Arditi, A., Holmes, E., Reedijk, P. and Whitehouse, R. (1997). Universal wayfinding system for building interiors. *Technology and persons with disabilities: Proceedings of the twelfth Annual International Conference on Technology for People with Disabilities.* Northridge, CA: California State University at Northridge.

# UNIVERSAL WAYFINDING SYSTEM FOR BUILDING INTERIORS

Aries Arditi
Emily Holmes
Peter Reedijk
Roger Whitehouse

Whitehouse/Reedijk/Arditi
and
The Lighthouse Inc.
111 East 59th Street
New York, NY 10022

We are developing a wayfinding system for public building interiors such as office buildings, museums, hospitals, hotels, and transportation facilities, that will increase accessibility of those spaces to visually impaired users. This computerized system, called Pathfinder (TM), will interact with users by artificial speech, an electronic touch tablet with tactile overlay, a video screen with enlarged text, and possibly voice input. Adhering as much as possible to the principles of universal design, it is intended to be accessible to all users, including fully sighted persons, those with low vision, deaf persons and wheelchair users, and potentially speakers of different languages.

We believe that the results we present here demonstrate the feasibility of such a system, because they show, using the most challenging user population (blind users) in an unfamiliar indoor environment, that an interactive tactile map system is both capable of training blind users with no experience with visual or tactile maps on its use, and of giving them sufficient information to find their way in that space. In this study, we compared participants' ability to walk to landmarks in an unfamiliar building environment using Pathfinder for route planning, with a comparison condition, in which participants were given a route description that might be obtained from a bystander queried for directions.

## Method

Materials and Apparatus. Our prototype Pathfinder (TM) system consisted of a computer-controlled electronic touch tablet with a tactile map overlay depicting the the 10th floor of the Lighthouse Inc. Manhattan Headquarters. The tactile overlay was printed on swell paper(and subsequently "toasted" to raise the image using a Reprotronics Inc. Tactile Image Enhancer) and mounted on a touch tablet. It allows free exploration of a relief surface on top of the membrane without transmitting any signal. When the user desires information, a firm press conveys information specific to the coordinates of the key press. Both the map and the touch pad are size A3 (42 cm x 29.7 cm). Custom software controlling the system ran on

Macintosh laptop computer equipped with Yamaha YM10 speakers, for artificial speech output.
After hearing a short introduction to the system including the location of the "you are here" symbol, and use of the Main menu, Cancel, Help and OK buttons, the user is prompted with the main menu. This menu has three choices from which he or she may choose a range of options. These include general descriptions of the floor space such as scale and orientation both in terms of compass directions and locally-accepted conventions (e.g. the 60th Street side of the building), interactive options which guide the user in where to move their finger to desired goals on the map, or allow free exploration of map features, where a tactile feature may be identified by pressing on it. If desired, the user may obtain an accurate route description that describes the route in terms that are useful to a blind person, including information about walls to trail, and physical and auditory landmarks they will encounter along the way. Users may make a "test-walk" on the map with their fingers, using these descriptions, prior to making the actual journey to their desired location.
The map, touch pad, computer, and speakers were installed at the reception area of the floor, just off the elevator. All participants were greeted by the experimenter in the lobby of the building and escorted to the 10th floor, so as to prevent uncontrolled or incidental learning of the test space.
A series of route description verbal scripts intended to be "ecologically valid" were obtained for use in a bystander directions condition (see below). In order to mimic the kinds of directions a blind person might obtain from a sighted bystander who is queried, we asked 18 office occupants of the 10th floor for actual "directions" they might give to a blind person asking how to get to each goal location used in the study. These descriptions were obtained at the reception location where the participants were later tested. The bystander directions were taped and subsequently transcribed. Only route descriptions that were factually correct were used. These descriptions are very likely significantly better than those that would be obtained from occupants of an ordinary business building since the occupants of the 10th floor are accustomed to interacting with, and in most cases, researching people with visual impairments. The fact that a significant proportion of candidate route descriptions thus obtained could not be used due to factual inaccuracies underscores the difficulty that blind people experience in obtaining such directions. To the extent that able-sighted bystanders are able to give effective geographic directions even to able-sighted strangers, they are especially poor at remembering nonvisual landmarks, and giving directions to blind people. In fact, we had to collect a total of 27 route descriptions in order to obtain 18 that contained factually correct wayfinding information! This is despite each participant being extremely familiar (i.e. their offices were on this floor)with the goal being asked for.
Participants. Ten blind persons whose visual capabilities were at most, "light perception," served as participants. All could travel to the Lighthouse building independently, but had never been on the 10th floor before. Most were recruited using records identifying them as having received services in Lighthouse satellite facilities in Queens, Staten Island, Westchester or Suffolk Counties rather than the

Manhattan facility. Some reported extremely limited familiarity with the building, such as being in the lobby or having been in the building prior to an extensive renovation that took place from July 1992 July 1995.

