On Self-Sufficiency of Verbal Route Directions for Blind Navigation with Prior Exposure

Aliasgar Kutiyanawala
Computer Science Assistive Technology Laboratory
Department of Computer Science
Utah State University
Logan, UT 84322-4205
aliasgar.k@aggiemail.usu.edu

Vladimir Kulyukin
Computer Science Assistive Technology Laboratory
Department of Computer Science
Utah State University
Logan, UT 84322-4205
vladimir.kulyukin@usu.edu

Daniel Bryce
Artificial Intelligence Laboratory
Department of Computer Science
Utah State University
Logan, UT 84322-4205
daniel.bryce@usu.edu

Abstract:
This paper presents a qualitative analysis of self-sufficiency of verbal route directions for blind navigation in outdoor environments with limited prior exposure.

Introduction:
We define verbal route directions to be *self-sufficient* if they can be used by independent visually impaired (VI) travelers to successfully navigate a route from A to B in a given environment without any electronic aid capable of receiving external signals or any human assistance [1]. We distinguish self-sufficient *route directions* from self-sufficient *routes*. A self-sufficient route anticipates potential route execution failures and provides either extra localization actions or contingencies for route repair. Self-sufficient verbal route directions are complete or partial verbal realizations of self-sufficient routes. We conducted a preliminary investigation of the self-sufficiency of verbal route directions for outdoor environments with three completely blind students of Utah State University (USU). In this study, the generation of routes and route directions was done manually. We selected two routes on the Utah State University (USU) campus and manually wrote a set of route directions which we believed to be self-sufficient and then encoded our route directions in a computer program than ran on a Nokia E70 cellular phone. Furthermore, our investigation was confined to the case when VI individuals receive prior exposure to the route they will have to navigate independently. This study models the situation when a visually impaired student navigates the route once with an O&M instructor or a friend and then has to navigate the route independently.

Experiment:

Participants:
Three participants were recruited from the local community for the experiment through phone interviews. Henceforth, they will be referred by fictitious names Alice, Bob and Carl.

All three individuals are completely blind USU students. All self report themselves as independent travelers with good O&M skills. Alice and Carl are cane users where as Bob is a dog user. Alice is in her mid thirties and Bob and Carl are in their twenties. All participants had some familiarity with the Utah State University campus but were not familiar with the routes that they had to navigate.

Method:
We partially followed the methods of Gaunet and Briffault [2]. Each of the two routes shown in Figure 1 was manually broken into logical segments and route instructions for each segment were written by the investigators and then machine-converted into audio files using a text to speech software. The generated files were loaded on to a Nokia E70 cell phone equipped with a TALKS screen reader. Additional software was written that allowed participants to browse the instructions.

The purpose of the experiment was explained to the participant and he/she was trained on using the cell phone. The participant was then taken to the start of a route and walked the entire route once. This was the training run where the experimenter read the route instructions for each segment of the route and pointed out the various landmarks to the participant. The participant was encouraged to ask questions and browse the instructions on the cell phone.

After completion of the test run the training run (prior exposure), the participant was asked to walk the route independently using *only* the instructions provided in the cell phone. The experimenter followed the participant closely to ensure the participant’s safety and to take observational notes. If the participant made a mistake (took a wrong turn, did not turn, etc), the experimenter did not interrupt the participant but allowed him/her to realize his/her mistake and, whenever possible, correct it. However, if the participant made a serious deviation (a deviation that, in the experimenter's opinion, could have resulted in an accident or caused the navigator to become lost) from the route, the experimenter stopped the participant, explained the error to the participant and brought him/her back onto the route. The time taken to complete the run was recorded along with the number and type of mistakes made by the participant and the number of times the participant browsed instructions for each segment. This procedure was repeated four times per participant per route. For each participant, the test runs were spread over multiple days with no more than two test runs per day.

Observations and Results:
Figure 2 shows graphs of the time taken by each participant to complete each test run of routes A and B respectively. As expected, the completion time decreases with the number of runs, which could be attributed to the increase in the participant's familiarity with the route. The one exception to this trend was Bob's third run for route A. Bob relied heavily on his dog and since there was a gap of a few days between Bob's second and third run, his dog had forgotten the route. It was also observed that participant's frequency of accessing route information decreased with the number of runs. All three participants almost never accessed the route directions on the cell phone during the final run.

