Context-aware Mobility for the Blind and Visually Impaired

Bharat Bhargava, Computer Science Department, Purdue University

bb@cs.purdue.edu, 765-494-6013

Mobility is important for the quality of life. The ability to see, hear, and experience the context of the environment is critical for safety and security. Visually impaired or blind persons have to use tools such as Braille, white cane, and guide dogs which keep them handicapped in achieving full navigation and mobility. Names of streets on intersections, names on building, and directions on highways are posted for normal humans to aid in mobility and travel. Emergency boxes have been installed on college campuses to aid students in distress or in some level threat. Some timing devices that count from ten to one at signal lights when walk will change to stop are available. In elevators, some help is available to help in identify the different floors. We believe that much can be done to increase the capabilities of blind individuals in navigating freely in buildings, college campuses, and cities.

The main approach is to increase capabilities for mobility is to learn the context of the environment. A walking person should be able to identify clear space around her so that a safe progress can be made in a particular direction. Similar ideas are used for robots or air traffic control. Even drivers are informed to keep certain number of car length distance from the car ahead of them based on speed and also stay in lane. Such contextual information should be made available to blind persons. Similar to the ideas of the air traffic control system that has a clear vision of the planes in the sky, surveillance cameras can be used on buildings, sidewalks, and streets to provide a data that can either be translated to audio messages directly or indirectly to the blind persons.

There are four directions of research that are practical with available technologies and are compatible with advances in science and engineering.

1. Vehicle to vehicle (V2V) communication [24,25,26]

One can learn much from other vehicles on road to make driving safe. Sensors are in common use in cars and additional sensors can track traffic and inform incoming cars about traffic conditions and other dangers. If we can use the same technology of such a cyber physical system to inform a blind person about hazards or safe conditions on the road, sidewalk, stairs, one can assist in safer navigation.

2. Surveillance video, webcams, CCTV, and GPS [27,28,29]

The idea here is similar to how a lost person calls up for help in finding directions to a particular location. The helper is aware of the geography, one way street, signal lights and provides directions from a distance. If a video of the area and context is available to a remote person, the blind person can be communicated such information for safe navigation and travel.

3. Haptics [6,7]

Of the five major human senses of vision, audition, taction (touch and proprioception), olfaction and gustation, only the first three have been engaged in most human-machine interface research. Of these three, a disproportional majority of work has been conducted on visual and auditory systems. Historically, work on tactile displays have been motivated by the desire to develop sensory-substitution systems for the visually or hearing impaired. The importance of vision and audition is implied by the need to replace them with other sensory modalities when they cease to function well. The existence of a more or less intact tactual sensory system is often taken for granted. An interesting idea was developed in [7]. It presents a wearable haptic interface that has been developed to impart vibrotactile information to its user with the goal of improving situation awareness. The effectiveness of the haptic interface has been evaluated in three experiments aboard the NASA KC-135A reduced gravity aircraft. During the third flight, subjects identified the locations of tactors embedded in the haptic display in a microgravity environment. Results show how cognitive load affects one's ability to identify the locations of vibrotactile stimulations in the altered-gravity environment. Cognitive load was manipulated by requiring subjects to be strapped to the floor of the KC-135 (low cognitive-load condition) or allowing them to float freely in microgravity (high cognitive-load condition). It was found that tactor-location identification was more accurate in the low cognitive-load condition than in the high cognitive-load condition. Our results have implications for the design of multimodal user interfaces in general.

4. Sensors in sidewalks, building corners, roads, devices to describe the environment.

We see emergency boxes installed in streetcorners to help a person in case of imminent danger. Similar devices have to be developed to help the blind person who may need to communicate with such pervasive devices for help in mobility and navigation. RFID tags have been used in [1,2,3,4] to help with navigation inside and outside buildings on the campus of University of Florida. In [5], the research presents a navigation and location determination system using an RFID tag grid. The retail industry has developed a low cost tagging system to electronically monitor products from manufacturing, warehouse and to the consumer. The design requirements to satisfy the needs of the retail industry are low cost per unit, reliable, powerless and the ability to transmit a wide range of data. By leveraging advances in RFID technology it is feasible to develop a system that utilizes RFID tags as a location based information grid. Each RFID tag is permanently installed under carpet, wood floors, behind trim in hallways, along sidewalks and as part of any pedestrian path. Each RFID tag is programmed upon installation with its X,Y coordinates and information describing the surroundings. This allows for a localized information system with no dependency on a centralized database or wireless infrastructure for communications. For under $1 per tag it is possible to store 250 bytes of information that can be read as the user approaches the tag. Using proposed compression and flexible XML based protocols, an RFID grid in a room can store a complete inventory and location of the room objects and information about neighboring rooms. Upon entry into a room the RFID tags at the door provide a summary of the room's content and the location of each object. This information is then read into the student's cell phone or PDA and when the student needs to find the electrical outlet, telephone, desk, vending machine, etc., the system - knowing its current location based on the RFID tag coordinates - can give the path to the object through voice prompts.

Broad Impact: The ideas presented here can be used in department of defense. For example, soldier injured and lost in the mountains of Afganistan can navigate to safer location using similar technologies and ideas presented here. Similarly a hiker lost in mountains may seek help using context aware information. Even a lost child may be assisted in situation such as malls, parks, big gathering such as state fairs. The ideas can also be used in aircrafts that are in difficult situations during some hazardous condition.

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