Off-Route Virtual Landmarks To Help Pedestrian Indoor Navigation

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Abstract. Users of navigational support systems often have difficulties in maintaining attention to instructions and visual representation to establishing a relationship with reality due to cognitive differences and navigation instruction difficulties. In traditional systems, especially in-car navigation systems, the form of instructions and representations help users to complete the goal, but not allow them to learn the way. Navigation support systems limit spatial learning and this becomes more relevant in restricted environments such as indoor navigation. This research presents the proposal of increasing virtual reference points on and off-routes as a way to approximate the creation of routes by algorithms to the way humans interact with reality. For this, an approach of highlighting reference points and topological relationships between them as a way of creating more natural routes than the current systems. The focus is the use of pedestrian support systems in unfamiliar environments using an augmented reality (RA) system on mobile devices. Evaluations will be conducted with volunteers with different backgrounds in two distinct regions of the Brazil.

Keywords. Virtual pedestrian navigation, Augmented Reality Mobile, 3D Cartography

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1. Introduction

The interest in navigation systems for pedestrians (PNS) has grown in recent years, as they become both feasible and popular (Ohm et al., 2016). Pedestrian movement is one of the most basic modes of mobility (Wang, Lo & Liu, 2017).

Car systems are generally based on positioning through the Global Navigation Satellite System (GNSS), or other continuous tracking mode, to provide real-time and on-site route information to the user (Huang et al., 2012). In contrast to the navigation mode in car navigation systems, pedestrians prefer route instructions based on landmarks (Ohm et al., 2016). One difference in pedestrian navigation is that the routes generally include outdoor environments and the passage to indoor environments, which renders systems such as GNSS unfriendly.

Different technological approaches can be used to communicate information about routes, such as maps on mobile devices, voice instructions, 3D representations and images. Even with the voice guiding strategy along with screen based maps, drivers still need to translate auditory information into visual cues, however, which causes an additional cognitive burden (Chung, Pagnini & Langer, 2016). A key prerequisite to designing successful pedestrian services, and delivering these over mobile devices, is to understand the nature of the navigation task and the information requirements of the pedestrian (May et al., 2003). The effectiveness of traditional systems requires a lot of cognitive attention to be effective and this is a problem for the user, since it must focus on the system itself and the path (Chung, Pagnini & Langer, 2016).

In navigation, understanding the spatial relationships between features requires a series of processing in the user's mind that connect what is perceived and what is understood. The most popular way to provide directions for pedestrians is to display maps on handheld devices like personal digital assistants and smartphones. On these devices, the augmented reality becomes more and more popular. Augmented Reality in Mobile Devices (AR) overlays a real image, as the setting for the user's environment, with virtual objects to create a composite view where the user has the feeling that overlapping objects are present in the scene. This give to the user a more natural relation with the ambient, letting to interpretation only those symbols that matter to self- location and to take decision along the route. But in indoor environment the absence of those features to be used as landmark could impair the adequate routing by user. Our hypothesis in this research is that complementary landmarks positioned off-route could work as global reference for indoor navigation using AR on mobile devices. Consequently there will be a reduction of the cognitive demand of reading to highly abstract and elaborate map, interpret and organize the spatial information on short memory and finally translate to visual cues.

2. Route Formation: User's Mind Versus Algorithm

To successfully navigate, people plan their movements using spatial knowledge acquired about the environment and stored on a representative mental map of the area using landmarks at different scales (Vinson, 1999, Schmidt & Delazari, 2013). From the distribution of these points, several types of knowledge and actions are developed such as self-orientation, self-location, estimation of distances and relative positions. These knowledge and actions are constructed from relation between objects and features distributed in space, and which have characteristics that distinguish them from their surroundings (Lynch, 1960). This correlation affects the organization of the internal representation of these same features in the mind of the people, that is, in the cognitive map.

Obviously in this process, initially, few features are highlighted by the human visual system and quickly processed in relation to their essential topological characteristics to work as landmarks. Quesnot & Roche (2015) divided the visual salience of the features to be taken as reference frames into three classes of salience: perceptual, cognitive and context. To Ohm et al. (2016), the visual salience is important for users to find the landmark quickly on the display and the way objects are presented on the display heavily influences the efficiency of self-localization. The accumulation of landmarks and how they are distribute in spatial mental model depends on how the person is exposed to the environment (Dünser et al., 2012).

