Initial Results from Using an Intelligent System to Analyse Powered Wheelchair Users' Data

Malik Haddad
School of Mechanical and Design Engineering
University of Portsmouth
Portsmouth, UK
malik.haddad@port.ac.uk

David Sanders
School of Mechanical and Design Engineering
University of Portsmouth
Portsmouth, UK
david.sanders@port.ac.uk

Martin Langner
Chailey Heritage Foundation / Engineering
Chailey Heritage Foundation
Chailey, UK
mlangner@chf.org.uk

Peter Omoarebun
School of Mechanical and Design Engineering
University of Portsmouth
Portsmouth, UK
peter.omoarebun@port.ac.uk

Mohamad Thabet
School of Mechanical and Design Engineering
University of Portsmouth
Portsmouth, UK
mahamad.thabet @port.ac.uk

Alexandar Gegov
School of Computing
University of Portsmouth
Portsmouth, UK
alexandar.gegov@port.ac.uk

***Abstract*—Research in this paper presents a technique to collect powered wheelchair users' data using an intelligent system. Python programming language is used to create a program that will collect data for future analysis. The collected data considers driving session details, medication administered that can affect driving ability, and the type of input devices used to control a powered wheelchair. Data is collected on a Raspberry Pi microcomputer and is sent after each session via email. Data is placed in the body of the emails and in an attached file. Data will be used for future analysis and will be considered as a training data set to train an intelligent system to predict future route patterns for different wheelchair users. In addition, data will be used to analyze the ability of a user to operate their wheelchair, and monitor users' progress from one session to another, compare the progress of different users with the same type of disability and identify the most suitable input device for each user and route.**

Keywords-analysis; disabled; intelligent system; data collection, python programming language; powered wheelchair; raspberry pi;

I. INTRODUCTION

Research described here is part of a larger research program at the University of Portsmouth funded by the EPSRC [1]. The overarching aims are to apply AI techniques to improve mobility and enhance the quality of life of disabled powered wheelchair users through increasing their self-confidence and reliance.

Estimates suggested that 7M individuals in the United States make use of an assistive mobility device. About 2M individuals use wheelchairs or scooters and 5M individuals use walkers or canes etc. [2]. Roughly, a third need help from other people to get around. Stroke and osteoarthritis sufferers often use scooters or wheelchairs [3] with a major condition associated with mobility devices being osteoarthritis [2]. People using powered wheelchairs can be missing the required mobility or dexterity because of problems with their hands, arms, shoulders or even more extensive disabilities. They may not have the power in their lower limbs to be able to push a manual chair [4].

Blind people or people who are not able to take any evading action by themselves are prospective new users for the wheelchair systems described in this paper. The new systems can assist new powered wheelchair users with the steering of their wheelchairs.

Wheelchair controllers are typically open loop control systems. A disabled user specifies a desired speed and bearing by placing a transducer into a position. For example, using switches or a joystick. A powered wheelchair will then have a tendency to progress along the route specified (and to move at the anticipated speed). A user can then make adjustments to avoid objects.

The strong steel wheelchair frame provides strength and stability. There tend to be two large driving wheels and two training casters. Fig. 1 shows three different types wheelchairs. In all cases, the driving wheels are on a common axis.

Figure 1. The different types of wheelchairs considered during the research

Motion, direction and orientation are achieved by driving each large wheel independently using a separate motor connected to each driving wheel. Wheelchair users steer by varying electrical current to the individual motors.

Powered wheelchair users often attend driving sessions to learn how to use input devices that operate their wheelchair. Joysticks are commonly used to control the velocity (direction and speed) of a powered wheelchair. If users could not use their fingers or hands or lacked the necessary coordination, then alternatives could be used: head or chin switches, foot control or puff / sip tubes etc.

Many researchers have studied the steering and navigation of powered wheelchairs [5-17]. The systems used were often local, and little effort has been made to improve movements using more global methods. Research has considered object avoidance [18 - 23] using sensors that provided a more local sense of the environment around the wheelchair [24].

Research has often contemplated the computation of an initial wheelchair path that can be locally modified if obstructions were noticed, but they have seldom been successfully applied to assist disabled wheelchair users. The new intelligent systems to predict potential desired direction that are under consideration and described here could quickly predict routes.

In this paper, a method that will collect data from driving sessions and the type of data collected is described. A Raspberry Pi was inserted between user input devices and powered wheelchair motors.

