Adaptive Prompting for Intelligent Wheelchairs

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Abstract

Cognitive impairments prevent older adults from using powered wheelchairs due to safety concerns, thus reducing their mobility and independence. An intelligent powered wheelchair is proposed to help restore mobility, while ensuring safe navigation. Machine vision and learning techniques are used to help prevent collisions with obstacles, as well as provide navigation assistance through adaptive prompts.

1 Introduction

Several residents in long-term-care facilities lack the cognitive and/or visual abilities to safely maneuver powered wheelchairs, and are thus not permitted to use them. This leads to reduced mobility, and, in turn, depression and an increased dependence on caregivers. We propose intelligent wheelchairs to enhance mobility and help improve the quality of life of older adults with cognitive and/or visual impairment, while simultaneously reducing the burden on caregivers.

Several intelligent wheelchairs capable of collision avoidance and path planning have been developed recently [1], however these wheelchairs navigate autonomously, thus taking control away from the user. On the other hand, wheelchairs that leave planning and navigation to the user and only provide collision avoidance support are not appropriate for users with cognitive impairment since they often lack planning abilities. We therefore suggest a mixed-initiative control strategy that combines artificial intelligence of the wheelchair with driver abilities to provide supportive, passive navigation assistance that increases independence and ensures safety.

Other assistive systems designed for older adults include the Nursebot Project [2], the Assisted Cognition Project [3], and an indoor wayfinding system [4]. Although these systems use AI techniques for planning and/or reminding, they do not incorporate user attitude modeling. A system for assisting persons with dementia during the handwashing task is described in [5]. This system estimates the user's cognitive state using a Partially Observable Markov Decision Process (POMDP) and issues audio prompts. Similar techniques are used in the proposed wheelchair system to determine an appropriate prompting strategy.

2 Methods

We have implemented vision-based anti-collision technology to prevent collisions and encourage the user to drive around obstacles [6]. We are using existing mapping and path planning techniques to determine the location of the wheelchair and compute optimal routes to goal locations. We have also completed preliminary work in identifying place types (kitchen, bathroom, etc.) based on visual cues [7]. Finally, we will provide audio prompts to assist the user in navigating to the destination while accounting for his/her needs and preferences, as well as obstacles in his/her path.

In this abstract, we present a prototype prompting system, which uses a POMDP to provide adaptive navigation assistance. For our experiments, we use a sample floor plan of an indoor environment. We then pick random start and goal locations and use a path planner, which finds the optimal path as described in [8]. We use a simple interface to simulate wheelchair motion using a keyboard. Noisy observations of wheelchair locations are read at regular time intervals and used to determine the user's most recent behavior (following path, deviating, turning, etc.). If the user is found to be deviating from the optimal route significantly, a new route to the goal is computed and used in subsequent prompting. We use the POMDP to compute the optimal system action (e.g. do nothing, issue prompt, call caregiver) at each time step, based on the user's estimated current status (on-route, off-route, etc.) and his/her cognitive state (ability to navigate independently to his/her desired location, and level of responsiveness to prompts). Transition and reward functions of the model are specified manually using domain knowledge.

3 Discussion

We tested the model qualitatively by analyzing the system action for different types of simulated user states. We also analyzed system response to user errors that might occur due to temporary distractions and errors due to noisy sensors. We found that in most cases, the model correctly determines various cognitive states and generates an appropriate action. Further data needs to be collected to incorporate information about the user's driving patterns. In addition, the model must be extended to include various levels of prompting. For example, users with mild dementia might require simple reminders, while more detailed prompts might be necessary to assist users with severe dementia. Future work involves using real wheelchair motion data and maps generated by the stereovision camera, as well as conducting user studies to determine the effectiveness of the system with the target user population. These studies will allow us to assess the level of accuracy needed for robotics and machine learning algorithms to be successfully applied to the field of assistive technology.

References

[1] R.C. Simpson, “Smart wheelchairs: A literature review,” J Rehabil Res Dev. Jul-Aug, 42(4), pp. 423-36, 2005.

[2] J. Pineau, M. Montemerlo, M. Pollack, N. Roy, and S. Thrun, “Towards robotic assistants in nursing homes: Challenges and results,” in Robotics and Autonomous Systems, 42, pp. 3–4, 2003.

[3] H. Kautz, L. Akarnstein L, G. Borriello, O. Etzioni, and D. Fox, “An overview of the assisted cognition project,” in Proceedings of the AAAI Workshop on Automation as Caregiver: The Role of Intelligent Technology in Elder Care, 60-65. Menlo Park, Calif.: AAAI Press, 2002.

[4] A. L. Liu, H. Hile, H. Kautz, G. Borriello, P. A. Brown, M. Harniss, and K. Johnson, “Indoor wayfinding:: developing a functional interface for individuals with cognitive impairments,” in Proceedings of ASSETS, 95-102, ACM Press, New York, NY, 2006.

[5] J. Hoey, P. Poupart, A. Bertoldi, T. Craig, C. Boutilier, and A. Mihailidis, “Automated Handwashing Assistance For Persons With Dementia Using Video and a Partially Observable Markov Decision Process,” in Computer Vision and Image Understanding (CVIU), 114(5), pp. 503-519, 2010.

[6] P. Viswanathan, J. Boger, J. Hoey and A. Mihailidis, “A Comparison of Stereovision and Infrared as Sensors for an Anti-Collision Powered Wheelchair for Older Adults with Cognitive Impairments,” in Proceedings of the International Conference on Technology and Aging, Toronto, Canada, 2007.

[7] P. Viswanathan, T. Southey, J. J. Little, and A. Mackworth, “Automated place classification using object detection,” in Proceedings of Canadian Robot Vision, Ottawa, Canada, pp. 137-141, 2010.

[8] K. Alton and I. M. Mitchell. “Fast Marching Methods for Stationary Hamilton-Jacobi Equations with Axis-Aligned Anisotropy”, in SIAM Journal on Numerical Analysis, 47(1) pp. 363-385, 2008.