Landmark Classification for Navigation in Indoor Environments

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Abstract. The representation of indoor environments got the attention of the researchers only recently, and more recently yet the cognitive aspects involved in indoor navigation. The cartography and visualization research group at Federal University of Paraná (UFPR)– Brazil, is investigating some important issues about the indoor representations, such map design, landmark selection and identification and routes formation in these restrict environments and some cognitive aspects related to. This is part of a bigger project named UFPR CampusMap. This paper presents the conclusions of two user experiments in navigation indoor: self-location using QR-Codes and landmarks descriptions using natural languages. These conclusions area addressing important issues on indoor map design, improving the understand of cognition changes and how to implement these considerations on Location Based Services.

Keywords. Indoor Navigation, Orienting, Landmarks.

1. Introduction

Navigation services have become one of the most widely used types of Location-Based Services (LBS) (Basiri et al, 2016). The key for a successful navigation process is a series of processing in the user's mind from the perception and selection of the certain spatial features to serve as reference and the storage of the spatial relations of them in a mental map

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representative of the region. After, different types of knowledge and actions are developed such as self-orientation, self-location, estimation of distances and relative positions. According to Gaunet et al. (2001), the integration and recognition of spatial features configurations are necessary for the people use these reference points as landmarks and choose an appropriate action at each decision point along the route.

However, the selection of objects used as landmarks for navigation is highly dependent of the environment and its restrictions. In outdoor environments people navigate with less features, yet these objects are separated in local and global references, depending on the mental route designed. In indoor environments, there are a great number of both static and mobile objects which can be used as local landmarks, but due to the environment conditions only few global references are available. For this reason, positioning techniques for indoor environments should consider the lack of spatial references in the process of cognitive map creation. In other words, people who navigate in an indoor environment must process a set of small cognitive maps and try to link them somehow.

The diversity of types of indoor environments as museums, libraries and convention centers which have characteristics related to specific human activities, present a set of difficulties that depend of heuristics related to the comprehension of the indoor environment (Bahm and Hirtle, 2017). Many of those characteristics can be defined as landmark elements, so it is important to have descriptions about these elements. In a narrow sense, it is necessary to provide a typology for the indoor landmarks (Sorrows and Hirtle, 1999). In indoor environments, landmarks have the main function of providing information about the point where decisions should be made in relation to a route or even, demarcating the point where the orientation of the navigator changes direction (Viaene et al., 2014). In the context of indoor personal navigation, this paper presents the UFPR CampusMap project, which aims to evaluate different indoor representations, including cognitive aspects related to landmarks selection and the use of natural language to describe these landmarks.

2. Background and Context

2.1. LandMark Selection: Indoor x Outdoor

People associate directions with visual cues, if features are easily recognizable, are based on cognitively salient features and followed by easy-to-follow instructions (Duckham et al., 2010; Basiri et al., 2016). This is interesting in indoor environments because pedestrians have a reduced speed of movement that, in contrast to drivers, allows to see the landmarks with greater clarity (Basiri et al., 2016). When encountering an unknown environment, the visual system uses few features for rapid visual scanning (Oulasvirta et al., 2009 and Marr, 1982). Typically, the features that stand out to the human visual system are selected for different reasons either by the differentiation of the surrounding features or by their own characteristics (Lynch, 1960, Oulasvirta et al., 2009, Quesnot, T., and Roche, 2015). The basic characteristics of these features are processed by the visual system and the topological structure based on their distribution is evaluated to serve as landmarks (Maceachren, 2004; Klippel, 2003). For Caduff and Timpf (2008), features are chosen because of their visual relevance in the scene observed in relation to their surroundings and not only due to their relative contrast or completeness as in Lynch (1960) and MacEachren (2004). Quesnot, T., and Roche (2015) divided the visual protrusion of the features to be taken as reference frames into three classes: perceptual salience, cognitive salience and context salience.

The perceptual salience is measured by the prominence of the feature or the symbol in relation to the others of its surroundings, along the lines of the relative contrast of the Gestalt (MacEachren, 2004). In real environments, the visual prominence depends on the visual variables that compose it and its relative position to the other elements surrounding. According to Schmidt and Delazari (2013), the combination of visual variables attracts the selective attention of the user and stimulates the selection of characteristics or objects and their recording in short-term memory. The cognitive salience, is the degree of distinction of features based on the personal meaning of some features and its can change perception according to the individual's experience and is constantly updated with repeated exposure of the user to an environment. Contextual relevance is related to the relative distribution and orientation of features and objects in space and the relative visibility they assume along the route.

