Department of Computer and Information Systems Engineering

CS-406 Computer Engineering Project

Proposal for the Final Year Design Project

Title	**REVIVE** - *Rehabilitation & Evaluation via IoT for Vital Exercises*

Domain	Internet of Things (IOT)	Embedded Systems	Biomedical Engineering	Artificial Intelligence (AI)	Machine Learning (ML)	Data Science

1. Nature of Project [Tick all that applicable]

☒ New Project OR ☐ Extension of Existing Project	☐ Industrial Collaboration	☐ Funded
☐ Other Department Collaboration (If yes) Department Name________________	☐ Other Academic Institution Collaboration (If yes) Institution Name_______________	

2. Brief Outline (*Problem Identification and Significance*)

Knee injuries and surgical procedures such as ligament reconstructions, knee replacements, and arthritis treatments are among the most common global medical challenges. Recovery heavily depends on correct and consistent physiotherapy exercises. However, most patients perform rehabilitation exercises unsupervised at home or they do not consistently keep in touch with professional physiotherapist, often leading to incorrect movement patterns, irregular routines, and unsafe overexertion. These problems contribute to slower recovery, risk of re-injury, and prolonged dependence on healthcare services.

Current rehabilitation devices are typically costly, bulky, and confined to clinical environments, limiting accessibility. Moreover, physiotherapists cannot provide continuous real-time monitoring for each patient, creating a significant gap between prescribed therapy and actual compliance.

The current concerns are lack of standardized protocols, insufficient validation of wearable systems, usability challenges, and underdeveloped AI-enabled monitoring. To address these limitations, our project proposes an IoT-based, AI-assisted knee rehabilitation device that is portable, affordable, and patient-centered. It ensures correct movement execution, delivers real-time feedback, and enables remote physiotherapist monitoring through cloud connectivity. By integrating features like feedback dashboards and a simple chatbot, the device supports improved adherence, usability, and clinical relevance.

3. Objectives

- **To design and develop a wearable IoT device** capable of monitoring knee joint movements such as angle, range of motion, and repetitions during rehabilitation exercises.
- **To provide real-time feedback** to patients through a mobile or web application, ensuring exercises are performed correctly and safely.
- **To enable remote monitoring** by transmitting exercise data to physiotherapists via cloud platforms, reducing the need for frequent hospital visits.
- **To generate progress reports and exercise analytics** that help physiotherapists track recovery and adjust rehabilitation plans.
- **To create an affordable and portable solution** that can be used at home by patients, reducing dependency on costly or bulky hospital equipment.
- **To integrate user-centered features** such as a chatbot for guidance, motivational support, and corrective feedback to improve adherence.

4. Scope

The project scope is limited to the design, development, and testing of an IoT-enabled wearable device tailored for knee rehabilitation exercises. The system will measure bending angles, range of motion, and repetition counts in standard physiotherapy routines. The collected data will be transmitted to a mobile/web app via IoT connectivity, visualized for patients, and stored on secure cloud servers for physiotherapist access.

Within this scope, the project covers:

- **Real-time performance feedback** through alerts/notifications when exercises are performed incorrectly.
- **Cloud-based analytics and progress reporting** to assist physiotherapists in clinical decision-making.
- **A compact, low-cost, user-friendly device design** optimized for home-based rehabilitation.
- **A chatbot interface** for patient guidance, motivation, and adherence support.

The project will not cover full-body gait analysis, or robotic-assistive rehabilitation. Instead, it complements physiotherapist expertise by offering standardized, AI-supported data collection. Future extensions may widen the scope of this project and especially explore advanced EMG-based muscle signal tracking, multi-joint rehabilitation, and integration with telemedicine ecosystems, in line with current research directions.

5. Proposed Methodology

Problem Study & Requirements

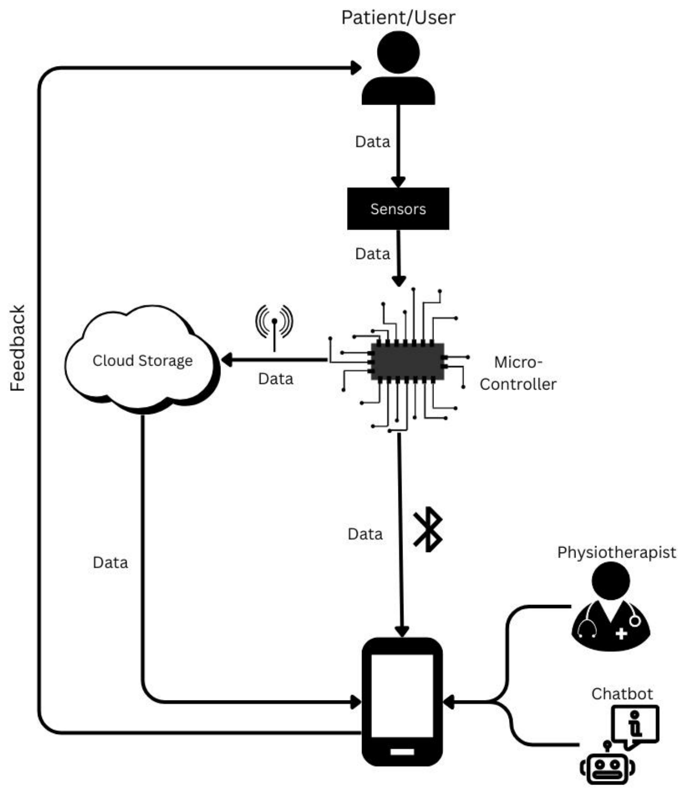
The initial phase involves identifying the core challenges faced during knee rehabilitation: incorrect exercise execution, irregular routines, and lack of real-time physiotherapist supervision. A detailed review of rehabilitation exercises and existing devices is carried out to understand their limitations. Input from the designed system is collected to determine essential tracking parameters such as:

- Core Metrics: Joint angle, range of motion (ROM), repetitions.
- Possible extended Metrics: Speed, smoothness, hold duration, symmetry, and fatigue.

System Design

A comprehensive system architecture is designed that integrates hardware, firmware, application, and cloud services. The data flow is defined as follows:

1. Patient performs exercise.
2. Sensors measure movement and transmit raw data to the microcontroller.
3. The microcontroller processes and filters data.
4. Data is transmitted wirelessly to the mobile/web application.
5. The application visualizes the results and stores them in the cloud for the patient/user as well as a physiotherapist (if the patient or user opts for it).



Hardware Development

The wearable device will consist of the following components:

- **IMU Sensor:** Captures knee joint angle and repetitions. In addition, velocity and acceleration data from the IMU are analyzed to evaluate the *smoothness* of movements, helping to identify abrupt or unsafe motions.
- **EMG Sensor:** Monitors muscle activation to confirm that target muscles (e.g., quadriceps, hamstrings) are properly engaged and to detect fatigue or strain, ensuring safe and effective rehabilitation.
- **Microcontroller (ESP32):** Performs sensor data acquisition, basic processing, and wireless transmission to the mobile/web application or the cloud.
- **Feedback Module:** A vibration motor provides real-time alerts if exercises are performed incorrectly, promoting safe rehabilitation.
- **Power Supply & Enclosure:** Rechargeable battery with charging circuit, embedded in a lightweight strap-based wearable casing for comfortable usage.

Software Development

The software stack includes both device firmware and user-facing applications.

Firmware (on ESP32):

- Sensor calibration and data acquisition.
- Angle, ROM, and repetition calculation.
- Error detection and haptic feedback control.
- Data transmission via Bluetooth/Wi-Fi.

Mobile/Web Application:

- Real-time visualization of exercise data.
- Progress analytics and performance reports.
- Chatbot interface for patient guidance, motivational support, and corrective feedback.
- Secure cloud integration for physiotherapist access.

Connectivity (IoT Integration)

- **Bluetooth Low Energy (BLE):** Used for real-time data transfer from the wearable device to the mobile application, enabling instant feedback during exercises.
- **Wi-Fi Connectivity:** Periodic synchronization with a secure cloud server to store exercise sessions and patient progress.
- **Dual Mode Operation:** BLE ensures low-latency local feedback, while Wi-Fi provides long-

term data storage and remote monitoring.

- **Remote Access:** If the patient opts for a physiotherapist instead of using the chatbot's real-time feedback, he can choose a physiotherapist for himself who can log in to review patient's exercise history, analyze progress, and adjust rehabilitation plans manually based on cloud-stored data.

Testing and improvements

- **Unit Testing:** Each hardware and software component, including sensors, the microcontroller, and the mobile application, will be tested individually to verify that they perform their intended functions correctly and consistently under different conditions.
- **System Testing:** Once the components are integrated, the complete prototype will be tested in standard rehabilitation exercise scenarios to ensure proper communication between modules, accurate data flow, and timely delivery of feedback to the patient.
- **Performance Review:** The outcomes of the system tests will be analyzed in detail to identify any potential issues such as inaccuracies in measurements, delays in real-time feedback, or interruptions in connectivity, ensuring that the device meets its design goals.
- **Iterative Refinement:** Based on the insights gathered from testing, improvements will be made to hardware placement, sensor calibration, and the feedback mechanisms in order to enhance both comfort for the patient and reliability of the system.

6. Resources Involved

Microcontroller: e.g., ESP32 or Arduino with Wi-Fi/Bluetooth.

Sensors: IMU (gyroscope + accelerometer) for angle detection. EMG and vibrational feedback module.

Power Supply: Rechargeable battery, charger module.

Straps & Enclosure: Any lightweight casing for wearability.

