Know your Surroundings with an Interactive Map

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Abstract
The advancement of mobile technology inspired research communities to achieve centimeter level accuracy in indoor positioning systems [2]. But to get the best out of it, we need assisting navigation applications that will not only help us to reach the destination quickly but will also make us familiar with the surroundings. To address this concern, we propose a two stage approach which can help pedestrians navigate in an indoor location and simultaneously enhance their spatial awareness. In the first stage, we will conduct a behavioral user study to identify the prominent behavioral patterns during different navigational challenges. Once the behavioral state model is prepared, we need to analyze the sensor data in multiple dimensions and build a dynamic sensor state model. This model will enable us to map the behavioral state model to the sensor states and draw a direct one to one relation between the two.

Author Keywords
Sensors, behavioral state model, navigation application

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction and Overview

The ubiquitous availability of mobile devices inspired research communities to achieve centimeter level accuracy in indoor positioning systems [2]. But is this the kind of accuracy that we all care about? Navigation in indoor environments is harder than outdoors because of its homogeneous pattern. Imagine a large corporate office where all the cubicles look exactly the same. When a new employee uses a navigation application in that office, step-by-step navigational instructions from source to destination may serve his immediate goal of wayfinding, but will this make him comfortable gradually about his surroundings? We need assisting navigation applications that will not only help us to reach the destination but will also make us familiar with the surroundings.

Now with the ongoing researches, are we moving in the direction of developing navigation applications which can help us gather spatial knowledge along with wayfinding? Through a detailed literature search, we found two main types of navigation applications for indoor spaces: 1) a You-Are-Here schematic map which projects the user's current location on the map [3] and 2) an application with augmented navigational instructions projected on the camera preview [1]. We conducted a preliminary user study where participants used either the type 1 or the type 2 navigation application to solve some navigation challenges in an academic building. We found that for both types of applications, participants always found it hard to process too much information simultaneously. A post experiment interview revealed that whenever more than one cue was presented through the interface, the users preferred to use only one of the cues at a single point of time, ignoring others to avoid confusion; otherwise they made more mistakes during navigation. Moreover, there was not a single cue which was preferred unanimously; rather participants preferred different cues in different scenarios. This study gives us an indication that various navigational cues can be useful if they are presented intermittently based on the context. So why not build an application that can present navigational cues based on context?

Extracting context from the environment with the specialized sensors like accelerometers, gyroscope, magnetometer, GPS and so on is not impossible in this digital world. However the context from the environment can tell us only half of the story; the other half will remain incomplete if we do not include the user in the design. Existing navigation devices like GPS devices always deliver navigational instructions in a certain granularity irrespective of the user's requirements. But the user's requirements are highly context sensitive. One solution to this problem is analyzing user behavior and taking necessary action based on the behavior. The large array of sensors available in mobile devices can make this a feasible option. However identifying appropriate behavioral patterns and mapping them to corresponding sensor states is nontrivial.

Keeping in mind the user's concerns, we propose a solution which can help pedestrians navigate in an indoor location and simultaneously enhance their spatial awareness. To achieve this, we want to approach this problem in two stages. In the first stage, we will conduct a behavioral user study to identify the prominent behavioral patterns during different navigational challenges. The study will help us build a scientific behavioral state model specialized for navigation tasks only. Once the behavioral state model is prepared, the second stage will start where we have to analyze the sensor data in multiple dimensions and build a dynamic sensor state model. This model will

enable us to map the behavioral state model to the sensor states and draw a direct one to one relation between the two. However designing something that can satisfy everyone's wish list is hard. Our ultimate goal is to actively bring the user into the process and present the model to them in such a way that they can observe and curate the model as per their own preferences and feel that the system is built only for themselves.

