Adaptive Shared Control for an Intelligent Power Wheelchair

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The NavChair Assistive Navigation System (Levine, Koren, & Borenstein 1990) is being developed to increase the mobility of severely handicapped individuals by providing navigation assistance for a power wheelchair. While designing the NavChair it became clear that obtaining the full range of desired functionality required several different "operating modes," each of which was appropriate in different contexts. This also necessarily created a need for a method of choosing between these modes. One solution is for the user to manage the task of mode determination, which may place unacceptable performance burdens on NavChair users with severe disabilities. Instead, a means for the NavChair to automatically choose the proper operating mode is being sought.

Research to develop such an adaptation method impacts a general class of human-machine systems that change their behavior based on fluctuations in the needs, goals, or capabilities of their human operator. Automatic adaptation is important for the NavChair because it allows both the operator and system to achieve levels of performance neither could reach alone.

Researchers have produced a variety of methods to perform automatic adaptation. Often, even though several sources of information relevant to the adaptation process may exist for a given man-machine system, very little effort is made to combine multiple information sources together within one system. An adaptation method that can make use of more information should make better adaptation decisions than one that is limited in the information it can consider. This research will examine one promising approach called Bayesian networks, which provide a method of probabilistically modeling a situation in which causality is important, but our knowledge of what is actually going on is not complete (Charniak 1991).

Experiments employing the NavChair are proposed to evaluate the performance of Bayesian networks in adaptation tasks through the following specific aims:

1. Test the hypothesis that combining multiple information sources improves adaptation in a man-machine system.
2. Determine whether reasoning about adaptation degrades the NavChair's performance in situations where no mode change (adaptation) is required.

This research will implement an adaptation system within the NavChair that makes use of Bayesian networks. The information available to the network will include the identities of objects in the NavChair's environment and an internal map of the larger environment in which the NavChair is moving.

This work represents a preliminary effort in the development of adaptation methods that are applicable to a wide variety of man-machine systems. The immediate impact on the NavChair will be an improved ability to make adaptation decisions and an increased ability to meet the needs of people with disabilities. Beyond the scope of this research, Bayesian networks could be used to drive adaptation in applications in fields such as intelligent vehicle control, aviation, factory automation and human-computer interaction. For example, an adaptive control system similar to the NavChair's could provide assistance to automobile drivers to improve driving safety and traffic flow on the highways.

Several of the pieces needed for the proposed research have been completed. Mechanisms for automatically steering the NavChair through doorways and along walls have been developed, and integrated into a method for recognizing environmental cues and automatically adapting the NavChair's behavior in response to them. Finally, a mapping mechanism for use in location-based adaptation has been completed.

References

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[2] Charniak, E. 1991. Bayesian Networks Without Tears. *AI Magazine* 12(4): 50-63.