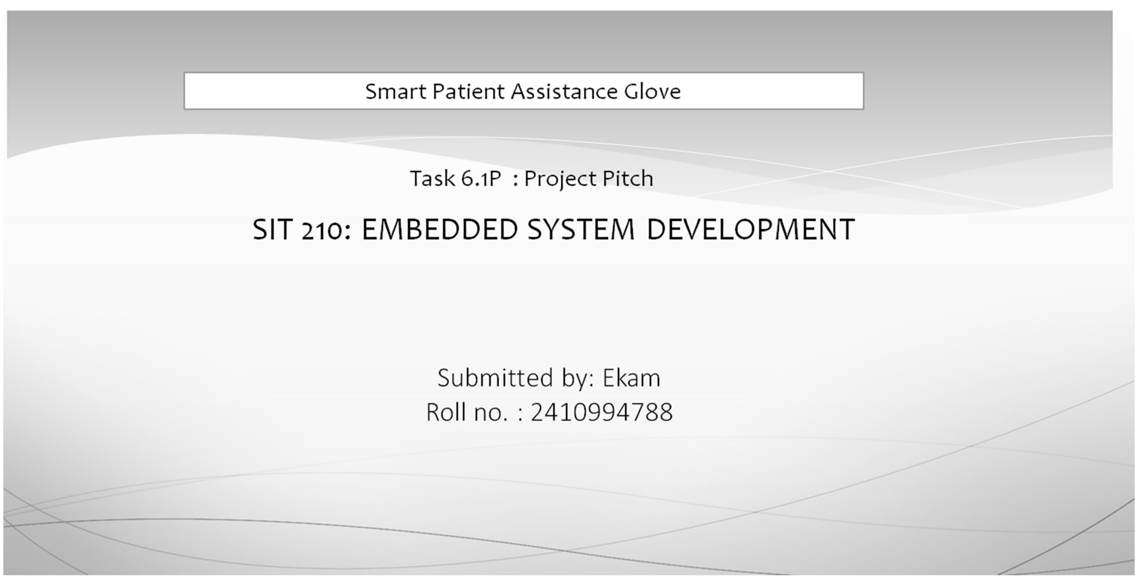
Embedded Systems Development

Task 6.1P

Project Pitch

Task overview:

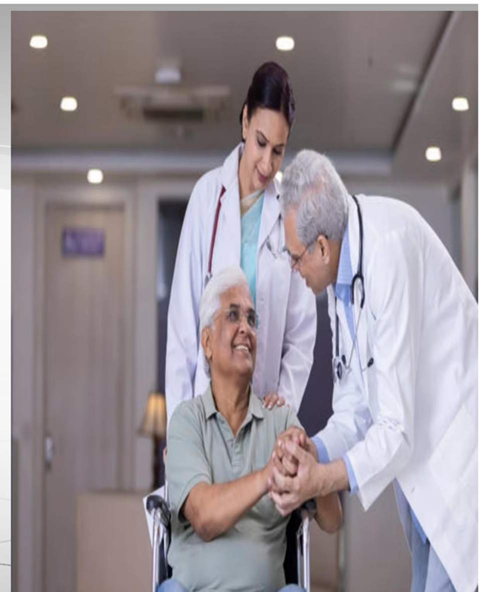
For this assignment we needed to pitch a prototype idea based on embedded systems. The purpose was to present and convey some understanding of the problem domain,identifying what the current industry practices are, their limitations, and where the potential exists for embedded systems to solve a problem effectively. We needed to be able to describe our proposed solution in general terms with respect to the predominant hardware and software components and links; examples of the communication protocols to be used; the possible user interface; and explain how the system would work with block diagrams and flow diagrams to show the design.



Problem Statement

Individuals suffering from paralysis or severe physical disabilities face significant challenges communicating even their basic needs, such as asking for water, requesting assistance or letting someone know they are in pain. The inability to communicate directly creates a dependency on vigilant attention from caregivers, which is often not feasible. Caregivers may miss or delay response to changes in the patient's status because they are unaware that clear alerts cannot be given or given in real-time by the patient.

Simultaneously, many of the current healthcare technologies only focus on assessment of vitals, like heart rate or oxygen saturation, and do not allow patients to effectively express themselves or interact even in their daily lives. There are very few systems that exist to assist these individuals that are not prohibitively expensive, too big to integrate into their living environment, or only meant for use in hospitals.



