Environmental Matching with Limited Displays

Stephen C. Hirtle and Cristina Robles

School of Information Sciences, University of Pittsburgh, Pittsburgh, PA 15260 USA
{hirtle,cmr93}@pitt.edu

Abstract. It is argued that to produce an informative spatial display on small devices one should focus on extracting distinctive features of the physical environment. These features can be communicated selectively to the user on small displays. By considering spatial, semantic, and visual information sources, one can generate cognitively adequate directions that foster spatial awareness, while limiting computational resources. This paper describes the issues involved in selecting appropriate elements within the cognitive collage of environmental spaces to generate such displays.

1 Introduction

The ability to adequately navigate using a limited information display is dependent on a variety of factors, but perhaps none as important as matching the physical environment with information in the display. It is well known that concise directions are generally preferred and easier to follow [1], but that the granularity of the directions depends on the complexity of the environment [2-3]. The problem of providing cognitively adequate directions remains a challenge for route guidance systems, which more often than not are tied to a specific level of granularity [4]. This limitation becomes more severe when the display presenting the information is limited.

One potential solution is focus on particular classes of information. It is well-established that spatial information can be viewed as a multi-level, cognitive collage in which certain kinds of information can dominate [5-8]. In this paper, we consider potential slices of the collage that can be highlighted in limited displays. We use current systems for insight into potential problem areas in applying this approach.

Thus, the focus of this paper is on environmental matching. That is, how does one take the information in the display and match it to the actual environment. For example, the simple instruction of ‘turn right’ at a location where five roads meet is most likely going to be inadequate and additional information would be needed to resolve the ambiguity of the instruction [9-10]. This might be through semantic information (turn right on Main St.), spatial information (make a sharp right), or visual information (turn right towards the McDonald’s). Each of these alternatives is discussed in turn below.

2 Information Classes

2.1 Spatial Information

Two-dimensional spatial information is found in virtually all modern navigation systems. For example, Figure 1 from Google maps shows a path along Pocusset Street, which then turns right onto Murray Ave. That right turn that is close to 90°, as opposed to the sharp right onto Forward (westbound) or bearing slightly right onto Forward (eastbound). Having the geometry of the intersection in a heads-up display would facilitate taking the correct turn over just a simple verbal description of "turn right". However, it is interesting to note that this particular intersection, found in Pittsburgh, Pennsylvania, can also be described by the topography of the area [11]. From Pocusset Street, southbound Murray Ave is right and up the hill passing over Route 30, while westbound Forward Ave is right and down the hill passing under Route 30. This kind of the three-dimensional information is rarely provided in current navigational systems.

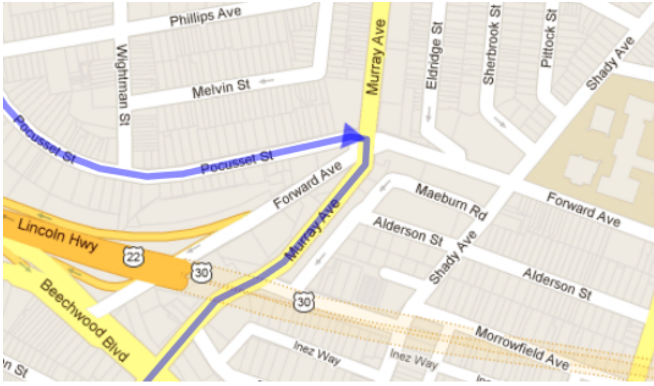

Fig. 1. Potential area of confusion for turning right in Pittsburgh, PA.

2.2 Semantic Information

Providing semantic information in terms of road names or landmarks is a second method for providing information a limited display. While typical of most current systems, problems arise when there is the signage in the environment is missing, limited, or does not match the labeling in the navigation system. For example, in Figure 1, a ramp is shown headed westbound from Forward Ave onto a shaded road labeled as "Lincoln Hwy/Route 22/Route 30", yet the physical sign onto that ramp, shown in Figure 2, reads "I-376 West Pittsburgh". The extent to which instructions match the physical environment, including what is printed on road signs, would make directions easier to follow.

Fig. 2. Visual information that does not match the labels on the map.

There is also a problem when there is limited semantic information to present to the user. Google now provides walking directions, which includes not only named streets, but also unnamed sidewalks.

Walking from the School of Information Sciences Building to Hillman Library on the University of Pittsburgh campus generates the route shown in Figure 3 with the accurate, but very confusing, set of verbal directions:

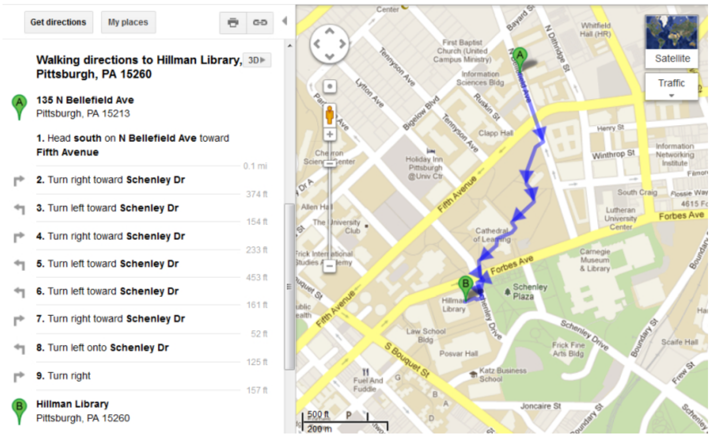

Fig. 3. Google map walking directions along a set of sidewalks

1. Head south on N Bellefield Ave toward Fifth Avenue 0.1 mi
2. Turn right toward SchenleyDr 374 ft
3. Turn left toward SchenleyDr 154 ft
4. Turn right toward SchenleyDr 233 ft
5. Turn left toward SchenleyDr 453 ft
6. Turn left toward SchenleyDr 161 ft
7. Turn right toward SchenleyDr 52 ft

8. Turn left onto Schenley Dr 125 ft
9. Turn right 157 ft [to arrive at] Hillman Library Pittsburgh, PA 15260

Pielot and Boll [12] found that such directions ignore the nature of human navigation skills and are of little use to wayfinding by pedestrians.

