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Integration of Active Tactile Control Braille Technology into Portable Navigation and Object Recognition Systems for the Blind and Deafblind

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Abstract. A small Braille display with Active Tactile Control (ATC) Braille technology was developed in association with the *Handy Tech* Company. With ATC technology text information can be read without pressing a scrolling button, as the system automatically shifts to the next line when the reading finger is detected at the end of the last word. This Braille display was connected to two compatible systems. The first is the TANIA (Tactile Acoustical Navigation and Information Assistant) navigation system, based on detailed maps, a movement sensor, and the Global Positioning System (GPS). The second is an object recognition system, which uses 3D environmental models, a movement sensor and stereo camera. Either system, or both in combination, provide information acoustically or in Braille. Blind and deafblind users report that the use of the portable ATC display technology combined with these systems represents an additional step toward increasing independent orientation and mobility.

Keywords: Assistive Devices; Deaf-Blindness; Information Technology; Navigation & Orientation Technology; Tactile Perception

1. Introduction

Over the last few years navigation and object recognition systems for the blind and deafblind have been developed at the University of Stuttgart based on augmented maps and 3D environment models. The TANIA (Tactile Acoustical Navigation and Information Assistant) navigation system supports orientation and mobility based on detailed maps (Hub, 2007). These maps include guiding grids for the visually impaired, comparable to a checkerboard with named rows and columns (Hub, 2008). The configuration of the guiding grids can be adapted to specific architectural and environmental shapes, such as curved sidewalks and streets, and asymmetrical rooms. Unlike raw GPS coordinates or conventional rectangular map grids, route descriptions based on guiding grids can be easily understood by users and can be accurate up to one step. Previous work has shown that 3D environment models can support interactive object recognition by using additional hardware (Hub, 2006). Current location data, augmented text information (such as public transportation schedules), and detailed object descriptions can be added to any location and any item stored in the model. The maps and environment models, augmented with user-specific information, can be produced by or with assistance from the non-profit organization *BNI Blindnavigation International* (BNI, 2008). Given such maps and models, individualized routes and navigational advice can be accessed even without GPS signals.

At about the same time, the *Handy Tech* company had developed the innovative Active Tactile Control technology (Kipke, 2006). ATC Braille displays detect the position of the reading finger, and allow users the advantage of speed when compared to other Braille displays. This technology was available only in large workplace Braille displays, however.

The aim of this work was to develop a portable ATC Braille display and to combine it with our navigation and object recognition systems, thereby enhancing independent and discreet navigation and information options for blind and deafblind people.

2. Methods

A new portable prototype of a Braille display with ATC technology and 16 Braille modules was developed by *Handy Tech*, the University of Stuttgart and *BNI Blindnavigation International*. Like other conventional Braille displays, this prototype uses what is referred to in physics as the "piezoelectric effect" to lift the single pins of its Braille modules. That is, when an electric field is applied to the material, it expands, activating the pin. The

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new ATC display utilizes in addition the reverse of this principle, or “direct piezoelectric effect”. The application of stress via finger position on the Braille pins generates electrical potential, which can be measured to determine degree of expansion, and thus, reading finger position. Given this technology even lengthy text information can be read without pressing a scrolling button, as the system automatically shifts to the next line when the reading finger is detected at the end of the last word. If necessary the user can go backwards by pressing a button. It also allows browsing through a longer text, especially in combination with an audible screen reader.

The new Braille display was connected to two compatible systems, which together support safe and independent orientation and navigation for the blind. The first is the TANIA system, a navigation system based on detailed maps and the Global Positioning System (GPS). Its movement detection technology enables blind and deafblind users to navigate independently in every environment where adequate mapping has been done. In addition, augmented text information can be linked to specific map locations and accessed acoustically. TANIA system hardware consists of a lightweight, portable tablet PC suspended from a strap worn around the neck. An inertial sensor (MTx, by Xsens) is fixed at the center of the strap and connected by cable to the tablet PC. Initial position is determined using GPS signals or entered by the user if GPS signals are weak or absent. As the user moves, current position is determined based on the inertial measurements and optionally synchronized with map and/or GPS information. The TANIA system allows virtual explorations by tapping on the touch screen, and real exploration by walking normally. Stored text information can be accessed via tactile-acoustical switches or by tapping on the map, allowing the user to address navigational tasks. Among the information that can be provided by the TANIA system outdoors are current location, street name and section, navigation advice, detailed route descriptions, and so on. Indoors, information such as floor and room numbers, restroom location and stairwell characteristics can be transmitted to the user. In both cases, any desired text information can be added to map elements, such as menus at restaurants and schedules at bus stops.

The second system provides object recognition based on 3D environmental models. It consists of a bicycle helmet with an integrated stereo camera and a movement sensor. By comparing sensor and camera information with 3D environment models using a connected portable computer, objects in viewing direction are recognized and named, and the presence of other people detected and announced. Additionally, distances and/or special features like the colour of objects can be provided to the visually impaired user. Different languages are available, allowing users to learn or practice basic vocabulary in foreign languages (Hub, 2005). All this information can be transmitted to the user via the Braille display.

Blind and deafblind users have tested the combinations of our navigation and object recognition systems with the ATC Braille display during typical tasks of orientation, navigation, route planning, guidance, object recognition and reading augmented text information.

3. Results

The combination of the ATC technology with navigation and object recognition systems is of obvious benefit, especially for the deafblind, for it allows them safe and independent navigation and immediate access to environmental information. Blind users reported that the Braille display proved useful in loud environments where acoustical information would be inaudible, as well as in situations where acoustical output would be inappropriate. Further, using Braille maintains personal privacy when others are nearby. They also reported that the ATC technology increases Braille reading speed, since scrolling at the end of each line is automatic. The advantages of the ATC Braille display are most obvious when text information is longer, as in schedules and menus, for it allows the user to quickly scan text, skipping undesired information and focusing on desired material.

4. Conclusion

The integration of Active Tactile Control technology into our portable navigation and object recognition system represents an additional step toward increasing independent orientation and mobility for the visually impaired. It offers the discreet and unlimited acquisition of longer texts in mobile systems for blind and deafblind users.

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