A Python program was created and installed on the Raspberry Pi. The program gathered the required data. The collected data was stored on the Raspberry Pi, at the end of each driving session, the data collected during that session was sent via email. Data was received in the body of the emails and in a Comma Separated Value (CSV) file. A graphical display in the shape of a pie-chart representing an overview of the data obtained from the emails was created and attached to the emails. Data will be used for future analysis and will be considered as a training data set to train an intelligent system to predict future route patterns for different wheelchair users. In addition, data will be used to analyze the ability of a user to operate their wheelchair, and users' progress from one session to another, compare the progress of different users with the same type of disability and identify the most suitable input device for each user and route.

In the work described in this paper, Raspberry Pi microcomputers were considered because of their compact physical size, low cost and simplicity [12]. The program installed on the Raspberry Pi is explained in Section 2. Section 3 is a discussion about how the collected data will be used for analysis. Section 4 presents some conclusions and Section 5 presents some future work.

II. THE PYTHON PROGRAM

Raspberry Pi Microcomputers were considered as reliable powerful computers with compact physical size and affordable price. They were first introduced in 2012 with a choice of two models: A and B. In 2014, Model B+ was introduced and contained some improvement compared to the previous versions [25]. The research conducted in this paper used Raspberry Pi model B+.

The Python programming language was used to create a program that will collect required driving session data for analysis. The program was loaded onto a Raspberry Pi. The Raspberry Pi digitized users supplied input. The desired direction supplied by the user was collected and saved to the Raspberry Pi.

A User Interface (UI) for the new program was created to interact with helpers and carers, the program asked a helper/carer to provide the following details using a virtual keyboard as shown in Fig. 2:

- User name.
- Name of the input device used.
- Any medication that could impair the user driving ability.
- When the last dose (of medication) administered hh:mm.
- When next dose (of medication) will be administered hh:mm

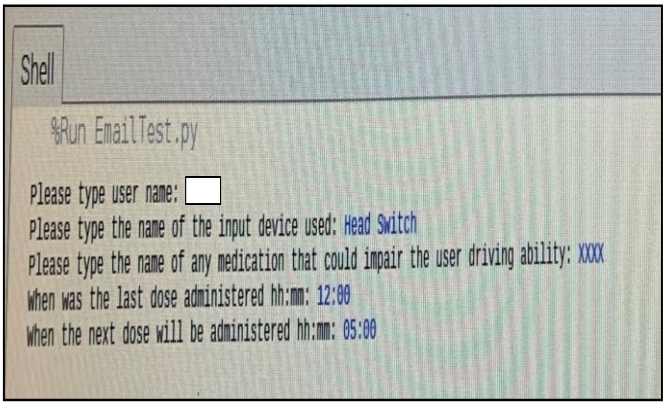


Figure 2. Screen shot of the User Interface for the new program

An emergency exit function was included in case anything went out of control. If helpers/carers required an emergency exit, then the Raspberry Pi would cut-off voltages from wheelchair motors, send an email detailing all the driving session data, mention that an emergency exit was required and provide a time stamp for the emergency exit. An example of the email sent in case of an emergency exit is shown in Fig. 3.

An End of Session exit function was created that cut off voltages from the wheelchair motors and exited the program. If Helpers/Carers tapped Stop icon in UI an End of Session exit will be activated the program would be terminated, an email would be sent containing all driving session data and indicated that no emergency was required as shown in Fig. 4. If no switch was pressed for more than sixty minutes an End of Session exit will also be activated.

……'s Driving Session

raspberrypiforwheelchair@gmail.com <raspberrypiforwheelchair@gmail.com>

03/10/2019 11:38

Hi,
The name of the user is …….. Session started at 2019-10-03 11:38:01.395756
The input device used was: switches
The user took XXXX at hh:mm:ss, the next dose will be administered at hh:mm:ss.
Duration of moving backward in seconds = [0, 0, 0, 0, 0, 0, 0, 0.6538441181182861, 0, 0, 0],
Duration of moving forward in seconds = [0, 0, 0, 0, 0, 0.7113142013549805, 0, 0, 0, 0, 0],
Duration of moving to the right in seconds = [0, 0, 0, 0.7200391292572021, 0, 0, 0, 0, 0, 0, 0],
Duration of moving to the left in seconds = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0.6857848167419434, 0]
Duration no switch was pressed in seconds = [1.0070903340001678, 1.0070929350004008, 1.0049715140003173, 1.0034300970000913, -0.0004776069999934407, 0.0016563630006203311, 0.0011204750007891562, 0.0007128690003810334, 8016.90527227, 8015.901975498, 8014.898451536],
Order of switch presses = ['Yellow switch was pressed', 'Green switch was pressed', 'Red switch was pressed', 'Blue switch was pressed'],
Number of times Red switch was pressed = 1,
Number of times Green switch was pressed = 1,
Number of times Yellow switch was pressed = 1,
Number of times Blue switch was pressed = 1,
Emergency Exit was required and session was terminated at 2019-10-03 11:38:15.449712.
Best regards,
………

