Enabling Opportunistic Navigation In Location-Based Notification Systems

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Abstract

Device-assisted navigation is rapidly becoming a major topic in computer science. PDAs and other small devices are enabling the introduction of navigational assistants to many different spaces. These areas are generally filled with points of interest with which users may choose to interact with. The natural behavior of users in such a space is to explore, interacting with objects the user deems worthy of further interaction. We call this behavior 'opportunistic navigation.' In this paper we define the challenges associated with and put forward several criteria for enabling opportunistic navigation in Location-Based Notification Systems. Our criteria have been implemented in the form of a prototype navigational assistant, SeeVT-ART, and have undergone a preliminary field test.

1. Introduction

Device-assisted navigation is a topic that recently has become very important. Consumers are rapidly embracing GPS navigation devices. Institutions such as museums are deploying systems to aid patrons in browsing their collections of objects. As computers have become ubiquitous, present in every area of our lives, it is logical that we now look to them to aid us in getting around.

As with any user-centered system, navigation systems must be designed in such a way that they assist the user in the best way possible. Of what use is a system if it does not assist you in an appropriate manner? The best way to assist a user is heavily dependent upon their task. Users of a vehicle navigation device expect the system to give them explicit, easy to follow, step-by-step directions. Their task is to get from point A to point B. It is the job of the system to facilitate this task.

Another common task where users may rely on devices to assist them in their navigation is perusing a space filled with objects that are interesting to the user. Examples of such a space include museums, retail stores, and trade fairs. In all of these spaces, there are a large number of things which a user may be interested in. While some users may have exact destinations, most will have an unclear or ill-defined goal. In such a situation, the system is most useful to the user by providing information to the user so that he may decide which pieces are worth visiting or viewing. It is this scenario which will be the focus of this work.

The typical behavior of people in a space filled with points of interest is one of browsing or exploring. People generally enter a space with an ill-defined goal such as "enjoy the art collection." In the space, they will generally browse in order to find pieces that interest them. These users navigate a space by wandering around and searching for pieces that interest them. Once a piece is identified as one that is of interest to the user, generally the user will engage in some sort of interaction with the piece, such as requesting more information.

We call such a method of navigating a space *opportunistic navigation*. Users are opportunistically moving through a space; taking advantage of any opportunities to view pieces which interest them. It is the responsibility of the designers of systems which assist in navigation to ensure that their system allows for such a behavior. Below, we present criteria designers must keep in mind when designing such systems.

Many of the lessons learned and presented here have been gleaned from our experience in designing a handheld navigation system for use at the Inn at Virginia Tech. The Inn, along with the attached conference and alumni centers, has a collection of art donated by alumni on display. Or solution, dubbed SeeVT-ART, is discussed below, along with the lessons we learned and the future directions we intend to take.

The biggest challenge in any device assisted navigation system is how to assist the user in navigation. The goal of the system is to provide information the user requires most at any given time. Users have many information requirements when they are navigating a space. All these information requirements are directly related to the user's environment. Such requirements include location information, identification of surrounding points of interest, information on points of interest, etc. It is the job of the system to provide for these requirements.

These requirements differ based on the task the user will be performing. If the user has a clear goal, such as getting from one point to another, the system needs to provide clear directions on how to travel there. If the user has an unclear goal, such as enjoying a collection of art pieces, the system has a different responsibility entirely. In such a situation, the job of the system is to assist the user in finding pieces which may interest him in order to provide the best experience possible.

From prior work and our own experiences, four general challenges facing designers of a navigation system can be derived:

1. The system must assist the user in determining a route through the space.
2. The system must identify points of interest around the user.
3. The system must provide information so the user can determine which pieces to interact with.
4. The system should provide additional information on the points that the user chooses to further interact with.

These challenges are discussed further in the context of opportunistic navigation.

2. Background and related work

Throughout this paper, several terms and concepts are used which may require additional explanation. This paper focuses on *device assisted navigation systems*. Such systems assist their users in navigating a space. Devices provide location and route information to a user. A common example of this is a GPS vehicle navigation system. The approach this paper describes utilizes *opportunistic navigation*. Similar to exploring, it allows users to navigate the space however they wish while the system supplements them with information as required.

