings with a resolution of 0.02°C.

- **Infrared Sensing**: Detects and measures the infrared radiation emitted by the target object.
- **Emissivity Compensation**: Accounts for differences in emissivity of different materials for accurate readings.
- **Ambient Temperature Compensation**: Automatically compensates for changes in ambient temperature to maintain accuracy.

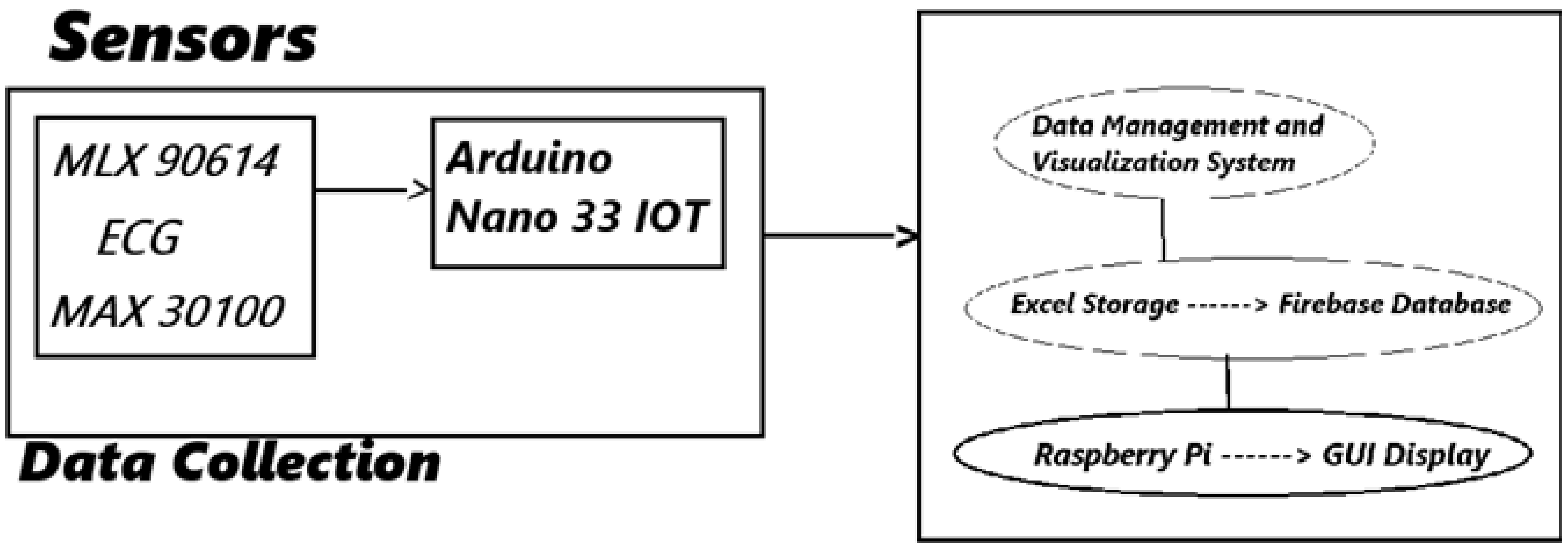
AD8232 ECG Sensor:

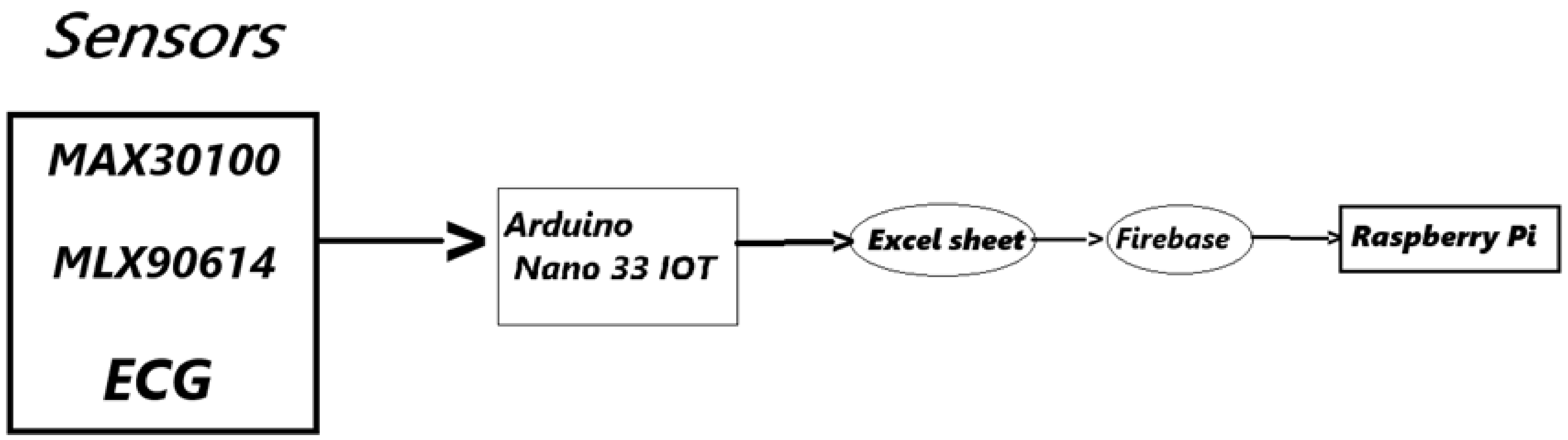
The AD8232 is a specialized sensor designed for measuring Electrocardiogram (ECG) signals, providing insights into heart activity and health.



- **ECG Monitoring**: Capable of acquiring and amplifying ECG signals for monitoring heart activity.
- **Low Noise Amplification**: Uses low noise amplifiers to ensure clear and accurate signal acquisition.
- **Single Supply Operation**: Operates on a single supply voltage, simplifying circuit design.
- **Lead-Off Detection**: Detects and alerts for electrode connection issues or signal loss.
- **Electrode Placement**: Requires electrodes placed strategically on the body to capture ECG signals.
- **Amplification**: Amplifies weak ECG signals from the body for further processing and analysis.
- **Filtering**: Filters out noise and interference to focus on the ECG waveform.
- **Analog-to-Digital Conversion**: Converts the analog ECG signal into digital data for processing by microcontrollers or computers.

PROJECT WORKFLOW :





Literature Review:

Title	Methodology/ Paper's Used
"A Review of IoT-Based Health Monitoring Systems"	Methodology involved a comprehensive literature search across various databases such as IEEE Xplore, PubMed, and ScienceDirect. Studies were selected based on relevance to IoT health monitoring systems and critically analyzed for their methodologies, sensor types, data collection techniques, and system architectures.
"IoT-enabled Health Monitoring: A Literature Review"	The methodology involved a systematic review of literature from databases including ACM Digital Library, SpringerLink, and IEEE Xplore. Selected studies were evaluated for their methodologies in terms of sensor deployment, data transmission protocols, cloud integration, and system scalability.
"Recent Advances in IoT-Based Health Monitoring Systems: A Review	Methodology included a structured search of peer-reviewed articles and conference proceedings in databases like Scopus and Web of Science. Selected studies were analyzed for their methodologies concerning sensor technologies, data processing algorithms, communication protocols, and usability aspects in health monitoring applications.
"A Comprehensive Review of IoT Applications in Healthcare"	The methodology encompassed a systematic literature search across various electronic databases such as PubMed, IEEE Xplore, and Google Scholar. Studies were assessed for their methodologies in IoT sensor deployment, data analytics techniques, communication protocols, and system integration in healthcare settings.