In the context of AR, the physical world is represented in two components, the physical object or feature and the context in which it is inserted, that is, the other features in its surroundings. The identification of naturally salient features favors the storage of reference points. Therefore, the process of constructing an AR system for PNS that allows the relationship in an improved way between the representing and its represented, which will allow the storage of the feature and its positioning in the cognitive map is necessary.

Alternatives to outdoor navigation were presented Wenig et al. (2017), Schall et al. (2011) and Raubal & Winter (2002). In these papers, strip maps on smartwatches were used to provide folow-the-line representation. Global references were indicated in direction and distance with textual descriptions and pictorial symbols. In the case of indoor navigation, these references cannot usually be seen as in the case of hospitals, universities, shopping malls and other complex structures. Therefore, this research adopts the use of pictorial symbols for user self-location and dynamic symbols for decision-making points along the route.

3. Assessment framework

To investigate the influence of virtual landmarks distribute along the route in indoor environment on users' navigation strategy, we propose a single navigation task, in three different situations, in a complex building of Universidade Federal do Paraná to identify design implications for landmark representation on mobile navigation device using AR.

Our research questions are:

1. What information is needed by pedestrians for indoor navigation purposes (adapted from Ohm et al., 2016)?

2. How landmarks in different points on- and off-route could improve the route and how this could be implemented on routing algorithm?

Our test framework counts with at least 30 volunteers on the campus of the Federal University of Paraná, Curitiba, Brazil, all with background in cartography or correlate areas. We started with two multipurpose buildings that include Docent rooms, laboratories, conference room and classroom. The two first and second floor buildings linked by a smaller building. The connection is made by winding corridors, stairs and an elevator and the entrances are on the sides of the smaller building, as in Figure 1.

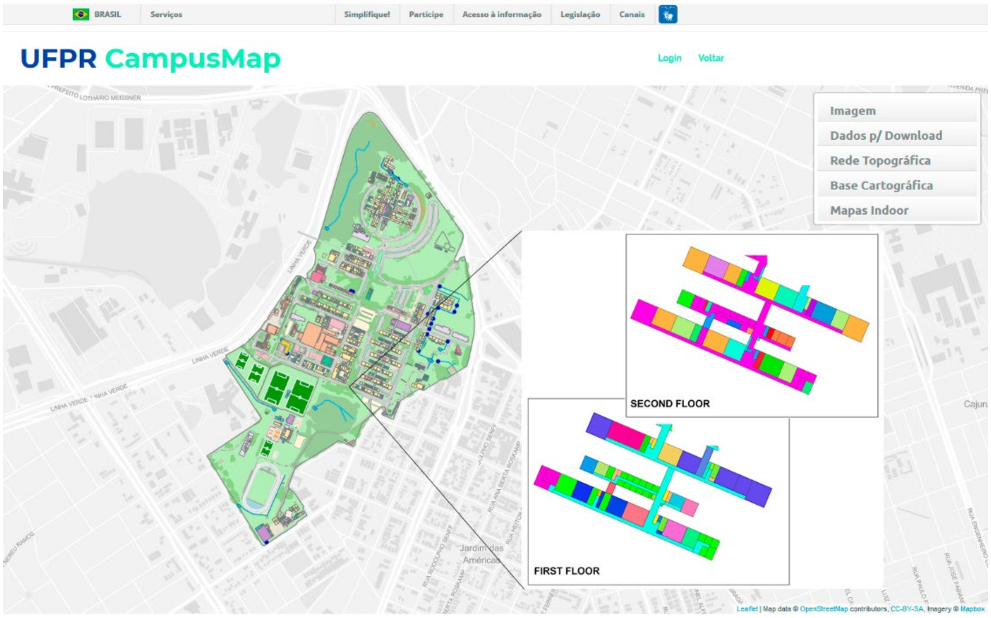


Figure 1. Universidade Federal do Paraná, campus Politécnico and details of the building with indoor map considered.

For user self-location, the developing system presents virtual objects of global references. These are sights or of relevance to the citizens of Curitiba. Points were chosen from four different buffers: locals reference points at out of the building, up to 2km from buildings, from 2 to 6km and over 6km. These distances were empirically selected due to the positioning of these references in the city (Figure 2). The features selected were university's restaurant and medical room, the Botanical Gardens, the Airport, the Telephone Tower, a cable-stayed bridge, a shopping mall near the campus and the city's bus station.