6. Deliverables

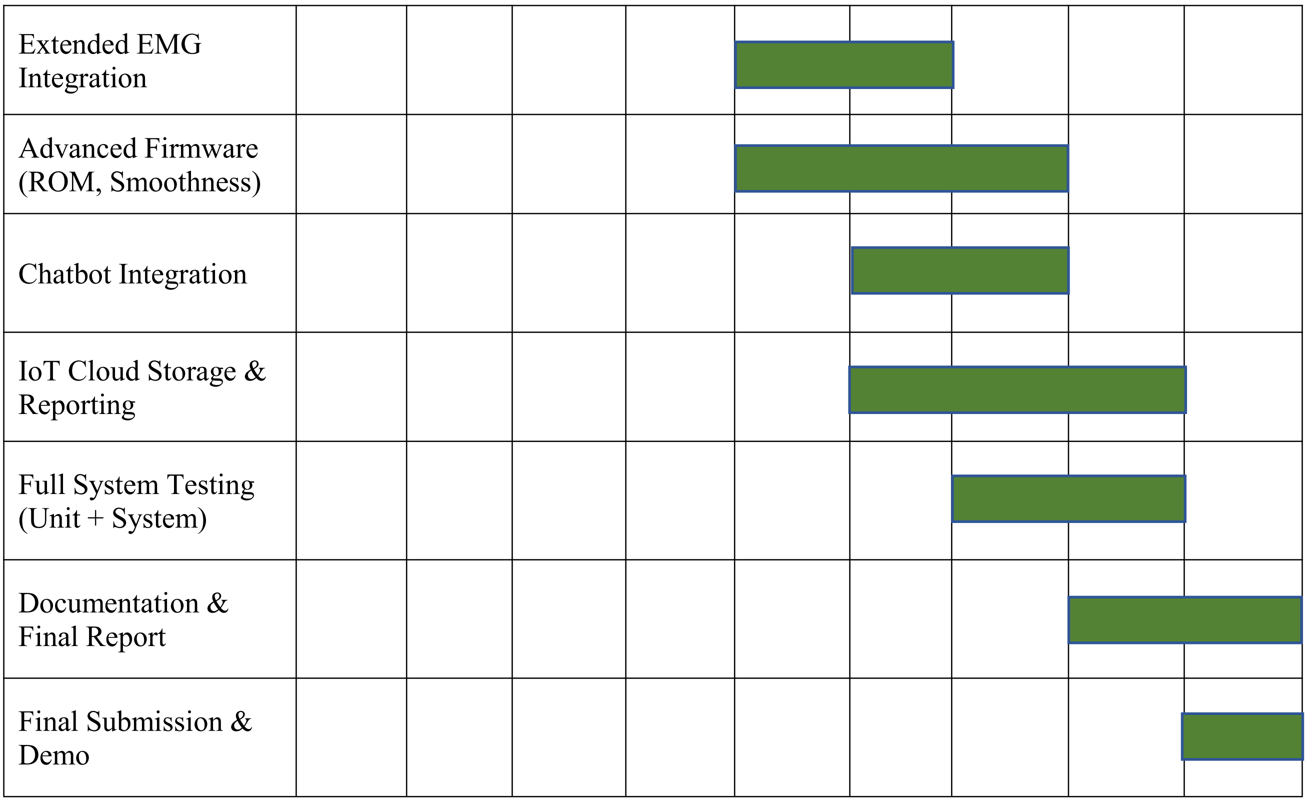
- **Wearable Device Prototype:** A working knee rehabilitation device with sensors to track knee movement.
- **Software Application:** A mobile/web app for patients and physiotherapists to view exercise data and feedback.
- **IoT Connectivity & Cloud Storage:** Data transmission and storage for remote monitoring.
- **Real-Time Feedback System:** Alerts, notifications, and a simple chatbot to guide patients during exercises.
- **Progress Reports & Analytics:** Summarized exercise performance and recovery tracking.
- **Documentation:** Project report, user manual, and technical documentation.

7. SDGs (If Applicable)

☐ No Poverty	☐ Zero Hunger
☒ Good Health and Well-Being	☐Quality Education
☐ Gender Equality	☐ Clean water and Sanitation
☐ Affordable and Clean Energy	☒ Decent Work and Economic growth
☒ Industry, Innovations and Infrastructure	☐ Reduced Inequalities
☐ Sustainable Cities and Communities	☐ Responsible Consumption and Production
☐ Climate action	☐ Life Below Water
☐ Life on Land	☐ Peace, Justice and Strong Institutions
☐ Partnerships	

8. Gantt Chart

Year	2025 to 2026								
Months	Sep’25	Oct’25	Nov’25	Dec’25	Jan’26	Feb’26	Mar’26	Apr’26	May’26
Study rehab exercises & requirements									
System Architecture Design									
Hardware Prototyping (IMU mechanism)									
Firmware Development (ESP32)									
Mobile App (Live Data Dashboard)									



9. Details of Project Team

i. Students

No.	Name	Seat No.	Signature (s)
1	Usman Faizyab Khan	CS-22076	
2	Muhammad Owais	CS-22080	
3	Zuhaib Noor	CS-22081	
4	Muhammad Zunain	CS-22086	

ii. Supervisors / Advisors

	Name	Designation & Department	Address & Contact	Signature(s)
Supervisor	Mr. Muhammad Ali Akhtar	Lecturer at CIS Department		
Co-Supervisor (If any)				
Industrial Advisor (If any)				

For Office Use Only		
Project Serial No.: ___________ Dated: ______________________	Signature Convener Steering Committee	Signature FYP Coordinator

☐ Proposal Approved	☐ Not Approved	☐ Returned for Clarification / Modification
Comments: (if any)		

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(Signature of Chairperson)

Date: ______________________________