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Research Article

AutoRehab Cycle Plus with Data Logging System

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Abstract: *The AutoRehab Cycle Plus with a data-logging system is an innovative rehabilitation device for patients with limited lower-limb movement. It integrates load cells and data logging to record parameters such as leg pressure, cycling direction, duration, and frequency. Its motor-assisted mechanism enables passive pedaling, thereby supporting movement without voluntary effort. The recorded data are stored in Excel/CSV format for easy analysis and long-term tracking. By providing real-time feedback and objective metrics, the system allows therapists to accurately monitor patient progress. This data-driven approach enhances rehabilitation outcomes, offering a more efficient and patient-centered therapy solution for semi-paralyzed individuals.*

1. INTRODUCTION

The AutoRehab Cycle is an automated rehabilitation exercise bike system designed to assist patients with leg physiotherapy. The upgraded version, AutoRehab Cycle Plus, integrates data logging and force sensor features to enhance patient monitoring and treatment effectiveness. The system uses load cells on the left and right legs to measure the foot pressure before starting a cycling session. These data were then recorded automatically using a data-logging system (Excel format) for further analysis by the therapists. Controlled by an ESP32 microcontroller, the system also included a pulse sensor, Wi-Fi connectivity (Blynk app), and motor control for forward/reverse cycling. With these improvements, the AutoRehab Cycle Plus with the data-logging system provides a modern and practical solution for individuals with complete leg paralysis, supporting their health and recovery more effectively.

2. LITERATURE REVIEW

Jaysrichai (2018) investigated the application of load cell sensors integrated with the HX711 signal conditioning module in the development of a weight-bearing assessment device for rehabilitation purposes. This study highlights the importance of accurately measuring weight-bearing forces during physiotherapy, as controlled and gradual load application is critical for patient recovery and injury prevention. Traditional rehabilitation assessments often rely on visual observation or subjective judgment by therapists, which may lead to inconsistent or inaccurate evaluations of patient progress. The proposed system utilizes load cells to detect the force exerted by patients during rehabilitation exercises, and the HX711 module amplifies and converts the analog signals into digital data for real-time monitoring. This integration allows for precise measurement of the applied force, enabling therapists to track patient compliance with the prescribed weight-bearing limits. This study demonstrated that the load cell–HX711 combination provides high sensitivity, stability, and reliability, making it suitable for continuous rehabilitation monitoring. Furthermore, Jaysrichai (2018) emphasized that real-time feedback enhances patient awareness and encourages correct posture and force application during exercises. These findings suggest that such a system can support objective progress tracking, reduce the risk of overloading injured limbs, and improve the rehabilitation outcomes. Overall, this study contributes to the growing body of work on sensor-based rehabilitation devices by demonstrating a cost-effective and accurate solution for weight-bearing assessment in clinical and home-based physiotherapy settings.