In order to accommodate the information needs that come with opportunistic navigation, it is necessary for our system to provide information of value to the user. Thus, our system is a *notification system,* providing information to users engaged in the task of browsing an art collection. The properties of notification systems are further defined and explored in [3]. In order to determine what information is pertinent to the user's current environment, our system must know its current location. As a *location-aware system,* it keeps track of its location in order to contextualize the information it delivers to the user.

Combining a notification-system with a location-aware system gives us a *location-based notification system.* Such a system is the primary method of implementation for device assisted navigation. Through keeping track of a user's location, we are able to deliver information that is of value and pertinent to a user's current location. This is further defined in [2].

In order to define guidelines for design of such a location-based notification-system, we use the *interruption, reaction*, and *comprehension (IRC) critical parameters* as discussed in [3]. These parameters allow us to quantify our design rationales in terms of their desired purpose. These parameters are also used to guide design choices by keeping in mind our desired levels for each.

Tto implement the location-aware component of our system, we used the SeeVT technology developed and described in [1]. By leveraging the ubiquity of wireless internet access, it is able to determine a user's location by viewing the strength of nearby access points. In designing this system, we followed a hybrid design methodology, as described in [4,16]. This methodology is a combination of eXtreme Programming, an agile software development process [5], and Scenario-Based Design, a usability engineering methodology [6]. This process enabled the efficient development of a usable system through close collaboration with our client and constant, incremental delivery of working software .

The field of device-assisted navigation has seen numerous projects in the past and will no doubt continue to be a hot area of research. Location-Based Notification Systems like the GUIDE project [9] provide a real world application designed to guide tourists around the city of Lancaster. Tourists using the system are guided around the city by their virtual companion. The system points out and identifies nearby landmarks which the user may be interested in. The system presents textual directions guiding a user from one spot to another. People request information from the device as they require it, such as to view a page of nearby points of interest. The Cyberguide project, detailed in [7], is a location-based notification system developed at Georgia Tech. It is a family of prototype systems, consisting of both an indoor and outdoor model. The indoor model relies on an innovative method of location awareness: they have strung up an array of TV remotes in and use the IR signals to determine location. The outdoor version utilizes GPS technology for a very accurate location derivation. Both projects were designed to guide visitors around their respective spaces. The indoor version guided visitors around the team's lab, encouraging them to interact with exhibits which they had set up. The outdoor projects guided people around the Georgia Tech campus. Another project in the field of location-based notification services is the Marble Museum project described in [11]. It is a navigational assistant available for use by visitors to the Marble Museum in Carrara. Visitors walk through the museum with a PDA and are made aware of nearby pieces of art and can request further information. Our project differs from these projects in that it is designed for a dedicated space (a museum) and it seeks to support users in a secondary manner who are only opportunistically looking at the art (it is not their primary task). Our work is designed for a multipurpose space, and visitors have very different motivations and objectives.

Many different technologies have been developed for the purpose of location determination. Global Positioning System, or GPS technology, is a widely available technology that has been embraced by consumers. Utilizing a network of satellites in orbit around the Earth, a GPS enabled device is able to determine its location. This location determination is quite accurate and relatively fast, once a signal is acquired. However, GPS technology requires a line of sight to the satellites in order to receive a signal. Thus, it is not particularly well suited for indoor applications. In addition, to perform location determination via GPS, additional hardware is required for receiving a satellite signal. Radio Frequency (RF) technology is another method that has been used in several applications for determination of location. It is discussed in the RADAR[12] project and a similar approach is used in the Active Badges of Xerox's ParcTAB [13]. This approach utilizes a radio frequency network to transmit data. This data is used to determine a uses location, as well as provide additional information to the user. Location technologies utilizing RF networks are very accurate. They are also very fast. However, extensive additional infrastructure must be installed. Also, additional hardware is needed so the devices can interface with the network. RF technology is a rapidly evolving technology, and things such as RFID tags may change the way we view location awareness.

