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Developing Effective Intelligent Assistance for the Powered Wheelchair User.

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1. Overview

This research is working towards developing a pre-production prototype system which can provide a low-cost real-time adjustable and adaptable driving assistance system for powered wheelchair users. Currently we are seeking to obtain information from user joystick input and their driving quality to identify symptoms and make adjustments to the driving assistance system.

2. Background

Our state of the art, proof-of-concept prototype platform has evolved over two European funded projects, starting with SYSIASS [1] in 2010 and followed by COALAS in 2012 [2], the technology was clinically evaluated in a European cluster project called EDECT during 2015 and is currently being refined by the Wellcome Foundation funded project SANAS. This current project involves obtaining a wide range of user performance data with the aim of determining a series of common symptoms that can be compensated for in an adaptive assistive system.

Extensive reviews of assistive wheelchair technologies were undertaken in 2005 [3] and 2014 [4] yet very few of the past and present research projects have been geared to bring smart wheelchairs to the market [5]. One of the few projects to do so is the IntellWheels project which has moved closer towards a possible product [6].

In order to produce a marketable assistive system our research has identified the need to develop a smart and adaptive system which is suitable for assisting a wide range of powered wheelchair users. Our research has identified that many users of powered wheelchairs find their medical condition and their ability to drive the wheelchair will change over time. In order to maintain independent mobility the powered chair will require adjustment over time to suit the user's needs. Currently, this need for regular input from the healthcare professional, and the limited resources, can result in the user having to wait weeks for appointments. This can result in the user losing mobility for significant periods of time, affecting theirs and their family's quality of life.

3. Methods

We investigated the quality of the user input as it appears to be highly likely to identify user driving difficulty. Data from joystick input was gathered from twelve users with different medical conditions: Duchenne MD, Cerebral Palsy, traumatic brain injury, Multiple Sclerosis, and Tetraplegia, who were asked to complete an obstacle course eight times; all testing on the obstacle course was undertaken by using the same powered wheelchair on a fixed profile. Collisions, direction changes, joystick data, and proximity to obstacles were recorded.

Additionally data from two users were collected whilst they operated the same test powered wheelchair chair over a five day period of their normal daily life. This data consisted of collision recording, a six axis Inertial Measurement Unit, and joystick data.

3.1 Ethical statement
Appropriate ethical approval was obtained.

4. Results

Early investigation has shown that for a range of symptoms given in Table. 1 it could be possible to identify the magnitude and the change in magnitude over time from the data we have collected. This would allow the system to modify the input trajectory and to adjust the driving assistance.

5. Discussion

Further analysis of the actual trajectory quality, direction change sign, and joystick input quality needs to be undertaken on the existing data to prove the features identified

are robust and perform satisfactorily with real-time pattern recognition techniques.

6. Conclusion

We conclude that data from a much larger number of powered wheelchair users with these identified symptoms needs to be collected and analysed. In addition a feedback-loop must be devised to keep the user informed and in overall command control of the system. Finally all the previous developments and technologies need to be amalgamated to produce a pre-production prototype system which can be easily mounted onto and integrated into most powered wheelchairs. This will be undertaken during a new European Union funded project EDUCAT, 2016-20.

7. References

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Symptoms	Reactions	Measurements	Identifying characteristics
Tremor	Low frequency vibration	Position, Velocity, Acceleration, Jerk	Small equal joystick repetitive position change
Attention, agitation, and impulse control	Sudden excessive motion	Position, Velocity, Acceleration, Jerk	Large irregular rapid equal joystick position change
Spasticity	Directional bias and amplitude of muscular activity	Position, Velocity, Acceleration, Jerk	Large regular rapid unequal joystick position change
Fatigue and weakness	Quality of user control	Position, Velocity, Acceleration, Jerk	Trajectory input will deviate more from platform output
Observational and visual bias	Hesitation when driving in certain directions	Position, Velocity, Acceleration, Jerk, Range to obstacle compensation	More collisions and a time bias in certain joystick quadrants
Reasoning and confusion	General hesitation and directional errors	Position, Velocity, Acceleration, Jerk	Random time bias in joystick inputs and more often reverse velocity direction

Table 1: List of symptoms and characteristics