Similarities and differences between outdoor and indoor space from the perspective of navigation

(Extended Abstract)

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Summary This study explores the similarities and differences between outdoor and indoor spaces from the perspective of navigation. This work is part of a larger project that lays the ontological and formal foundations for a unified model of outdoor and indoor space, with applications to seamless navigation in outdoor and indoor spaces.

1 Introduction and motivation

This poster describes part of the research being undertaken for the NSF sponsored project "Information integration and human interaction for indoor and outdoor spaces". We will discuss the similarities and differences between outdoor and indoor space in the context of navigation. This extended abstract describes the concepts underlying the poster.

The terms "outdoor space" (O-space) and "indoor space" (I-space) here both refer to built rather than natural environments. I-space covers the enclosed interiors of buildings above the ground and spaces underneath the ground that afford platforms for human activities.

Traditional geospatial science focuses on O-space. However, humans spend most of their time in indoor environments. In 1992-1994, the EPA conducted the National Human Activity Pattern Survey, where 9,000 participants across the USA were involved. The average percentage of time spent indoors was 87% [5]. It is important, therefore, to investigate I-space and also to explore the relationships and connections between the two spaces. With this approach, I-space can be explored using

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some of the existing mature theories (i.e., the theory of point-set topological spatial relations proposed by Egenhofer and Franzosa [2]) and technologies for O-space.

When we consider informatic assistance for the task of navigation, GPS has been an indispensable device for positioning in O-space. However, navigation assistance for I-space is much less well developed. We are developing the underlying principles necessary to make navigation seamless between O-space and I-space by building a unified model of the two spaces. Such a seamless model is important in many applications. Consider, for example, emergency response to a fire in a complex indoor space. Ideally, responders need support for seamless navigation both for their route to the building, and then for navigation and co-ordination within it.

To build a unified model of O-space and I-space for navigation, investigating these two spaces separately is a good starting point. Finding the similarities and differences between the two spaces from a navigational perspective is one of our research questions. Section 2 describes the similarities, section 3 the differences, and section 4 draws brief conclusions.

2 Similarities between O-space and I-space

2.1 Affordances

The term "affordance" was originally introduced by Gibson [3] referring to the action possibilities perceived in a direct, immediate way with no sensory processing (for example, buttons for pushing and levers for sliding). Norman [6] interpreted affordance in the field of human-computer interaction (HCI) to refer to just those action possibilities that are readily perceivable by an actor. The concept is thus dependent both on the physical capabilities of an actor and the actor's past experiences.

Some of the entities in O-space and I-space have the same affordances. Below we list some of the most important ones. Some definitions are from OpenCyc [1].

Passage: A way or channel through or along which agents may pass. For example, outdoor roads and indoor corridors both afford the function of passage.

Container: Anything whose primary function is to contain something. For example, outdoor cities and indoor rooms have the affordance of containing things.

Portal: An opening with or without a covering, affording going through from one container to another. For example, both outdoor gateway and indoor doorway offer the affordance of portal.

Node: A connecting point representing an entity at which one or more links come together. For example, outdoor road junction and indoor corridor intersection both afford node functionality.

Surface: A spatial thing that has extent in at least two dimensions and supports other objects. For example, outdoor pavement and indoor floors both have the affordance of surface.

Barrier: A structure or object that impedes free movement. For example, walls and rivers afford the barrier function.

Connector: A kind of passage, assisting in transitioning through a barrier and connecting two objects that are separated by the barrier. For example, outdoor bridges and indoor staircases both perform the function of connectors.

2.2 Geometry and topology

Many geometric and topological constructs can be used to represent the structure of both O-space and I-space. For example, both spaces can often usefully be represented by networks. For example, roads are represented by edges and road junctions by nodes, and in I-space, nodes represent rooms which are connected by edges representing corridors.

2.3 Landmarks

Landmarks play the same role in both O-space and I-space, with similar principles and characteristics. For example, a red building located near a crossing in O-space and a blue mailbox at the corner of a corridor in I-space both serve as landmarks.

