DEPARTMENT OF
COMPUTER SCIENCE AND ENGINEERING

IoT Analytics & Security

IOT632P

A Mini-Project on

Smart Healthcare System - Pulse Oximeter

B. Tech Computer Science and Engineering (IOT)

School of Engineering and Technology,

CHRIST (Deemed to be University)

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CHRIST

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Certificate

This is to certify that the mini project report on Smart Health Care - Pulse Oximeter is carried out by ***Aishwarya Chundru (2162143), Bettina S Mathew (2162414)*** *have successfully completed the CIA-3 Component for* ***IOT Analytics & Security (IOT632P)*** *in partial fulfillment for the award of Bachelor of Technology in the Department of Computer Science and Engineering during the year 2023-2024.*

HEAD OF DEPARTMENT **FACULTY- IN CHARGE**

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Introduction

Problem Definition

The project addresses the need for efficient and accessible monitoring of patients' vital signs, specifically oxygen saturation levels and heart rate, using the MAX30100 sensor. The significance of this endeavor lies in the importance of real-time oximetry measurements for patient well-being, particularly in scenarios where continuous monitoring is essential. The current healthcare landscape demands seamless data collection and presentation for medical professionals to make informed decisions. Therefore, the challenge is to develop a system that records and displays oximeter measurements, storing them in a centralized dashboard for easy access by healthcare providers. This solution aims to enhance patient care by providing a comprehensive history of vital sign data, enabling medical practitioners to make informed decisions and monitor trends over time.

Objective

The primary objective of our project is to utilize the MAX30100 sensor to accurately measure and display oximeter readings of a patient. Through this, we aim to provide real-time monitoring of vital signs, specifically focusing on oxygen saturation levels and heart rate. The project further seeks to establish a seamless integration of the collected data into a user-friendly dashboard accessible to medical professionals. This dashboard will serve as a centralized platform for doctors to review and analyze the historical oximeter measurements of patients over time. The overarching goal is to enhance the efficiency of patient monitoring, enabling healthcare providers to make informed decisions based on a comprehensive understanding of the patient's vital sign trends. By achieving these objectives, our project aims to contribute to the advancement of remote patient monitoring systems and facilitate more effective healthcare management.

Overview

The mini project revolves around the utilization of the MAX30100 sensor to monitor and display oximeter measurements of patients, subsequently storing this data in a user-friendly dashboard for future reference by healthcare professionals. The primary purpose of this endeavor is to enhance the monitoring of vital signs, with a particular focus on oxygen saturation levels and heart rate, in a convenient and accessible manner. This project holds significant importance in the context of advancing remote patient monitoring systems and streamlining healthcare processes.

The MAX30100 sensor serves as the linchpin of our project, allowing for precise and real-time measurement of essential health parameters. By focusing on oximeter readings, we address a critical aspect of patient well-being, as oxygen saturation levels are indicative of respiratory health and can be pivotal in the early detection of potential complications. The project's core functionality lies in the ability to capture these readings and present them in a comprehensible format for medical professionals.

The key features of our project include the integration of the MAX30100 sensor with a microcontroller, which facilitates the accurate collection of oximeter data from patients. This data is then processed and displayed in real-time on a user interface, allowing for immediate monitoring of the patient's vital signs. The innovative aspect of our project lies in the subsequent storage and presentation of this data in a dashboard. This dashboard acts as a centralized repository for a patient's historical oximeter measurements, providing an invaluable resource for doctors to assess trends, track changes, and make informed decisions regarding patient care.

The significance of our project extends beyond the immediate monitoring of patients. The creation of a centralized dashboard serves as a comprehensive solution for doctors seeking to access and analyze a patient's historical data efficiently. This feature holds immense value in scenarios where long-term trends and patterns are crucial for diagnosis and treatment planning. By consolidating patient history in a single platform, healthcare professionals can gain a holistic understanding of the patient's health trajectory, facilitating more personalized and effective care.

Components

SOFTWARE

<u>ARDUINO UNO</u>: Blynk plays a vital role in our Smart Healthcare Pulse Oximeter project by facilitating seamless communication between the Arduino Uno and ESP8266. The Arduino Uno, equipped with the MAX30100 sensor, measures oxygen levels. Blynk acts as a bridge, allowing the Arduino Uno to upload code wirelessly to the ESP8266 module. The ESP8266 then transmits real-time oximeter readings to the Blynk app, creating an interactive mobile dashboard. This integration ensures immediate accessibility for healthcare professionals to monitor oxygen levels remotely. Additionally, Blynk assists in archiving historical data, enabling doctors to review a patient's past records for comprehensive health analysis, enhancing overall healthcare management.

