Study the Effect of Allocentric and Egocentric Interfaces in Indoor Navigation

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ABSTRACT: From the User Interface(UI) point of view, all the navigation systems implemented in mobile devices can be broadly divided into two categories: 1) allocentric approach and 2) egocentric approach. Our focus is to understand how these two different approaches affect the user experience and navigation accuracy in indoor environment.

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ABSTRACT
Navigation with the help of smart devices has gained popularity in everyday life due to the abundance of smart devices and advancement of research in this domain. From the User Interface (UI)point of view, all the navigation systems implemented in mobile devices can be broadly divided into two categories: 1) navigation with schematic map (allocentric approach)and 2) navigation with augmented reality(egocentric approach). Our focus in this paper is to understand how these two different approaches affect the navigation process in indoor environments. In order to study the effect, we implemented both the interfaces in a tablet. Our system can be useful to observe the users natural tendency of using these interfaces during navigation. The goal of our study is to allow the user to freely switch between the egocentric and the allocentric view in the assisting mobile devices as per their requirements so that they can reach the destination without any discomfort; at the same time they can build a mental map about the environment, a necessary requirement of the navigation process.

Author Keywords
Mental mapping; Indoor Navigation; User Interfaces; Orientation

INTRODUCTION
Localization has gained immense attraction these days. With the rapid advancement of mobile devices, applications solving the localization problem have become popular. In outdoors, the Global Positioning System (GPS) works reasonably accurately for vehicles and pedestrians. But the situation is not the same in the indoor environment. The task of navigation is generally hard for a user when she is required to navigate in an unknown indoor environment due to lack of visual cues, presence of physical obstacles, lack of orientation sense etc. Imagine the scenario of a big shopping center. Although the authorities put a large board with the product type for each aisle, those boards are not visible from all parts of the store. A similar situation can arise in a large international airport where the passengers experience a lot of confusion in locating their departure gate. Navigation application for large indoor places is helpful especially for time and cost sensitive settings. However the GPS signal cannot propagate through the walls of the buildings. So, researchers came up with alternative solutions suitable for indoor space. Some popular assisting techniques used for indoor navigation systems are wifi signal strength [2], RFID tags[17], FM signal [27, 10], ultrasound [28], Bluetooth signal strength [8], magnetic field strength [14], dead-reckoning with inertial sensors and compass [4], image processing [7, 12, 34] and so on. New researches are still going on to improve the accuracy of these systems by combining multiple techniques together or by applying new technologies [30].

As the main focus has been put on the technological advancement of this field, not much work has been done to study how the user interfaces of these applications can affect the experience of the end user. There are mainly two types of user interfaces used for indoor navigation applications: 1) navigation with interactive schematic maps (allocentric approach) and 2) navigation with augmented reality representations (egocentric approach). Both these interfaces have their own pros and cons. For example, the allocentric approach provides an overall view of the indoor space but the user has to translate the navigational instructions from the schematic map back into real world. On the other hand, the egocentric approach helps the user navigate without further information processing, by overlaying navigational instructions on the augmented view, but lacks the overview about the environment. Much quantitative research has been done to measure the performance of each approach, but it is also important to analyze these interfaces qualitatively. Most of the off-the-shelf navigation applications are developed based on one of these approaches but to the best of our knowledge, no comparative study has been done to measure the impact of these two approaches.

The goal of our work is to study the natural tendency of the pedestrian during navigation in indoor spaces. We want to understand how people switch between these two views to perceive the mental map of the enclosed space as well as navigate correctly to the destination. Mental mapping is not a research technique; rather it is a concept that is studied to understand cognitive orientation and spatial behavior [6, 21]An approach to understanding people's mental map is to probe people's perception of building environment in large cities and neighborhoods and to delve deeper into the governing city life [29]. We want to extend that concept into indoor environments. We expect that our study will provide a clear idea about user's requirements in the navigation task and will capture the best of both worlds in a seamless manner. This study can potentially figure out how the allocentric and egocentric views can be combined together in the user interfaces for navigation applications to explore the advantages of both the interfaces.

The rest of the paper is organized as follows: we begin with a discussion about the work relevant to this field. Subsequently, we introduce our designed interface, followed by the plan for future work and conclusion.

RELATED WORK

The off-the-shelf systems built to assist indoor navigational tasks are mainly of two types: 1)sensor and external signal based systems and 2)vision and augmented reality based system. In terms of the UI, these systems can again be classified into two types: 1) an egocentric approach and 2) an allocentric approach. Here we briefly discuss these categories.