Figure 3. Screen shot of email sent from Raspberry Pi showing an Emergency Exit was required

……'s Driving Session

raspberrypiforwheelchair@gmail.com <raspberrypiforwheelchair@gmail.com>

03/10/2019 11:38

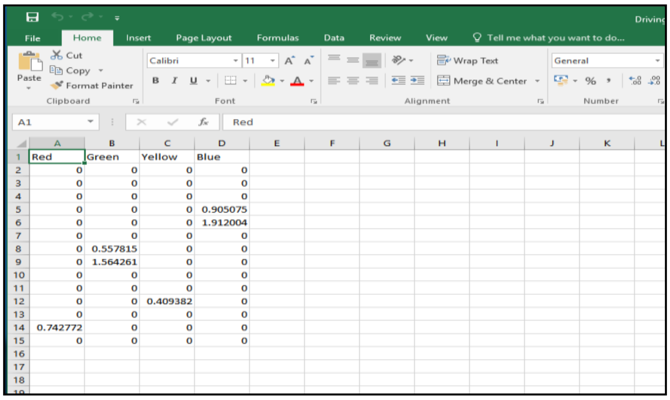
Hi,
The name of the user is …….. Session started at 2019-10-03 11:38:01.395756
The input device used was: switches
The user took XXXX at hh:mm:ss, the next dose will be administered at hh:mm:ss.
Duration of moving backward in seconds = [0, 0, 0, 0, 0, 0, 0, 0.6538441181182861, 0, 0, 0],
Duration of moving forward in seconds = [0, 0, 0, 0, 0, 0.7113142013549805, 0, 0, 0, 0, 0],
Duration of moving to the right in seconds = [0, 0, 0, 0.7200391292572021, 0, 0, 0, 0, 0, 0, 0],
Duration of moving to the left in seconds = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0.6857848167419434, 0]
Duration no switch was pressed in seconds = [1.0070903340001678, 1.0070929350004008, 1.0049715140003173, 1.0034300970000913, -0.0004776069999934407, 0.0016563630006203311, 0.0011204750007891562, 0.0007128690003810334, 8016.90527227, 8015.901975498, 8014.898451536],
Order of switch presses = ['Yellow switch was pressed', 'Green switch was pressed', 'Red switch was pressed', 'Blue switch was pressed'],
Number of times Red switch was pressed = 1,
Number of times Green switch was pressed = 1,
Number of times Yellow switch was pressed = 1,
Number of times Blue switch was pressed = 1,
No Emergency Exit required,
Session was terminated at 2019-10-03 11:38:15.449712.
Best regards,
………

Figure 4. Screen shot of email sent from Raspberry Pi showing No Emergency Exit was required

Data collected from emails provided the following information:

- Name of the user.
- Session start time.
- Type of input device used.
- Name of any medication that could impair user ability.
- Time when the user was last administered that medication.
- Time of the next dose of that medication.
- Duration of moving backward in seconds.
- Duration of moving forward in seconds.
- Duration of moving to the left in seconds.
- Duration of moving to the right in seconds.
- Duration when no switch was pressed.
- Order of switch presses.
- Number of time each switch was pressed.
- Whether an emergency exit was required.
- Session end time.

Fig. 5 shows a screenshot of the CSV file attached to the emails. Fig. 6 shows a graphical display (pie-chart) for data obtained from the switches, in this example four switches were considered (Red, Green, Yellow and Blue). A block-diagram of the developed program is shown in Fig. 7.