<u>BLYNK</u>: Blynk serves as a pivotal component in our Smart Healthcare Pulse Oximeter project, streamlining real-time monitoring and historical data storage. It dynamically displays current oxygen levels on a customizable mobile dashboard. Simultaneously, Blynk securely archives historical oximeter measurements, ensuring past records are readily accessible for future reference by healthcare professionals. This integration empowers doctors to remotely access and analyze a patient's health history, enhancing timely decision-making. Blynk's functionalities not only provide immediate insights into vital signs but also create a comprehensive repository for a more profound understanding of a patient's health trends over time.

HARDWARE

<u>ESP8266</u>: In the Smart Healthcare Pulse Oximeter project, the ESP8266 module plays a crucial role in enabling wireless connectivity and data transmission. Serving as the communication interface between the Arduino Uno and the Blynk app, the ESP8266 facilitates the seamless transfer of real-time oximeter measurements. With its Wi-Fi capabilities, the ESP8266 ensures that healthcare professionals can remotely monitor patients' oxygen levels via the Blynk dashboard. Its compact size and low power consumption make it an ideal component for portable healthcare devices. Overall, the ESP8266 enhances the efficiency and accessibility of healthcare monitoring systems, contributing to improved patient care and management.

<u>OLED</u>: In the Smart Healthcare Pulse Oximeter project, the integration of an OLED (Organic Light-Emitting Diode) display proves instrumental. The OLED screen serves as a compact and efficient interface for presenting real-time oximeter measurements. Its high contrast and vibrant colors enhance the visibility of critical health data, providing instant feedback to users. Displaying oxygen levels directly on the device ensures immediate awareness and monitoring convenience. This feature, combined with the project's wireless capabilities, contributes to a comprehensive and user-friendly healthcare solution, where patients and healthcare providers can readily access vital information for timely decision-making and improved overall healthcare management.

<u>MAX10300</u>: The MAX30100 sensor is integral to our Smart Healthcare Pulse Oximeter project, playing a pivotal role in monitoring vital signs. This sensor excels in non-invasive measurement of blood oxygen saturation levels and heart rate. Its advanced capabilities make real-time data acquisition possible, offering accurate and immediate insights into a patient's health. Compact and efficient, the MAX30100 ensures reliable pulse oximetry, making it a key component in our system. The collected data, including oxygen levels, is seamlessly integrated into our platform, providing healthcare professionals with essential information for timely interventions and informed decision-making in patient care.

Technical Architecture & Schematic Diagram

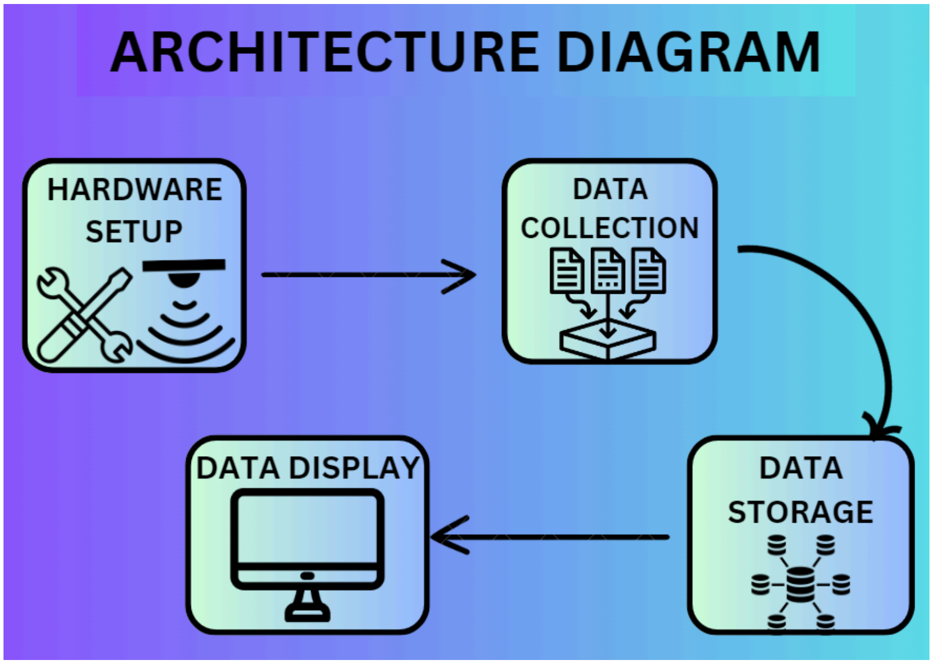
The Smart Healthcare Pulse Oximeter mini project relies on a well-structured technical infrastructure to seamlessly collect, process, and present health data. The key components include the MAX30100 sensor, Arduino Uno microcontroller, ESP8266 module, Blynk IoT platform, and a display interface.