Vision based navigation technique and user interface

With the term vision based navigation, we address those systems where computer vision, image and video processing techniques have been used to correlate reference frames and to generate the location specific directional instruction. Features invariant to changes in illumination, view point, scale, rotation and image translation are used for developing applications for indoor navigation [7, 12, 34]. This approach has the advantage that an image can be captured with the device's camera at any location which can later serve as a query image. Hile et al. correlated a floor plan or a previously captured reference image to estimate the device's pose and to calculate an information overlay [15] although the system works only for static images. Visual markers present in the environment have also been used to point a location in the map [25].

Along with visual localization techniques, user interfaces are also designed with augmented reality (AR) views where virtual elements are superimposed over a live camera view [1]. Kray et al. [18] used sketches, maps or pre-rendered 3D views to estimate location whereas Butz et al. [9] proposed to use directional arrow when the estimated localization accuracy is high, and suggested to use 2D map and additional cues in case of lower localization accuracy. Superimposed directional arrows along with textual navigational instruction is also explored in [20]. Narzt et al. [26] exploited augmented reality techniques to show elements of the real world which are normally invisible due to physical obstacles in a car navigation system. However similar approaches can be acquired for pedestrian navigation as well. AR based UIs are also used for museum guidance systems [22, 31]. In Museums, augmentation of the application provided additional information so that the visitor can follow a predefined path to reach their desired attraction piece.

Another important feature extensively used for navigation is the landmark. Multiple researches are done where route description contains geo-tagged images as additional cues other than textual instructions [5]. Panoramic images are also explored in [23] as they provide additional information about surroundings. Mulloni et al. [24] extended this work and proposed different perspectives for displaying panoramas. They found that the user can find an object more quickly in top down and bird's eye views than from a frontal panoramic view.

Inertial sensor and external signal based navigation

The most popular external signal based navigation technique is GPS. In outdoor space, localization with periodic recalibration with GPS is quite efficient [11, 32]. However, as GPS is a space-based satellite navigation system that computes the location through use of satellites [16], it becomes obsolete when it loses line of sight to the device or when signals are obstructed by building materials. That is why, there is no global standard for indoor navigation systems. Despite that, indoor navigation technology has advanced using inertial sensors and various external signals. One of the early works in this domain is RADAR [2] which used a WiFi fingerprinting technique. Later, this technique was improved to reduce the calibration effort. Some of the important continuing work can be seen in : Cricket [28], Lease [19], PAL [13], PinPoint [33].

Other than WiFi fingerprinting, some other techniques used extensively for indoor navigation are: navigation through bluetooth signal strength [8, 3], GSM or FM signal fingerprinting [27, 10], RFID signal strength fingerprinting [17], fingerprinting of ambient magnetic field [14]. Inertial sensors like accelerometers and gyroscopes are also extensively used along with the previous techniques to cope up with the energy requirement. However, in terms of user interfaces, most of these systems used interactive schematic map where the user's location updates periodically based on the underlying technology.

INTERFACE DESIGN

To study the effect of egocentric and allocentric user interfaces, we developed two android applications for assisting people in indoor navigation. For development purposes, we used a Nexus 7 tablet running the android 4.3 (Jelly Bean) operating system. We are using a tablet for two reasons: 1) as most of the users are comfortable using applications from smart devices in urban settings, using navigation applications built in smart devices will be natural to them. 2) we prefer to use a tablet over a smartphone because the dimensions of the tablet are more suitable for viewing navigation details. However our applications are equally compatible for smartphones.

Allocentric Interface

In the allocentric interface, we use the schematic map of our academic building. The basic interface is shown in Figure 1. We used standard the Google Maps Android API V2 for this interface where the detailed floor plan is overlaid on top of it. There are few buttons in this interface for the operation. The first button is the 'Start Navigation' button. Once the user is ready to navigate, she will press this button and will start walking. The inertial sensors like the accelerometer and gyroscope keep track of the user's movement and show the user's current location on the schematic map periodically after detecting each step. Once the user reaches the destination, she can press the 'Stop Navigation' button to stop the tracking process.