Objective

Our aim is to develop a remote health monitoring system that feels like a caring companion, leveraging the strengths of Arduino Nano 33 IoT and Raspberry Pi. Here's how our system will make you feel:

- **Stay Connected**: Keep track of your vital health signs like heart rate, ECG, SpO2 levels, and body temperature in real-time, ensuring you're always in the know about your well-being.
- **Reliable Insights**: Guarantee the accuracy and dependability of the data through thorough testing and advanced validation methods, so you can trust the information provided.
- **Ease of Use**: Making it effortless for you to access your health metrics, receive alerts for any concerning readings, and track your health trends over time.
- **Connect and Care**: Enable seamless remote access to your health data for both you and your healthcare team, fostering collaborative care and ensuring timely interventions when needed most.
- **Empowerment for Wellness**: Empower yourself to take control of your health by providing real-time access to vital health metrics, helping you make informed decisions and potentially prevent health issues before they escalate.

Methodology

1. System Components:
    - Arduino Nano 33 IoT: Primary data acquisition unit with SAMD21 Cortex-M0+ and NINA-W102 WiFi module.
    - Sensors:
        - MAX30100: Measures heart rate and SpO2 using optical technology.
        - AD8232 ECG Sensor: Captures and processes ECG signals.
        - MLX90614: Non-contact infrared thermometer for body temperature measurement.
    - **Raspberry Pi:** Handles data processing, storage, and GUI hosting.

Methodology

2.Hardware Setup:

- Sensor Connections:
  - MAX30100 and MLX90614: Connected via I2C(I2C Communication Protocol)
  - to Arduino for efficient data transmission.
  - AD8232: Analog output to A0 pin of Arduino for ECG data

Methodology

3.Software Implementation:

- Arduino Programming: Using Arduino IDE with necessary libraries for sensor data reading and WiFi communication.

- Data Processing: Filters noise and stores data.

- GUI Development: Real-time display of heart rate, SpO2, body temperature, and ECG data.

4.Data Transmission and Storage:

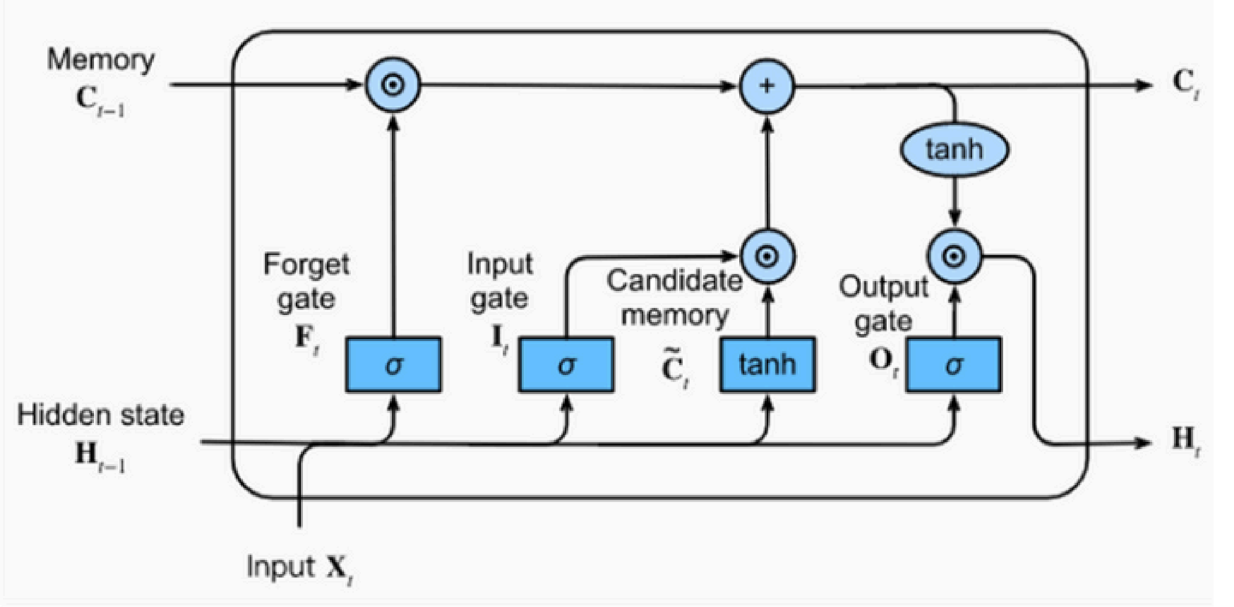
- Real-Time Data Synchronization: Utilizes Firebase for instant data updates.

