IT4010 Research Project – 2025 July

Topic Assessment Form

Project ID : 25-26J-472

1. Topic (12 words max)

Gamified VR-Based Therapy System for Upper Limb Rehabilitation in Children with Hemiplegia

2. Research group the project belongs to

MR - Mixed Reality

3. Specialization of the project belongs to

Software Engineering (SE)

4. If a continuation of a previous project:

Project ID	
Year	

5. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

Hemiplegia is a neurological condition that results in paralysis or severe weakness of one side of the body, most caused by early childhood stroke or cerebral palsy. Children with hemiplegia often experience restricted or uncoordinated movement in their upper limbs, which significantly affects their ability to perform daily activities such as reaching, grasping, and holding. Clinical evidence supports that early and consistent rehabilitation can help restore function through neuroplasticity. However, in practice, access to regular therapy is limited especially in countries like Sri Lanka where therapist availability is scarce, travel for therapy is costly, and adherence is low due to therapy being monotonous or demotivating for children.

Recent research shows gamified rehabilitation, games to validate sensor-based movements, and virtual reality (VR) may be key innovations to increase engagement and improve the accuracy of rehabilitation. Yet, as the research and evidence also show, most systems are only designed for older adults, are generally too expensive, or require complicated robotic hardware and equipment that may only be available through equipment being purchased from overseas. With serious technology and economic barriers, there is a large research and implementation gap to develop an affordable real-time engaged, and child-friendly system specifically for children with unilateral motor deficits (i.e. completed stroke).

This project proposes a low-cost, wearable VR-based therapy system for hemiplegic children, using sensors and machine learning to monitor upper limb movement in real time. It provides corrective feedback through a gamified VR environment, adapts to emotional states, and is designed for affordable use in both clinical and home settings in Sri Lanka.

[1] M. Elsaeh, P. Pudlo, M. Djemai, M. Bouri, A. Thevenon and I. Heymann, "The effects of haptic virtual reality game therapy on brain-motor coordination for children with hemiplegia: A pilot study," 2017 International Conference on Virtual Rehabilitation (ICVR), Montreal, QC, Canada, 2017, pp. 1-6, doi: 10.1109/ICVR.2017.8007472.

[2] K. -L. Liao et al., "A Virtual Reality Serious Game Design for Upper Limb Rehabilitation," 2021 IEEE 9th International Conference on Serious Games and Applications for Health(SeGAH), Dubai, United Arab Emirates, 2021, pp. 1-5,

[3] M. J. Fu, A. Curby, R. Suder, B. Katholi and J. S. Knutson, "Home-Based Functional Electrical Stimulation-Assisted Hand Therapy Video Games for Children With Hemiplegia: Development and Proof-of-Concept," in IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 28, no. 6, pp. 1461-1470, June 2020,

[4] M. Elsaeh, M. Djemai, P. Pudlo, M. Bouri, A. Thevenon and I. Heymann, "Quality and quantity assessment in Home-Based therapy for hemiplegic children," 2018 6th International Conference on Control Engineering & Information Technology (CEIT), Istanbul, Turkey, 2018, pp. 1-7, doi: 10.1109/CEIT.2018.8751812.

[5] Hinchliffe, T. (2017, July 12). Indian Entrepreneur Creates Virtual Rehab Through Physical Therapy Gamification - The Sociable. The Sociable. https://sociable.co/technology/therapy gamification-india/

