Demonstration of a universally accessible audio-haptic transit map built on a digital pen-based platform

ABSTRACT

In this demo, conference attendees will try out a new system for providing multi-sensory transit and way-finding information about New York City subways to riders who are blind, visually impaired, or otherwise print disabled. The system includes a booklet of raised-line and textured maps of train routes; users explore the maps through various combinations of vision and tactile sense, and then touch the tip of a special pen to locations on the map to hear station names and other information spoken aloud. Train lines are rendered as narrow channels that help to guide a user's hand as he or she moves the pen along a route, and small depressions within these channels mark individual station stops. This novel combination of tactile graphics and a haptic audio probe may provide an intuitive and information-rich interface that could help disabled individuals travel around the city with greater self-confidence, safety, and independence.

Author Keywords

Tactile, cartography, pen, computer, blind, subway, map, orientation

ACM Classification Keywords

H.5.2 User Interfaces (Haptic I/O, Audio (non-speech) feedback)

INTRODUCTION

Visually impaired travelers have difficulty accessing information that their sighted counterparts take for granted. For example, subway maps provide sighted riders with an overview of an entire network of underground trains, and also offer details about individual routes and stations. Without maps and other tools for acquiring up-to-date information prior to setting out on a journey, and for consultation *en route*, blind and low vision individuals experience navigation difficulties. This project embodies ideas that might help to reduce levels of inconvenience, frustration and hazard that often interfere with capable individuals' efforts to reach their employment and education objectives. The authors have developed a practical system for making and distributing accessible transit maps that are portable and inexpensive to manufacture. This work combines static tactile images with dynamic audio content, and adds a proprioceptive component that may make the system easy and intuitive to use for transit riders with a wide range of capabilities and preferences.

Background

The New York City subway is one of the most extensive public transportation systems in the world, with 468 stations and 842 miles (1355 km) of track [1]. Understanding the layout of the system and planning routes between stations is a daunting exercise for many riders, with and without disabilities. *The Map*, originally developed in 1979, and continually updated since then, is appreciated by many transit riders, because it presents the system's complexity in a surprisingly comprehendible way [2]. The map thoughtfully balances diagrammatic clarity and spatial accuracy [3], and it is the outcome of an evolutionary design process over more than 100 years. Without easy access to *The Map*, which is ubiquitously displayed in train cars and stations, and widely distributed to the public at no charge, navigating complex routes would be unmanageable for many riders. Yet, this is the exact situation faced on a daily basis by those who cannot see well enough to make sense of *The Map* in its current print-only format.

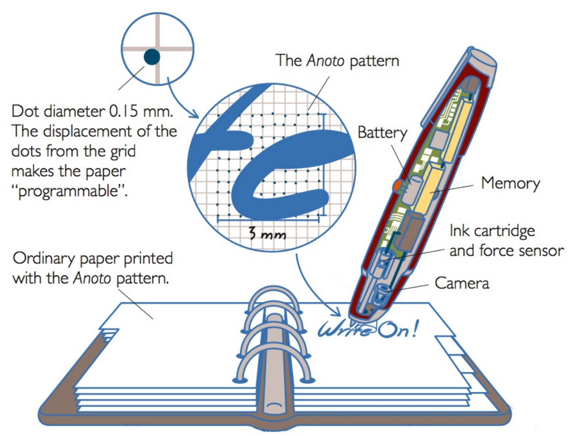

Figure 2: The Livescribe Pulse Pen and the Anoto pattern

Project Description

The pen-enabled talking tactile subway map that is the subject of this demonstration appears to be the first portable and comprehensive cartographic system that is accessible to riders who cannot read print documents. In the current implementation, only the 1-2-3 lines are shown; in future versions, the entire system will be presented in a bound booklet of maps. Each page will show a single route, along with a simplified outline of the geographical context of the four boroughs[1], and major parks and airports. While the map can be used by itself (two-character Braille abbreviations identify the most important transfer points and a legend for each subway line explains their meanings), its full potential as a navigational tool is only revealed when the map is used in conjunction with the computer-pen (Livescribe's Pulse Pen [3]). This powerful, compact device, developed as a consumer product and used mainly as part of a smart note-taking system, includes a tiny video camera in its tip (see figure 2). The camera "sees" a very fine (almost invisible) *Anoto* dot pattern on the map's surface, and through analysis of the position of the dots, the pen's on-board microprocessor is able to determine the precise location of the nib on the map's surface [4]. After consulting a program that associates each x,y coordinate position on the map with place names, the pen's audio system plays recorded messages that include names of the stations touched. Additional useful information is embedded as a series of layers that are accessed when the user taps multiple times on a station. These layers include descriptions of platform and stations physical layout; information on transferring to connecting services, such as bus and ferry; data on routes and schedules; and instructions about what to do in case of an emergency. In Phase 1, this material will be collected for all 84 stations along the 1-2-3 line, output through a speech synthesizer, and saved to the pen's 1 GB flash memory for playback on demand during map exploration.