Model Architecture:

The model architecture plays a pivotal role in the performance and effectiveness of the binary classification of ECG signals using Long Short-Term Memory (LSTM) networks. The architecture encompasses the design and configuration of the neural network layers, defining how data flows through the network and how features are extracted and processed.

1. LSTM LAYER:

The core component of the architecture is the LSTM layer, which is specifically designed to capture temporal dependencies and patterns in sequential data such as time-series signals



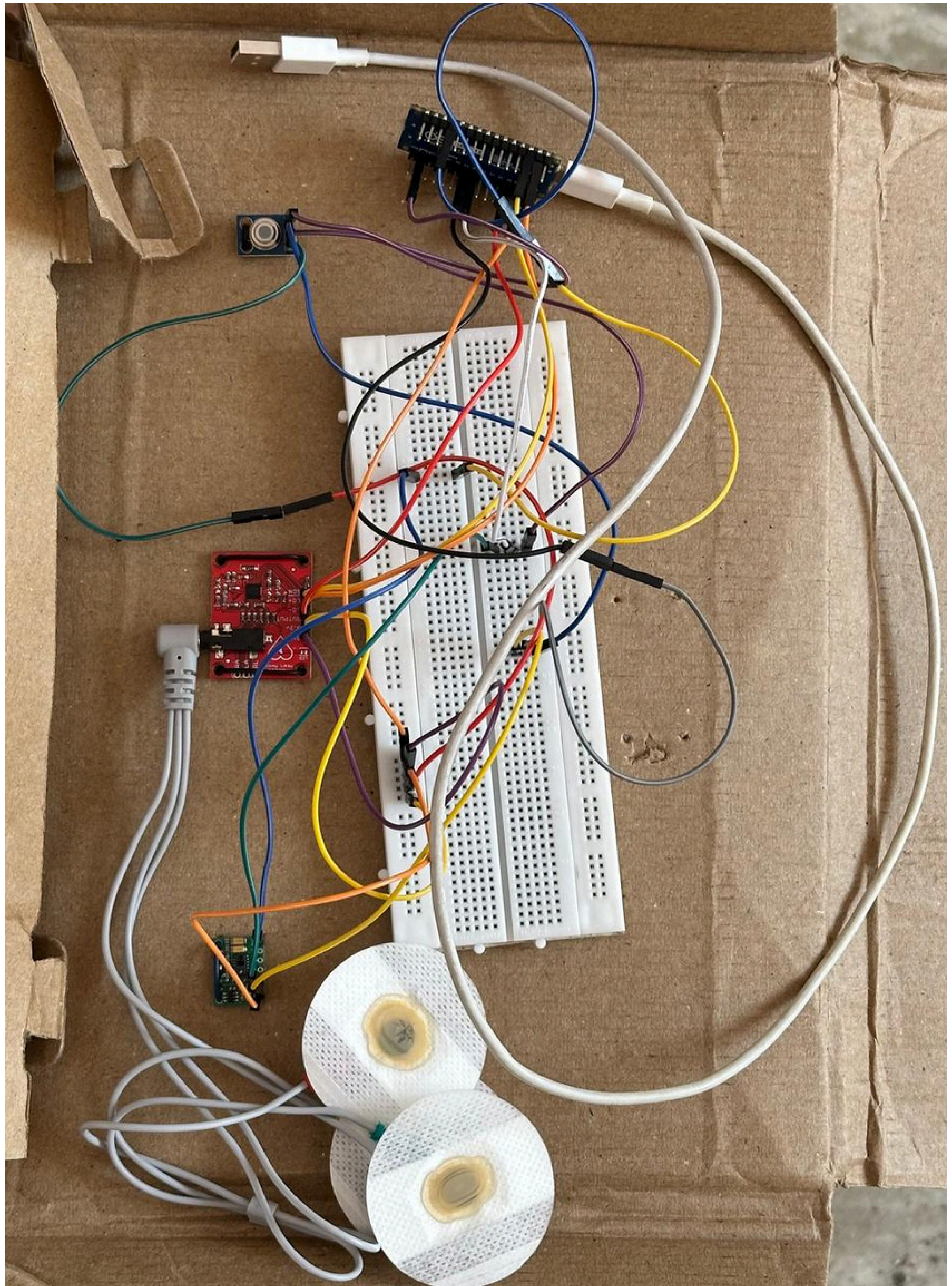
2. Dense Layer:

Following the LSTM layer, a dense layer is added to the architecture to perform the final classification based on the features extracted by the LSTM units.