Design

Imagine a scenario where a student needs to pick up an energy drink from a grocery store before catching the next bus in five minutes. Now take another instance, where the same student goes to the same grocery store, but this time for his next week's grocery shopping. These two hypothetical scenarios can give us a rough idea about how context can be different in different instances irrespective of the same location or the person in both the instances. However, these two situations can be clearly distinguished if we observe the student's overall behavior: in the first scenario he is in a rush, whereas in the second scenario, he is most likely be in a more relaxed state. Our proposed system will leverage this behavioral diversity and configure the navigation interface in such a way so that the user can get the most suitable information at any specific time. Of course, the behavioral model can be different from user to user. That is why our solution will keep the provision for the user to curate their own model so that everyone can enjoy the advantage of the personalized context. Our solution has contributions in three major parts:

1. Design the behavioral state model of the navigation tasks
2. Identify the dynamic sensor model to classify the behavioral states
3. Allow users the opportunity to curate their daily personalized navigation route

Design the behavioral state model

Understanding the user's behavioral state during the navigation tasks is important in our solution. Different navigational challenges can create different states of mind which can trigger various behavioral states. For example, if we consider the hypothetical scenarios described above, in the first scenario, the user was tense because he had to catch the bus soon, whereas at the second scenario, he was more calm and relaxed. Relaxation and tension are the states of mind which can affect user's cognitive state. A calm, sound mental state helps people build a rich cognitive or mental map of a location, which is an essential part of spatial awareness.

Analyzing the mental state of a user has several challenges. Sometimes even the users themselves find it difficult to explain their mental state precisely. Moreover, this is not recognizable through any standard physical activity, and it varies from user to user. However in our previous user study, we observed some promising behavioral aspects in this direction. We initially asked the users to use an assisting mobile device to navigate and later asked them to find a place shown in a picture without using the assisting device. We found that the users who eventually failed to reach the designated place took longer time to think than the successful participants before starting their walk. This gives us a hint that if we can observe user's micro behaviors and try to analyze them against other regular activities, we may find some distinct patterns in their behavior. Our goal is to identify these micro activities through extensive behavioral study across diverse situations and map them with the corresponding mental state.

Identify the dynamic sensor model
Once the behavioral state model is defined with the recognizable physical micro activities, we need some tool to detect those activities on the go. The sensors in mobile devices can be used extensively to identify those subtle physical behaviors. Specialized as well as general purpose sensors together can detect a large set of activities with high precision. For the hypothetical scenario mentioned in the beginning of this section, in the first situation the walking speed of the user will be much higher than the second situation, and this information can be detected accurately with an accelerometer.

Although we described that the two instances of the hypothetical scenario can be detected easily with an accelerometer, using sensors in mobile devices has also some inherent challenges. Sensor readings are generally very noisy, and in a complex situation, this noise can become a major issue. To handle this challenge, we need to process the signal optimally to not only remove the noise but also retain the information about the user's micro activities. Our behavioral state model can help us in this regard to identify the appropriate frequency range,sensor modes so that the processing can make use of the context. Another important aspect of using sensors is the power budget. Using all the sensors simultaneously will drain the battery of the device in a very short amount of time. Our system will use the behavioral state model to probabilistically determine the sensor requirements. which can eventually enable us to present the appropriate navigation cues based on the user's mental state.

User driven curated model
The technology is built for people, not the other way around. Then why does the system always make decisions on behalf of the user? In an ideal scenario, the system should only process the data and present it to the user in an organized way. But it should be the user who has the power to curate the data to fit his own requirements. We agree that a behavioral model may not fit the requirements of all the users. Our system will aggregate the analysis of the navigation tasks performed by the user and present it to the user for different time intervals. This can benefit the user in two ways. It can help the user understand his own behavioral pattern more precisely. For example, a person suffering from high blood pressure can figure out how tense he remains during navigation tasks and can take necessary initiative to relax more for his own health. Moreover, this feature will allow the user to customize the internal model of the system. The curated system will be able to capture these user specific preferences. The user can also add his personal notes on the space during this curating process which may become useful for future reference. The goal is to build an interface utilizing the context for the sake of the user instead of exploiting the user as a consumer.

References

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