Assistive Robots For Blind Travelers

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Objective

As robotics technology evolves to a stage where co-robots, or robots that can work with humans, become a reality, we need to ensure that these co-robots are equally capable of interacting with humans with disabilities. The proposed work addresses this challenge by exploring meaningful human-robot interaction (HRI) in the context of assistive robots for blind travelers.

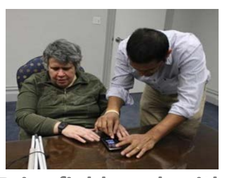
Intellectual Merit

The proposed work explores three research areas in the context of assistive robots for blind travelers:

(1) Accessible Interfaces, which will be a crucial component of assistive robots.
(2) Assistive Interaction between humans and robots, which we envision happening both directly and remotely via accessible smartphone interfaces.
(3) Effective Cooperation, which will have to accommodate a variety of teaming options including human-robot teams, flexibility in teaming based on capabilities and resources, and also allow a range of connectedness and heterogeneity for the cooperating agents.

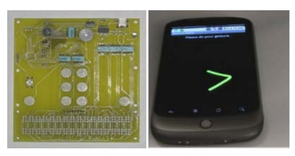
Research Description

- We will begin this research element with stakeholder interviews and task shadowing under the status quo. These data will help identify high value robot tasks and functional constraints.


Prior field work with blind travelers

- The three principal research areas will be applied to three scenarios relevant to assistive robots for blind travelers:

(1)Information Exchange and Object Manipulation
- Robots can provide travel related information, assist with locating lost objects such as a cell phone, help blind travelers sort unfamiliar currency, etc.
- Accessible interfaces will be necessary to allow blind travelers to effectively communicate their intents, needs, and state to the robots and vice versa.


Prior work in accessible interfaces

(2)Assistive Localization
- Accurate localization allows robots to rendezvous with users and helps discriminate between nearby features (e.g., up vs. down escalator).
- We propose to use a combination of robots and smartphones carried by the blind travelers to achieve assistive localization.

(3)Urban Navigation and Emergency Building Evacuation
- Effective route planning and path following are important when navigating unfamiliar environments.
- We propose a route planner that has both high throughput and low delays in terms of query processing, and is capable of dynamically re-planning.

Illustration of assistive robots interacting with blind travelers

Anticipated Outcomes

- New knowledge on how to support interactions between co-robots and their blind users (in travel context)
- Advances in the areas of multi-robot skill coordination, and crowdsourcing assistance to robots
- Developments in three key components of proposed solution (information exchange and object manipulation, assistive localization, and assistive navigation and evacuation), as well as other algorithms, tools, and best practices
- Peer-review publications and infusions into classes and the team's existing outreach program to occur throughout project

Acknowledgements

National Science Foundation WHERE DISCOVERIES BEGIN
rethink robotics
Western Pennsylvania School For Blind Children
Fostering a Vision of Independence
Blind & Vision Rehabilitation Services of Pittsburgh

Motivation

- According to the World Health Organization, over a billion people worldwide have some form of disability.
- The number of people with disabilities is on the rise with a growing elderly population worldwide, and more disabled war veterans and other trauma survivors.
- Thus, issues of accessibility have increasingly important social and economic consequences, globally.
- For people with vision or ambulatory disabilities, navigating through indoor and outdoor spaces can be challenging and often daunting, especially in emergency situations necessitating evacuation.
- The ability to independently and safely travel to and navigate unfamiliar environments is a fundamental necessity for all in today's globalized world.
- We propose the use of co-robots to enhance the safety and independence of these travelers by assisting them to navigate unfamiliar urban environments effectively.

Related Work

- Human-Robot interaction (*e.g.* Rethink Robotics and Akgun, B., *et al.*)
- Assistive transportation and navigation for the visually impaired (*e.g.* Kehret, G., *et al.* and Talking Signs)
- Crowdsourcing for assistive tasks (*e.g.* Zimmerman, J., *et al.* and Steinfeld, A., *et al.*)
- Directional interfaces for the visually impaired (*e.g.* Golledge, R. G., *et al.* and Vázquez, M. & Steinfeld, A.)
- Cooperating teams of humans and robots (*e.g.* Dias, M. B., *et al.* and Tang, F. & Parker, L. E.)
- Assistive robot-human interaction gap (*e.g.* Dragan, A. & Srinivasa, S. and Cooper, R. A., *et al.*)

Evaluation Plan

- Evaluation Framework
  - Whenever possible, use live robot autonomy and working components for experiments to capture more realistic human behavior
  - Apply Wizard of Oz method to test ideas and approaches early in the development process
  - Use experiment best practices and established and well-documented HRI metrics for evaluation
  - Build from team's experience in measuring human interaction with robots, learning systems, and intelligent transportation systems to conduct high quality experiments and valid analyses
- Example Experiments
  - Evaluate concepts and approaches corresponding to the three research platforms: smartphone, mobile guide robot and local Baxter agent
  - For experiments involving participants, include both blind and sighted people to identify universal design approaches
  - Conduct system tests and user studies in mix of locations (partner/researcher sites and public spaces), based on functionality or interaction being explored
  - Ensure that each study has an appropriate number of participants or component trials
  - In years 4 and 5 conduct integrated experiments to follow users through a series of interactions where smartphones, mobile guide robots, and Baxters will be used to complete a set of lifelike tasks

Broader Impacts

- Opportunities for undergraduate students to engage in research and interact with graduate students, which could encourage them to pursue graduate study in science and engineering
- Incorporate research findings into class presentations, guest lectures, and seminars, which will contribute to several courses at Carnegie Mellon University (CMU) and neighboring University of Pittsburgh
- Further enhance efforts to assist Institutional Review Board office at CMU by reviewing IRB applications and presenting best practices in ethical conduct for research involving human subjects from underserved communities
- Community outreach through regular presentations of project outcomes that target both academic and non-academic audiences
- Several workshops at community partner organizations targeting both instructors and learners, and focused on relevant technology topics, including elements of proposed research
- Impact operations and methodologies used at community partner organizations
- Mentoring and leadership activities to encourage and sustain the participation of women in computing and to address the needs of technologically underserved communities around the world
- If successful, research will have a direct, positive impact on lives of people with disabilities, as well as add value to the wider public, and will favorably affect a wide range of robotics and transportation applications
- Contribute to the broader field by disseminating research results through scientific, peer-review publication outlets, an accessible project website, social media, and other avenues