During the navigation process the interface will show the walking direction with a directional arrow periodically so that the user can keep track of her orientation and direction. The button denoted as 'Show Trace' will allow the user to see all the directional arrows simultaneously at the end of the walk,

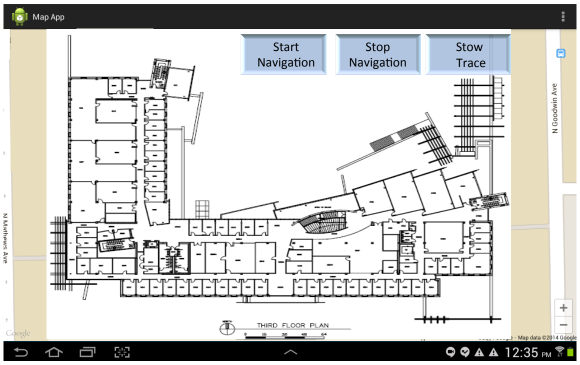

Figure 1: Basic user interface for the allocentric approach

so that the user can get an overall picture of how she traversed from the initial location to the destination in the building. Here the source location will be shown with a marker denoted as ‘S’ (Figure 2). The availability of the traveled track will allow the user to consult the map even when the navigation task is over. Potentially this will help the user build a mental map of the environment more efficiently.

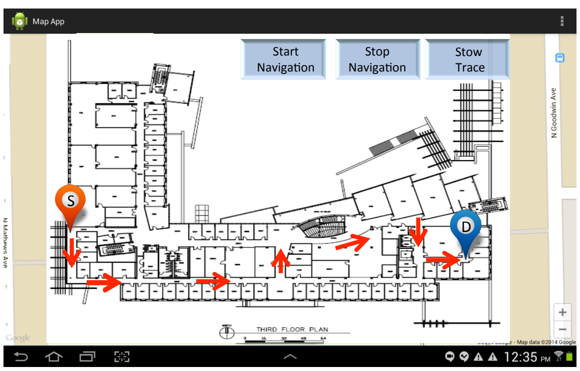

Figure 2: Allocentric interface with the marker for source, destination and traveled track on the schematic map.

In this interface, the user also has the option to declare the destination. Once the user mentions the destination, a marker marked with ‘D’ will be placed on the map in the desired location (as in Figure 2). This will allow the user to plan the navigation in advance as well as the user will be able to track her advancement towards the destination instantly after each and every step.

This interface accuracy may drift over time due to noise in the sensor data. It will consider the natural turns taken by the user as anchor points and will correct its location information whenever an opportunity is available. In this system, the initial location and the initial facing direction is crucial for further precessing. This problem can be solved by scanning some fixed physical landmark like printed bar code. The user can also start the navigation from the main entrance of the building (if possible) and mark that location manually in the schematic map. The fingerprint of the ambient magnetic field or wifi signal can also potentially be used to figure out the initial location.

Egocentric Interface

The second interface will represent the egocentric approach for indoor navigation. Human beings sometimes find it difficult to translate the navigational instructions presented in the schematic map to the real environment. People spend a lot of time finding a correlation between these two worlds. For that reason, we designed our egocentric interface so the user can look straight through the back facing camera of the tablet. The basic egocentric interface is shown in Figue 3. In this interface, we have one ‘Start Navigation’ and one ‘Stop Navigation’ button to denote the start and end of the navigation task. But unlike the previous allocentric interface, this view does not have a bird’s eye view. That is why, we placed one text box at the bottom of the interface called ‘Destination’. Before the start of the journey, the user will mention the destination of his journey in this text box. Once the destination is set, the interface will calculate the shortest path to the destination and will instruct the user to navigate accordingly. We use Dijkstra’s algorithm to calculate the shortest path for a fixed set of source and destination.

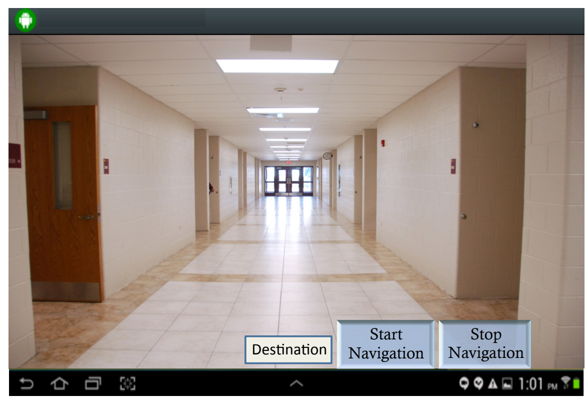

Figure 3: Egocentric interface with the button for starting and stopping the navigation process.

