**Provisional title**: The Development and Comparison of Impedance and Admittance Control Strategies for a 2 Degree of Freedom Planar Rehabilitation Robot.

**Statement of Research Question**: Much work has been done in the area of rehabilitation robotics over the last 30 years, including the development of control strategies. Is there any clinical benefit in the use of one control strategy over another? Is there any clinical benefit to using a more complicated control scheme vs a less complicated control scheme?

**Research Proposal (max 2 pages)**:

Objectives:

1. To develop an Admittance Control Scheme for the MyPAM.
2. To develop an Impedance Control Scheme for the MyPAM.
3. To compare the effectiveness of the Control Schemes.

A great amount of research has been done in the area of rehabilitation robotics over the last 30 years, including at the University of Leeds. Various control strategies have been developed. The most promising of these strategies are Admittance Control and Impedance Control, which are different methods to control the interaction forces (Maciejasz et el, 2014) at the end effector rather than just controlling position or force of the robot itself. The main benefit of these 2 control approaches is that patient safety is ensured, since by controlling the interaction forces it is possible to prevent dangerous contact with the patient.

The myPAM (formerly hCAAR) is a 2 degree of freedom planar device design to aid in the rehabilitation of Stroke patients. The patient moves the end effector of the device while completing reaching tasks, where visual feedback is provided by a computer game showing on a screen (Sivan et al, 2014). The device is able to provide varying levels of assistance. This is inline with current research, which demonstrates that neurofunctional plasticity post-Stroke is provoked by intensive and repetitive exercise. Whilst not fully understood, evidence shows that increased levels of rehabilitation correspond with increased motor control of the targeted muscle groups.

The myPAM currently uses only position control to provide movement assistance. The benefit of this is that the sensors required for this are relatively inexpensive. This helps to achieve one of the main goals of the myPAM, which is to produce a cost-effective device suitable for home use. The disadvantage of this control scheme is that there is no mechanism to account for the interaction forces with the patient at the end-effector, and so dangerous forces may be produced which could be damaging or painful for the patient.

The aim of this research is to ascertain whether there is any clinical benefit to using a more complicated control scheme (which accounts for masses and inertias) compared with using a simple control scheme (and further, to compare the costs and benefits of using an Admittance control strategy or an Impedance control strategy), as suggested by Marchal-Crespo and Reinkensmeyer (2009). This will involve the simulation, development, implementation and testing of a simple Admittance control scheme, a complex Admittance control scheme, a simple Impedance control scheme and a complex Impedance control scheme. In order to achieve this, a low-cost force sensor must be developed which is capable of being fitted to the end effector, and low-cost torque sensors must be developed which are capable of being fitted to each powered joint. A statistical analysis will be carried out to compare and contrast the results of testing each control scheme, to ascertain whether there is any benefit of one control strategy over another and whether adding complexity increases motor learning.

**High-Level Outline/Plan for the next 3 years**:

Year 1:

* Perform a literature review.
* Design a ‘Simple as Possible’ Admittance controller.
* Design a low-cost force sensor for the end effector.
* Simulate the ‘Simple as Possible’ Admittance controller.
* Test the ‘Simple as Possible’ Admittance controller.
* Design a ‘Simple as Possible’ Impedance controller.
* Design a low-cost torque sensor for the joints.
* Simulate the ‘Simple as Possible’ Impedance controller.
* Test the ‘Simple as Possible’ Impedance controller.

Year 2:

* Characterise the dynamics of the system.
* Design a complex Admittance controller.
* Simulate the complex Admittance controller.
* Test the complex Admittance controller.
* Design a complex Impedance controller.
* Simulate the complex impedance controller.
* Test the complex Impedance controller.

Year 3:

* Finish all tests.
* Perform statistical analysis
* Write thesis.

**References**

* Marchal-Crespo, L. and Reinkensmeyer, D.J., 2009. Review of control strategies for robotic movement training after neurologic injury. *Journal of neuroengineering and rehabilitation*, *6*(1), p.20.
* Sivan, M., Gallagher, J., Makower, S., Keeling, D., Bhakta, B., O’Connor, R.J. and Levesley, M., 2014. Home-based Computer Assisted Arm Rehabilitation (hCAAR) robotic device for upper limb exercise after stroke: results of a feasibility study in home setting. *Journal of neuroengineering and rehabilitation*, *11*(1), p.163.
* Maciejasz, P., Eschweiler, J., Gerlach-Hahn, K., Jansen-Troy, A. and Leonhardt, S., 2014. A survey on robotic devices for upper limb rehabilitation. *Journal of neuroengineering and rehabilitation*, *11*(1), p.3.