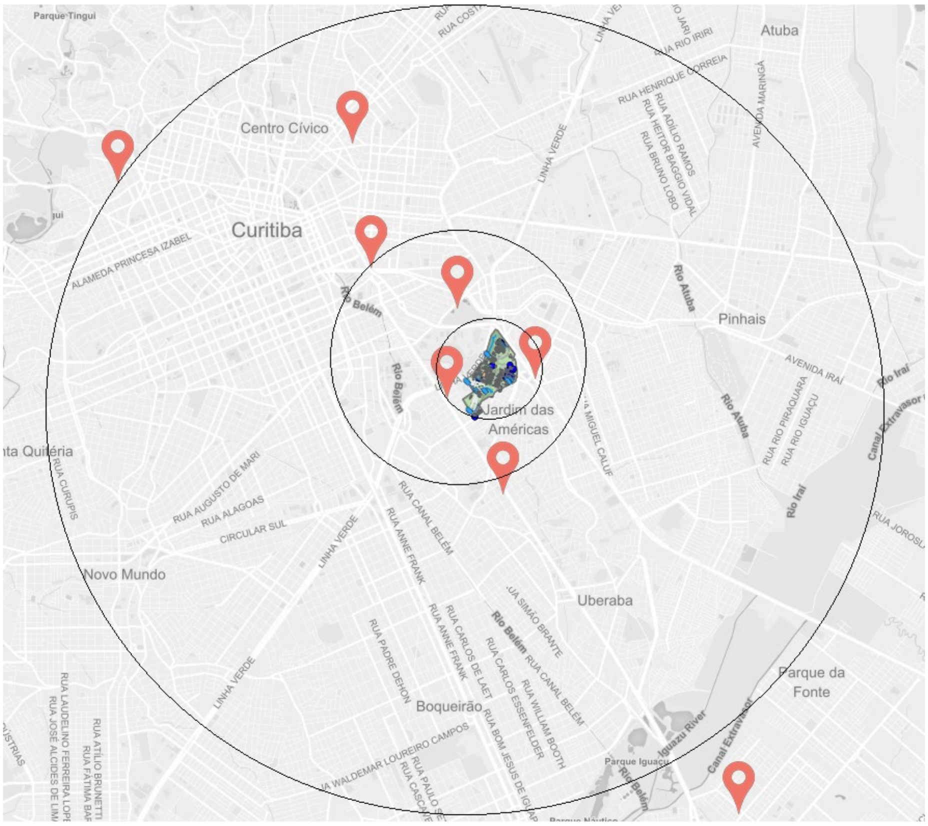
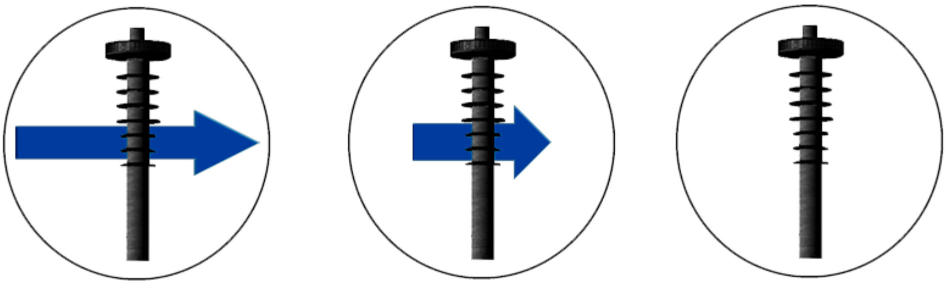


Figure 2. Location of Global References Points selected and the buffers

The system presents these locations as simple pictorial symbols with black outline and transparent background. The elaboration of the symbols themselves is part of research in development by the research group (figure 3a). An important issue is that symbols that are not directly aligned with the smartphone's position but that matter in the selected route receive an additional symbol, an arrow. The length of the arrow varies according to the alignment of the device with the real position of the symbol. Thus, the farther the larger the arrow and the closer the smaller the arrow (figure 3b).

a)



b)

Figure 3. a) Tower icons change from far to close as the smartphone is rotate up to straight direction of where the tower actually is. b) Shows how the global references points are presented in smartphone (under development)

The importance of the symbols mentioned is due to the relative distance between the start and finish points informed by the user and the position of the global reference. In the route formation process, global references can be seen as reference line in user's mind in which the initial self-orientation is determined ().