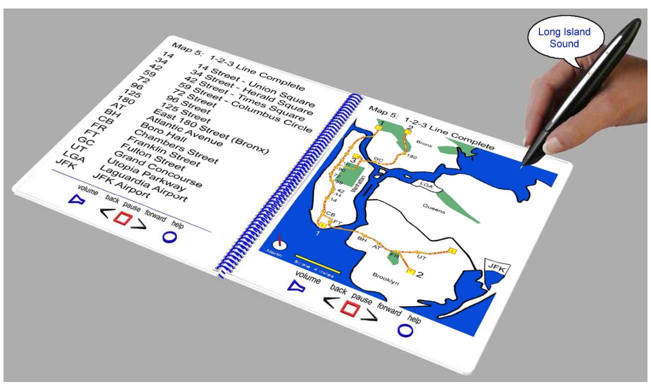

Fig.3: A map showing the 1-2-3 lines of the New York City subway system.

The subway map system demonstrates a new approach to delivering information through a static haptic display. This approach relies on some of the same sensory mechanisms that adept blind pedestrians rely upon as they move about in the world. Most blind travelers use long canes to interrogate the environment and to draw inferences about terrain conditions prior to taking each step, and also to detect and negotiate local obstacles [5]. They do this by interpreting haptic data transmitted from the cane's tip, through the shaft and grip of the cane, and into the palm of the hand. In the case of the subway maps, in similar fashion, the map's three-dimensional form encodes information that travels up the pen's body and into the user's hand. The raised parallel ridges that form channels guides the users hand along the train's route in an approximation of the actual track configurations, possibly creating mental linkages between the abstraction of the map and real-world conditions. Small dimples mark the location of each station, creating haptic events as the pen drops into each one. Users may find it easy to count the number of stations along a route. Furthermore, the dimples may stabilize the pen's tip at a single point, which is helpful if the user has difficulty with fine motor control, or if he or she experiences hand tremor.

[1] Staten Island, the fifth borough, has its own separate above ground light rail system.

CONCLUSION

This demonstration will introduce conference attendees to an innovative application of interactive audio-haptics. The New York City subway map system discussed here is an example of universal design, because it sets out to be usable by a very broad audience, it presents information in multiple and redundant formats, and it adapts to, or can be reconfigured for, a large variety of user profiles. If upcoming trials reveal that the subway maps are effective for blind and low vision transit riders, we envision other applications that leverage this technology, including DAISY-compliant illustrated digital talking books in categories such as children's literature; technical manuals; tourist data; emergency preparedness information; standardized assessments; maps of all kinds; and text books and curricula for mathematics, history and the sciences.

ACKNOWLEDGMENTS

The product demonstrated here is being developed through a Phase 1 SBIR grant administered through US Department of Education, National Institute on Disability and Rehabilitation Research (H133S080030).

REFERENCES

1. New York City Transit Information website. http://www.mta.info/nyct/facts/ffsubway.htm
2. Ovenden, M. (2007). **Metro Maps of the World**. Viking-Penguin.
3. Wood, M., Marggraff, J., Brown, M., & Fishbach, M. Interactive learning applicance. US Patent No. 6801751 Filed Aug 4, 2000, issue Oct 5, 2004.
4. Luff, P., Heath, C., Norrie, M., Signer, B. & Herdman, P. (2004). Only touching the surface: creating affinities between digital content and paper, *Proc. Conference on Computer Supported Cooperative Work (CSCW 2004)*
5. Blasch, B., Wiener, W. & Welsh, R., eds. (1997) **Foundations of Orientation and Mobility** (second edition). AFB Press, New York.