Infrared beacons are another method of determining location. Two examples of projects utilizing this are Cyberguide [7] and Marble Museum [11]. Through simple object like TV remotes or complex IR beacons, somehow a signal is propagated with location information. Devices equipped with IR scanners receive this signal and thus determine their location. While the materials for this are cheap compared to RF, it still suffers from the downside of requiring additional infrastructure. Also, line of sight is required, making this ideal only for large, open rooms.

Last, wireless local area networks (WLAN) can be sued to determine location. This is shown in the GUIDE [9] project, as well as in SeeVT [1]. The main advantage of using WLAN is its flexibility. It works in many different spaces and requires no additional infrastructure (at least not today, when WiFi blankets most popular regions). We can leverage existing infrastructure for use in location determination. Also, as many PDAs are now coming with a wireless card standard, no additional hardware is required beyond the base device. It is for these reasons that we chose to go with WLAN as our means of location determination in our implementation.

Another space in which opportunistic navigation has been carefully addressed is in consumer web spaces. In [14], Bryan et al. discuss what they call the 'opportunistic exploration' of consumers in a product space. Their discussion is primarily limited to information visualization in an online retail space. They present a novel metaphor dubbed the 'aquarium' in which a user is immersed in a field of products. The user then opportunistically explores through the space, aided by the system through preferences and keywords. Another field briefly touched on later is that of multimodal notifications. Multimodal notifications are not a requirement for opportunistic navigation, but they are a feature which can serve to enhance the experience. Such a system is explored in [8] and [10]. Both papers explore the idea of including audio features in a navigational assistant and methods of implementing such a feature. They also discuss the efficacy of their chosen methods in relaying information and conclude to the effect that multimodal notifications can be used to increase user comprehension of information in navigational assistants.

3. Opportunistic navigation

Opportunistic navigation leverages the natural behavior of users to explore in a space of interest. This behavior is necessary because many times users enter a space with a primary goal like navigation to a destination, but with a secondary desire to enjoy their surroundings. High level goals such as 'enjoy the art collection' are only satisfied through lower level tasks, such as viewing pieces in that collection. In designing for and evaluating the success of opportunistic navigation in an interface, designers must employ metrics of success—in our case we employ *critical parameters* as defined in [3] and described in this section.

Opportunistic navigation is applicable to many spaces—e.g., web spaces, theme parks, and shopping centers. Such a behavior is fundamental for us in how we get around. It must be considered in designing spaces where people will need to get around. It is also being used as a model for decision processes in artificial intelligence. The focus of this work is on enabling opportunistic navigation in device assisted navigation systems. Opportunistic navigation is extremely important for such a system as it is the natural behavior of the system's user base. As such, a device assisted navigation system should enable opportunistic navigation to provide a maximal user experience.

Our specific problem space, the Inn at Virginia Tech, is a multipurpose space. Visitors have main tasks, such as attending a conference, but may have secondary goals, such as seeing some of the art on display. In such a setting, opportunistic navigation is ideal, as it allows the users to catch some pieces en route from one location to the next. As the users do not have a specific piece in mind, the system must assist the user in identifying nearby pieces and providing the information necessary for the user to pick which pieces to dwell on.

A system that supports opportunistic navigation allows users to explore the space on their own, providing relevant information as necessary. This is in contrast to a guided tour. In a guided tour, users are guided along a particular path. Many users, however, would prefer to see the space on their own and create their own experience. Use of opportunistic navigation allows users the freedom to walk around the space at their leisure and see the pieces that are of interest to them. Through this method of navigation, each user has an experience tailored to his or her unique preferences.

Another advantage of opportunistic navigation is that it does not necessarily interfere with a user's experience. With a guided tour, users are required to constantly check the 'system' (be it a map, a tour guide, or an actual computer system) to ensure that they are on the correct, pre-ordained path. With opportunistic navigation, however, users are free to explore as they wish, without being constrained by the system. Users can enjoy the environs and reference the system only as they deem necessary.

