The Development of a Novel Safety Architecture for Semi-Autonomous Wheelchair Platforms

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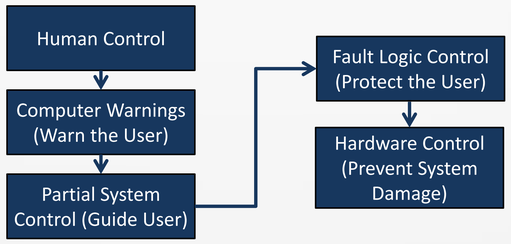
Motivation: Build a Safe and User-Friendly Semi-Autonomous Wheelchair

This project sought to develop a semi-autonomous wheelchair platform for persons with disabilities, namely ALS. Development included retrofitting an existing electric wheelchair with sensors, a computing platform, and a modular power management system. This project focused on incorporating greater safety features onto the wheelchair, such as inhibiting the wheelchair from driving down stairwells, roadside curbs, and other sudden drop-offs, general obstacle avoidance, and basic system battery state of charge estimation. As a result, a comprehensive, novel safety architecture was designed and implemented. The goals in designing the safety system include a simple user interface, robust fault detection, and simple expandability. Capabilities of the wheelchair system, such as the aforementioned drop-off detection, will be tested in a simulated home or work environment.

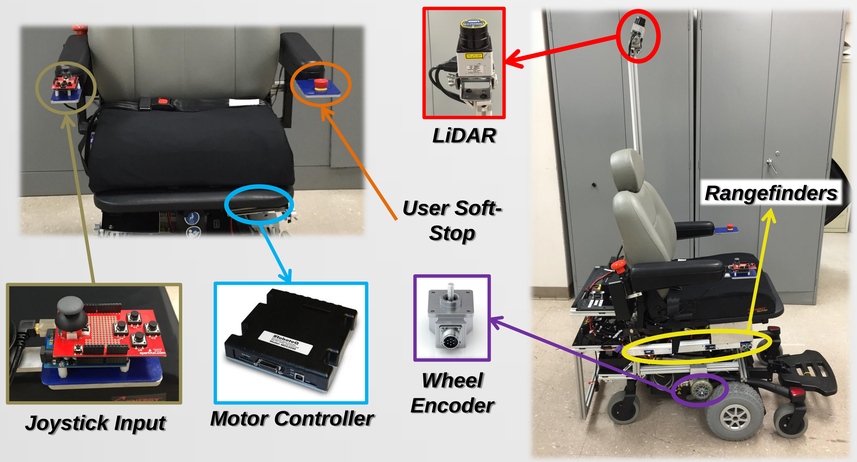


Safety architecture for semi-autonomous wheelchair

Nearly 150,000 individuals in the United States rely on electric wheelchairs to regain lost mobility. Much of current electric wheelchair technology relies on direct user joystick input, which, to the detriment of many, assumes the user has retained their fine motor skills. Individuals without fine motor skills can become reliant on their caretakers, losing much of the independence intended by wheelchair use.

Many autonomous and semi-autonomous wheelchairs exist, however most systems only provide researchers with control of a few aspects of the wheelchair system. More importantly, nearly all autonomous wheelchair systems today do not provide patients with the necessary safety features for use outside of a laboratory environment .

Semi-Autonomous Wheelchair Platform

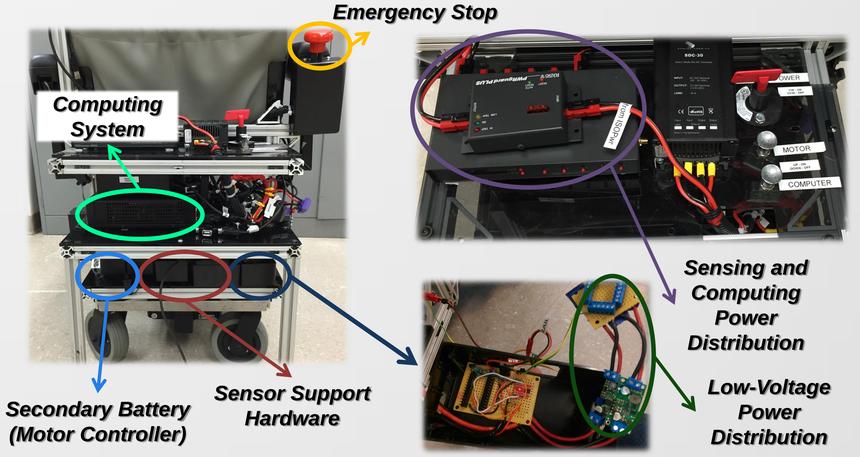


Sensing System
Wide variety of sensors to monitor both the environment around the wheelchair as well as many aspects of the wheelchair's system health.

Power Distribution System
Completely custom power system to allow researchers to quickly install new hardware.

Computing System
Powerful computing system to allow for collecting significant amounts of environment data, simple sensor integration, and realizing complex autonomous navigation algorithms.

User Input System
Currently a simple joystick, but easily expanded to complex joysticks, voice control, or brain-computer interfaces.



Positive and Negative Obstacle Avoidance Implementation

Goals

Develop and test algorithms to detect and avoid:

- **Large obstacles, such as furniture or other people**
- **Small obstacles, such as small pets or a child's toys**
- **Negative obstacles, such as pot holes, curbs parallel to the wheelchair, or sudden drop offs, such as stairs**

Ultimately, the goal of this algorithm is to make the wheelchair safe for home use.

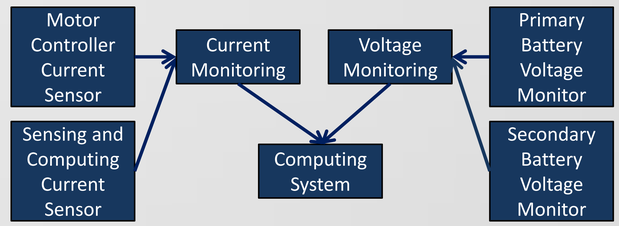
Sensors for drop off detection and small obstacle avoidance

Battery State of Charge Prediction for Retrotraversal

Goals

To develop an algorithm that will:

- **Monitor the State of Charge (SoC) of the battery system on the wheelchair**
- **Prevent battery over usage by preventing the user and system from over-discharging the battery**
- **Monitor the distance traveled from the battery charger and alert the user when they should begin to return to the charging station to ensure the user is never without a fully charged system**



Power monitoring architecture

Future Work and System Expansion

Design and integrate a system to monitor patient's health based upon wheelchair usage; monitor joystick usage patterns to track neurological degeneration patterns

Realize full autonomy algorithms to allow a user to provide the wheelchair with simple such as "take me to the kitchen"

Generate environment maps of commonly used areas by sensing the magnetic fields in the floors of buildings due to electrical wiring

Design a surface EEG-based brain-computer interface system to allow severely disabled persons the opportunity to regain freedom of mobility