The MAX30100 sensor is responsible for non-invasive measurement of blood oxygen saturation levels and heart rate. The Arduino Uno, equipped with the MAX30100 sensor, captures the physiological data. The ESP8266 module facilitates wireless communication, enabling the Arduino Uno to transmit data to the Blynk IoT platform.

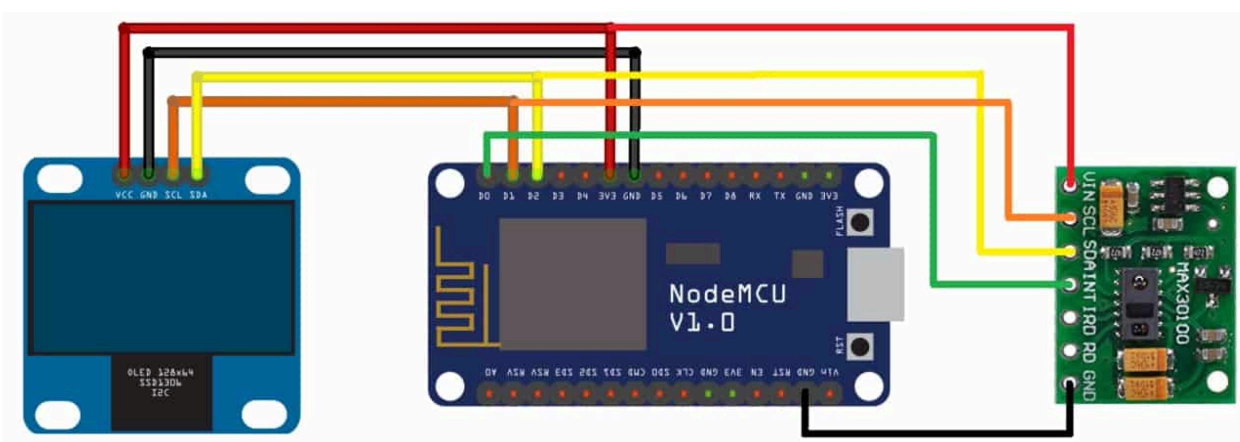
Blynk serves as the central hub, creating an interactive mobile dashboard for real-time data visualization and storage. The historical health data, including oxygen levels, is securely stored in the Blynk cloud, ensuring accessibility for healthcare professionals. Additionally, Blynk enables remote monitoring and notifications based on specific health conditions.

The overall technical infrastructure ensures the reliability and efficiency of the Smart Healthcare Pulse Oximeter system, enabling continuous monitoring, historical data analysis, and timely healthcare interventions.

Technical Architecture



Schematic Diagram



Implementation

Step 1: Connect the ESP8266 with the MAX30100 and OLED as shown in the above figure.

Step 2: Write the ESP8266 code in the Arduino IDE software.

Step 3: Edit the code where the Blynk ID, Blynk authentication ID, Blynk Project Name, WiFi SSID and password to connect to the Blynk app.

Step 4: Edit the code where the Host name, HTTP port and Google script ID to connect ESP8266 to Google sheets.