When navigating, pedestrians use at least one feature identification strategy to be used as landmarks (Oulasvirta et al., 2009, Basiri et al., 2016). According to Redish (1999) these strategies are: Random navigation, Taxon navigation, Praxic navigation and two more. The last two strategies are based on the individual's cognitive aspects. In the fourth strategy, people associate directions with visual cues, such as "turn left in church,"; In the last one, people form a mental representation of the environment from one or more specific points to become able to plan routes between any locations within the area (local navigation). These last two approach the more natural interactions that humans use to navigate. When we look at indoor environments, some problems arise. The global orientation becomes impossible because the view of the area is limited and may not be completely observed along the route. The landmarks along the route and potential landmarks can be fixed or mobile and change according to people, their culture and even mood. Fixed points along the route, decision points, are the ones with the greatest potential for implementation in LBS systems, since they tend to have a fixed and unchanging over time. Incorporating them as landmarks into navigation support systems, such as smartphones and vehicular devices, can transform the way users navigate, especially pedestrians.

3. Methods

3.1. Context: UFPR CampusMap Project

The Federal University of Paraná (UFPR) has 26 different Campi in the Parana State, Brazil; what summarize 500 thousand m2 of constructed area distribute in 316 buildings. UFPR has more than 6000 employees, about 40,000 undergraduate students and 6,000 graduate students. The natural unfamiliarity with these spaces has direct impacts in several issues, such as management of resources (humans and materials), Campi infrastructure management, security, and other issues. From this perspective, we have started a Project named UFPR CampusMap (UCM) whose main goal is to implement a Geographic Information System with information from the indoor and outdoor environments. From the main project, different aspects are being addressed in this research, two of them addressed below.

3.1.1 Landmarks evaluation with use of QR-Code for positioning in indoor environments

Oliveira (2014), Ning (2013), Chang et al. (2007) and Basiri, Amirian and Winstanley (2016), developed applications in their studies based on the positioning method using QR-Codes to analyze images. The mobile device camera captures the QR-Code, which is decoded by the system that then presents a map of the place and the user's position. The innovative aspect of our study is the hypothesis that if a user performs recognition of QR-Code codes only in places considered to be reference points, by using the indoor positioning system developed when this in turn shows the user's location, the user will then be able to carry out orientation and navigation tasks based on the positioning information provided. However, the need exists to understand which places are considered to be reference points and which are really used by a user during navigation. It is also of fundamental importance to understand to which categories reference points most used by users belong, so that this information can support decision-making regarding placement of labels in projects or similar applications.

The elements most mentioned by the participants as landmarks are elements that stand out in the environment because of their structures, such as stairways, lifts and decision-making points. We conclude that those structural reference points are most used within an indoor environment to aid navigation and orientation and, therefore, they are the most indicated for affixing QR-Code labels. Through this comparative analysis between two buildings, we found that building's architecture influences the determination of reference points. For example, in the environment that only has two floors, the lift is practically not mentioned as a reference, while in the environment with five floors the lift takes on significant importance for participant orientation.

3.1.2 Landmarks and spatial relations descriptions in indoor environments

The proposal of this experiment was based on the studies of Dogu and Erkip (2000), Schmidt and Delazari (2012), Viaene et al. (2014), Sarot and Delazari (2018), Antunes (2016), Bahm and Hirtle (2017), and Delazari et al. (2017). These studies focus on the determination of mental routes, addressing the level of familiarity with the subject, with the symbology of indoor maps. These researches search for specific places in the maps and how people describe them in natural language for extraction of spatial relations. The experiment conducted at UFPR evaluated the level of familiarity of the subject with the indoor environment, and sought to identify in them the potential landmarks, and the most used spatial relations. The use context of buildings directly affects the choice and frequency of use of a given element as a spatial reference point. When comparing elements that were cited in both buildings evaluated in this research (such as floors, elevator, stairs), it is noticed that the frequency of its use was directly related to the context in which the user was at the moment.

The spatial relations of our research were classified in terms of prepositions, prepositional phrases, adverbs of place, nouns, adjectives, and verbal expressions. The group of spatial relations with the most occurrences (80) (in, on, or at with a male or female definitive article). The second most common group of spatial relations, at 63 occurrences, was in front (of), by the front (of), at the front, with words that fit as prepositional phrases. In third place, with 62 occurrences, was the group next to, near, close to with words that fit as adverbs of place. As the two latter groups had almost the same number of occurrences (63 and 62), the fourth group presenting 56 occurrences: "to the right (of)", "on the right (of)", "at the right", "on the right side of", "to the left (of)", "on the left (of)", "at the left", "on the left side of"), with words that fit as nouns

4. Conclusions

The objective of these experiments was to contribute to the advancement of orientation and spatial navigation studies in indoor environments, in relation to spatial relations and spatial reference points (SRP), when collected through descriptions in spoken natural language. There is still much to be studied, analyzed and understood when dealing with experiments on humans. The freedom of expression of the natural spoken language makes complex the task of generalizing expressions for computational uses. The understanding of spatial relations of spatial descriptions and spatial reference points (SRP) for the representation of geographic locations leaves gaps to be studied semantically. Therefore, further experiments are needed to conclude that spatial relations and spatial reference points contribute to the representation of geographical locations.

