AudioNav: A Mixed Reality Navigation System for Individuals Who Are Visually Impaired

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ABSTRACT

This research is to design a novel indoor navigation tool called AudioNav for users with visual impairment. Current navigation systems rely upon expensive physical augmentation of the environment or expensive sensing equipment. The proposed system is infrastructure-free and low cost as it uses only a virtual representation of a building to be navigated.

Our proposed system: 1) extracts a floor-plan and recognizes landmarks in the three-dimensional model of a building, 2) locates and tracks the user inside the building while there is no GPS reception, 3) finds the most suitable path based on the user's special needs, and provides step-by-step direction to the destination using voice, speech, or haptic feedback.

General Terms

Assistive Technology, Visually Impaired, Path Planning, Localization.

1. PROJECT SUMMARY

1.1 Problem

The ability to navigate effectively and safely in unfamiliar environments relies upon being able to build a cognitive map of the environment [5]. Whereas sighted people primarily rely upon vision to create such a map, individuals with vision impairment (VI) have to rely upon their remaining senses such as touch, hearing or proprioceptive cues. Cognitive mapping as such is a relatively slow process leading to lower mobility of individuals with VI.

1.2 Motivation

To increase the mobility of users with VI, a number of indoor and outdoor wayfinding techniques have been developed. Whereas outdoor systems rely upon GPS to locate the user [2, 10], indoor systems typically rely upon expensive physical augmentation of the environment such as infrared (IR) [9, 8], ultrasound [7], or radio frequency idenfitier (RFID) tags [1, 4, 3] or expensive sensing equipment such as the systems based on computer vision [6]. Since these techniques are expensive, no indoor navigation system has been implemented on a large scale. Most of these techniques require that the user carries extra equipment which is not desirable as individual with VI already carry additional equipment such as cane or Braille-reader.

While planning the path is a key for successful navigation, few navigation systems [7, 8, 3] provide some form of specialized path planning. The objective of this proposal is to develop a navigation system that addresses these issues.

1.3 Solution

AudioNav is a navigation system that is infrastructure free, low cost, and considers special requirements of individuals with VI. The three unique characteristics of this system are that it augments reality, uses the user as a sensor, and applies probabilistic techniques to reduce uncertainty.

Our aim is to localize the user using a 3D model of the building and a dead-reckoning approach achieved with low cost sensing provided by a portable device, such as a cell phone with an internal or external accelerometer and magnetometer. The disadvantage of using dead-reckoning is un-bounded accumulation of errors over time. During indoor navigation, the user is constrained by physical infrastructure such as doors and walls which reduce the chance of veering from a straight path. Therefore, localization with the same precision as outdoor navigation may not be required.

Nevertheless, dead reckoning can maintain accuracy through periodic calibration. At the same time, since individuals with VI have a good sense of touch, the identification of spatial landmarks plays an important role in navigation of these spaces. This project uses probabilistic localization schemes that incorporate the feedback provided by the user via confirming the presence of landmarks along their path.

Safe paths with minimum uncertainty will be planned by adapting techniques from the fields of robotics and artificial intelligence. Such techniques model and mitigate the uncertainty associated with localization as well as user's varying ability to positively confirm landmarks encountered along their path.

AudioNav provides information and direction to the user using augmented reality. While augmented reality is typi-cally associated with visualization, in this proposal we seek using audio or haptic feedback.

From a user point of view the proposed system overs multiple advantages. It is a ordable, since it has minimal hard-ware requirements and can run on a cellphone. Required sensing can be achieved through inexpensive motion sensing controller technology. It is ubiquitous since it relies only upon a 3D model of the building, which allows for large scale implementation due to recent advances in the technol-ogy for creating such models. 3D models are available on the free virtual globe application Google Earth which can be used with AudioNav. Also, new models can be created using 3D modeling programs such as SketchUp and added to the Google Earth.

The proposed system can be also used by users with cognitive disabilities and sighted people, the anticipation is that it will be possible to have community-based e orts for the annotation of large scale model creation for public spaces such as train stations, airports, libraries etc. The proposed system also o ers an information service, which will answer spatial queries that can be solved by analyzing an augmented model of the building. For example models can be augmented with information which may be useful to a user with VI, such as the location of washrooms, the spatial layout of rooms or the nearest re exit.

