Path Oriented Powered Wheelchair Navigation Assistance

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Introduction: Electric wheelchairs can greatly improve an individual’s life and independence. The literature indicates that 40% of patients using wheelchairs found it “difficult or impossible” to steer an electric wheelchair and up to half of patients would find it beneficial to have an added navigation system (Fehr et al., 2000). Wheelchair navigation systems, however, have seldom been implemented due to expense of the associated technologies and complexity of the components required. Horn summarizes that navigation systems used in “smart wheelchairs” during the past few decades include technologies such as infrared, sonar, laser, radar, and physical modalities (Horn, 2012). The research presented here aims to help people with disabilities navigate in a daytime, suburban or urban environment. Using a simple color camera, differences in the color and shape of the environment can be used to isolate a navigable path. Like lane keeping systems used in modern cars, the design presented here makes use of a passive interference system, to provide the user with direct navigational control, but aids in steering (Yu et al.,2008).

Materials and Methods: To minimize system cost, the materials selected are those commonly used in open-source hardware design. The Raspberry Pi 3 is used as the computational device with the Raspi camera module attached. The board runs Raspbian Jessie, the most recent operating system and a 10 Ah battery bank provides power. To analyze input, the Python programming language was used along with the OpenCV library to process images. Finally, as a proof of concept, an LED array provides visual feedback to the user. To identify the sidewalk, the software removes anything in the picture that doesn’t share similar appearance characteristics, then calculates the position of the centroid of the remaining shape. This determines whether the user is on path. To test the device, it was attached to a powered wheelchair and driven down the sidewalk. In one case, the wheelchair was manually driven according strictly to the path shown by the LED array. In another case, the wheelchair was pivoted from side to side to analyze the reaction by the device

Results and Discussion: Case one was successful in terms of intervention. Only when turning corners or navigating a split in the path did the subject have to divert from the device’s suggestion. Case two demonstrated that the user was able to complete a full turn with consistent tracking of the sidewalk for the entirety. In addition, the device kept accurate error logs and reported an average of near 6 frames per second over multiple trials while simultaneously recording video. The battery supplies power for approximately 5 hours, but the system could be integrated into the wheelchair’s power.

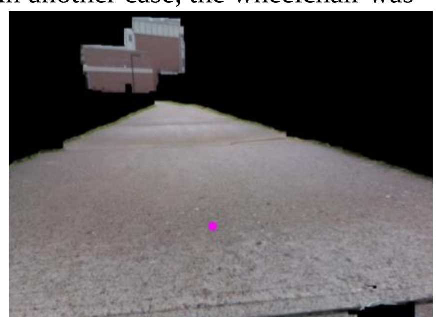

Figure 1. This screengrab shows the output of a sidewalk after calculating the centroid (pink circle). Only the largest part of the visible mask is considered.

Conclusions: This navigation system represents a tool to help people that use wheelchairs navigate their surroundings with greater confidence. This prototype is sufficiently capable of indicating which part of the environment is navigable. Implementation of this system can be modified to include an intervention into the control system of a powered wheelchair.

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