Figure 4 shows the interface with the directional arrow. The overlayed red arrow at the top shows that the user needs to move forward to reach to the destination. In this interface, the user cannot see the destination until she reaches it. This may make the user feel uncomfortable during the navigation. That is why we overlayed the destination pin denoted as ‘D’ (shown at the top left corner) on the augmented view. This indicates that the final destination is located towards the north-east corner from the current location. As the user keeps following the directional arrow(red arrow), the destination pin will also change its position to show the current location of the destination.

Figure 5 shows a screen shot of the interface after a few minutes of walking. Here, the destination pin moved from the north-east corner to east. The black dotted arrow shows how the destination pin moved from its previous location to its current location. However as the destination is now located to the right side of the user and as there is a corridor towards the right, the directional arrow (at the top) changes its direction to instruct the user to take a right turn. Once the user takes the turn, the directional arrow as well as the destination pin changes accordingly.

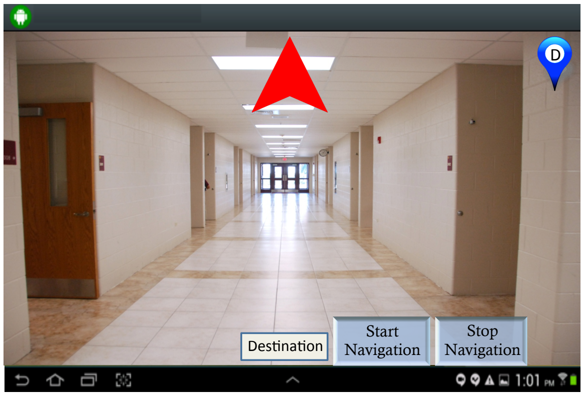

Figure 4: Egocentric interface with the directional arrow and the destination pin.

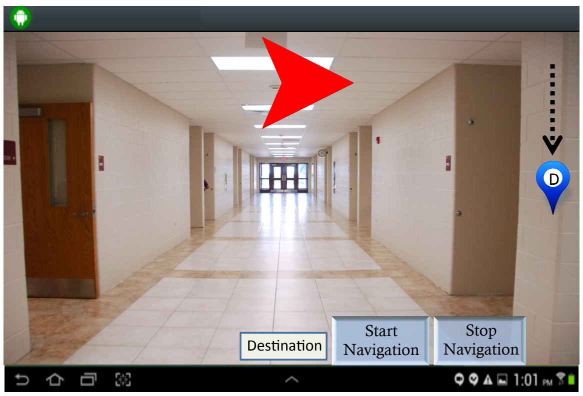

Figure 5: The direction of the directional arrow changes as per the current location of the destination pin. The black dotted line shows how the destination pin moved from it's previous location. The star mark show the corridor where the user are supposed to take the right turn.

In the back-end of this interface, we used the same dead-reckoning technique as used in the first interface so that the performance of the two interfaces can be compared against each other without any actual difference in the accuracy.

DISCUSSION AND FUTURE PLAN

The two interfaces discussed in the previous section are the main platform of our work. To measure the effect of these interfaces on the user, we will conduct a user study. In the user study, we want to make sure that the participants are completely unaware of the buildings structure so that they face maximum challenges during navigation. The participants will receive a real life navigation problem. The goal of the participants will be to solve the problem i.e., to reach the destination with the help from the interfaces.

In this process, we would also like to observe how users behave when they face a navigation challenge. As the prime goal of any navigation application is to remove the burdens of finding a route to the destination without any knowledge, this observation of user behavior can point out the requirements of some key components which are missing in current standard interfaces. Along with the qualitative measurement, we would like to measure the performance of both interfaces quantitatively. There are many parameters which we can use in our measurements such as the time taken by the users to reach the destination, the number of wrong turns taken during navigation, the number of times the users stop to decide the next step and so on. Apart from these, we would also like to know how well the interfaces help the user build their mental map of the building.

Overall, a study like this can provide basic guidelines about the utility of different interfaces. We believe our findings will help people build interfaces which can guide a person in unknown locations with less confusion from the user's point of view.

CONCLUSION

This paper presents our motivation to experimentally evaluate the two main user interfaces used for indoor navigation systems. We explained how our interfaces are designed and developed for the experiment. Both the egocentric and allocentric interfaces have been extensively used in many applications. While previous work has proven the efficacy of both methods individually, we present a study plan to probe and provide a clear idea of which view best suites indoor navigation. Perhaps the study could reveal how the combination of the two views may produce the best results over using a single view. The user study can tell us how users consume the best of both the views in different circumstances without disrupting their natural behavior.

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