Existing Healthcare Solutions and their Limitations

Current industry practices, while serving their purposes, fall short in providing comprehensive, integrated care. Each solution presents significant limitations when applied to continuous home monitoring and accessible communication.

Alert Buttons

Strength: Widely used in hospitals, simple, and direct.

Limitation: Only works within a specific area, less portable, and lacks any health monitoring capabilities.

Wearable Smart Devices

Strength: Provide valuable SpO_2, heart rate, and activity tracking data.

Limitation: No gesture-based communication and not customizable for specific medical needs.

Hospital Monitoring Systems

Strength: Offer comprehensive monitoring with advanced alert functionalities.

Limitation: Very expensive, non-portable, and fundamentally unsuitable for home-based care environments.

Addressing Critical Gaps in Patient Accessibility and Care

1. Accessibility Barriers

   Many existing systems rely on pressing buttons or navigating complex applications, which can be impossible for patients with speech impairments.

2. Lack of Integration

   Communication tools and vital sign monitors typically operate as separate, disconnected devices, leading to fragmented data and delayed responses.

3. Prohibitive Costs

   Advanced medical monitoring systems are often too expensive for widespread home use, limiting access for many who could benefit.

4. Caregiver Workload

   Absence of automated logging or reminder systems increases the burden on caregivers, leading to potential human error and burnout.

Bridging Gaps in IoT Healthcare

Our Opportunity

The proposed solution is to develop **Care Gloves**, a smart wearable glove designed for individuals with paralysis or speech impairments to communicate through simple hand gestures.

The glove uses flex sensors and IMU placed along the fingers to detect specific hand motions or gestures. These sensors generate electrical signals based on the degree of finger bending or hand movement. The signals are processed by an Arduino nano microcontroller, which identifies the gesture and maps it to a predefined message (e.g., "I need water", "Call someone", "I'm in pain").The message is then sent via WiFi to a caretaker's app or device (e.g., using Blynk).This system enables the patient to express their needs independently, improving their quality of life and ensuring faster response from caretakers.

Hardware Modules

Arduino Nano 33 IoT

The core processing unit, handles sensor input, local processing, and wireless communication.

Flex Sensors

Integrated into a glove, these detect precise finger bending for accurate gesture recognition coded .

MPU6050 (Accel + Gyro)

Enables detection of wrist motion and orientation, crucial for complex gestures.

MAX30100 Pulse Oximeter

Accurately measures real-time blood oxygen saturation (SpO_2) and heart rate (HR).

RTC Module (DS3231)

Provides precise timekeeping for scheduling critical medicine reminders.

Buzzer

The buzzer alerts the patient to reminders.

Data Flow and Alert Mechanisms

Sensor Data Acquisition

The Arduino reads continuous data from Flex sensors, MPU6050 (for motion), and MAX30100 (for SpO_2 and HR).

Gesture Recognition

A pre-defined algorithm on the Arduino recognizes gestures. Telemetry data (gesture, SpO_2, Heart rate) is then packaged into JSON format.

MQTT Transmission to Raspberry Pi

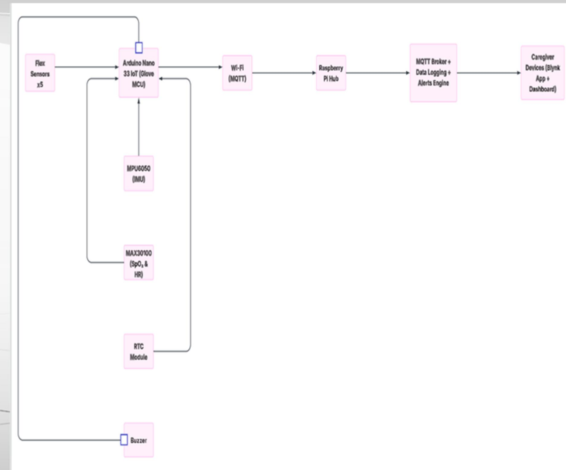
The JSON telemetry is sent via MQTT to the Raspberry Pi hub, ensuring low-latency communication.

Raspberry Pi Processing & Alerts

The Pi stores data in a database. It triggers alerts if SpO_2 drops below 90% or HR is abnormal. It also checks the RTC module for medicine reminder schedules.