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References

Antunes, A. P. (2016). Avaliação de pontos de referência com uso de QR-CODE para posicionamento em ambiente indoor (Master's thesis). Available from Dissertations of Federal University of Paraná. Curitiba. Brazil.

Bahm C R, Hirtle S C (2017) Global Landmarks in a Complex Indoor Environment. 13th International Conference on Spatial Information Theory COSIT, L'Aquila, Italy, 2017; Dagstuhl Publishing: Germany, 2017; n.18.

Basiri A, Amirian, P, Winstanley A, Marsh S, Moore T, Gales G (2016) Seamless Pedestrian Positioning and Navigation Using Landmarks. *The Journal* of Navigation. 69: 24–40. The Royal Institute of Navigation doi:10.1017/S0373463315000442

Caduff D, Timpf S (2008) On the assessment of landmark salience for human navigation. Cogn Process 9:249–267 DOI 10.1007/s10339-007-0199-2

Chang, Y. J., Tsai, S. K., Chang, Y. S. and Wang, T. Y. 2007. A Novel Wayfinding System Based on Geo-coded QR Codes for Individuals with Cognitive Impairments, 9th international ACM SIGACCESS conference on Computers and accessibility. Tempe, Arizona, USA, pp. 231-232.

Delazari, L. S., Stock, K., Ferreira, M. E. S., Marchis, C. K. (2017, July). ANNALS ICC 2017. Use of Spatial Relations in English and Portuguese: Syntax and Semantics. Proceedings of the 28 th International Cartographic Conference. Washington, D.C., USA.

Dogu, U., Erkip, F. (2000). Spatial factors affecting wayfinding and orientation: A case study in a shopping mall. Environment and Behavior, 32(6), 731–755.

Duckham M, Winter S, Robinson M (2010) Including Landmarks in Routing Instructions. Journal of Location Based Services, 4:1, 28-52, DOI: 10.1080/17489721003785602

Gaunet F, Vidal M, Kemeny A, Berthoz A (2001) Active, passive and snapshot exploration in a virtual environment: Influence on scene memory, reorientation and path memory. *Cognitive Brain Research, 11*(3): 409-420. http://dx.doi.org/10.1016/S0926-6410(01)00013-1

Klippel A (2003) Wayfinding Choremes – Conceptualizing Wayfinding and Route Direction Elements. Bremen: Universität Bremen. Tese: SFB/TR 8 Monographs; Bd. 1. ISBN 3-88722-590-2

Lynch K (1960) The image of the city. Cambridge, MA: MIT Press.

Maceachren A M (2004) How Maps Work: Representation, Visualization, and Design. 513 páginas. The Guilford Press. ISBN-10: 157230040X.

Ning, A. J. 2013. QR-MAP: byod indoor map directory service. Dissertation Bachelor of Computer Science, University Tunku Abdul Rahman. Perak, Malasia.

Oliveira, N. M. F. L. 2014. Localização indoor por identificação de marcos. Dissertação de mestrado em Engenharia Informática, Universidade do Minho, Escola de Engenharia.

Oulasvirta A, Estlander S, Nurminen A (2009) Embodied interaction with a 3D versus 2D mobile map. Pers Ubiquit Comput 13:303–320 DOI 10.1007/s00779-008-0209-0

Quesnot T, Roche S (2015) Quantifying the Significance of Semantic Landmarks in Familiar and Unfamiliar Environments. In S. I. Fabrikant et al. (Eds.), Spatial Information Theory. 9368: 468-489. Switzerland: Springer.

Redish D (1999) Beyond the cognitive map: from place cells to episodic memory. Cambridge: MIT. http://redishlab.neuroscience.umn.edu/Papers/1999%20ByCM.pdf Acessed 9 July 2018

Sarot, R. V. and Delazari, L. S. (2018). Evaluation of Mobile Device Indoor Maps for Orientation Tasks. Bulletin of Geodetic Sciences, 24 (4): 564-584. doi: 10.1590/s1982-21702018000400034

Schmidt, M A R, Delazari L S (2013) Gestalt aspects for differentiating the representation of landmarks in virtual navigation, Cartography and Geographic Information Science, Doi:10.1080/15230406.2013.807031

Sorrows M E, Hirtle S C (1999) The Nature of Landmarks for Real and Electronic Spaces. Spatial Information Theory: Cognitive and Computational Foundations of Geographic Information Science, International Conference COSIT 39 Eds.; Springer: Heidelberg, Berlin, Germany, 1999: 37-50.

Viaene, P., Vanclooster, A., Ooms, K., Maeyer, P. (2014). Thinking Aloud in Search of Landmark Characteristics in an Indoor Environment. 2014 ubiquitous positioning indoor navigation and location based service (UPINLBS), 103-110.