	A	B	C	D
1	Red	Green	Yellow	Blue
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0.905075
6	0	0	0	1.912004
7	0	0	0	0
8	0	0.557815	0	0
9	0	1.564261	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0.409382	0
13	0	0	0	0
14	0.742772	0	0	0
15	0	0	0	0

Figure 5. Screen shot of CSV file containing driving session data

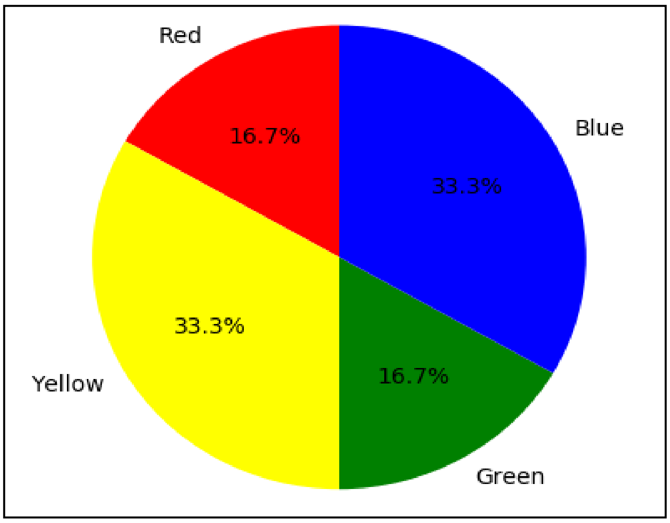


Figure 6. Graphical display (pie-chart) representing data obtained from switches

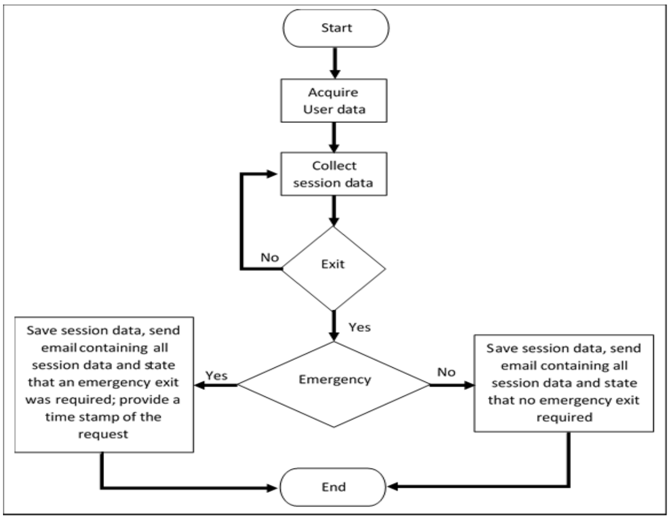


Figure 7. Block-diagram of the developed program

III. Discussion

Research presented here forms part of a bigger research project being conducted by the authors at the university of Portsmouth [1] that aims to improve mobility and enhance the quality of life of disabled powered wheelchair users by increasing their self-confidence and reliance.

This research used a Raspberry Pi to store users' driving session data and send the data via emails for future reference and analysis. The new system was tested and results showed that it successfully emailed the required data to a desired email address as shown in Figs 2 & 3.

Data collected from input devices will be used as a training set to train an intelligent system to predict routing patterns for different wheelchair users, assess users' progress from one session to another and compare the progress of the different users with similar types of disability. Data will be used to identify how different types of disability could affect user progress, what and how different types of medication could affect driving ability, identifying a "best time in the day" for each user to conduct driving session, how a user's driving ability was affected by the duration of driving. Also, data will be used to estimate the time of travelling by a user in each session, monitor user ability factors and the need for assistance and analyze which type of input device best suited each user and different route patterns.

IV. Conclusions

This paper presented a system that could be used as an interface between any user input device and powered wheelchair motors. The work will apply simple and computationally inexpensive AI software.

A python program was created and loaded on a Raspberry Pi to collect users' driving session information and send the collected information via emails to a required email address. A CSV file was created and attached to the emails containing required driving session data.

A graphical display (pie-chart) was created and attached to the emails to improve understanding of any patterns in an input device function.

The authors are currently studying ways to apply machine learning and other AI techniques to improve this research. Results showed that the new systems performed satisfactorily.

V. Future Work

Future work will consider the application of machine learning techniques on the collected data set to train an intelligent system to predict driving patterns, assess driving skills progress and analyze ability factors denoting the ability of a user to operate their wheelchair.

Future work will also consider adding a new function to the Python program to indicate if an intervention by the helper/carer or from a collision avoidance device occurred during a driving session, this will be used to provide a distinction of who is operating the device and providing information regarding driving ability and the need for assistance factors. Data collected will also be linked to driving and environmental situations and the targeted activity.

Finally, some decision making systems will be applied to the data [26, 27 & 28].

Systems are to be clinically trialed at Chailey Heritage School this year as part of the bigger project [1].

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