3. METHODOLOGY

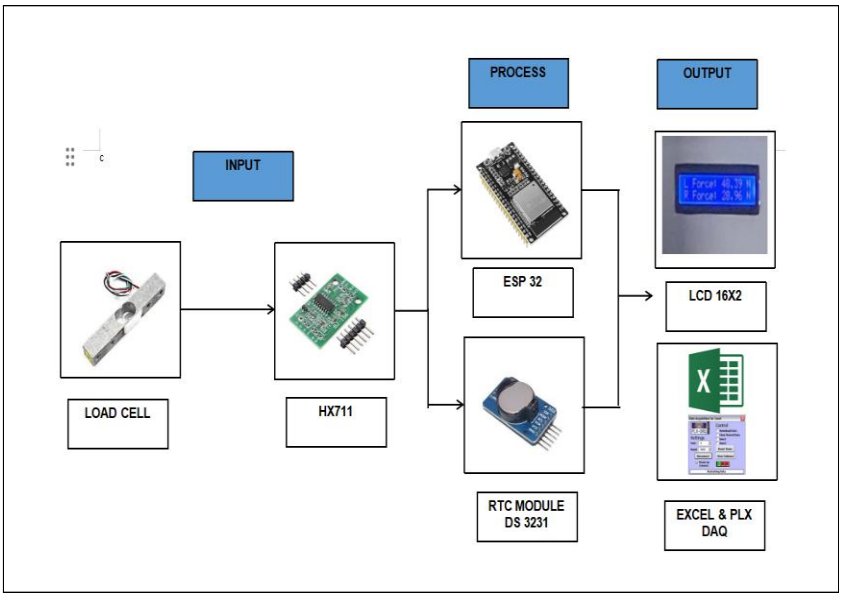


Figure 1 : Block Diagram of Load Cell

In the block diagram shown in Figure 1, a load cell is used to detect the applied pressure, where the changes in resistance are converted into readable signals for the ESP32. The ESP32 functions as the main controller, processing the sensor data and performing multiple tasks at the same time. The processed values were displayed in real time on a 16 × 2 LCD for easy monitoring. Simultaneously, the ESP32 transmitted the data to a computer through serial communication, where the PLX-DAQ tool was used to log the readings directly into Microsoft Excel. This enables systematic data storage, analysis, and graphical representation of measured force values. Thus, the system provides immediate feedback through the LCD display and long-term data recording through Excel integration. As shown in the block diagram in Figure 2, the ESP32 microcontroller operates as the system central processing unit (CPU), receiving input signals from various sources. It interprets commands from the keypad, allowing the user to select the motor direction and input the duration, which is displayed on the LCD screen. In addition, it interfaces with Blynk to offer an alternative control method for the motor. The ESP32 also collected BPM data through an attached sensor and presented the results on an LCD screen. Once the duration is set, the motor is activated accordingly, moving either forward or in the reverse direction as specified.

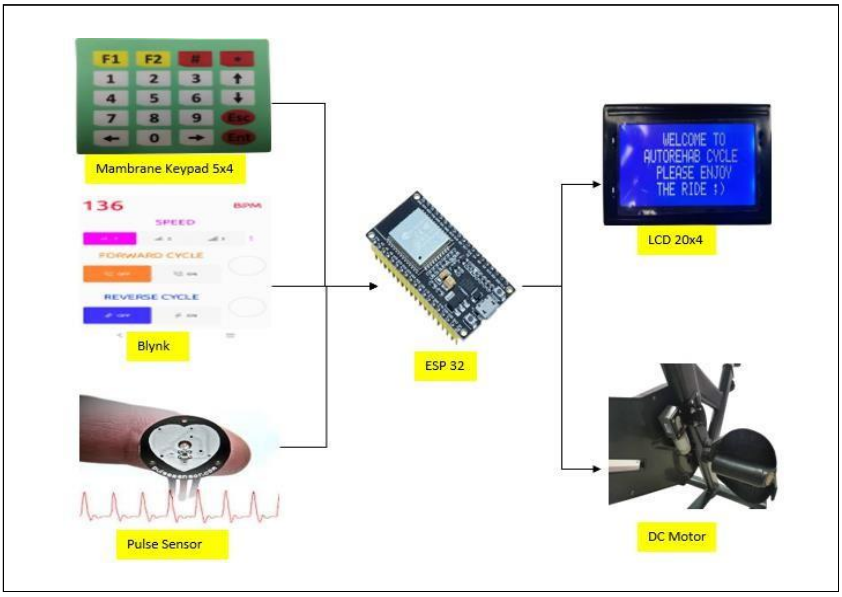


Figure 2 : Block Diagram of AutoRehab Cycle

4. FINDINGS

Although AutoRehab Cycle Plus with the data-logging system improved rehabilitation monitoring, several limitations were identified. The force sensors used may not provide perfectly accurate readings if they are not calibrated properly or if the user's leg placement varies. The data-logging system depends on a computer connection and may face issues with Excel file formatting or storage errors. In addition, the system currently records only basic force data and does not include advanced features, such as heart rate or motion tracking. Future improvements could focus on wireless data transfer, mobile application integration, and more detailed performance analysis to enhance the user experience and reliability.

