The Tangible Pathfinder
Design of a Wayfinding Trainer for the Visually Impaired

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Abstract

We detail our proposal for an orientation and mobility (or wayfinding) trainer for the visually impaired—the *Tangible Pathfinder*. The *Tangible Pathfinder* allows autonomous learning of a new setting, self-assessment of the resulting cognitive map, and eventually on-site mobility assistance when physically walking through the environment. The *Tangible Pathfinder* integrates a tablet-like tangible user interface (TUI) which tracks a set of physical objects placed on its surface, and accompanying, spatially-related, 3D auditory cues. The detachable physical set of objects affords a "cane-vision" tactile vocabulary, based on a set of miniature representations designed from the point-of-view of a vision-impaired person walking with a cane. The *Tangible Pathfinder* supports various wayfinding training activities and can be employed as a static or as an interactive tactile portable map. Its tactile legend and auditory cues can be used to represent practically any desired environment, and can be downloaded directly onto the *Tangible Pathfinder* by the visually impaired user from an online database.

1 Tangible User Interfaces and the Blind

Tangible user interfaces (TUIs) can be viewed as physical objects that mediate interaction with shape, space and structure in the virtual domain [1]. We believe that TUIs, with their intuitive, tactile embodiment of digital entities, would have an important role in future HCI paradigm for the visually impaired. For example, young visually impaired children could benefit from an automatic trainer based on 3D constructional TUIs, such as ActiveCube [1], when learning basic spatial relations like "on top" or "in the corner", notions that are often extremely difficult to understand when lacking vision from birth. Such a trainer could interactively map, in a game-like environment, physical actions performed on the TUI to audio verbal messages summarizing the current spatial state of the interface.

2 Wayfinding Training for the Visually Impaired

The visually impaired rely heavily on their remaining hearing and tactile senses while perceiving and interacting with the world [2]. There are many techniques designed to help the visually impaired relate to the environment by using only these senses (see for example [2-4). The common ground of all of these techniques is that they all help the visually impaired person gain *cognitive knowledge* about the world by sampling and transforming information into a tactile or audible form.

This effort of gaining cognitive information about the world by using only hearing and touch has an important subset: the need to gain wayfinding, or orientation and mobility skills (we will use the common abbreviated form "O and M skills" or, *the diverse set of challenges facing a traveler and the physical and mental skills required to meet those challenges* [5]).

Many visually impaired people are an extreme case of "landmark navigators". Unlike guide-dog walkers, cane walkers, apart from finding their landmarks, also need to avoid moving or fixed obstacles along the route. Many of the objects a visually impaired cane walker would consider to be important landmarks would be almost unnoticeable for a seeing person. For example, curbs and ramps are important landmarks for cane walkers as they are an important part of their sensory input (perceived by the cane) and very rarely move.

Several techniques are used for O and M training of the visually impaired [2,3,5]: detailed verbal description of the new environment; audio descriptions and samples from the environment; tactile metaphors (most notably, tactile maps—similar to traditional maps but with raised edges, and even Lego™ blocks). When such training aids are not available the training usually takes place in the physical environment, with continuous presence of a trained instructor. Technological attempts to support O and M learning include Nomad [6], a tablet-based device which enables visually impaired users to interact with maps, graphs or pictures. The blind user can place a tactile 2D raised line diagram on top of the Nomad tablet. By pressing the diagram the user can hear an audio feedback sample that is mapped to the pressed area. The Nomad, however, does not allow tangible interaction, other than pressing, and does not support editing or rearrangement of the spatial information. Another interesting example is AudioDoom [7]—a Doom-like computer game for blind children. The children interact with a simple game maze by walking through it and fighting opponents using only 3D auditory representation of the maze. Interestingly, it was found that most children captured a cognitive spatial map of the maze in a relatively short time by simply playing the game, and were later able to describe the maze spatially, building it with physical blocks.

3 The Tangible Pathfinder

The *Tangible Pathfinder* (see accompanying poster for system illustrations) is a TUI based orientation and mobility trainer for the visually impaired, currently under design. The *Tangible Pathfinder* is intended to allow detailed, autonomous learning of a new physical setting and self-assessment of the resulting cognitive map. The system is based on tactile vocabulary which represents the way an environment is perceived by a visually impaired person walking through it with a cane. The *Tangible Pathfinder* consists of a tablet-like surface which tracks the identities and locations of various objects that can be placed on top of it. The objects represent pavement, sidewalks, curbs, ramps, walls and poles which are all common landmarks for a cane-walker.

Learning a new environment using the *Tangible Pathfinder* can involve a combination of the following three different activities:

1. Tactile sensing and feedback: using the *Tangible Pathfinder* as a static tactile map, gaining information about objects and route layouts by touch.
2. Tactile browsing and audio feedback: using the *Tangible Pathfinder* as a static tactile virtual world, moving a tracked physical avatar on top of the world while receiving detailed 3D audio feedback.
3. Tactile rearrangement with audio feedback: attempting to reconstruct an environment from memory. While rearranging the objects the user receives both tactile and 3D audio feedback relating to actions correctness.

The *Tangible Pathfinder* can enable visually impaired users to independently upload an environment from an online database when learning new environments, much like a seeing person downloads a map off the web. The online text or auditory information would include a set of coordinates and object identities, based on the *Tangible Pathfinder*'s vocabulary. Following this data the user could construct a detailed physical replica of the online information on her personal *Tangible Pathfinder*, gradually placing the right objects at the right places. At the same time the *Tangible Pathfinder* software would download the digital representation of the environment and the supporting audio information. Following, the manual construction process would be supported by 3D audio feedback from the *Tangible Pathfinder*, correcting wrongly positioned or missing objects. Once the construction has been completed the user could use the *Tangible Pathfinder* for learning, following the interaction techniques mentioned earlier (that is, the *Tangible Pathfinder* being used as static, interactive or editable tactile map).

Given sufficient miniaturization the *Tangible Pathfinder* could be used as a portable, autonomous O and M guide. Once the user finished using it for learning a new environment at home, she can simply carry it as a static and interactive tactile map while walking through the physical environment. Hence, the *Tangible Pathfinder* would allow visually impaired users to download a new environment, learn it, and then carry its replica along when visiting the physical site for the first times.

One of *Tangible Pathfinder's* greatest challenges is to physically capture and miniaturize the blind user's tactile, "cane sampled", object perception. One approach is to base the *Tangible Pathfinder* vocabulary on existing legends such as the ones used in tactile maps for blind orienteering (see for example [8]). Describing urban and even indoor settings, we might need to develop a supplemental tactile vocabulary for the *Tangible Pathfinder.* We believe that by adding precise details to a miniature object we might distract the user's attention from the abstraction we are trying to convey. Following this policy of simplistic abstraction we will represent, for example, fire hydrants as short poles, pavement as smooth or bumpy textured blocks, etc.

Another important component of the *Tangible Pathfinder* is its spatially-aware 3D auditory feedback. Each *Tangible Pathfinder* environment integrates verbal audio information and supporting sound effects. For example, when learning a transit center environment, 3D audio effects will include car and bus sounds coming from realistic directions according to the transit center's layout and the physical avatar location. When tangibly referred to, objects will "speak" and provide information about themselves and their surroundings.

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