USING WIRELESS NETWORKS TO ASSIST NAVIGATION FOR INDIVIDUALS WITH DISABILITIES

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Abstract – *Using wireless networks to assist navigation by determining a user's location and alerting the user of his proximity to accessible building entrances and facilities.*

Introduction

Despite improvements brought about by the Americans with Disabilities Act (ADA) of 1990, travel in and around many urban areas continues to be challenging for individuals with disabilities. Both new construction and retrofitted buildings are still difficult to navigate. Typically, ADA-compliant parking, building entrances, and facilities, such as accessible restrooms, elevators, and drinking fountains, are sometimes outside of the main traffic areas and may require additional time and effort to be found.

University campuses, large building complexes, and even hospitals serve as examples of environments that are difficult to navigate through. Additionally, it is often difficult to locate accessible entrances or facilities within these environments. For example, at Virginia Tech, the modern three-floor building we work in is less than five years old. Although four of the six building entrances have automatic door entry, only one of the three accessible restrooms in the building has an automatic door to assist persons with certain mobility impairments.

While Virginia Tech has a detailed accessibility map [1] for locating accessible parking and accessible entrances to buildings, the only other access features identified on the map are elevators. Accessibility features built into lecture halls, classrooms, administrative offices as well as accessible restrooms and drinking fountains are not noted on these maps. As a result, faculty, students, and visitors to campus are left to their own devices to locate these facilities once they have gained access to the buildings. This internal access problem led us to

pursue a wireless navigation system that alerts people with disabilities when they are approaching an accessible feature of a building.

Background

There are several different methods to determine one's location. The most popular method is the Global Positioning System (GPS) that uses satellites to estimate the user's location. Additionally, researchers at Intel Research have developed an open-source application program called Place Lab [2], which monitors the surrounding 802.11 (WiFi) access points (APs) and uses their signal strengths and proximities in order to estimate the location of the computing device. The user's location is then marked on an image of the area. The image can be a map, a building floor plan, or an aerial photo.

Advantages of Using Wireless Access Points for Location

There are several advantages to using this approach [3]. As with GPS, Place Lab hosts can determine their location privately without constant interaction with a central server, unlike badge tracking or mobile phone location services [4]. The access point signals radiate in all directions, and the location estimate is calculated locally on the host device running the application. As a result, only the user (or anyone that can see his computer screen) knows where he is located based on the location estimation. This enhances privacy because users cannot be tracked by another entity while using the application.

Unlike GPS, applications that use wireless APs as beacons work both indoors and outdoors. An application can guide a user to a particular building and then continue to guide the user once inside. For example, our application can steer a user toward the building, then alert him to the closest accessible entrance to the building and then to the nearest elevator or accessible facility.

Today, most laptops, tablet PCs, and personal digital assistants (PDAs) include built-in wireless devices. Since the only equipment the application requires is a computer and a wireless network device, there is no additional cost or equipment required. No GPS receivers are needed to use this application.

The Application: Navigational-System of Accessible Facilities (N-SĀ F)

Virginia Tech employs a campus-wide network infrastructure of 802.11 (WiFi) wireless access points to support the computing needs of the faculty and students. One of the by-products of this WiFi network is that a user's current position can be estimated using the ambient signals from nearby APs. In this project, the Place Lab location estimation software was used as the foundation for our application.

Using Place Lab, the first step is to identify the wireless APs and establish a baseline database of WiFi coverage on campus. Once this database of APs and their approximate locations is populated, the application uses the signal strengths of nearby APs to estimate the user's position.

In conjunction with Virginia Tech's Assistive Technologies Department, we developed a locator system with visual indications of relative distance between the user and accessible facilities. N-S Ā F combines WiFi location estimation capabilities with proximity icons and displays them on access maps for several campus buildings.

