Recommended Reading


Wayfinding Behavior

Wayfinding, Landmarks

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Synonyms

Anchor points; Cognitive mapping; Navigation aid; Organizing concept; Trichotomous theory of landmarks; Survey knowledge; Typology of landmarks

Definition

A landmark is a prominent element or location in an environment that serves to define the location of other elements or locations. A landmark can serve as an organizing feature or as a navigational aid and can be characterized by its visual, structural and semantic features [1]. Landmarks, or anchor points, are used in two fundamentally different ways [2]. First, a landmark can be used as an organizing concept for an environment. In this way, a landmark can be used in part to define a neighborhood. Second, landmarks can serve as navigational aids by providing choice points along a route of travel, confirmation of the correct route of travel, verification of arrival at the destination, or evidence of the present orientation in the case of distal landmarks. Landmarks are set apart from non-landmarks by a number of defining characteristics that include visual characteristics, such as singularity and prominence of the landmark in contrast to surrounding locations [3], semantic characteristics, such as content, meaning, use or cultural significance,
and structural characteristics, such as accessibility and the centrality in transportation network. Landmarks may be local landmarks that you navigate to and from or distant landmarks that you use as a general referent to orient directional movement [2,3]. Each of these characteristics can be quantified for automated inclusion into wayfinding systems.

**Historical Background**

In a pioneering work, Kevin Lynch [3] argued that the cognitive map of a city environment was defined by five types of elements: paths, edges, districts, nodes and landmarks. Landmarks according to Lynch ranged from local cues, such as signs, to distant cues, such as mountains, as long as they were visually distinctive.

Siegel and White [4] presented the most influential theory relating landmarks to wayfinding in a trichotomous theory of landmarks, route and configurational knowledge. According to Siegel and White, individuals learning a new space will first acquire knowledge of specific landmarks, followed by knowledge of the routes between landmarks. With enough experience with a space, one finally acquires configurational or survey knowledge of the environment, which allows for an understanding the relative orientation of landmarks within a 2-dimensional space.

There have been numerous refinements and challenges over the years to both Lynch’s typology and Siegel and White’s original formulation [5]. There is some evidence that landmark and route knowledge are acquired in parallel rather than sequentially, while others argue that the acquisition of survey knowledge requires more than just experience [1]. There is also evidence that route and survey knowledge may be mediated by different neural structures [6].

**Scientific Fundamentals**

There are several attempts in the literature to quantify what objects should be used as landmarks to assist with the automatic generation of landmarks for navigational systems. The exact choice of landmarks will depend in part on the mode of transportation with most of the current research on landmarks for either vehicle drivers or pedestrians [7,8]. The extraction of landmarks from the environment also depend on the image schemata that is used by the navigator with indoor navigation more often dependent on signage and the flow of other pedestrians.

In large survey of respondents in Columbus, Ohio, it was observed that half the locations listed as best known and most familiar were common with other respondents, while the other half reflected individual activity patterns. In a describing pedestrian routes in Venice, Italy, individuals used landmarks that were both on the route, such as streets, bridges, and plazas, near the route, such as distinctive buildings or prominent signs. Children have been known to use transient items as landmarks (e.g., *turn left at the house with the large red ball in the front yard*) and travelers often need to spend some effort to extract distinctive characteristics in a foreign environment.

The typology of landmarks has included landmark identity, location, and dominance (with regard to the surrounds), while landmark use has included landmarks as choice points, origin or destination, orientation along a route, regional differentiating feature, home base for path integration vectors, and priming features influencing expectations [2].

**Key Applications**

**Wayfinding Systems**

Automated wayfinding systems are the most common application for the generation and display of landmarks. While human generated directions are often based on landmarks (e.g., *turn right just past the movie theatre*), most automated systems do not use local landmarks other than for the final destination. Landmarks are particularly difficult to determine given the large number of possible landmarks. However, several recent studies have developed algorithms for measuring “landmarkedness” of a location [9]. In this case, the dimensions of a landmark were taken from earlier work [1], which classified landmarks according to their semantic, structural, and visual attributes. Their analysis of characteristics, such as size, color, building shape, cultural importance and signage, showed that each of these components were important in the selection of buildings to be used as landmarks in the instructions for a given path. Caduff and Timpf use a diagrammatic approach that selects spatial cues based on orientation and distance to the landmark along with the salience of the potential landmark objects. Elias used data mining to determine the relative uniqueness of visual characteristics among the pool of potential landmarks using unsupervised learning methods [10].

**Urban Design**

To the extent that landmarks are an important determiner of the navigability of a city [3], then using the landmarks to improve the design of urban environments is a natural extension of the research on landmarks [11]. Homogeneous, non-differentiated spaces are going to be particularly difficult to navigate. Furthermore, the uniqueness of landmarks is culturally dependent. Redundant artifacts that define a the nature of particular city can be useful land-
marks (a metro stop in Paris or the corner dairy shop in New Zealand), as can the artifacts that unique, in terms of geometry, symbolism, or even legend (such as Balcone di Giulietta in Verona, Italy).

Virtual Environments
A number of researchers have shown that the inclusion and use of landmarks in virtual environments can improve navigation [12,13]. Related work in robotic navigation is often dependent on landmarks, as well.

Electronic Navigation
The dissertation research by Sorrows found that landmarks on the Web have a variety of visual, semantic and structural characteristics, and are used as key elements in navigation, which are recalled easily [14]. This research involved evaluating web page elements such as the number of links to the page, the amount of text and graphics on the page, the content of the text, and the number of link choices on the page. The research showed that pages that were easily recalled in a series of path navigation questions had higher value on the landmark quality measure than the general set of pages from the web site.

Future Directions
The explosion of interest for developing in-car navigation systems with multi-media displays provides a fertile ground for future work on landmarks. Most likely the usability of such systems will be greatly improved by providing schematic information with selective landmarks. In addition, systems will improve by matching the information in the database used for routing with the signs and landmarks that are found in the environment. Such systems should be tied to an audio output so that visual attention is not taken away from the primary task of monitoring traffic conditions on the road.

Other important developments will most likely occur in developing appropriate wayfinding theories for inter-modal transportation, such as moving from bicycle to bus to subway and navigation through three-dimensional environments, such as subway stations. There is also active research programs in exploring spatial cognition and the use of landmarks in special populations, such the elderly or visually impaired travelers [15].

Finally, an increase in the use of intelligent sensors, such as RFID and GPS, will likely have dramatic effects on wayfinding technologies.

Cross References
- Privacy Preservation of GPS Traces

Recommended Reading

WCS
- deegree Free Software
- OGC’s Open Standards for Geospatial Interoperability

Weather Analysis
- Weather Information, Surface Transportation