Development of Outdoor Navigation for a Robotic Wheelchair System

Holly A. Yanco *
MIT Artificial Intelligence Laboratory
545 Technology Square, Room 705
Cambridge, MA 02139
holly@ai.mit.edu

The goal of this research is the creation of a complete robotic wheelchair system to be used by people unable to drive standard powered wheelchairs. A complete robotic wheelchair system must be able to navigate indoor and outdoor environments and should switch automatically between navigation modes. For the system to be useful, it must be easily customized for the specific access methods required for each user. This abstract focuses on the vision system being developed for outdoor navigation and the method for selecting whether to use the indoor navigation mode or the outdoor navigation mode. A report of the indoor navigation mode and user interface can be found in (Yanco In press).

Navigation is divided into two classes: indoor and outdoor. In both navigation modes, the user gives a high-level command ("forward," "left," "right," and "backward") through the graphical user interface which has been customized to accommodate the user's access method. The system carries out the user's command using common sense constraints such as obstacle avoidance. Since the user must be able to successfully navigate novel environments immediately, the system does not use maps or environment modification.

The navigation problem in an indoor environment is simplified by regularities such as level floors and walls. A vision system can be used in an indoor environment, but it is not necessary. Robots navigating indoors can use sonar and infrared sensors to avoid obstacles.

Outdoor navigation is not feasible using only sonar and infrared sensors. To facilitate navigation in outdoor environments, a vision system with one camera is being added to the wheelchair. Initial image processing is aimed at finding and navigating sidewalks, crosswalks, curb cuts and handicapped ramps. To stay on sidewalks and in crosswalks, the vision system will detect long straight lines that head towards the vanishing point. Ground-plane constraint or optical flow using successive frames will be used to approximate the distance of obstacles in the camera image from the wheelchair.

Outdoor navigation for a robotic wheelchair in a sidewalk domain differs from outdoor navigation for an automobile in a highway domain (see, for example, (Thorpe 1997)). Sidewalks are not as regular as roads; they may be made up of bricks, concrete segments, wooden boardwalks or tar and the materials may change as the user moves in front of a new building.

The robot must determine whether it is in an indoor or outdoor environment in order to select the proper navigation mode. Given the abilities and access methods of the system's users, it is not realistic to require the user to indicate a change of indoor/outdoor status. Researchers in the vision community have investigated ways to determine if an image is an indoor or outdoor scene. However, the user will not change between the environments with high frequency. For this reason, the vision system should not be devoting processing time to determining the current environment. Instead, this research includes the development of an indoor/outdoor detector which will determine the location of the chair by getting values for variables such as ultraviolet light, color characteristics of the light, polarization of the light, the characteristic frequency of electric lights, the presence or absence of a ceiling, and sudden temperature differences.

The indoor/outdoor detector and vision system for outdoor navigation under development will be added to the existing indoor navigation system and customizable user interface to form a complete robotic wheelchair system.

*This research is supported by the Office of Naval Research under contract number N00014-95-1-0600 and the National Science Foundation under grant number CDA-9505200.

References

Mittal, V.; Yanco, H. A.; and Aronis, J., eds. In press. *Lecture Notes in Artificial Intelligence: Assistive Technology and Artificial Intelligence.* Springer-Verlag.

Thorpe, C. E., ed. 1997. *Intelligent Unmanned Ground Vehicles: Autonomous Navigation Research at CMU.* Kluwer Academic Publishers.

Yanco, H. A. In press. Wheelesley, a robotic wheelchair system: Indoor navigation and user interface. In Mittal et al. (In press).