Opportunistic navigation is not without its downsides. The primary downside is the cognitive burden it sets on the user. Users are required to determine their own route. While this should not be a problem for most users, there are some who would prefer a guided tour. Another downside is that users may miss important pieces. Guided tours can be designed so that all the most important points of interest are hit. With opportunistic navigation, users may accidentally miss important pieces. In many situations, the upsides of opportunistic navigation greatly outweigh the downsides. In addition to being the preferred behavior of many users in a variety of settings, it should provide a better experience than other methods of navigation.

To further assist the design of navigation systems to enable opportunistic navigation, we now explore the topic in terms of the critical parameters for notification systems, as introduced in [15] and elaborated in [3].

Critical parameters are a quantitative value we can assign to the qualitative properties of our design. In the case of notification systems, these parameters measure how interruptive the system is, how critical it is for the users to react, and how important it is for the user to fully take in the information presented. These parameters can be determined through requirements analysis. They are then used to guide the hand of design, as each new step is weighed against the desired values of these parameters. Determination of critical parameters results in an abstract, three-dimensional design space. We then work within the design space we have created. For our design, we use the IRC parameters: interruption, reaction, and comprehension.

Interruption is a measure of how 'interruptive' the system is, or how often it interrupts the user's task to provide information. For a system aiming to enable opportunistic navigation, one would expect that a medium interruption is reasonable in most situations. We do not wish to interrupt the user repeatedly as it may interfere with the user's experience of the space. The user should be interacting with his environment, not the system. The system is a supplement to the user's experience of the space. However, we cannot have a low interruption value that would indicate not enough information for the user to realize when there are points of interest nearby.

Reaction is a measure of how fully we want users to change their task based on the information we provide to them; e.g., by noting a piece of art. In our navigation system, we want to encourage users to visit points of interest which they decide are interesting to them based on the information we provide. Thus, we aim for a high reaction value. One of the main goals of the system is to assist users in locating and interacting with the points of interest that they determine to experience. This is done through providing information. When users view this information, they decide whether or not to interact with the piece. If the user determines from the information provided that the piece is suitable for interaction, the user should change from the task of walking around browsing to interacting with the object.

Comprehension is a measure of the information relayed to a user that is retained. In a sense, it is how well the user understands the details of the information provided to a degree that they can be later recalled. A tour guide aiming to enable opportunistic navigation will generally want to aim for a medium to high level of comprehension. For example, in a shopping mall scenario, it may be very important for users to recall the details about the points of interest in their vicinity. This is an important aspect of their decision making process, as they may wish to comparison shop or revisit certain locations. In a museum, by contrast, we do not need as high of a comprehension. Casual users do not need to be able to recall all the features of a piece they have encountered. What matters is the overall experience.

4. The SEEVT-ART interface

The notion of opportunistic navigation and what must be done to enable it came from our experiences in working at the Inn at Virginia Tech on the SeeVT-ART project. This project is a navigational assistant for use by visitors to the Inn who wish to view the various art pieces on display. Our system was developed for use in the Inn at Virginia Tech along with the attached conference center and alumni center. The full name of the complex is The Inn at Virginia Tech, Skelton Conference Center, and the Holtzmann Alumni Center. This complex is a relatively recent addition to campus. Its patrons include visiting alumni and conference goers. Distributed throughout the many halls of the Inn and attached buildings is a portion of the Virginia Tech Foundation's extensive art collection. This work includes pieces donated and produced by alumni of the University. The Inn is a structure composed of many hallways leading to its various rooms. As such, it can at times be difficult to navigate on one's own. Many of the pieces of art are in out-of-the-way places where they may never be found by visitors looking to experience the collection.

Prior to the development of SeeVT-ART, the Foundation had developed a map of all the pieces. The Foundation was interested in other ways of assisting visitors in browsing the collection. A representative of the Foundation and the Office of the university Architect approached us and we began to develop a system designed to assist visitors in browsing the collection. Working with our client, we developed requirements for our system. As we moved through the design process, we gradually settled on our present approach. Our approach has 3 main features, as discussed previously in this paper: *opportunistic navigation*, *multimodal notifications*, and *location awareness*.