3. Model Compilation:

Once the architecture is defined, the model is compiled with appropriate loss functions, optimizers, and evaluation metrics to facilitate training and evaluation

IMPLEMENTATION:



CODE:

sketch_jun6a.ino

```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#include <Adafruit_MLX90614.h>

#define REPORTING_PERIOD_MS 1000


PulseOximeter pox;
uint32_t tsLastReport = 0;

Adafruit_MLX90614 mlx;

void onBeatDetected() {
 Serial.println("Beat!");
}

void setup() {
 Serial.begin(9600);
 Serial.print("Initializing pulse oximeter..");

 // Initialize the PulseOximeter instance
 // Failures are generally due to an improper I2C wiring, missing power supply
 // or wrong target chip
 if (!pox.begin()) {
  Serial.println("FAILED");
  for(;;);
 } else {
  Serial.println("SUCCESS");
 }
 pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);

 mlx.begin();
 pinMode(10, INPUT); // Setup for leads off detection LO +
 pinMode(11, INPUT); // Setup for leads off detection LO -
}

void loop() {
 // Make sure to call update as fast as possible
 pox.update();
```

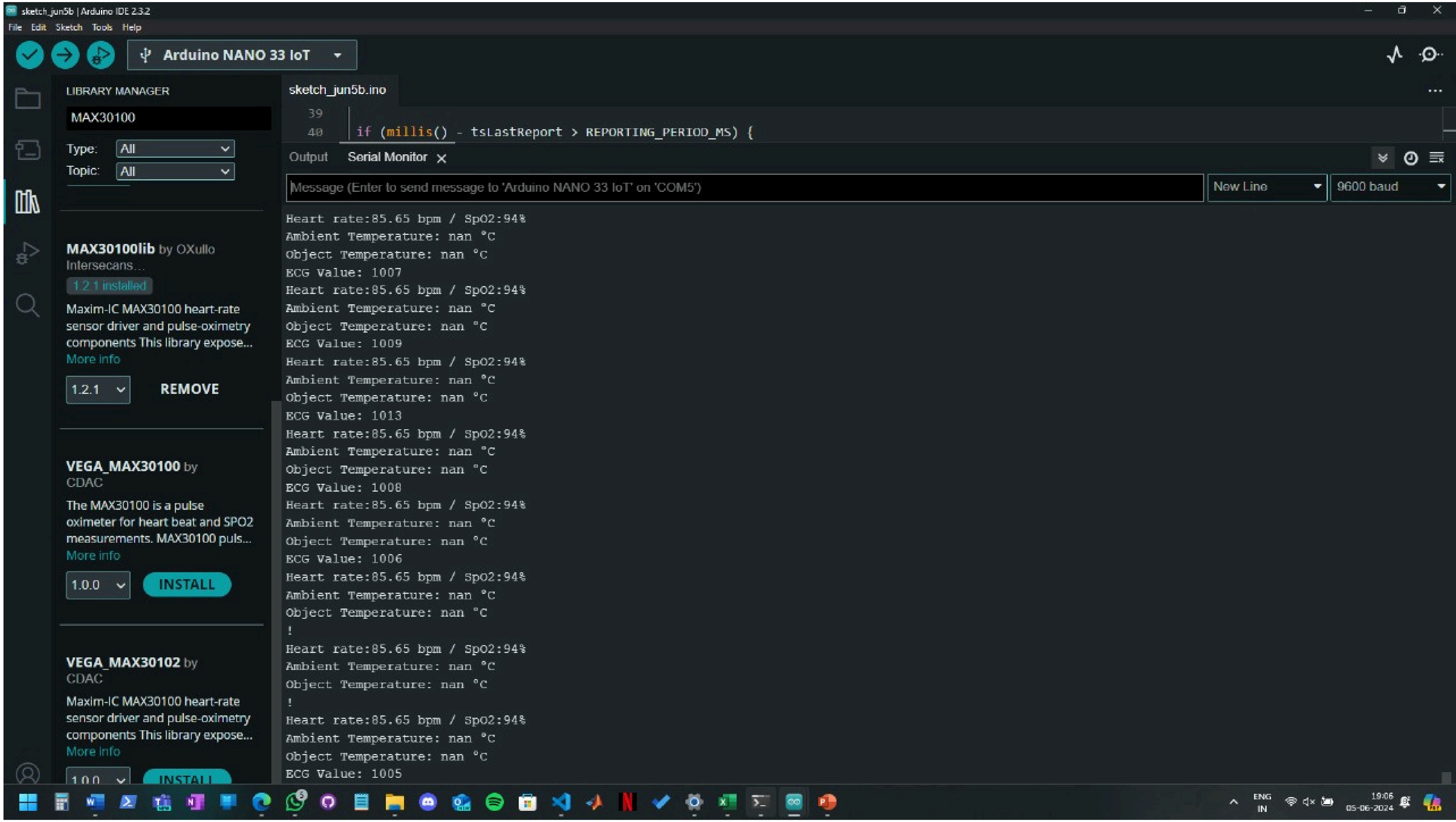
CODE:

sketch_jun6a.ino

```
}

void loop() {
 // Make sure to call update as fast as possible
 pox.update();

 if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
  Serial.print("Heart rate:");
  Serial.print(pox.getHeartRate());
  Serial.print(" bpm / SpO2:");
  Serial.print(pox.getSpO2());
  Serial.println("%");

  float ambientTemp = mlx.readAmbientTempC();
  float objectTemp = mlx.readObjectTempC();

  Serial.print("Ambient Temperature: ");
  Serial.print(ambientTemp);
  Serial.println(" °C");

  Serial.print("Object Temperature: ");
  Serial.print(objectTemp);
  Serial.println(" °C");

  if ((digitalRead(10) == 1) || (digitalRead(11) == 1)) {
   Serial.println('!');
  } else {
   // send the value of analog input 0:
   Serial.print("ECG Value: ");
   Serial.println(analogRead(A0));
  }

  tsLastReport = millis();
 }

 // Wait for a bit to keep serial data from saturating
 // Adjust the delay as needed
}
```

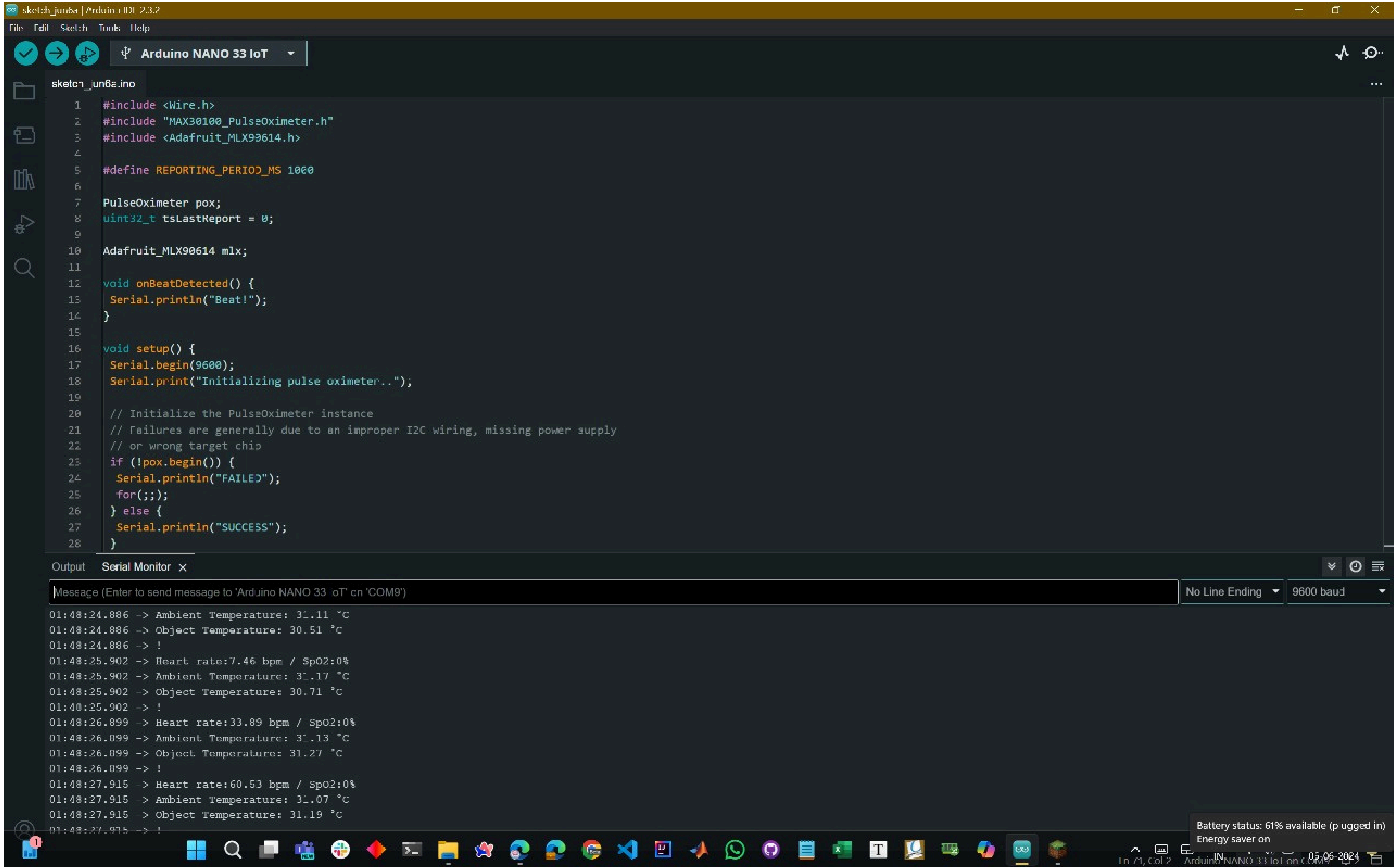
RESULT:

OUTPUT:



RESULT:

OUTPUT:



Conclusions & Future Scope :

- **Real-Time Monitoring**: The Remote Health Care Monitoring System is meticulously engineered to capture vital signs—such as heart rate, oxygen saturation (SpO2), and temperature—in real-time. This advanced capability is made possible through the seamless integration of the MAX30100 Pulse Oximeter and the Adafruit MLX90614 temperature sensor, both interfaced with the versatile Arduino Nano 33 IoT.

- **ECG Prediction**: Integrate ECG sensors and develop predictive algorithms to analyze ECG data, allowing for early detection of arrhythmias and other cardiac abnormalities. This will enhance the system's capability to monitor cardiovascular health comprehensively.

- **Portability**: Focus on making the entire system more portable and compact. Develop a wearable version that includes a small, lightweight housing for the Arduino Nano 33 IoT, sensors, and power supply, enabling patients to carry or wear the device easily during daily activities.

References

1. IoT-Based Remote Patient Monitoring System to Measure Vital Body Signs. IoT Design Pro. Available at: IoT-Based Remote Patient Monitoring System to Measure Vital Body Signs (iotdesignpro.com)

2. IoT-Based Healthcare-Monitoring System towards Improving Quality of Life: A Review. MDPI. Available at: Healthcare | An Open Access Journal from MDPI

3. Remote Health Care Monitoring System Based on Arduino Nano 33 IoT and Raspberry Pi. Instructables. Available at: Remote Health Care Monitoring System Based on Arduino Nano33 IOt and Raspberry Pi : 8 Steps - Instructables