Evaluation of the Navigation and Obstacle Avoidance Help (NOAH) system for Wheelchair Users with Cognitive Impairment

Abstract

Powered wheelchairs are usually prescribed to older adults who are unable to propel themselves on manual wheelchairs. However, users with dementia often do not possess the reasoning and decision-making skills required for safe powered wheelchair operation. They are therefore excluded from powered wheelchair use and have to rely on caregivers to porter them around. This reduced mobility and independence can, in turn, lead to depression and social isolation.

An intelligent powered wheelchair (NOAH) is proposed to restore independent mobility, while ensuring safety. Wayfinding assistance is also provided to ensure timely navigation. A stereovision camera and laptop are added on to a commercial powered wheelchair. Upon the detection of an imminent collision, the wheelchair is stopped, and motion towards the obstacle is prevented. Wayfinding assistance to the goal is provided by determining the wheelchair's location using visual landmarks detected in camera images. The optimal route to the goal is constructed using existing path planning techniques. Adaptive audio navigation prompts that account for the users' cognitive state are then issued using a probabilistic user model.

The system is tested with older adults with mild-to-moderate cognitive impairment through a single-subject research design. Results demonstrate the high diversity of the target population, and highlight the need for customizable assistive technologies that account for the varying capabilities and requirements of the intended users. The collision avoidance module is able to improve safety for all users by lowering the number of frontal collisions. The wayfinding module assists users in navigating along shorter routes to the destination. Prompting accuracy is found to be high during the study. While compliance with correct prompts is high across all users, a distinct difference is found in the rates of compliance with incorrect prompts. Specifically, users who are unsure about the optimal route rely more highly on all system prompts for assistance, and are thus able to improve their wayfinding performance by following correct prompts.

Improvements in wheelchair position estimation accuracy and joystick usability can help improve user performance and satisfaction. Further user studies can help refine user needs and hopefully allow us to increase the mobility and independence of several cognitively-impaired older adults.

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