6. Brief description of the nature of the solution including a conceptual diagram (250 words max)

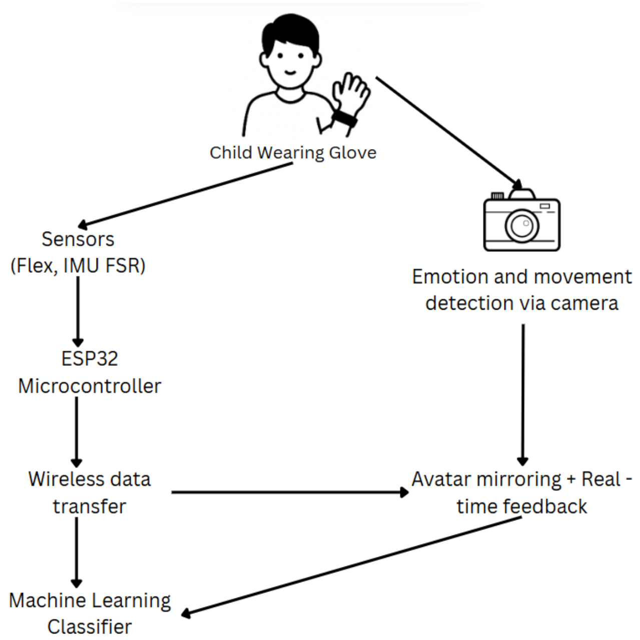
The envisioned solution is a low-cost, sensor-based, gamified rehabilitation technology for upper limb therapy for children with hemiplegia. It incorporates wearable hardware, machine learning algorithms, and a virtual reality (VR) game to deliver real-time feedback, increase engagement, and provide clinically guided motion training.

The wearable device will use flex sensors, IMUs, and FSRs affixed to a glove or armband to register joint angles and movement patterns, and pressure data while performing therapeutic movements. The wearable device sends the data to the local backend server wirelessly via an ESP32 microcontroller as required by the child.

The data will be routed to a machine learning model that classifies movements as correct or compensatory, based on strict physiotherapy criteria. The system will provide immediate visual and auditory feedback within a VR game using Unreal Engine. While participating in a game, the child's physical movements are represented by an avatar movement that encourages proper rehabilitation task completion.

A camera will observe the child's facial expressions and emotional state to further enhance the experience. If any fatigue or frustration is detected by the system, the game can adjust the difficulty or speed to provide motivation

All movement and performance information is stored in a secure database, allowing therapists to access and review progress through remote access or follow-up sessions. The system functions offline and in low-resource environments, which is well suited for delivery to homes, schools, or perhaps rural clinics in Sri Lanka.



7. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

This research spans several interdisciplinary domains, requiring both technical and clinical expertise to ensure the system is effective, safe, and aligned with pediatric rehabilitation goals.

From a biomedical and physiotherapy perspective, domain knowledge is required to define clinically relevant upper limb exercises, understand common compensation patterns in hemiplegic children, and determine motion correctness. Engaging the insights from pediatric physiotherapists or rehabilitation specialists will be invaluable when specifying movement goals, validating movement patterns and planning therapy progressions. The literature on hemiplegia, neuroplasticity and unilateral motor recovery in children will assist in shaping the definitions.

On the technical side, there is a need for expertise on embedded systems and sensor integration. This includes using flex sensors, inertial measurement units (IMUs), and force-sensitive resistors (FSRs) to capture real-time joint and limb data. Understanding how to calibrate and filter analog signals is key for accuracy.

Machine learning knowledge is necessary to build models that can classify movements as correct or compensatory. This involves collecting labeled motion data, extracting features, training models (e.g., LSTM, Random Forest), and evaluating classification accuracy. The model must align with physiotherapy rules to ensure clinical relevance.

Skills in game development and user experience design are essential to build an immersive interactive VR environment using Unreal Engine. The game has features that include avatar control and reward mechanics and feedback loops that are used to help enhance the overall engagement of the users.

Expertise in emotion detection allows the system to interpret facial expressions and adapt gameplay for better motivation. Required data includes motion recordings, labeled movement examples, facial emotion datasets (e.g., FER-2013), and gameplay logs. This supports accurate motion validation and therapist review. The project's success depends on integrating clinical knowledge, sensor hardware skills, machine learning techniques, and user-centered design to deliver a personalized and effective rehabilitation experience for children with hemiplegia.

8. Objectives and Novelty

Main Objective

- Design and build a wearable system to track upper limb motion.
- Collect and label motion data for machine learning.
- Train a machine learning model to classify motion.
- Develop VR-based therapy game with feedback system.
- Integrate emotion detection for adaptive feedback.