2.4 Routing information

Verbal route descriptions are based on a combination of actions (e.g., turn right, turn left, go straight ahead) and landmarks (e.g., a church, a mailbox). Egocentric and allocentric cues can be used in both spaces..

3 Differences between O-space and I-space

3.1 Scale and dimension

The scale of O-space is generally larger than I-space. Structurally, O-space is usually represented in two dimensions, whereas I-space uses three dimensions (e.g., levels of buildings) [4], see figure 2.

Fig. 1. Differences between O-space and I-space: Scale and dimension.

3.2 Geometry and topology

I-spaces generally have more "regular" geometries [4], for example, the boundary of a room compared with a coastline. In O-space, distances, angles and coordinates play essential roles (e.g., latitude and longitude), so Euclidean concepts are important. In I-space, topology plays a more prominent role, for example, connectivity becomes more important than direction.

3.3 Positioning technologies

GPS has become indispensable for navigation in O-space. Because I-space is enclosed, GPS signals cannot be received well (see figure 2), and we need to resort to other positioning technologies, such as Wi-Fi and RFID.

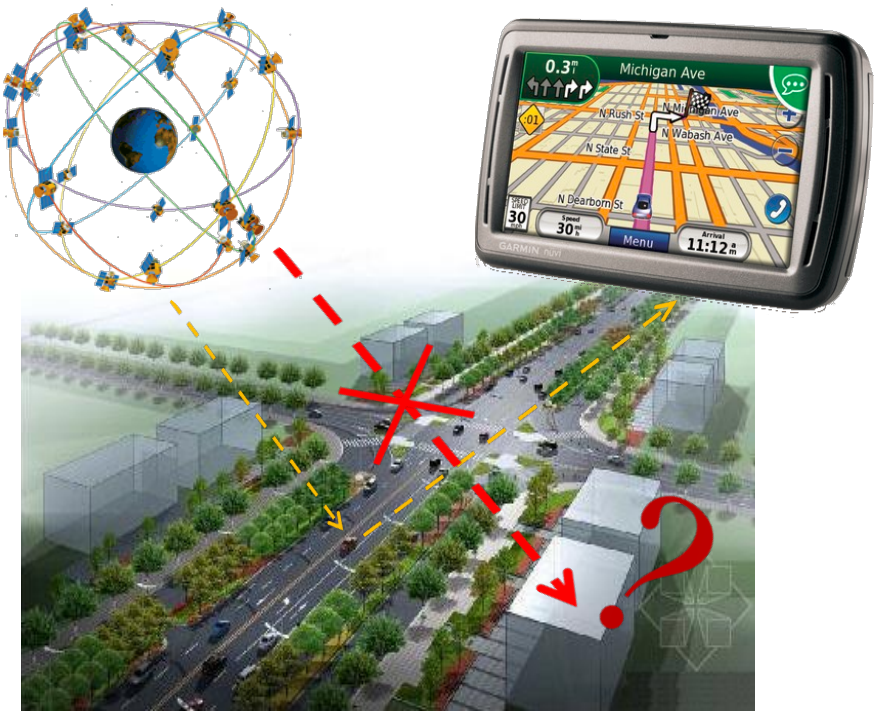

Fig. 2. Differences between O-space and I-space: Navigation technologies.

3.4 Landmarks

In O-space, both distant and local landmarks are recognizable. However, landmarks used in I-space are generally local ones, because corners or walls block our vision. Outdoor landmarks are usually fixed, whereas indoor landmarks may not be.

3.5 Navigation agents

In O-space and I-space, agents are different. The navigation agents in O-space are pedestrians and vehicles, whereas in I-space, indoor navigation is currently mostly for pedestrians.

3.6 Routing information

I-space is multi-layered, and so verbal directions like "go up to the 4th floor" are used. This is not the case in O-space.

4 Conclusions

The poster will begin by motivating the study of indoor spaces, then graphically lay out the similarities and differences between O-space and I-space, based on the criteria set out above. Future work will be on development of a unified model of O-space and I-space focusing on navigation. This will be achieved by extracting the common concepts and using the relationships between the two spaces.

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