2.3 Visual Information

Providing visual information in terms of signage, landmarks, geographical cues, can also be helpful. In examining tricky parts of directions, Hirtle et al[4] found both cases where the visual information was obscured making directions difficult and cases where the visual information was useful in providing key information. In hand-written directions, navigators were warned, for example, when signs were obscured or where signs are missing. In contrast, landmark-rich environments were never flagged as being difficult to navigate in.

Current navigation systems rarely take advantage of visual information. One minor exception is Google Navigation for the Android, which automatically switches to street view at the end of the directions for help in locating your final destination.

3 Conclusions

It has been argued that limited information displays can successfully support spatial knowledge acquisition by providing cognitively adequate directions, which highlight the preferred knowledge of the traveler, be it spatial, visual or semantic information. This is to say, by identifying the unique attributes [13] that make up a location, an intersection or a route, one can start to build meaningful, low-resolution systems. At a first pass, such a system could be built on both user preferences and the granularity of the space [2]. In line with much of the cognitive literature, general overviews with detailed local knowledge will assist in the creation of a cognitive collage.

While the focus of this paper has been the visual display of information, it also possible to augment, or even replace, a visual display with auditory or tactile information. In these modalities it has been shown that even simple information, akin to the children's game "Hot or Cold" where feedback is given that your are on-track moving the correct direction (getting warmer) or you are off-track headed in the wrong direction (getting colder). Yang, et al [14] demonstrated that such information supports spatial awareness in pedestrians with visual impairments allowing participants to discover new points of interest and even improvise new wayfinding routes.

References

1. Daniel, M., Denis, M.: The production of route directions: Investigating conditions that favour conciseness in spatial discourse. Applied Cognitive Psychology 18, 57-75 (2004)
2. Tenbrink, T., Winter, S.P.: Variable granularity in route directions. Spatial Cognition & Computation 9, 64-93 (2009)

3. Timpf, S.: Ontologies of wayfinding: A traveler's perspective. Networks and Spatial Economics 2, 9-33 (2002)
4. Hirtle, S.C., Richter, K.-F., Srinivas, S., Firth, R.: This is the tricky part: When directions become difficult. Journal of Spatial Information Science 1, 53-73 (2010)
5. Hirtle, S.C., Sorrows, M.E.: Designing a multi-modal tool for locating buildings on a college campus. Journal of Environmental Psychology 18, 265-276 (1998)
6. Oomes, A.H., Bojic, M., Bazen, G.: Supporting cognitive collage creation for pedestrian navigation. 8th International Conference on Engineering Psychology and Cognitive Ergonomics. LNAI vol. 5639, pp. 111-119. Springer-Verlag, San Diego (2009)
7. Sorrows, M.E., Hirtle, S.C.: The nature of landmarks for real and electronic spaces. In:Freksa, C., Mark, D. (Eds.), Spatial Information Theory, pp. 37-50. Springer, Berlin (1999)
8. Tversky, B.: Cognitive maps, cognitive collages, and spatial mental models. In:Frank, A.U., Campari, I. (Eds.), Spatial information theory: Theoretical basis for GIS (pp. 14-24). Springer-Verlag, Berlin (1993)
9. Hirtle, S.C.: The use of maps, images and "gestures" for navigation. In:Freksa, C., Brauer, W., Habel, C.,Wender, K.F., (Eds.). Spatial Cognition II: Integrating Abstract Theories, Empirical Studies, Formal Methods, and Practical Applications, pp. 31-40. Springer-Verlag, Berlin (2000)
10. Klippel, A.:WayfindingChoremes. In: W. Kuhn, M. F. Worboys S. Timpf (Eds.), Spatial Information Theory: Foundations of Geographic Information Science. Conference on Spatial Information Theory (COSIT), pp. 320-334. Springer, Berlin (2003)
11. Hirtle, S.C.: Geographical design: Spatial cognition and geographical information science. Morgan & Claypool, San Rafael, CA (2011)
12. Pielot, M., Boll, S.: "In fifty metres turn left": Why turn-by-turn instructions fail pedestrians. Paper presented at Using Audio and Haptics for Delivering Spatial Information via Mobile Devices (in conjunction with MobileHCI '10) (2010)
13. Nothegger, C., Winter, S., Raubal. M.:Selection of salient features for route directions. Spatial Cognition and Computation 4, 113-136 (2004)
14. Yang, R., Park, S., Mishra, S. R., Hong, Z., Newsom, C., Joo, H., Hofer, E., Newman, M. W.: Supporting spatial awareness and independent wayfinding for pedestrians with visual impairments. In: Proceedings of the 13th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '11) pp. 27-34. ACM, New York (2011)