Power Wheelchair Instrumentation to Assess Mobility Performance: Preliminary Accuracy Evaluation

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INTRODUCTION

Inadequate training of wheelchair driving skills may lead to suboptimal driving proficiency and independence. Hence, users are prone to common wheelchair accidents such as collision and falls on uneven terrains.

Various assessment tools like the Wheelchair Skills Test and Power Mobility Driving Assessment exist but rely on subjective interpretation.

Motion capture systems offer detailed quantification but lack practicality in clinical settings.

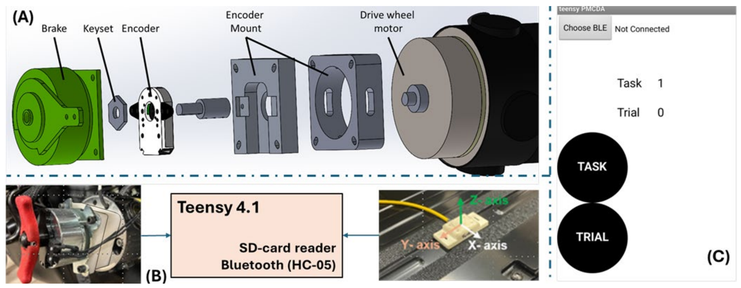
The proposed study introduces an efficient data acquisition tool to quantify and assess power wheelchair driving skills; bridging the gap between complex assessments and everyday needs.

OBJECTIVES

- Identifying wheelchair driving quantitative metrics.
- Assess accuracy and precision of a data acquisition tool to measure driving quantitative metrics.

DATA ACQUISITION TOOL

- The DAQ is designed as an add-on unit that includes an embedded system, encoder, and IMU reading at 100Hz.
- Encoders, attached in each motor, measure the wheelchair linear speed, and distance traveled.
- An IMU on the seat pan measures the seat orientation, wheelchair rotation, and acceleration (not calculated in this study).
- The system includes an SD card reader for onboard storage, enabling secure logging of quantitative driving metrics during each task.
- Bluetooth capabilities are incorporated to allow wireless data transfer, with a corresponding mobile app for real-time recording and monitoring of driving tasks.



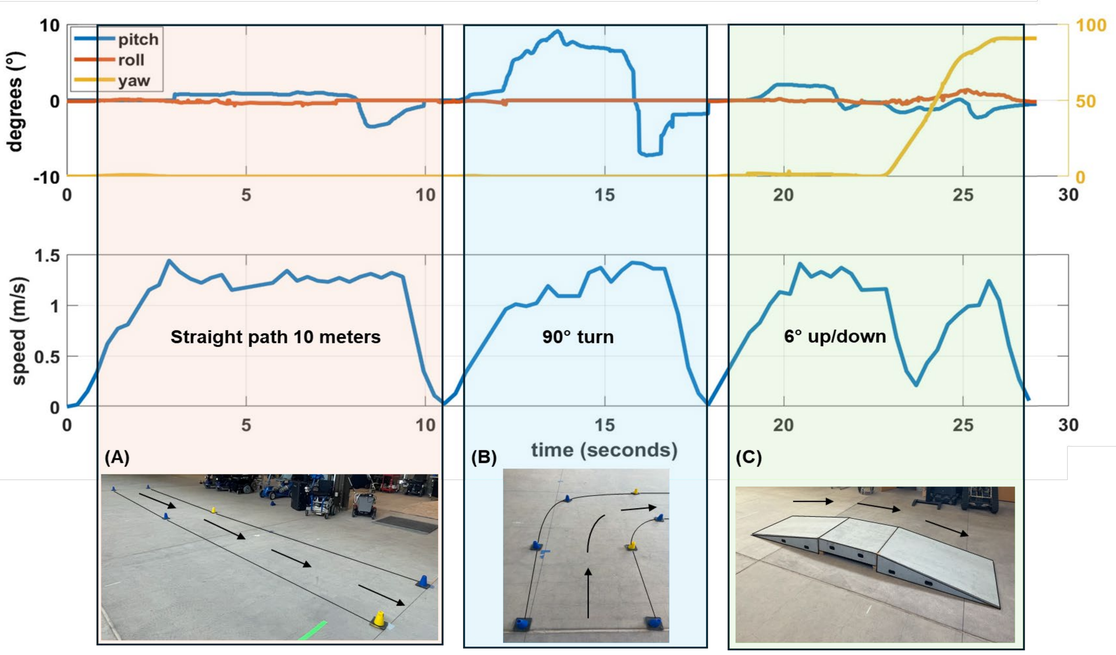
METHODS

Quantitative Driving Metrics identified from motion capture research:

- Time (seconds) and Velocity (m/s): Demonstrates efficient driving practice.
- Pitch/Roll/Yaw angles (degrees): Assesses seat inclination for safety and stability.
- Distance Traveled (meters): Monitors trajectory deviation.

Protocol:

- Acquisition tool was attached to a mid-wheel drive Group 3 power wheelchair
- An expert user drove it for three trials on three controlled driving tasks (See image below).
- Accuracy and precision of the recorded average driving metrics were compared with real values.



Accuracy	Straight path 10m		90° Turn Driving Forward		Ascend/Descend 6° slope	
	Real value	Recorded	Real values	Recorded	Real values	Recorded
Average Speed (m/s)	1.2	1.0 ± 0.1	0.9	0.8 ± 0.2	1.09	0.9 ± 0.1
Time (s)	9.2	10.6 ± 0.3	8.2	10.6 ± 2.0	6.3	8.1 ± 0.6
Pitch	0	0.0 ± 0.0	0	0.5 ± 0.0	6	6.5 ± 0.2
Yaw	0	0.1 ± 0.2	90.0	88.9 ± 2.7	0	0.1 ± 0.1
Traveled Distance (m)	10.6	10.9 ± 0.1	7.4	7.8 ± 0.1	6.9	6.9 ± 0.1

DISCUSSION

Results showed an average speed difference of 0.16 m/s, travelled distance difference of 0.23 meters, and average completed time difference of 1.9 seconds across all obstacles.

Lastly, wheelchair orientation showed 1.1° difference when driving on the 90° turn task and 0.5° difference on the 6° ramp.

Except for task duration, the data acquisition tool demonstrated high accuracy to measure the quantitative driving metrics

CONCLUSION

Utilizing a data acquisition tool with IMU sensors and encoders holds promise to quantify power wheelchair driving skill assessment; hence reducing clinician bias and wheelchair skills training time.

The tool shows potential benefits for mobility monitoring in the community to address wheelchair maintenance and energy consumption to improve navigation and battery lifespan.

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