Figure 3 shows the graphs of the number of errors performed by each participant during the test runs of route A and route B respectively. The number of errors performed while navigating the route also decreases with the runs. Most of the errors made by the participants were undershoot/overshoot errors where the participant either took the turn too early or too late. A likely explanation for this behavior is that there were a lot of small pathways breaking off from the main route and it was easy to get confused and take a wrong path. There was also a location near the library where a sidewalk progressed to a small open area which the participants had to cross to pick up the sidewalk on the other side. Most errors were made at this location in the first and second runs. At the third and fourth runs, the participants learned to cross the area.

Our observations and subsequent interviews with the participants made us conclude that the problem was with our route directions. Thus, the errors could have been prevented by issuing better route instructions that warned the participants about the possibility of making those errors. It would have been beneficial to issue more specific localization and repair route instructions for the participants to avoid making the errors or to detect mistakes and then take appropriate corrective measures to get back on the route. If a route segment has multiple pathways breaking off from one side, it may be better to have instructions that ask the traveler to walk on the other side.

Although our instructions provided distance information for each route segment, Alice said that she could not keep track of how far she had moved and so this information was of no use to her. On the other hand, Carl was able to use the distance information very well. He would walk the majority of the segment really quickly and start to look for the turns only near the end of the path segment. This observation leads us to conclude that some amount of cognitive modeling would be helpful for we want to automate the generation of self-sufficient routes [3]. At the very least, the cognitive model should contain information on the utility of distance information for the traveler.

Conclusion:

Visually impaired navigators can navigate a route successfully if they are provided with route instructions for each segment of the route. The amount of time required for navigating a route and the number of errors made in navigation decreases with the familiarity with that route. It was also observed that some potential error situations could be avoided by issuing warnings and error detection and correction mechanisms to the user.

References:

[1] Nicholson, J., Kulyukin, V., and Marston, J. (2009). Building Route-Based Maps for the Visually Impaired from Natural Language Route Descriptions. To appear in Proceedings of the 24-th International Cartographic Conference (ICC 2009), Santiago, Chile, November 2009.

[2] Gaunet, F., and Briffault, X. Exploring the functional specifications of a localized wayfinding verbal aid for blind pedestrians: Simple and structured urban areas. Human-Computer Interaction 20, 3 (2005), 267–314.

[3] Crandall, B., Klein, G., Hoffman, R. (2006). Working Minds: A Practioner’s Guide to Cognitive Task Analysis. The MIT Press, Cambridge, MA.