4.1 Data Logging System

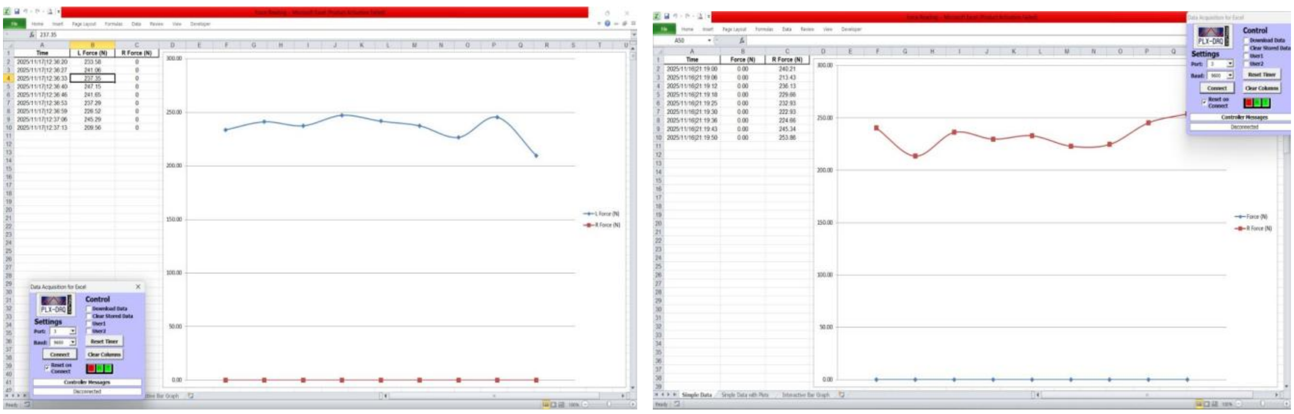
The data-logging system can be upgraded to collect more detailed information about the patient's exercise sessions. It will record the number of times the patient uses the cycle, the duration of forward and reverse pedaling, and the total time spent in each mode of exercise. These additional data will help therapists monitor progress more accurately and provide better analysis for rehabilitation improvement.

4.2 Belting and Motor

The current motor and belting system can be replaced with a high-torque motor to prevent unwanted belt movement when the system is turned off. This change will also improve the smoothness and stability of the cycling motion, thereby reducing the wear and tear on the mechanical parts. A stronger motor enhances the system's durability and makes it more reliable for continuous use in rehabilitation centers.

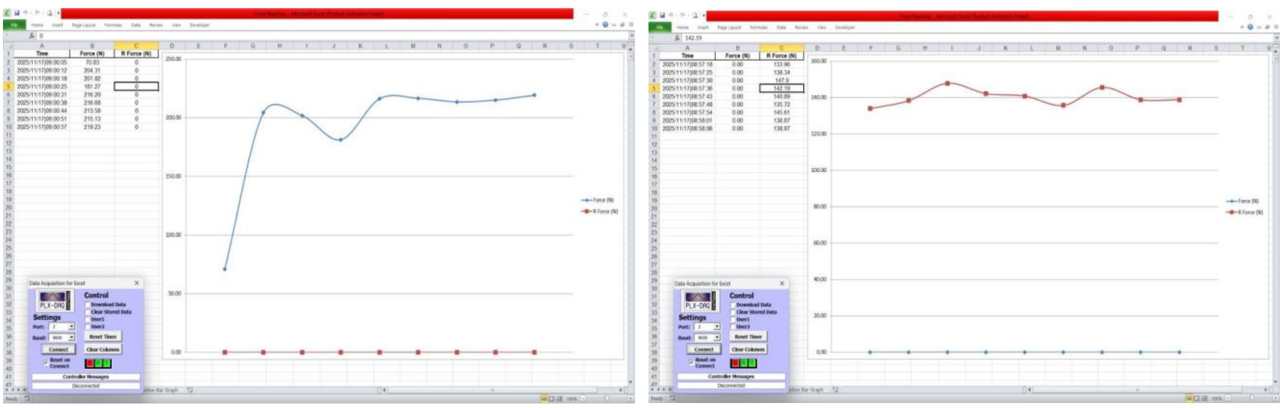
5. DISCUSSION

Figure 3 and 4 show a comparison of the force values in active rehabilitation recorded between a healthy person and a patient who is still in recovery. Active rehabilitation is a process in which the patient or a normal person steps onto the pedal in the stall position and pushes the pedal with his leg using his own energy. Based on data logging, the force readings for the normal and recovering legs were almost the same, at approximately 200 Newtons. However, the right recovering leg shows a lower force of approximately 140 Newtons because it is still weak after the accident and still needs therapy to recover fully. From the force data, it can be concluded that the recovering patient foot pressure is lower than that of a normal person.



a) Left foot b) Right foot

Figure 3: Data Logging of Normal Person in Active Rehabilitation



a) Left foot b) Right foot

Figure 4: Data Logging of Recovery Patient in Active Rehabilitation

6. CONCLUSION

Based on the recorded load cell data, a comparison between a normal individual and a patient in recovery can be clearly observed through the difference in pedaling force. A normal individual can generate more than 200 Newtons of force, indicating strong and fully functional leg muscles. In contrast, a person who is still in the recovery phase produces only approximately 140 Newtons, reflecting lower strength and less consistent pedaling performance. This significant difference proves that load cell measurements are highly effective for assessing performance, distinguishing physical capability levels between the two groups, and objectively monitoring a patient's rehabilitation progress using actual data.

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