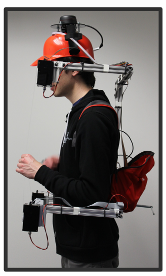
In-Sight: Tension-Based Haptic Feedback to Improve Navigation for Blind People

Co-Investigators: Zachary Sussman, Alexander Baikovitz, Jonathan Duffy
Website: zacharysussman.com/insight

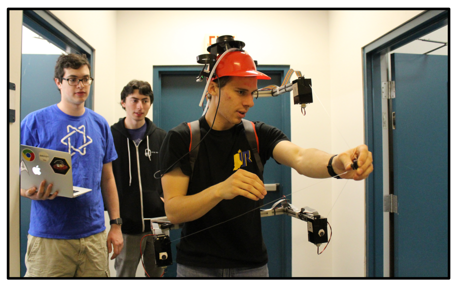
Abstract

The predominant mode of haptic feedback for people who are blind is vibration. While an effective way to aware users of their surrounding environments, this widely used method has inherent difficulties in communication bandwidth. The In-Sight platform, created in the Human and Robot Partners Laboratory (HARP Lab) last spring, presents a novel approach to conveying the depth of the user's surrounding environment using force feedback.

The initial prototype of In-Sight, which was tested on a small sample of sighted individuals, successfully enabled user navigation in a constrained environment using tension applied to three strings, converting a LIDAR generated point cloud into a tactile map. This area of research has compelling motivation as it provides a similar perceptual response to the white cane, while extending user depth and removing the need to physically interface with obstacles. Our proposal is to improve the In-Sight system and run a series of user studies to determine the performance of the system as a navigational aid.



The In-Sight System



In-Sight in Action

Who

In-Sight originated as a final project for 16-467, Human-Robot Interaction, and all three students involved in this continuation were integral members in that project. Our faculty advisor, Professor Henny Admoni, was the professor for the course and has already had experience with this project. We are also working with Benjamin Newman, a PhD student of Professor Admoni. Our student team is Zachary Sussman, a junior in Computer Science, Alexander Baikovitz a junior in Mechanical Engineering; and Jonathan Duffy, a junior in Electrical and Computer Engineering.

So What?

Globally, 1.3 billion people live with some form of vision impairment, and 36 million people are blind[1]. For years, the main device used by blind people for navigation has been the traditional white cane, used to detect floor level changes and obstacles and also signaling that its

[1] "Blindness and Vision Impairment." World Health Organization. Accessed October 11, 2018. http://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment.

user is blind. However, this trusted method of navigation has its own issues, most notably that it requires contact with obstacles to detect them.

As the state of the art in robotics and embedded systems advances, it has become more feasible to create wearable navigational assistants for blind people. In recent years, a number of research groups have attempted to create an assistant that matches the white cane's reliability, low cost, and ease of use. However, there is still a long way to go in this field, not only in the three areas mentioned before but also in creating navigational assistants for new activities, like jogging, that are not handled well by the white cane. This area of research is at the intersection of human-computer interaction, robotics, and embedded systems and is being propelled forward by the fast development of its constituent fields.

Research in haptic feedback for blind individuals has focused primarily on vibration. While actuators that generate vibration are commonplace in many existing devices, they have inherent difficulties in intuitively conveying depth. Depth perception is the crux of successful navigation, so blind individuals can benefit greatly from a mechanism to convey spatial geometry. Tension and force-based haptic feedback has not been extensively researched and presents a novel and effective approach to convey a user's surroundings through depth.

Our research question is the following: how well does tension and force-based haptic feedback perform as a navigational aid? A comparative user study can be used to validate the use of force-based haptic feedback as an effective mode for navigation. The results of this technology can advance research in the field of assistive robotics and contribute to navigational aids that would improve the mobility and independence of blind individuals.

Project Plan

In order to explore our research question, we will build a navigational aid based around tension and force-based haptic feedback and then perform user studies to evaluate how well our system works.

We've already constructed a prototype tension-based system. We tried out the prototype on ourselves and one volunteer, and we found that we were able to feasibly navigate with our eyes closed. However, we found many critical issues during testing, and our first task is to improve the robustness of our prototype. This will include redesigning the motor housing, reworking our electrical system to improve motor control, and improving our localization capabilities by testing different visual systems, such as a stereo ZED camera.

Following this period of improvement, we plan to conduct a series of user studies on people who are visually impaired. This is keeping in line with the norm in the field of navigational aids; almost all papers published in this field include a study validating that the system under evaluation is actually effective for navigation. We plan to start with a pilot study to evaluate the system performance under a range of environmental and lighting conditions with sighted individuals. Then, the primary user study will test the relative effectiveness of our system against a white cane and other possible navigation aids on people who are visually impaired. The results of this study would determine the direct effect of our system on our target audience.

Project Goals: 100%

100% completion of the project would involve the improvements to In-Sight detailed above, followed by both user studies.

Project Goals: 75%

75% completion of the project would involve the improvements to In-Sight detailed above, followed by the pilot study and a scaled-down version of the main user study, possibly involving fewer participants or sighted participants.

Project Goals: 125%

125% completion of the project would involve the improvements to In-Sight detailed above, followed by both user studies. In addition, we would evaluate alternative improvements to In-Sight, such as different vision systems or augmentation with other navigational aids.

Milestones

December 17th	Complete a literature review. Procure a stereo camera. Develop the software capable of evaluating stereo imagery, using the existing prototype for validation.
February 1st	Complete major new components and system design of In-Sight 2.0.
February 15th	Complete software, mechanical, and electrical integration.
March 1st	Finish designing and planning for pilot user study.
March 22nd	Complete pilot user study.
April 5th	Analyze pilot study, and plan relevant improvements to In-Sight 2.0.
April 19th	Complete relevant improvements, and design and plan main user studies.
May 3rd	Complete main user studies. Analysis of data and completion of publication will continue throughout the summer.

Literature Search

We have already reviewed a number of papers relating both to navigational aids for blind people and to the specific mode of feedback we intend to study (bas-relief tension-based force feedback). What remains is to synthesize all of these resources into a clear view of the problem domain.

Resources Needed

All software that we need is open-source. We need a significant amount of hardware to complete this project, including but not limited to a stereo camera, such as a Zed camera; motors and motor controllers; and general hardware like aluminum and acrylic. In addition, we will need stipends for study participants. To fund this project, we have applied for a SURG/CW grant, and we are also relying on funding through Professor Admoni's HARP Lab.