Step 5: ESP8266 Code:

```
#define BLYNK_TEMPLATE_ID "TMPL3N8YWUHHy"
#define BLYNK_TEMPLATE_NAME "Oximeter"

#include <Arduino.h>
#include <ESP8266WiFi.h>
#include "HTTPSRedirect.h"
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#define BLYNK_PRINT Serial
#include <Blynk.h>
#include <BlynkSimpleEsp8266.h>
#include "Adafruit_GFX.h"
#include "OakOLED.h"

// Define Blynk authentication token, WiFi credentials, and other constants
char auth[] = "0yi-geYsp9O_lbmRMxi5ELtSQMBNWyu7";
char ssid[] = "Betty";
char pass[] = "uztz2486";
const char* host = "script.google.com";
const int httpsPort = 443;
```

```
const char* GScriptId =
"AKfycby5nPUhynvn2w30062VM5JprlOGSat6foswVPdhAm4u1ymbsT07GMCx
1Ci7251Yc9BR";
String payload_base = "{\"command\": \"insert_row\", \"sheet_name\": \"Sheet1\",
\"values\": ";
String url = String("/macros/s/") + GScriptId + "/exec";
HTTPSRedirect* client = nullptr;

// Define variables for pulse oximeter
float BPM, SpO2;
uint32_t tsLastReport = 0;
const unsigned char bitmap [] PROGMEM = { /* bitmap data */ };

// Declare OLED object
OakOLED oled;

void setup() {
  // Initialize serial communication
  Serial.begin(115200);

  // Initialize Blynk
  Blynk.begin(auth, ssid, pass);

  // Initialize OLED display
  oled.begin();
  oled.clearDisplay();
  oled.setTextSize(1);
  oled.setTextColor(1);
  oled.setCursor(0, 0);
  oled.println("Initializing pulse oximeter..");
  oled.display();

  // Initialize pulse oximeter
  if (!pox.begin()) {
```

```
    Serial.println("FAILED");
    oled.clearDisplay();
    oled.setTextSize(1);
    oled.setTextColor(1);
    oled.setCursor(0, 0);
    oled.println("FAILED");
    oled.display();
    for (;;);
  } else {
    oled.clearDisplay();
    oled.setTextSize(1);
    oled.setTextColor(1);
    oled.setCursor(0, 0);
    oled.println("SUCCESS");
    oled.display();
    Serial.println("SUCCESS");
    pox.setOnBeatDetectedCallback(onBeatDetected);
  }
}

void loop() {
  // Update pulse oximeter and Blynk
  pox.update();
  Blynk.run();

  // Get heart rate and SpO2 readings
  BPM = pox.getHeartRate();
  SpO2 = pox.getSpO2();

  // Publish data to Google Sheets
  publishToGoogleSheets();

  // Display readings on OLED
  displayReadingsOnOLED();
```

```
}

// Callback function for beat detection
void onBeatDetected() {
  Serial.println("Beat Detected!");
  oled.drawBitmap(60, 20, bitmap, 28, 28, 1);
  oled.display();
}

// Function to publish data to Google Sheets
void publishToGoogleSheets() {
  if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
    // Create payload for Google Sheets
    String payload = payload_base + "\"" + BPM + "," + SpO2 + "\"}";

    // Use HTTPSRedirect class to create a new TLS connection
    client = new HTTPSRedirect(httpsPort);
    client->setInsecure();
    client->setPrintResponseBody(true);
    client->setContentTypeHeader("application/json");

    // Connect to Google Sheets
    if (client->connect(host, httpsPort)) {
      Serial.println("Connected to Google Sheets");
      if (client->POST(url, host, payload)) {
        Serial.println("Data sent to Google Sheets successfully");
      } else {
        Serial.println("Error sending data to Google Sheets");
      }
      client->stop();
    } else {
      Serial.println("Connection to Google Sheets failed");
    }
```

```
    tsLastReport = millis();
  }
}

// Function to display readings on OLED
void displayReadingsOnOLED() {
  oled.clearDisplay();
  oled.setTextSize(1);
  oled.setTextColor(1);
  oled.setCursor(0, 16);
  oled.println(BPM);

  oled.setTextSize(1);
  oled.setTextColor(1);
  oled.setCursor(0, 0);
  oled.println("Heart BPM");

  oled.setTextSize(1);
  oled.setTextColor(1);
  oled.setCursor(0, 30);
  oled.println("SpO2");

  oled.setTextSize(1);
  oled.setTextColor(1);
  oled.setCursor(0, 45);
  oled.println(SpO2);
  oled.display();
}
```

Step 6: Deploy the model and check the output in the Blynk app and also in Google sheets.

Challenges Faced

The development and deployment of the mini project, the Smart Healthcare System, presented several challenges that required thorough research and strategic problem-solving. One primary obstacle was the need for extensive exploration of pulse oximetry, MAX30100 sensor functionalities, and their integration into a cohesive system. This initial phase, although time-consuming, laid the foundation for a comprehensive and well-informed project, emphasizing the importance of understanding the intricacies of the chosen topic.

Financial constraints posed another significant challenge, particularly regarding the substantial investment required for high-quality sensors, such as the MAX30100. Despite the financial burden, we recognized the critical role that sensor accuracy plays in healthcare applications and allocated a considerable budget to ensure reliability and precision. This commitment was essential to meeting the accuracy standards expected in the healthcare domain and delivering a reliable Smart Healthcare System.

