**Script**

Slide 1 – introduction

Hello. My name is Adam Metcalf. I am a Mechanical Engineer and a PhD student working on the MyPAM project. I was lucky enough to be awarded an Undergraduate Research and Leadership Scholarship during the first year of my undergraduate studies, which allowed me to spend 2 summers performing research here at Leeds. This is when I first became involved with the MyPAM project. MyPAM is a low-cost robotic rehabilitation device intended for home installation.

Slide 2 – First year of Scholarship research

During my first summer of research with the Undergraduate Research and Leadership Scholarship I developed a passive version of the MyPAM, which was designed solely for data acquisition. This included designing the hardware, optimising the internal components and programming the data acquisition system. The project introduced me to some of the maths involved with robotics, and the programming skills I acquired helped to secure an industrial placement with a prestigious global data acquisition company. This really set me up for success in the future. The project was my first taste of real research, and it was the beginning of my aspirations to do a PhD and work in the field of robotics.

Slide 3 – Second year of Scholarship research

During my second summer of research with the Undergraduate Research and Leadership Scholarship I developed a proof of concept facial recognition login system, which was intended to be integrated into MyPAM, utilising the Microsoft Azure services. One of the anticipated issues of a home-based rehabilitation robot, especially one that uses computer games, is that lots of people would want to have a go. It is, after all, novel to lots of people. The issue with this is that for a home-based system, we want to stream the data for review by physiotherapists to track patient progress, so it is important to know who has produced the data. With a facial recognition login system, we would be able to separate ‘guest’ data from patient data, and more accurately track patient progress. The intention is to incorporate some form of facial recognition login system to the final MyPAM

Slide 4 – Current state of MyPAM

As previously/will be demonstrated, the MyPAM is a planar device, which means that it moves only in 2 dimensions. It is designed to be a cost-effective solution for rehabilitation robotics. This is important because whilst there are similar commercial systems, they cost in excess of $100 000 and are only suitable for clinical use.

The assistance provided by the MyPAM relies on a position error, which means that more power is provided to the motors when the current position of the handle is further away from the target position of the handle, and less power is provided to the motors when the current position is closer to the target position. Whilst this is a standard control scheme industrially, clinically it is potentially uncomfortable for a severely debilitated patient. A better solution would take into account interaction forces between the patient and the robot, to ensure that these interaction forces are comfortable. It is the aim of my PhD to implement a number of improved control schemes and to compare their effectiveness.

Slide 5 – Controller design 1 – Admittance

One such improved control scheme, and the current focus of my work, is known as an Admittance control scheme. An Admittance control scheme also relies on a position error where more power is provided to the motors when the current position is further away from the target position, but there is an important addition to this. The target position is modified depending on the interaction force between the handle and the patient.

The benefit of implementing an Admittance control scheme is that it is not necessary to have an accurate dynamic model (which can be difficult, especially when trying to account for friction), but robust position control is required to prevent controller instability.

Slide 6 – Controller design 2 – Impedance

Another improved control scheme is known as Impedance control. This is a control scheme which is less intuitive to understand. Impedance control is based on a force control scheme, where the output forces of the robot vary depending on a force error (again, the greater the difference between the current force and the target force, the greater the power provided to the motors). The target force is modified depending on the position of the robot. Implementing an Impedance control scheme will be my next task, once the Admittance control scheme is complete.

The benefit of implementing an Impedance control scheme for the MyPAM is that it lends itself to controlling electric motors, since there is an established relationship between torque and input current. The disadvantage is that an accurate dynamic model is required to prevent controller instability.

Slide 7 – Control scheme comparison and Future work

Once the 2 control schemes have been developed, more complicated Admittance and Impedance control schemes will be developed which will use a model of the MyPAM to counteract any inertial effects. The idea here is to determine whether there is any noticeable benefit to using more complicated control schemes over less complicated control schemes. Other work involves creating and testing trajectory generation code, as well as ensuring good communication between the game and the MyPAM robot.

Slide 8 – Force Sensor

Both the Admittance control scheme and the Impedance control scheme require a measure of the interaction forces between the patient and the handle of the MyPAM. Since the MyPAM is a planar device, it is necessary to measure the force in 2 directions (otherwise known as 2 degrees of freedom): The X-direction and the Y-direction. Reliable multi degree of freedom force sensors can cost thousands of pounds, which is not feasible considering the design parameters of the MyPAM. This means that it is necessary to create a bespoke force sensor, for which progress is well under way. The chosen design utilises research that was done here at Leeds by a different research group.

The integrated handle/force sensor assembly will consist of a rigid aluminium tube with magnetic sensors placed flush to the outer face. This will be surrounded by a silicon sleeve. Around the silicon sleeve will be placed a larger aluminium tube with strong magnets placed in line with the magnetic sensors. When a force is applied to the handle by the patient, the outer tube will displace relative to the inner tube by a distance determined by the stiffness of the silicon sleeve. This means that distance between the magnets and the magnetic sensors will change, from which a force can be determined. The assembly will cost around £20, a far cry from the thousands of pounds that an industrial sensor would cost. I’m currently pretty excited about this part of the research because it feels like an intuitive and elegant solution, but also because I love messing with electronics!

Slide 8 - Outro

Thanks for your time, and if you have any questions please feel free to find me during the event.