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Smart Crutches using IOT

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ABSTRACT: Over the past decade, clinical reasoning in physical therapy has increasingly focused on developing systems that enable physiotherapists to make rapid, effective, and efficient clinical decisions. This evolution is driven by the growing complexity of health and rehabilitation needs. Various studies highlight the significance of walking aids during rehabilitation for certain conditions and post-surgery recovery, particularly arthroplasty and in elderly patients with balance disorders or muscle weakness. Walkers are crucial devices that support the rehabilitation process. Their use is particularly recommended for gait alterations and imbalance due to factors like lower limb surgery or neurodegenerative changes, especially during the early recovery period. This project aims to design a solution for patients using walkers, helping them maintain proper balance. This Smart Walker Tool is equipped with sensors, GPS, and GSM Modules. The sensors embedded in the walker are designed to extract relevant information related to its use during physiotherapy sessions, such as the forces applied to the walker. This device will automatically provide haptic feedback to alert users if they apply excessive pressure on one side. Additionally, it features a fall detection system employing MEMS sensors for automatic detection. If the sensor hits its threshold value, it will automatically send an emergency SMS with the user's current location to their caregivers or doctors. The walker also includes an automatic internal lighting system that adjusts based on the surrounding environment.

KEYWORDS: Rehabilitation centre, neurodegenerative, IOT

I. INTRODUCTION

The World Health Organization (WHO) defines rehabilitation as “a set of interventions designed to optimize functioning and reduce disability in individuals with health conditions, in interaction with their environment.” These interventions enhance wellbeing by addressing various health conditions and their interaction with the environment. Rehabilitation addresses impairments, limitations, and restrictions in various areas, including mobility, vision, and cognition. It also considers personal and environmental factors. Individuals with health conditions or injuries may need rehabilitation throughout their lives. The timing and type of intervention a rehabilitation provider selects depend on several factors: the etiology and severity of the health condition, the prognosis, how the condition affects the person's ability to function, and the individual's personal goals. Rehabilitation services can be delivered in any setting, including hospitals and communities, depending on the individual's needs and circumstances. While this document provides examples of various type styles, some components such as Specific guidelines do not prescribe multi-leveled equations, graphics, and tables. The formatter must create these elements according to the relevant criteria provided.

BACKGROUND

The way you walk is referred to as your gait. Numerous diseases and conditions can impact your gait and cause walking difficulties. These include abnormal development of the muscles or bones in your legs or feet.

Stance phase:

The stance phase, encompassing 60% of the entire gait cycle, involves a portion of the foot maintaining contact with the ground. This phase is then subdivided into five sub-phases.

- Initial contact (heel strike)
- Loading response (foot flat)
- Mid-stance
- Terminal stance (heel off)
- Pre-swing (toe off)

Swing phase:

The swing phase accounts for 40% of the complete gait cycle, where the foot is lifted off the ground, and the bodyweight is supported by the opposite leg and foot. It is further divided into three sub-phases