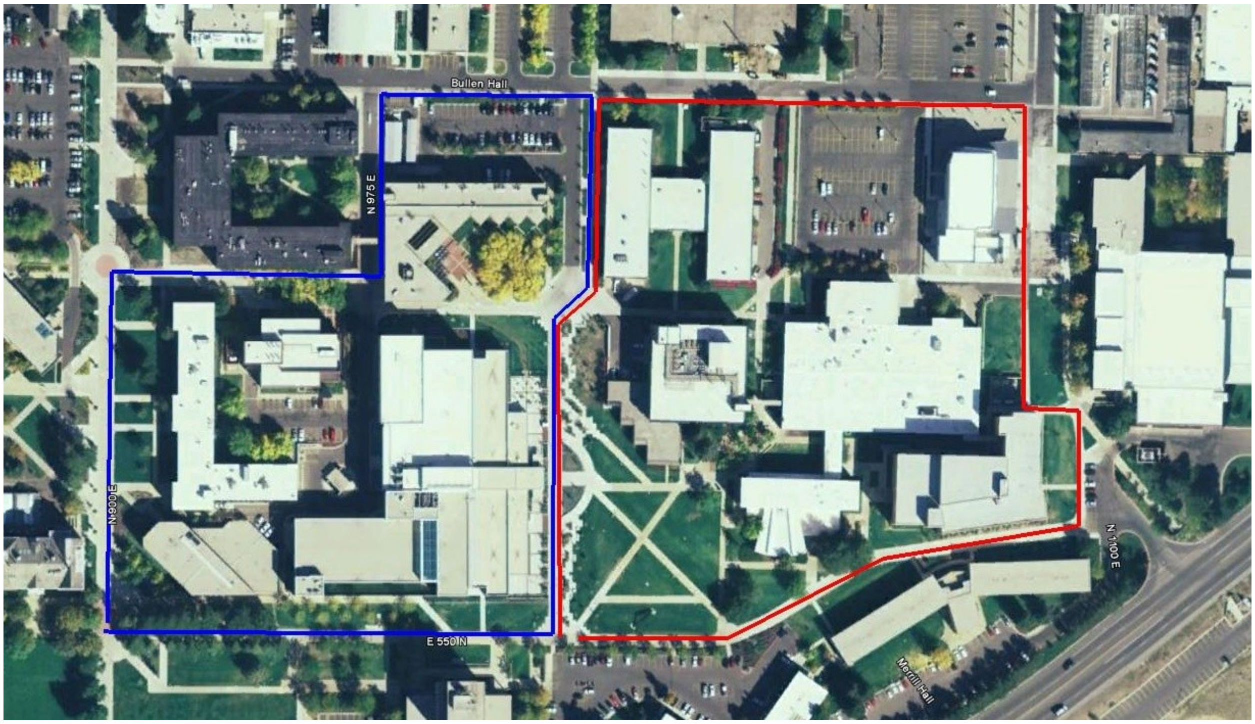


Figure 1: Route A (in blue) and Route B (in red)

Image Description: This figure shows route A and route B on the Utah State University campus.

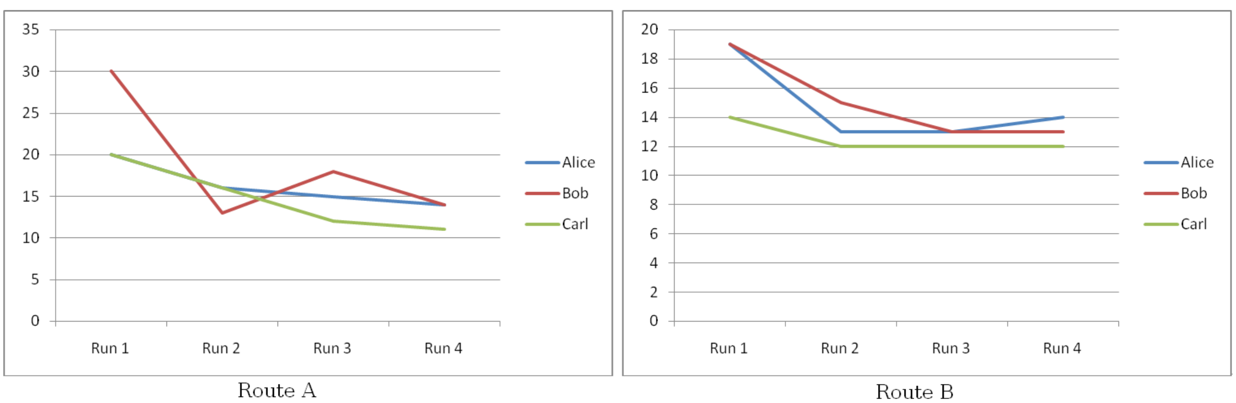
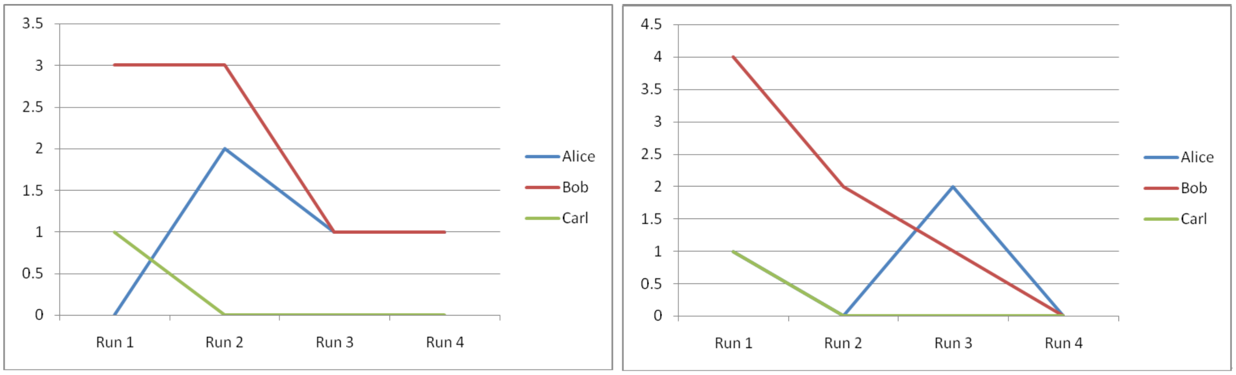


Figure 2: Time Taken to Complete Each Run of Route A and Route B

Image Description: This figure shows the time taken by each participant to complete each run of Route A and Route B. It can be observed that the time taken to complete each run decreases with the number of runs.



Route A   Route B

Figure 3: Number of Errors for Each Run of Route A and Route B

Image Description: This figure shows the number of errors made by each participant in each run of Route A and Route B. It can be observed that the number of errors decreases with the number of runs.