**Msc conversion computer science HCI project proposal**

Project title: Virtual reality (VR) rehabilitation/training system with haptic feedback and motion tracking for developing touch sense and motor control

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Project category/topic:

* HCI

Project aim:

* This project aims to create an immersive VR environment where individuals with neurological conditions can engage in controlled motor movements, while receiving tactile feedback through haptic devices and have their motion tracked for progress monitoring. By incorporating haptic feedback and motion tracking, the system provides a realistic and interactive rehabilitation experience, promoting motor skill improvement, sensory perception enhancement and overall rehabilitation outcomes. The overall goal is to contribute to the field of neurorehabilitation by utilising virtual reality and haptic technology to facilitate rehabilitation of motor control and developing a touch sense.
* The HCI content of this project will include designing a user-friendly interface, implementing interaction techniques through haptic devices while monitoring movement patters of the participating individuals, and making sure the haptic feedback provides real time information to the user.
* Finally, as this project will be simulating exercises in VR, the exercises can be adapted to the user based on their (Ranzani *et al.*, 2020)individual needs, preferences, and abilities.

Related work:

* “Sensorimotor Training in Virtual Reality: A Review” (Adamovich *et al.*, 2009)
* “Haptics to improve task performance in people with disabilities: A review of previous studies and a guide to future research with children with disabilities” (Jafari, Adams and Tavakoli, 2016)
* “Haptic wearables as sensory replacement, sensory augmentation and trainer – a review” (Shull and Damian, 2015)
* “Effects of visual–haptic asynchronies and loading–unloading movements on compliance perception” (Di Luca *et al.*, 2011)
* Anything (Piggott, Wagner and Ziat, 2016)

Project objective/deliverables:

* Develop a user-friendly VR environment including exercises and materials which target aspects of motor control and coordination, that can measure movement accuracy of users performing the exercises
* Develop an adaptive difficulty adjustment mechanism by implementing algorithms that adjusts the difficulty of exercises performed in VR using the haptic device. This is allow tracking of progress and maintain an optimal challenge level for users to promote rehabilitation and skill development
* Design a feedback system that which can evaluate the impact of haptic feedback on motor skill improvement (may be theoretical)
* Implement a motion tracking system that captures users gestures and movements. Develop and optimise algorithms that can analyse motion data which can monitor the accuracy of movements.
* Create virtual objects with varying textures, shapes and resistance, potentially sculpting exercises, where participants can interact with these virtual objects using the haptic feedback system. Use these objects to analyse the impact of virtual object properties on the development of the users sense of touch
* Evaluate the accuracy and realism of the haptic feedback. This may require use of specialised equipment to quantify force output and comparing this to the intended feedback. This will also increase the realism of the VR materials and objects so the human computer interaction becomes more realistic
* Develop a calibration mechanism for haptic device. This will ensure accurate and consistent haptic feedback. This can be done by evaluating the correspondence between the desired haptic dieback and the actual perceived sensations
* Validate the system with clinical populations, e.g, will participants have specific neurological conditions and can the system be tailored to their specific needs and challenges.
* These objectives collectively cover crucial aspects such as usability, adaptation, feedback, evaluation, motion tracking, sensory development, accuracy, calibration and clinical validation which means a comprehensive and effective VR based rehabilitation system can be developed to achieve the aims of this project
* Use of EEG to provide additional insights into the cognitive and neurological aspects of rehabilitation???

Methodologies:

* User-centred design and iterative development
  + Approach:
    - neurorehabilitation and motor control deficiency research to understand the requirements and challenges of rehabilitation
    - Apply specific user design to develop prototype of VR rehabilitation system with exercises
    - Gather feedback to improve user interface design and enhance the overall user experience
    - Iterate on the design based on feedback, making refinements and making necessary adjustments
  + Contribution:
    - This will ensure the system is user friendly as it will be more intuitive and effective
  + Feeds into:
    - Feedback gathered will influence exercise design, system optimisation allowing for a more refined user-friendly VR rehabilitation system
* Exercise design and progress monitoring
  + Approach:
    - Design a range of VR exercises with varying difficulties, incorporating virtual objects and targets relevant to motor control, coordination and touch development
    - Implement a progress monitoring mechanism (e.g scoring system) to objectively measure participants performance
    - Integrate adaptive algorithms that adjust difficulty of exercises to maintain an optimal challenge level to promote skill development and rehabilitation progress
  + Contribution
    - Provides challenging and engaging exercises tailored to individual needs in VR. Also allows for personalised and adaptive training through difficulty adjustment
  + Feeds into:
    - Exercise design and progress monitoring feeds into outcome evaluation, exercise effectiveness and rehabilitation outcomes
* Sensory feedback integration and evaluation
  + Approach:
    - Integrate haptic feedback mechanisms into the VR system to provide users with a sense of touch and realistic interactions with virtual objects
    - Design a feedback evaluation system that assesses the impact of haptic feedback on motor skill development
    - Gather subjective feedback and evaluate the perceived effectiveness and realism of the haptic feedback
  + Contribution:
    - This approach contributes to enhancing the VR rehabilitation system by providing realistic sensory feedback, promoting engagement, and potentially facilitating motor skill improvement
  + Feeds into:
    - This will feed into system optimisation, adjustments to haptic feedback mechanisms to allow continuous refinement and improvement of the system experience
* Motion tracking and accuracy analysis
  + Approach
    - Implement a motion tracking system to capture users gestures and movements accurately
    - Develop and optimise algorithms to analyse motion data, enabling the assessment of movement accuracy and precision
  + Contribution:
    - This contributes to assessing users motor control and coordination by analysing their movements with the VR environment. It provides measurements of movement accuracy, aiding in evaluating the effectiveness of the rehabilitation exercises and tracking users progress
  + Feeds into:
    - This allows for continuous improvement and optimisation of the systems accuracy and effectiveness.

Project plan:

* Feasibility:
  + With 10 months of computer science experience, including programming in Java and C++, and a background in biology with a BSc degree, I possess a strong foundation in both technical skills and understanding of human physiology. This interdisciplinary knowledge equips me with the ability to comprehend the complexities of the project at the intersection of computer science and rehabilitation. Additionally, having access to a lab equipped with haptic devices and virtual reality technology provides the necessary resources for developing and testing the VR rehabilitation system. Attending a VR workshop will further enhance my understanding of the fundamentals of VR, enabling me to leverage Unity and the Force Dimension SDK effectively. With these skills, expertise, and available resources, I am confident in my ability to complete the project within the designated time frame and deliver a comprehensive and functional VR rehabilitation solution.
* Resources:
* Gantt chart + explanation:
  + I am unsure as to how long is realistic for each task will take so I am unable to develop a gantt chart

Risks and contingency plan:

* The integration of haptic devices, motion tracking systems, can present technical complexities. Ensuring these components are synchronised may require thorough testing and troubleshooting
  + Allocate sufficient time for testing components individually before integration. Seek support if technical challenges that arise are a struggle to solve
* Time constraints: with only 2-3 months, I am unsure on what is realistic to achieve with little knowledge of how long tasks will take to complete
  + Break down the project into smaller milestones, and make sure the design of the project is realistic for the dedicated time frame

Hardware/software resources:

* Software such as unity and force feedback sdk are required and I have access to these
* Haptic devices are required and I have access to these

Data:

* No data sets are required

References:

Adamovich, S.V. *et al.* (2009) ‘Sensorimotor Training in Virtual Reality: A Review’, *NeuroRehabilitation*, 25(1), p. 29. Available at: https://doi.org/10.3233/NRE-2009-0497.

Di Luca, M. *et al.* (2011) ‘Effects of visual–haptic asynchronies and loading–unloading movements on compliance perception’, *Brain Research Bulletin*, 85(5), pp. 245–259. Available at: https://doi.org/10.1016/j.brainresbull.2010.02.009.

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Ranzani, R. *et al.* (2020) ‘Neurocognitive robot-assisted rehabilitation of hand function: a randomized control trial on motor recovery in subacute stroke’, *Journal of Neuroengineering and Rehabilitation*, 17(1), p. 115. Available at: https://doi.org/10.1186/s12984-020-00746-7.

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