However, in indoor navigation decisions along the route are strongly based on local landmarks. The problem then becomes that there are no features that stand out in the user's cognitive system and can easily be tied up as route confirmation points. For this reason, we understand that indoor navigation should provide users with more route confirmation points than the turn points provided by current routing algorithms, known as turn-by-turn routes. Therefore, at these points and several other relevant decision making and route confirmation points the system uses dynamic symbols to guide users (figure 4).

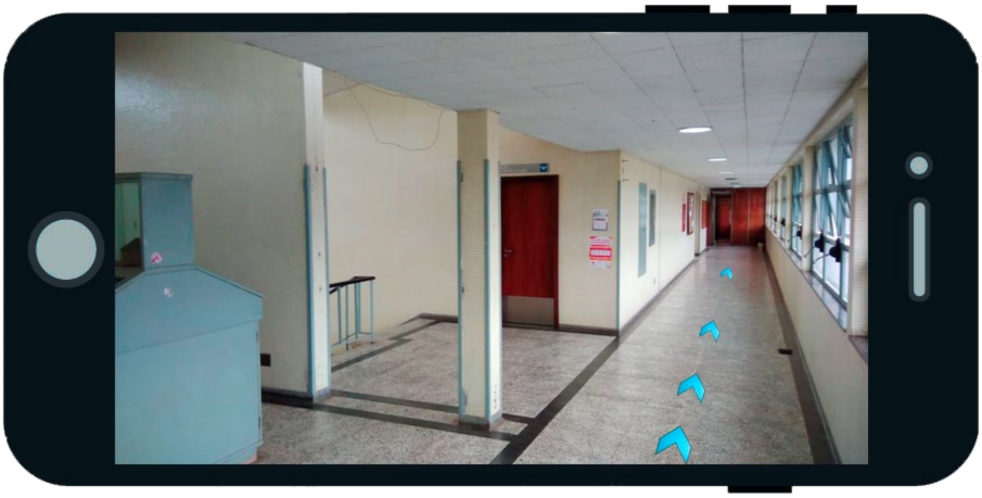


Figure 4. Representation automatically changes to local dynamic representation in decisions points along the route (under development)

The indoor location takes into account the geomagnetic mapping of each floor of the buildings and a refinement by wi-fi is being implemented. This mapping is developed using IndoorAtlas® and consists of evaluating the magnetic and signal oscillations like Wi-Fi inside to create a potential map. This map is free and can be accessed by other systems.

The expected results are empirically based on indoor environment of building universities, where participants were presented to three study situations. The first one is a free route inside the building (exploratory navigation). The second situation, presents two external landmarks well-known in the city, virtually represented as being out of the building, but with their position accessible and indicated in the display during all route. The third situation is a routing algorithm presented on PostGis and the representation of start-to-end line.

To the tests we use the Think Aloud protocol to register what he/she will identify as landmark. Based on Ohm et al. (2016) we will ask to volunteers to identify in detail the information that they think a pedestrian unfamiliar with the area would need in order to navigate those routes successfully. Our device is a smartphone with an Augmented Reality App developed with the ARCore® and the base map is from UFPR Campus Map (Delazari, 2019). In the tests with the Think Aloud protocol we hope to identify a) the semantic and structural relevance of global references as a function of participants' browsing habits and knowledge of the region; b) identify characteristics of the decision-making process at route change points such as the use of dynamic visual variables, degree of symbolic abstraction, cultural aspects such as linguistics and region of origin (the sample group has people from various countries); c) perform the statistical evaluation and validate the solution and point out system improvements. In this moment, the system is under development.

4. Conclusion

The expected conclusions should demonstrate how virtual landmarks could help people to keep their self-orientation in indoor navigations and, specifically, in change from outdoor to indoor ambient to navigate adequately. We expect identify how local culture could influence the descriptions of landmarks and correlate to how people describe their way in order to improve our knowledge about route formation on user mind. Based on this information we intend to propose a new algorithm based routing application. Finally, we expect scientifically contribute to improve personal navigation systems.

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