- Initial swing
- Mid-swing
- Late swing

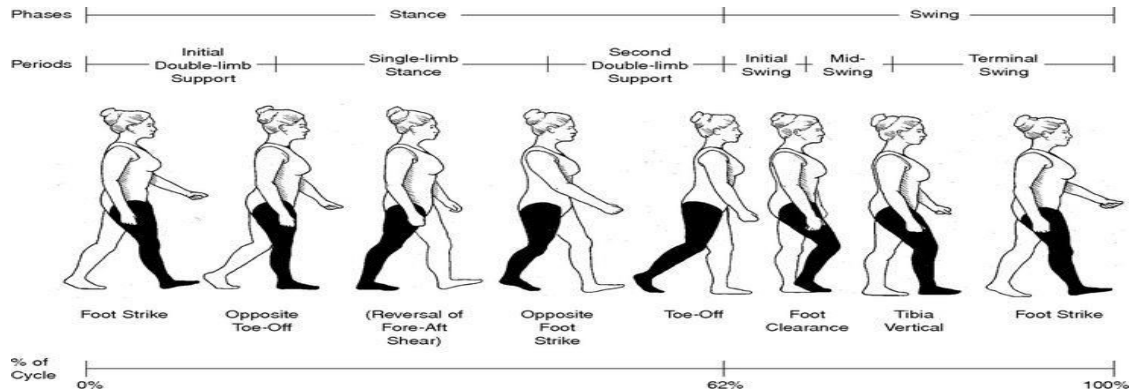


Fig 1: Gait cycle

II. METHODOLOGY

Crutches are essential devices that support the rehabilitation process. They are recommended for addressing gait changes and imbalance caused by such as lower limb surgery or neurodegenerative conditions, especially during the early recovery period. In this project, we designed a solution for patients using walkers, helping them maintain proper balance. This smart crutch tool is equipped with sensors, GPS, and GSM modules. The sensors embedded in the walker gather relevant information about its use during physiotherapy sessions, such as the forces applied to the walker. The device provides haptic feedback to automatically warn users if they apply excessive pressure on one side. Additionally, it includes an automatic fall detection system using MEMS sensors. If the sensor reaches its threshold value, it will automatically send an emergency SMS with the user's current location to caregivers or doctors. The walker also features an automatic internal lighting system that adjusts based on the surrounding environment.

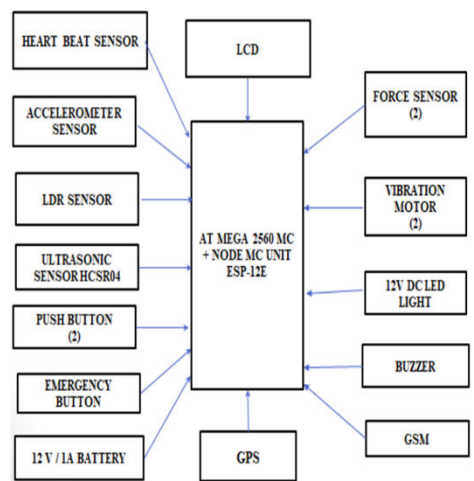


Fig 2: Methodology

HARDWARE COMPONENT

Arduino Uno:

The Arduino UNO uses the ATmega328P microprocessor. It offers a variety of digital and analog I/O pins, which can be expanded by combining extension kits with multiple devices. The board features 14 digital I/O pins and 6 analog I/O pins and is programmable via a type B USB connector using the Arduino IDE.

LDR Sensors:

LDR (Light Dependent Resistor) as the name states is a special type of resistor that works on the photoconductivity principle means that resistance changes according to the intensity of light[6]. Its resistance decreases with an increase in the intensity of light.

Heartbeat sensors:

An optical heart rate sensor detects the pulse wave activity, which are changes in the volume of a blood vessel that occur Pulse waves, generated when the heart pumps blood, are detected by measuring volume changes using an optical sensor and green LED.

GPS(Global positioning system):

The GPS module, integrated into the mainboard of a mobile phone or machine, is a wireless chip that communicates with the global satellite positioning system in the United States. It enables location detection and navigation on the condition of a wireless network signal. A GPS (global positioning system) unit utilizes data from United States satellites to offer precise location information virtually anywhere on Earth. This network of satellites and receiving devices is employed to determine the location of objects on Earth.

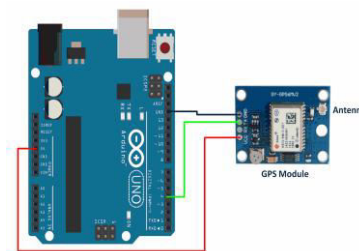


Fig 3: GPS

Buzzers:

An active buzzer sensor module has a built-in oscillation circuit[8], thus the sound frequency is fixed. It can generate the sound itself. So, you can simply turn it on and off with a UNO/Nano pin, just like the way of turning on and off an LED that is connected to the UNO/Nano board.

