A Location Representation For Generating Walking Directions

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1. Introduction

We present a knowledge representation of location that incorporates concepts that people commonly use when thinking about space. Current representations model either the physical relationships between different spaces or the functional purpose of a given space. We model both of these aspects in our representation, and we describe how this can be used to develop a person's understanding of a route when generating written walking directions.

The representation is inspired by Ben Kuipers' TOUR model of a person's cognitive maps of large-scale spaces (Kuipers, 1977). The TOUR model is based not just on metric distances but on higher-level concepts such as places and paths between places. This allows us to model the topological and geographical relationships between different places. We supplement the TOUR model by associating a place with a description of its functional purpose. For example, a certain area of a building may be a meeting area, lounge, or kitchenette.

2. The Stata Walking Guide

To demonstrate the use of this representation, we created the Stata Walking Guide. This application provides a route map and written walking directions between different places in the Stata Center. This building is home to MIT's Computer Science and AI Lab (CSAIL). The application is especially useful since many visitors (and current occupants!) find the building's irregular floorplan bewildering. The written directions produced from our representation also include landmarks. This is in contrast to the type of directions produced by Mapquest, which only lists a sequence of "go-to" and "turn" instructions. The written directions supplement the route information presented on the map and provide further information to help a person develop his cognitive map of the Stata Center.

The Stata Walking Guide consists of a route-finding component that produces a graphical route map between two places and a translation component that converts the route information into written directions. The route-finding component uses A^* search to produce a series of waypoints that represents a route from one place to another.

3. Generating Written Directions

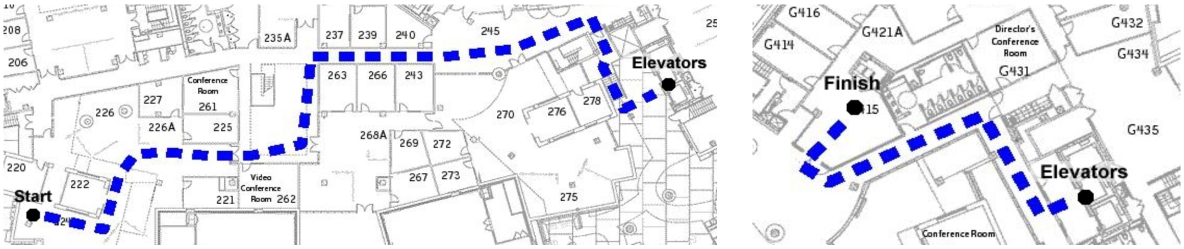
To generate written directions from a sequence of waypoints, we first group the waypoints into sets, with each set representing part of a path along the route. The points that are in the intersection of two sets represent places where two or more paths intersect in reality. Since we model the geometry of intersections and we know the previous and the next waypoint on the route, it is straight-forward to determine where to turn and in which direction.

To describe where to turn, we use a number of different rules. The first rule uses the fact that sometimes, a particular path will come to an end, forcing a person to turn one way or another. Since we model where paths begin and end, it is straight-forward to generate statements such as "turn right at the end of the hallway," when appropriate. The second rule used to describe where to turn reflects the fact that landmarks are usually used at decision points to identify the places where a turn is required (Denis et al., 1999). At these decision points we insert a functional description of the area that a person has entered, for example, "when you enter the lobby, turn left."

Landmarks are also used to confirm that a person is headed in the right direction, for example, "walk down the hall, pass the copy room on your right..." The translation component inserts a landmark if the length of a particular path on a route, as measured by the number of waypoints provided by the route-finding component, is above a particular threshold. For these long paths, the translation component searches for landmarks along the path and inserts the landmark that is nearest the midpoint of the path segment.

4. Grouping Directions For Easier Understanding

Finally, the last part of the generation process groups directions into segments to make it easier for a person to under-



Face the main entrance. Walk out the main entrance into the lounge. At the lounge, turn right onto the main hallway. Walk down the hallway. Near the end of the hallway, turn right. Walk down the steps to the elevator lobby and then take the elevator to the 4th floor.

On the 4th floor, turn right from the elevator lobby and then left at the end of the hall. Walk down the hall and the main office will be on your right.

Figure 1. An example of a route and written directions produced by the Stata Walking Guide.

stand the directions as a whole. The grouping is a recursive procedure that counts how many instructions are presented in a given segment. If the number is above a certain threshold, the instructions are split into two groups, with the starting and ending points in separate groups. Points along the route (and their corresponding directions) are grouped together based not on metric distances, but rather on geographic similarities, as modeled in the ontological structure of the knowledge representation. For example, depending on the length of a route, two points may be grouped together if they are on the same floor of a building. A third grouping may be required for intermediate points that differ greatly from both the start and end points.

For example, consider a route from my office to the CSAIL main office (see Figure 1). In our representation, my office, 224, is contained in the AIRE research neighborhood, which is contained in the second floor, which is contained in the Stata Center (we denote this by writing 224 $<$ AIRE neighborhood $<$ Second floor $<$ Stata Center). CSAIL's main office is located in the north wing on the fourth floor of the Stata Center's Gates Tower (Main office $<$ North wing $<$ Fourth floor $<$ Gates Tower $<$ Stata Center).

In our representation, the most significant geographic difference between my office and CSAIL's main office is that my office is located on the second floor whereas the main office is located in the Gates Tower. This forms the basis of our first split. This procedure is then applied recursively to the resulting two sets of directions and terminates when either the number of directions is below threshold or when the start and end points of a segment differ only at the level of spatial containment immediately one level above them. While the recursion is not very deep for routes within the Stata Center (usually, only one segmentation is needed for routes between floors, and none for intra-floor routes), this algorithm can segment directions for longer routes, such as those used for coast-to-coast road trips.

5. Evaluation and Future Work

An evaluation of the quality of the directions we produce is underway. In this study, visitors to the Stata Center will be asked to compare how understandable a route description taken from our corpus is to the corresponding route description produced by the Stata Walking Guide. The goal of this study is to gauge how well a person understands the directions presented to them, and how effective the directions are at presenting a cognitive overview of a particular route. We also plan to investigate how this subjective assessment of a person's understanding of a route correlates with his ability to actually follow the route.

There are two areas of future work. The first is being able to automatically build up a model of space from architectural CAD drawings (Kulikov, 2004). The second is to deploy the Stata Walking Guide to OK-Net, the Stata Center's information kiosk network (Van Kleek, 2003).

References

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