Guiding Grids in Augmented Maps for Precise Installation-Free Worldwide Blind Navigation

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Summary
Guiding grids were integrated into the TANIA system's maps. Precise navigation support is provided indoors and outdoors even in large open spaces without physical guidelines.

Introduction
During the 2007 CSUN Conference a navigation aid for the blind and visually impaired was presented based on the integration of augmented maps and a step-recognition method [4]. The TANIA (Tactile-Acoustical Navigation and Information Assistant) system determines the user's position using maps, inertial measurements of 3D sensors (compass, gyroscope), an acceleration sensor delivering the user's velocity, and a GPS sensor. By tapping on the touch screen of the TANIA system, information about current position and environmental architectural details can be provided acoustically or in Braille. Additionally, maps can be augmented with information such as conference schedules and object location.

Usability tests with blind subjects revealed a navigational challenge whose solution forms the basis for this paper. Specifically, in large, open rooms the lack of physical prompts (such as aisles or rows of chairs) makes it difficult for users to assess their movement direction and progress. Similarly, large outdoor spaces lacking sidewalks or curbs are difficult to navigate precisely. Available maps, often created for car navigation, may lack sufficient detail to support safe mobility for the blind.

To address this problem we have integrated guiding grids, comparable to a checkerboard with named rows and columns, into the augmented maps of the TANIA system. 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.

Related Work
For indoor environments, when GPS signals are weak or absent, there are two frequently-used tracking methods for blind navigation. One is to use additional hardware infrastructures like WiFi [1], RFID [6,10] installations or optical beacons [8]. The other, so-called dead-reckoning, is to use map information and inertial sensors [4,5]. Outdoor navigation systems based on GPS offer the option to enter user-made

points of interest that can be used for enhanced route descriptions, e.g. [2]. Additionally, others use cell phone software to describe the current environment [9].

System Setup and Mode of Operation
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. TANIA can be connected to commercially available Braille displays, allowing its use by deafblind people, and by blind users in situations where acoustical output cannot be heard or must be avoided. In addition, TANIA can be used as a communication device by deafblind people and anyone able to type on its conventional keyboard [3].

Pilot Studies
During the 2007 CSUN conference in Los Angeles, the 2007 National Convention of the National Federation of the Blind in Atlanta, and the SightCity exhibition in Frankfurt, Germany, usability tests with blind subjects were conducted indoors. These tests were extended to outdoor environments in several German cities. Augmented information was linked to appropriate map positions – e.g., menus at restaurant entrances, schedules at bus stops and train stations. Blind users reported that TANIA significantly enhanced their navigation abilities.

Guiding Grids for Worldwide Precise Navigation Support
A conventional GPS guiding system typically provides the user with street name, the current GPS coordinates, and occasionally with house numbers. Some systems incorporate points of interest into the map, linking user-made text or speech information. While quite helpful, these points are time-consuming to install and edit, and unavailable until set up by the user or others.

In contrast, TANIA's guiding grids produce a route description like this: "Walk along Main Street from segment A1 to A10, turn right and cross the intersection using segments A10, B10, C10, then turn left at C10." To accommodate curves that might be missed when walking along the curb with the cane, grid segment sizes and names can be varied. These accommodated grids allow safe navigation of multilane intersections with or without traffic islands, roundabouts, and crooked crosswalks. Information can be added to the street names, such as whether and on which side/s of the street sidewalks exist, the direction of traffic in multilane streets, the presence of beeping traffic lights, and the location of Braille markers on architectural objects.

Besides the new grid information, compass headings and distance information remain accessible to the user. The number of steps can be counted and saved or reloaded when paths are completed.

Another advantage of guiding grids over conventional street maps is their usefulness in extreme weather conditions. If sidewalks are covered by snow or dirt from roadwork, and the boundary between street and sidewalk occluded, it is difficult to stay on a sidewalk using only GPS signals. With guiding grids the user is always aware of his or her position relative to map segments, even when physical features of the pathway may have changed since map construction. Further, detours around obstacles pose no problem for the user, who can use adjacent grids to return to the desired path.

The drawing of useful grids can be accomplished by anyone who is familiar with drawing programs and experienced in the area of blind navigation. Automatic drawing or simple cut and paste strategies are adequate for streets laid out in regular patterns, and for rows of similar buildings. Grids can be easily integrated into city maps often available in digitized form from local governments and other public institutions. When accessibility laws are extended to include existing maps and related information, as has been accomplished in several countries already, mapping is even easier.

The addition of guiding grids makes the TANIA system useful even in developing countries or regions where there are no streets at all. It is much easier to draw virtual paths on a map than it is to construct real pathways, whether paved or unpaved.

Implementing Guiding Grids for the Conference Environment

Previous CSUN Conference attendees – including those who are sighted – know how easily one can become disoriented when walking within and between conference hotels. Especially challenging to both pedestrians and drivers is one hotel which has a circular driveway entrance without a continuous sidewalk. The TANIA system, enhanced by guiding grids, could offer safe and efficient navigation to blind users throughout the conference area. Further, maps can be augmented with agenda information provided by hotel management and conference agenda committee, e.g. room numbers, lecture and exhibition halls, booths, products and timetables.

Conclusion

In contrast to other navigation systems where extensive mapping and time-consuming or costly pre-installations are necessary, the addition of guiding grids to existing maps results in a simple, inexpensive and precise navigation system for the blind and visually impaired. Estimations of map file sizes show that relatively extensive map areas can be saved on TANIA's hard drive, making connection to an internet server optional. This supports user independence, ensures privacy and data security, and allows use of the device even during power blackouts. In summary it seems that safe and precise blind navigation is possible in every corner of the world if adequate mapping with guiding grids has been done. Nevertheless, it would be useful to define a global standard.

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