Integration of the Blynk app for creating a dashboard to visualize real-time sensor data presented an unexpected hurdle due to the app's lack of built-in features for storing historical data. Creative problem-solving was necessary to overcome this limitation, leading to the exploration of alternative platforms and methods for data storage. By devising a workaround, we ensured that our system could effectively store and visualize historical sensor data, enhancing its utility and functionality for healthcare professionals.

Storing sensor data for historical analysis and the installation and configuration of numerous libraries posed additional challenges during the project's development. Experimentation with various configurations and meticulous attention to detail were necessary to establish reliable connections between the MAX30100 sensor and platforms like Google Sheets. Through perseverance, adaptability, and systematic problem-solving, we successfully addressed these challenges, delivering a functional and reliable Smart Healthcare System that demonstrated the potential of integrating technology into healthcare for improved monitoring and patient care.

Future Scope

The Smart Healthcare System project, integrating a pulse oximeter with the MAX30100 Sensor, OLED display, Blynk dashboard, and Google Sheets for data storage, presents significant potential for further development and expansion. As technology advances and healthcare systems evolve, there are numerous avenues for enhancing its capabilities and impact. One such avenue is the integration of additional sensors and parameters to provide a more comprehensive health monitoring solution.

Enhancing the data visualization and analysis capabilities of the Blynk dashboard could significantly improve the usability and effectiveness of the Smart Healthcare System. Features such as customizable alerts, trend analysis, and predictive analytics would empower healthcare providers to make informed decisions in real-time, potentially leading to improved patient outcomes and reduced healthcare costs. This would not only benefit individual patients but also contribute to broader public health initiatives by enabling more proactive and preventative healthcare practices.

Another area for future exploration is the integration of cloud-based storage and analytics platforms. Leveraging platforms like Amazon Web Services (AWS) or Microsoft Azure would enable scalable storage solutions and advanced analytics capabilities, including machine learning algorithms for predictive modeling and personalized healthcare recommendations. By securely storing and analyzing sensor data in the cloud, the system can unlock new insights and opportunities for improving patient care and healthcare delivery.

Furthermore, incorporating wireless connectivity options such as Bluetooth or Wi-Fi would enhance the mobility and accessibility of the Smart Healthcare System. Patients could monitor their health remotely and share data with healthcare providers in real-time, benefiting those with chronic conditions or requiring continuous monitoring outside traditional healthcare settings. Additionally, exploring opportunities for interoperability and integration with existing electronic health record (EHR) systems would facilitate seamless data exchange and collaboration between healthcare providers, ultimately improving continuity of care and patient outcomes. Overall, the future scope of the Smart Healthcare System project is vast and promising, with the potential to revolutionize healthcare monitoring and management for more personalized and effective patient care.

Limitations

While the Smart Healthcare System project incorporating a pulse oximeter with the MAX30100 Sensor and utilizing Blynk for the dashboard, along with Google Sheets for data storage, signifies a significant advancement in remote health monitoring, it is crucial to acknowledge certain constraints and drawbacks inherent in its current implementation. One notable limitation is the system's capability to detect the oxygen levels and heart rate of only one patient at a time. This limitation impedes its scalability for scenarios where simultaneous monitoring of multiple patients is essential, such as in hospital or clinical settings. As the project primarily targets individual or home use, its applicability in broader healthcare contexts is somewhat restricted.

Additionally, the system's focus solely on monitoring oxygen levels and heart rate points to a technical limitation. While these vital signs are pivotal indicators of overall health, a comprehensive health monitoring solution ideally encompasses a broader range of parameters, such as blood pressure, temperature, and respiratory rate. Expanding the system's capabilities to include a more comprehensive set of vital signs would undoubtedly enhance its utility and relevance across diverse healthcare scenarios.

A notable drawback associated with the project lies in the utilization of the Blynk platform for the dashboard. The necessity for a monthly subscription to access the dashboard may present financial constraints for users, thereby limiting the system's accessibility. To mitigate this limitation and broaden the system's user base, exploring alternative platforms or providing a more cost-effective solution for continuous dashboard access could be considered.

Moreover, the reliance on Google Sheets for data storage poses a challenge concerning the management of the substantial volume of data generated over time. As the system continually collects and stores data, efficient data management becomes increasingly crucial. Exploring more robust and scalable data storage solutions, such as cloud-based platforms, could alleviate this limitation and ensure seamless data management and analysis, further enhancing the system's effectiveness and usability.

GitHub Repository

https://github.com/Bettina03/Smart-Healthcare-System

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