Procedure. Each participant was tested in both the Pathfinder condition and the "bystander directions" condition. Half the participants were tested on Pathfinder (TM) first, the other half on the "bystander directions" condition. In both conditions, participants were told that their task was to walk to specified goals on the floor, by either planning a route with Pathfinder (TM) or by carrying out the "bystander's directions." Participants started at the same location and orientation, and were instructed to find the goal using their customary navigation techniques. 18 goals were chosen from those available on the floor randomly divided into two sets of 9 for the two conditions. In both conditions, an error was scored if the participant was incorrect in identifying a specified goal, or if they made an error at a decision point (e.g. a wrong turn), and proceeded at least 2 feet in this wrong direction (at which time they were guided back to the point at which the incorrect decision was made)or paused and were unable to continue. Under all circumstances they could opt for a "hint"; this hint was a repeat of the instructions given either by Pathfinder (TM) (in the Pathfinder condition) or in the bystander script (in the bystander direction conditions). Requests for hints were also recorded and analyzed.

Pathfinder condition: In this condition the Pathfinder (TM) software was run and participants and were allowed to interact freely with the map without intervention or assistance (except when occasional bugs in the software turned up), and when the participant was querying the system for a name or room number. Because the text input facility was not yet implemented, in this one case, the experimenter typed the desired name or room number into the system for the participant. When the participant felt sufficiently confident, they walked to the goal location.

Bystander directions condition: In this condition the experimenter read out a set of valid directions to the target goal. After this, the participant walked to the specified location. The only restriction imposed on their strategy was that they were not allowed to ask other bystanders for help. All staff on the 10th floor were warned in advance of the experiment and asked not to offer assistance, but to otherwise go about their daily activities in a natural way, including talking and walking about on the floor.

Questionnaire: After both conditions were completed, a questionnaire was given that solicited participant ratings with respect to both conditions.

## Results and Discussion

Errors in wayfinding: Wayfinding errors averaged 5.60 in the Pathfinder condition, compared with 10.05 in the bystander directions condition. This difference is significant (Wilcoxon matched pairs signed ranks test $T=8$, $n=10$, $p < 0.05$). Thus even in this first generation test system, the interactive touch map system reduced wayfinding errors by half!

Wayfinding with zero errors: We also examined the trials on which no wayfinding errors were made, i.e. those in which the participant

reached the goal fully independently and correctly. Wayfinding with zero errors was achieved on 65.6% of trials using Pathfinder (TM) and on 45% of trials using bystander directions. Per person, 5.9 such "perfect" trials on average were Pathfinder trials, whereas 4.1 were bystander directions trials. This difference is also significant (Wilcoxon matched pairs signed ranks test, $T=2$, $n=9$, $p < 0.01$). Thus Pathfinder (TM), used virtually independently, produced almost 1/3 more "perfect" wayfinding experiences than did a condition intended to mimic directions obtained by a stranger (although rated superior to actual directions obtained from strangers see below).

Hints requested: There were 24 requests for hints in the bystander directions condition, relative to 16 in the Pathfinder condition, suggesting that participants could more easily recover from their wayfinding errors with Pathfinder (TM) than with bystander directions. However this difference was not statistically significant using the Wilcoxon matched pairs signed ranks test.

Learning effects: We tested whether participants' wayfinding accuracy improved with additional trials. Neither a Friedman two-way analysis of variance, nor a standard ANOVA showed any significant effect of trial. This is consistent with the idea that Pathfinder (TM) produces accurate wayfinding immediately, and thus is feasible for first-time users, as most of the users in an ordinary building would be.

Participant ratings: Results from the questionnaire will be presented in detail at the conference. Ratings for Pathfinder (TM) were generally high, averaging 5.59 out of a possible 7 (scale is 1=extremely, 2=very, 3=fairly difficult; 4=neither easy nor difficult; 5= fairly, 6=very, 7=extremely easy), indicating that Pathfinder (TM) was rated to be quite easy to use in a number of different ways. Of special note is the fact that it was rated to be very useful for travel alone and with strangers in an unfamiliar building. Also, for each question in which Pathfinder (TM) was compared with the bystander directions condition, Pathfinder (TM) was rated higher.

Finally, in order to be sure that our bystander directions were a fair comparison with those that might be obtained from a real bystander, we asked participants to rate the quality of verbal directions they typically experienced in everyday travel. The average (and standard deviation) rating was 3.2 (1.99), which was significantly different from the rating of the quality of verbal directions of 5.1 (3.1) in the bystander directions condition ($t = 2.70$, $p = 0.024$, $df = 9$).

Strategies used by participants: The sequential strategies used in planning a route using Pathfinder (TM) were also analyzed from the video records. Participants utilized a rich variety of ways to acquire their wayfinding knowledge. On 59% of the trials, participants used interactive "explore map" functions. As one participant said: "Feeling the map as well as hearing the route meant I could really see where I was going to go." All participants used the "orient to overall floor space" option at least once, and many commented that this feature was extremely useful in understanding the route.

Our results strongly support the feasibility of interactive tactile wayfinding systems supporting blind persons' independent travel in unfamiliar buildings.

This work was supported by National Institutes of Health Grant EY10665.