Our system is made location aware through use of SeeVT [1], a WLAN-based location determination technology for handhelds. This allows us to determine the location of the system and the user in order to provide relevant, context specific information to the user. Our system provides navigational information through its use of a map of the region surrounding the user. By utilizing a map showing the layout of the region the user is in, we convey topographical information to the user so that he may determine a path through the space. Our system identifies nearby points of interest via numbers overlaid on the map. The location of the point of interest in the user's region is indicated by the location of the number on the map. All the pieces in the user's immediate region are shown on the map. Our system displays information about the various points of interest in a window located below the map. This window consists of the title of the piece and a thumbnail version of it. Through this information, users are easily able to determine whether they wish to further interact with the piece. If they see the thumbnail, they may decide that a piece is worth further inspection. Our system allows users to request additional information on points they are interested in by clicking on a 'Details' button. Clicking on this button brings up a larger thumbnail along with textual information about the piece. This information contains details such as the artist, medium, date, and a general section of 'flavor text.' This additional information serves to complement the user's experience in viewing the artwork. See Figure 3 for interface screenshots.

Our system is designed to support any user who wishes to enjoy the art collection. These users have ill-defined goals regarding the collection, and generally do not know exactly what it will take in order to enjoy the collection. Our system allows them to browse the space as they wish, seizing upon opportunities as they see them. Thus it allows these users to accomplish many sub-goals which lead to the satisfaction of their overall goal.

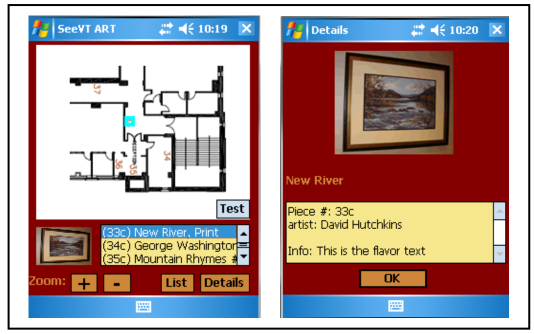

Figure 3. Screen shots of the interface

Shown in Figure 3 are two screen shots of our prototype. On the left, the user's surrounding region is displayed. Points of interest in the region are highlighted on the map and displayed below. As users explore the space, they may request additional information from the system. We place a slight cognitive burden on the users in requiring them to determine which piece they are near, but preliminary evaluations have indicated that this is not a problem. On the right is our information page. When users select a piece to view additional information, they are presented with both text providing additional information and a thumbnail to provide context.

5. Preliminary evaluation

A field study was conducted using the SeeVT-ART interface. For this field study, we recruited 15 participants who were members of our target audience: alumni and other visitors with little or no experience with the Inn or handheld devices. After filling out a background survey to confirm their membership in the target audience, participants were allowed to explore a limited space with the assistance of the system. Upon completion of the evaluation, users were asked to fill out several subjective questions regarding the effect of the system on their experience. These questions were targeted in order to gather feedback on our use of opportunistic navigation and our multimodal notification system.

Analysis of the user response surveys showed positive response. Participants reported supplemental information provided by the system increased their satisfaction with their experience. Participants were divided on the amount of attention they felt they devoted to the system. We expected users to only refer to the system when they found a piece they wished to gather further information on. However, many users relied on the system to navigate the entire space.

Of particular note were the user's responses indicating their preference for a guided tour of the system as implemented (opportunistic navigation). Overwhelmingly, participants responded that they favored the freedom and flexibility offered by our device through its allowance for opportunistic navigation. Many users responded that they enjoyed being able to decide what their experience would consist of, being assisted by the device rather than led.

6. Conclusions

Opportunistic navigation is a natural behavior of humans when presented with a space filled with points of interest. People naturally begin to explore, seeking out objects which merit further inspection. As navigational systems have become more and more commonplace, they have moved off the streets and into the rest of our lives. It is important that in systems designed for navigation assistance in application spaces filled with points of interest we leverage this behavior of opportunistic navigation in order to create the best user experience possible.

Thus, it is our responsibility as designers to create navigational systems which allow and even encourage this sort of behavior. In order to do that, we are presented with several information challenges. These challenges, along with the criteria derived from them must be kept in mind as new navigational systems are designed and implemented.

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