Member Name with Registration No	Sub Objective	Tasks	Novelty
Wickramasurendra K.D.A.D IT22115720	Integrate wearable sensors for shoulder movement tracking. Implement VR-based therapy game focused on shoulder exercises. Train ML model on shoulder motion classification. Implement the shoulder related	Research and select appropriate sensors (IMU, flex sensors) for shoulder joints. Design and build hardware integration for shoulder movement tracking (ESP32/Arduino +breadboard+ IMU sensors). (6 Movements) Map sensor data to shoulder motions (abduction, flexion, etc.). Collect shoulder movement data and label it for training.	Real-time shoulder motion tracking using wearable IMU sensors. Adaptive VR game related to the sensor movement in the shoulder and adjust difficulty according to the movement in the shoulder.

	game part in the mirror game which give to identify the upper limb movement	Develop VR-based therapy activities focusing on shoulder mobility (e.g., ball-throwing, lifting objects). Train a machine learning model (e.g., SVM, LSTM) to classify shoulder movements. Add adaptive feedback based on performance and emotion detection input related to the shoulder movements	
Nimesh S.D.S IT22102546	1.Integrate wearable sensors with glove for fingers movement tracking. 2.Implement VR-based therapy game focused on finger exercises. 3.Train ML model on finger motion classification. 4.Implement the fingers related game part in the mirror game which give to identify the	Research and select appropriate sensors (flex sensors) for finger joints. Design and build hardware integration for finger movement tracking (ESP32/Arduino +breadboard+ flex sensors). (Mainly 6 Movements there will be tiny movements with main movements) Map sensor data to finger motions (pinching, gripping, extending) Collect finger movement data and label it for training.	Real-time motion tracking using wearable flex sensors using a glove Adaptive VR game related to the sensor movement in the fingers and adjust difficulty according to the movement in the fingers.

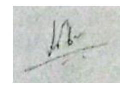
	upper limb movement	Develop VR-based therapy activities focusing on finger mobility (e.g., piano, object grasping). Train a machine learning model (e.g., SVM, LSTM) to classify finger movements. Add adaptive feedback based on performance and emotion detection input related to the elbow movements.	
Weerasinghe D.N.T IT22119230	1.Integrate wearable sensors for elbow movement tracking. 2.Implement VR-based therapy game focused on elbow based exercises. 3.Train ML model on elbow motion classification. 4.Implement the elbow related game part in the mirror game which give first to identify	Research and select appropriate sensors (IMU sensors, Flex sensors) for elbow joints. Design and build hardware integration for elbow movement tracking (ESP32/Arduino +breadboard+ imu sensors). (2 Movements) Map sensor data to elbow motions e.g., flexion, extension). Collect elbow movement data and label it for training. Develop VR-based therapy activities focusing on elbow mobility (e.g Fruit Slicer).	Real-time motion tracking using wearable flex sensors using a glove Adaptive VR game related to the sensor movement in the elbow and adjust difficulty according to the movement in the elbow.

	the upper limb movement	Train a machine learning model (e.g., SVM, LSTM) to classify elbow movements. Add adaptive feedback based on performance and emotion detection input related to the elbow movements.	
Siyambalapitiya S.V.A.P.B IT22557292	1.Integrate wearable sensors for wrist movement tracking. 2.Implement VR-based therapy game focused on wrist-based exercises. 3.Train ML model on wrist motion classification. 4.Implement the wrist related game part in the mirror game which give first to identify the upper limb movement	Research and select appropriate sensors (IMU sensors, Flex sensors) for wrist joints. Design and build hardware integration for wrist movement tracking (ESP32/Arduino +breadboard+ imu sensors). (4 Movements) Map sensor data to wrist motions e.g., flexion, extension). Collect wrist movement data and label it for training. Develop VR-based therapy activities focusing on wrist mobility (e.g catch fish). Train a machine learning model (e.g., SVM, LSTM) to classify wrist movements.	Adaptive VR game related to the sensor movement in the wrist and adjust difficulty according to the movement in the wrist.