Vibration sensors:

A vibration sensor is a device that detects mechanical vibrations[9]. It measures the vibration levels in your machine and alerts you to any potential problems, like equipment failure or worn parts that need replacement. Vibration sensors can help improve efficiency and prevent costly downtime by Identifying these issues preemptively..

Bluetooth:

The HC-05 is a class 2 Bluetooth module intended for seamless wireless serial communication. It comes pre-configured as a slave Bluetooth device. Upon pairing with a master Bluetooth device like a PC, smartphone, or tablet, its functionality becomes transparent to the user. Any data received through the serial input is promptly transmitted wirelessly.

Pressure sensors:

A pressure sensor is a device or instrument capable of measuring pressure. In a smart crutch, a pressure sensor is typically configured to detect the force or pressure exerted on the crutch by the user.

LCD(Liquid crystal display):

An LCD (Liquid Crystal Display) is a flat panel display that relies on liquid crystals as its primary mode of operation.

SOFTWARE IMPLEMENTATION

A. Arduino ide:

The Arduino Integrated Development Environment (IDE), also known as Arduino Software (IDE), comprises a text editor for coding, a message area, a text console, a toolbar with commonly used functions, and a series of menus. This IDE simplifies code writing and offline board uploading. It's particularly suitable for users with limited or no internet access. Furthermore, this software is compatible with any Arduino board.

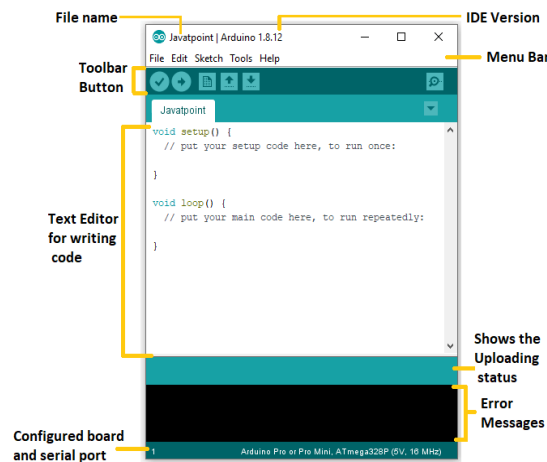


Fig 4: Arduino ide

III. IMPLEMENTATIONS

- Step 1 involves gathering all the necessary components mentioned in the preceding pages for the project.
- Step 2 entails dividing the components into two groups: one for the sensor module and the other for the GPS module.
- Step 3 connects the sensor module to an Arduino UNO, while the GPS module is connected to an Arduino NANO.
- Step 4 involves adding a Bluetooth module to each of the two modules.
- Step 5 consists of writing code and executing it using the Arduino IDE software.
- Step 6 includes checking the output by connecting to a smartphone via Bluetooth HC05, with one of the output displayed on the LCD.

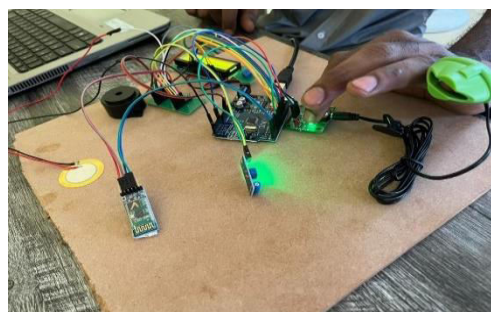


Fig 5: Read-out device

Microelectronic: Arduino Uno, an open-source platform that efficiently collects data from sensors, is cost-effective, facilitates wireless transmission, and enables real-time monitoring and alarms.
Sensor Integration: Integrate sensors relevant to monitoring pregnant women, such as heart rate monitors, temperature sensors, and movement detectors, to gather essential health data.

GSM Module Integration: Incorporate a GSM module for wireless communication, allowing the transmission of collected data to a remote server or designated recipient for monitoring purposes.