This research seeks to answer three main questions:

1. Can we accurately localize the user using dead-reckoning and user feedback?
2. Can we find a safe path and provide directions to the user with VI so the user may arrive safely at their destination?
3. What is the best way to interact with the user?

1.4 Stage

We have implemented AudioNav for an Android phone. The tool extracts the oor-plan and landmarks from the 3D model of a building such as doors and windows. We have implemented a pedometer using the accelerometer built into the phone and using the pedometer and compass the system tracks the user and estimates user's location. The current implementation plans the shortest path and provides speech instructions.

Future research includes implementing probabilistic localization and dead-reckoning, improving path planning to minimize uncertainty, improving the object recognition to extract more complicated landmarks such as staircases and toilets, implementing voice recognition to receive user's feed-back, and investigating machine learning and information collection from the user to improve accuracy. As part of future work, we need to do user studies to answer our research questions and modify our system to improve usability.

1.5 Contributions

The proposed system can increase the mobility of mil-lions of visually impaired users around the world, which will allow them to enjoy a more independent lifestyle and improve their quality of life. Increased mobility allows access to higher education as well as broaden their employment opportunities as visually impaired suffer from high unemployment rates. This contribution will be particularly important in low-income regions, as well as in developing and third world countries where the use of portable and wireless devices is emerging, due to its lack of physical infrastructure dependence.

1.6 Gain

By attending the ASSETS 2009 Doctoral Consortium, I hope to receive feedback from researchers with experience in variety of related fields. This can help me to improve my research goals and plans, discover new ideas to consider in my research, and find new problems that need to be answered.

REFERENCES

[1] Amemiya, T., Yamashita, J., Hirota, K., and Hirose, M. Virtual leading blocks for the deaf-blind: A real-time way- nder by verbal-nonverbal hybrid interface and high-density r d tag space. In VR '04: Proceedings of the IEEE Virtual Reality 2004 (2004), IEEE Computer Society, p. 165.

[2] Arikawa, M., Konomi, S., and Ohnishi, K. Navitime: Supporting pedestrian navigation in the real world. IEEE Pervasive Computing 6, 3 (2007), 21-29.

[3] Bessho, M., Kobayashi, S., Koshizuka, N., and Sakamura, K. Assisting mobility of the disabled using space-identifying ubiquitous infrastructure. In Assets '08: Proceedings of the 10th international ACM SIGACCESS conference on Computers and accessibility (2008), ACM, pp. 283-284.

[4] Gifford, S., Knox, J., James, J., and Prakash, A. Introduction to the talking points project. In Assets '06: Proceedings of the 8th international ACM SIGACCESS conference on Computers and accessibility (2006), ACM, pp. 271-272.

[5] Golledge, R., Klatzky, R., and Loomis, J. Cognitive mapping and way nding by adults without vision. In The Construction of Cognitive Maps (1996), Kluwer Academic Publishers, pp. 215-246.

[6] Hub, A., Diepstraten, J., , and Ertl, T. Design and development of an indoor navigation and object identi cation system for the blind. SIGACCESS Access. Comput., 77-78 (2004), 147-152.

[7] Ran, L., Helal, S., , and Moore, S. Drishti: An integrated indoor/outdoor blind navigation system and service. Pervasive Computing and Communications, IEEE International Conference on 0 (2004), 23.

[8] Ross, D. A., and Lightman, A. Talking braille: a wireless ubiquitous computing network for orientation

and way nding. In Assets '05: Proceedings of the 7th international ACM SIGACCESS conference on Computers and accessibility (2005), ACM, pp. 98-105.

[9] Sonnenblick, Y. An indoor navigation system for blind individuals. In Proceedings of the 13th annual Conference on Technology and Persons with Disabilities (1998).

[10] Strachan, S., Williamson, J., and Murray-Smith, R. Show me the way to monte carlo: density-based trajectory navigation. In CHI '07: Proceedings of the SIGCHI conference on Human factors in computing systems (2007), ACM, pp. 1245-1248.