9. Individual component description of how it is complied with the specialization.

Member Name with Registration No	Description
Wickramasurendra K.D.A.D IT22115720	This component involves the development of a wearable system to track shoulder movements using IMU sensors and embedded hardware. The solution applies Software Engineering principles through modular system design, sensor integration, and software testing. Motion data is processed and classified using supervised machine learning models like LSTM, aligning with AI & ML. The collected data flows into a VR game interface that visually mirrors the user's motion, meeting visualization and UI feedback objectives. The system design reflects architectural thinking and real-time feedback mechanisms, complying with RAAD and ADD aspects.
Nimesh S.D.S IT22102546	This component focuses on integrating flex sensors into a wearable glove to detect finger movements. The system supports real-time motion tracking and gamified therapy through a VR game built in Unreal Engine. The project involves the design and deployment of embedded systems and Software Engineering goals. Finger movement data is classified using ML models, satisfying AI & ML and ADD domains. The mirror-game visuals give real-time feedback to users, addressing the need for engaging and accurate visualizations, and modularity in system design meets RAAD criteria.
Weerasinghe D.N.T IT22119230	This component addresses elbow movement tracking using IMU sensors, integrated into a VR-based rehabilitation game. The component includes software-hardware integration, real-time data streaming, and emotion-adaptive feedback, reflecting SE best practices. ML models, such as LSTM, are trained to classify elbow motions, aligning with AI and ML, as well as Algorithm Design and Dev (ADD). The elbow motion is visualized through therapeutic VR games (e.g., Fruit Slicer), meeting visual feedback requirements. System architecture, including data flow and user interaction design, demonstrates compliance with RAAD.
Siyambalapitiya S.V.A.P.B IT22557292	This component develops the wrist tracking module using wearable sensors and real-time data processing. It is integrated with a VR therapy game that adapts based on the user's wrist motion and emotional state. The component covers Software Engineering through modular development, testing, and documentation. ML models are trained on wrist movement data, fulfilling AI & ML and ADD areas. Game-based visualization delivers immediate feedback to users on wrist movement quality, while the system's architecture supports seamless integration of sensor data and user interface, satisfying RAAD.

10. Supervisor details

	Title	First Name	Last Name	Signature
Supervisor	Mr	Didula	Thanaweera Arachchi	
Co-Supervisor	Mr	Eishan	Dinuka	
External Supervisor	Dr	Buddhika	Senevirathne	

Summary of external supervisor's (if any) experience and expertise

Head of Physiotherapy (Pediatric) and Rehabilitation , Sirimawo Bandaranaike Specialized Children's Hospital, Kandy, Sri Lanka.

Dedicated Head of Pediatric Physical Therapy with 15 years of clinical and teaching experience, specializing in pediatric neuro-disabilities. SLMC (SL) and HCPC (UK) registered. Expertise in early diagnosis, intervention, and rehabilitation services.

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IT4010 Research Project – 2025 July

Topic Assessment Form

This part is to be filled by the Topic Screening Staff members.

a) Does the chosen research topic possess a comprehensive scope suitable for a final-year project?

Yes	✓	No	

b) Does the proposed topic exhibit novelty?

Yes	✓	No	

c) Do you believe they have the capability to successfully execute the proposed project?

Yes	✓	No	

d) Do the proposed sub-objectives reflect the students' areas of specialization?

Yes	✓	No	

e) Supervisor's Evaluation and Recommendation for the Research topic:

Project recommended.

Topic Assessment Form

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	
Topic Assessment Accepted with minor changes*	
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

Staff Member's Name	Signature

*Important:

1. According to the comments given by the evaluator, make the necessary modifications and get the approval by the **Evaluator**.
2. If the project topic is rejected, identify a new topic, and request the RP Team for a new topic assessment.