Data Transmission Protocol: Choose a data transmission protocol, such as MQTT or HTTP, to securely and efficiently send health data from the monitoring system to the designated destination.

User Interface: Develop a user-friendly interface, such as a web page or mobile app, to enable users to access and interpret monitored data. Implement user authentication for privacy protection.

Testing and Calibration: Conduct comprehensive testing of the entire system to ensure accurate sensor readings, reliable communication, and proper functionality. Calibrate sensors as necessary for precision.

Feedback and Iteration: Solicit feedback from users and healthcare professionals to identify areas for improvement. Continuously refine the system based on feedback to enhance performance and user satisfaction.

IV. RESULT

Real-time Monitoring: IoT sensors embedded in the crutch could monitor various parameters such as pressure exerted on the crutch[13], user's gait patterns, and the angle of the crutch to detect any abnormalities or potential falls.

Data Collection and Analysis: Collected data could be transmitted to a smartphone app or cloud platform for analysis. Machine learning algorithms could analysis the data to offer insights into the user's walking patterns and health status.

Adjustable Settings: IoT connectivity could enable users or healthcare providers to remotely adjust settings, such as crutch height or sensor sensitivity, to enhance comfort and functionality.

Navigation Assistance: Integration with GPS and mapping services could offer navigation assistance, particularly for users with mobility impairments navigating unfamiliar or intricate environments.

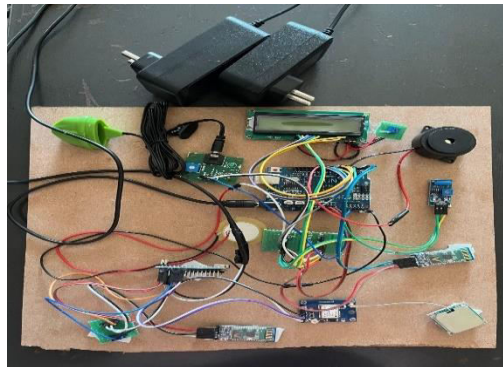


Fig 6: final product

V. CONCLUSION

Smart crutches, leveraging IoT technology, represent a promising advancement in assistive devices for individuals facing mobility challenges. Through the integration of sensors, connectivity, and data analytics, these crutches enable real-time monitoring of user movements, gait patterns, and environmental conditions. This data not only enhances user safety but valuable insights for rehabilitation professionals, facilitating personalized adjustments to optimize comfort and effectiveness. Additionally, features such as pressure sensors, vibration sensors, GPS tracking, and remote monitoring offer additional layers of security and support. While further research and development are necessary to refine usability, accessibility, and affordability, smart crutches hold significant potential to enhance the independence and quality of life for individuals with mobility impairments.

VI. FUTURE SCOPE

The future potential of smart crutches using IoT technology is vast and promising, with several potential advancements and applications:

Advanced Sensor Integration: Future iterations could incorporate more sophisticated sensors to capture additional biomechanical data, including muscle activity, joint angles, and weight distribution. This comprehensive dataset can offer deeper insights into user mobility patterns and facilitate more personalized rehabilitation programs.

Expanded Connectivity: As IoT infrastructure continues to evolve, smart crutches may become integrated into larger networks within smart cities or healthcare ecosystems. Integration with cloud platforms and secure communication protocols can enable seamless data sharing among healthcare professionals, caregivers, and emergency responders, enhancing overall coordination and support for users. 3. Accessibility and Customization: Future advancements may prioritize enhancing the accessibility and customization options for smart crutches. This could include features such as adjustable height settings, interchangeable grips, and personalized user interfaces. By incorporating user feedback and ergonomic design principles, these devices can better meet the diverse needs of individuals with varying abilities.

Health Monitoring and Preventive Care: Smart crutches have the potential to evolve into proactive health monitoring tools. They could detect early signs of fatigue, joint strain, or other musculoskeletal issues. By offering real-time feedback and alerts, these devices can assist users in preventing injuries and managing their conditions more effectively, ultimately promoting long-term mobility and independence.

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