Hypothesis or Research Question(s): In this study, we will test whether delivery of our gamified rehab program in the late subacute stage after stroke stimulates recovery of arm function in the long-term. Specifically we will test a semi-immersive virtual reality game to determine whether it can stimulate improved paretic arm range of motion after stroke.

PROJECT BACKGROUND & SUMMARY

The proposed interdisciplinary project spans the fields of artificial intelligence (AI), Neuroscience, and Engineering, with a focus on mapping how movements change as individuals learn a new motor skill. Importantly this approach will enable the mapping of movement associated with recovery from stroke in real world environments as well as during gamified rehabilitation. The use of AI is important to this line of research as it enables rapid data analyses of both arm kinematics and change associated with learning and recovery after stroke. In this work we aim to map abnormal movements without the use of a purpose-built motion capture lab. Thus, this approach will allow mapping of movement in natural environments that span from the hospital to the home environment. Investigating the neural underpinnings of motor learning is crucial to understanding human movement. However, brain data is non-interpretable without accurate behavioural information to contextualize it. To understand the brain, it is vital to gather kinematic data (e.g., movement displacement, velocity, acceleration and rotation) to characterize the complexity of movements and changes in movement behaviours. Kinematic variables are traditionally mapped with motion capture systems. Current research grade motion capture systems are cumbersome and expensive, often lack the sensitivity to capture small movements of the hand or individual fingers, and are labor intensive, requiring extensive post-processing. MediaPipe and DeepLabcut are two different open-source 3D markerless motion capture systems that uses AI and neural networks for pose estimation and movement tracking. This new technology can be used to map accurate kinematic movement data through inexpensive means with less effort as compared to traditional marker-based motion capture systems. It also can be deployed in any environment where video capture can occur. In past work we established data processing and analysis pipelines for human motor learning data with DeepLabCut; we are currently working to do the same with MediaPipe. In the current proposal we seek to extend this work to determine which is the optimal method for mapping movement after stroke as well as how well this data integrates with our motor learning analyses.

Deliverables of the proposed project include:

1. Create integrated, user-friendly interface between motion capture systems and our newly redesigned gamified rehabilitation task.
2. Assess the two approaches to determine which optimally discriminates task related movements in individuals with stroke. We will integrate video data of individuals with stroke as they play our gamified rehab task with time based data that characterizes motor learning. Our existing data processing pipelines will characterize motion in individuals with stroke. We will determine if the data can accurately map the relationships between change in motor learning and arm kinematics during our gamified rehabilitation task. The results of this project will enable behaviour to be captured in a wide range of Neuroscience studies, improving our ability to study brain-behaviour relationships.

BENEFIT TO THE STUDENTS

Students involved in this project will be exposed to a program of highly inter-disciplinary research spanning from basic to applied science. They will gain specific skills related to study design, data collection of motor neuroscience studies, script-based analyses, and data interpretation derived from machine learning technology. Importantly they will learn to translate their work into a real world setting and to generate and process data from individuals with stroke. Finally, they will learn to work in an integrated team that crosses disciplinary boundaries and levels of training. The students will collaborate and meet regularly (on a weekly basis) with project supervisors, the graduate student advisor, and other graduate student trainees on the research team. At the outset of the project, supervisors will provide the students with a reading list of previous research and evidence that has been used to develop the rationale for this study, ensuring they are oriented to the field. The students will be mentored on effective oral and written scientific communication and will have the opportunity to practice these skills when presenting their work to the research team during lab meetings. A monthly journal club will be led by the students where they can share their knowledge with other members of the supervisors' labs. Because the proposed work spans both UBC campuses the students in this project will have the opportunity to work in either setting. Lastly, students will be able to engage in knowledge dissemination activities, including presenting their work at scientific meetings, and manuscripts prepared for publication.

Working with markerless motion capture systems and our gamified rehab task requires key skills that are transferable to many other research projects. These include knowledge of the programming language Python, and a basic understanding of working with data to be provided to machine learning models. The students selected for the project will be trained in these two areas. They will learn the basics of Python (if they are not already familiar with computer programming) and will learn about training and testing the machine learning neural network. With this training, the students will be responsible for integrating the kinematic data processing pipeline with data that characterizes movements from people with stroke. Critically, the students will develop code to integrate the two data collection systems in real time and subsequently assess the resulting outputs.

The ability of this process to simultaneously capture movement and response time data associated with both normal and pathological movements will be evaluated. Students will be mentored on how to develop key outcome measures for evaluating a machine learning model and kinematic data, giving them an opportunity to integrate data analysis in the fields of AI and motor learning. To characterize movement behaviours from the neural network the students will learn probabilistic methods, such as principal component analysis. These methods are important when working with large amounts of data and it is important that research trainees become familiar with these analyses early.

It is expected that initial training to become familiar with the gamified rehab task and kinematic mapping approaches will take 2-3 weeks for the students. Data collection and integration across the two platforms will take 4 weeks. Refining the acquisition and processing pipelines, and evaluation of outputs will take an additional 4 weeks. The created pipeline will then be used to characterise a range of simple and complex upper limb movements associated with motor learning over the remaining 4 weeks.

Ultimately, over the 16-week period, the students will integrate the two systems and create a full data processing pipeline for human movement using a gamified rehab task and motion capture. The students will be provided training for the necessary skills to integrate the data collection systems, create the pipeline, conduct an evaluation on the pipeline, and use the generated kinematic data to depict motor learning in healthy human subjects and individuals with stroke. The skill-set gained by students during this work is applicable to a wide range of future projects, and in high demand in a number of professions, including academia, and private sector (i.e., data analysts, technology start-ups, film and marketing agencies).