Medicine Reminder& caregiver interface

If a medicine time matches, the Pi sends an MQTT reminder signal back to the Arduino, activating the buzzer.Blynk mobile app and web dashboard display real-time vitals, gesture notifications, and alert statuses, keeping the caregiver informed



Communication & Distributed Processing

1. **Arduino IDE:** Used for writing, compiling, and uploading code to the microcontroller, which manages both gesture detection and reminder control logic.

IoT Integration and System Design

2. **Blynk App:** Used to wirelessly send predefined gesture outputs or medication alerts to a mobile phone or external monitoring system via Wi-Fi. Enables real-time communication between the user and the caretaker.
3. **Arduino nano:** Allows direct internet connectivity, enabling remote alerts and updates .
4. **Raspberry Pi Hub** Handles overall processing and integration . The Pi runs the MQTT broker software, stores health data, processes alerts, and schedules the medicine reminder. The Pi also will send notifications to the caregiver's app or web dashboard.

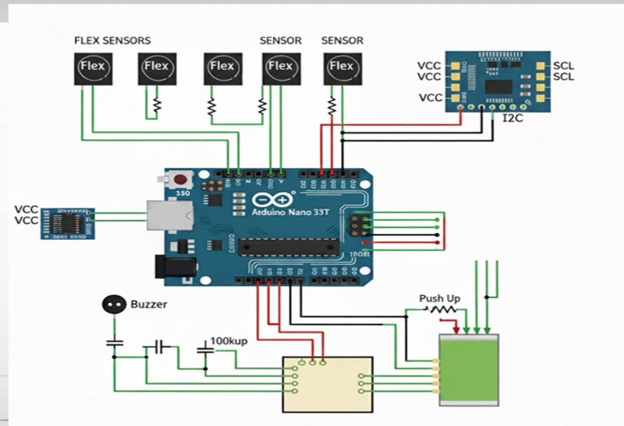
Data Processing Architecture

5. **Flow: Sensor** Input (Flex Sensor) → Arduino nano → Raspberry pi → Output: Text/Audio Alert via Blynk.
6. **O2 & Heartrate sensor:** Whenever patient heartrate or 02 varies the care get notified.

Wearable System Design

7. **Battery Management:** Low-power consumption with options for USB charging or lithium polymer batteries for portability.
8. **User-Centric Design:** Focused on comfort, flexibility, and ease of gesture recognition, especially suited for elderly or physically challenged individuals.

Circuit Diagram



Innovative Features

- **Gesture Translation** – Converts simple hand gestures into messages sent wirelessly to a caretaker, enabling faster and clearer communication.
- **Assistive Technology** – Empowers people with paralysis or speech impairment to express their needs independently.
- **Real-Time Alerts** – Sends instant messages through WiFi to the caretaker’s smartphone or dashboard, ensuring quick responses.
- **Customizable Gestures** – Gestures and their mapped messages can be easily reprogrammed to suit each patient’s specific needs.
- **Portable and Comfortable** – Lightweight, fabric-based glove designed for daily use without discomfort.
- **Affordable Solution** – Uses low-cost components (ESP32, flex sensors) making it feasible for widespread adoption.
- **Scalable Design** – Can be expanded with future upgrades, such as voice synthesis or more advanced gesture libraries

Impacts

Bridges Communication Gaps: Converts hand gestures into text or alerts, enabling paralyzed individuals to communicate with caregivers or family without speaking.
Promotes Independence: Empowers users to request help or express needs without physical or verbal strain.
Enhances Caregiver Response: Allows faster, clearer understanding of the user's needs, leading to quicker assistance and better care.
Boosts Confidence: Builds a sense of autonomy and dignity by enabling interaction through simple, natural movements.
Social, Economic, and Environmental Impact
Social Impact: Fosters inclusivity by giving a voice to those with severe physical limitations, promoting better integration into daily life and society.
Economic Impact: Reduces dependency on full-time assistance and improves caregiver efficiency, lowering long-term care costs.
Environmental Impact: Promotes sustainable design through low-power components, rechargeable batteries, and minimal electronic waste in wearable technology

Github link:

https://github.com/Ekam08/SIT201_ESD.git

Youtube Link:

https://youtu.be/0f7TW7xYy0k?feature=shared