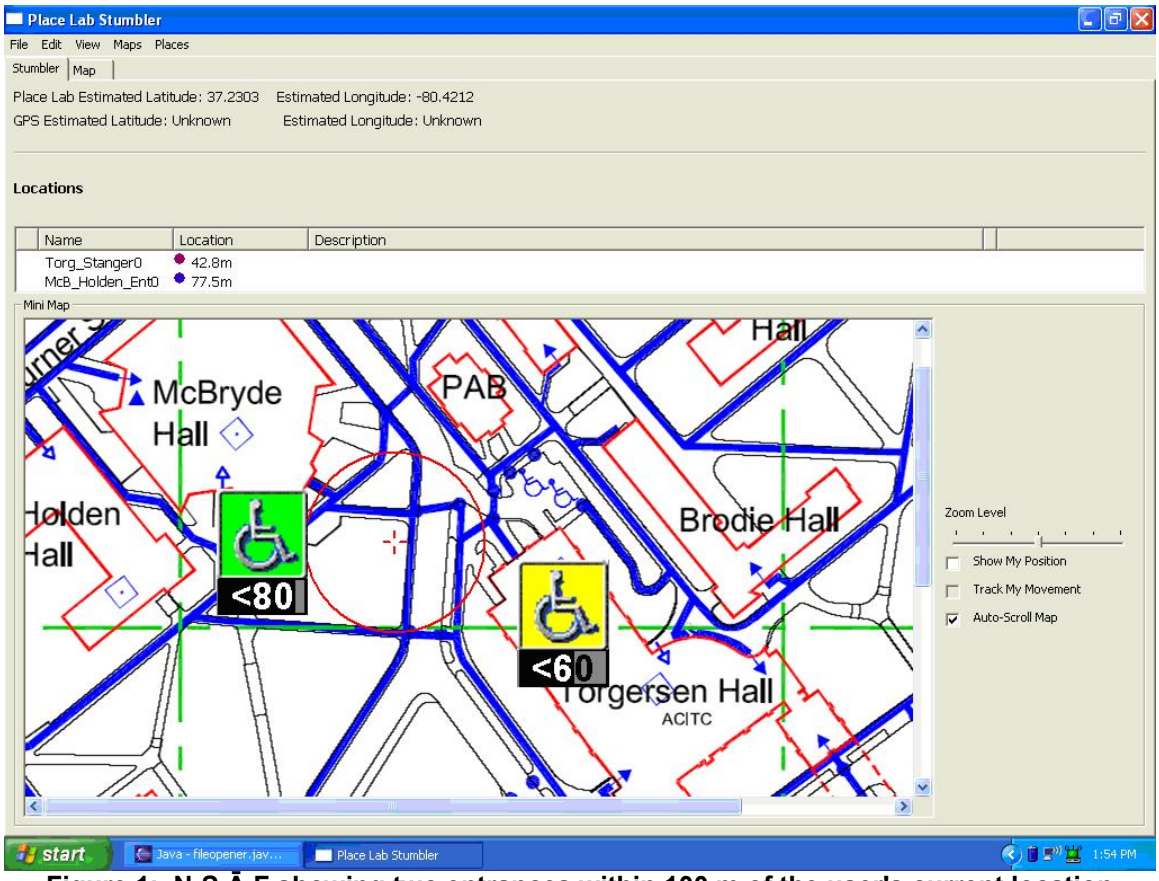

Figure 1: N-S Ā F showing two entrances within 100 m of the user's current location denoted by the red crosshairs within the red circle

As shown in Figure 1, N-S Ā F displays a map of the area and pops up icons when the user approaches special features, such as the assisted entrances to a building. The application dynamically displays icons on a map of possible accessible entrances to various buildings near the user's location. Each icon is designed to show the estimated distance to the entrance using both numerical text and proportional shading in black. Additionally, the color of the icon changes depending on the distance the person is from the entrance, serving as a visual indication of relative distance. The colors were chosen to serve as a measurement of "hotter" or "colder". **Error! Reference source not found.** shows

the symbols displayed when a user approaches a building with an accessible entrance. To date, only the entrances have been built into the system. However, the program can be extended to the interior accessible facilities as discussed above or any other features that the system designer would like indicated.

Distance from Facility	Example of the Symbol Displayed	Background Color of the Symbol
< 20 meters		Red
21 < 40 meters		Orange
41 < 60 meters		Yellow
61 < 80 meters		Green
81 < 100 meters		Blue

Table 1: Pop up Icons which indicate relative distance to a facility

The initial development of N-S Ā F was a proof-of-concept to test the Place Lab location estimation algorithms. We successfully demonstrated N-S Ā F to an enthusiastic audience in an extended tour of three campus buildings that included both indoor and outdoor facilities. Several types of indicators are supported by the current application, such as building entrances, restrooms, elevators, and chair lifts. The user can also select which features are indicated. For example, the user can request to see only the restrooms. The application can easily be extended to include additional features as addressed in the Future Work section.

Future Work

Currently, N-S Ā F only runs on a PC platform and is most viable on a tablet PC. Migration to a PDA is also a potential developmental path. Once complete, the Assistive Technologies Department could provide new arrivals and visitors with tablet PCs or PDAs that are already loaded with N-S Ā F.

Since N-S Ā F was developed using Place Lab as a foundation, the current implementation only uses WiFi signals to estimate location. Additional work could be done to calculate position estimates using various types of signals. The other wireless protocols that are present in today's varied infrastructures, including GPS, Bluetooth, Cellular, and Radio Frequency Identification (RFID). Currently, GPS is the most accurate signal to calculate outdoor positions, but it does not work indoors. As a result, we plan to study the potential of conducting a handoff from GPS to another type of signal that works indoors. Additionally, we plan to consider new algorithms for combining these varied signals and have the resulting location estimate be more accurate than any of the stand-alone estimates.

From an application perspective, the next evolution of N-S Ā F is to add routing algorithms to draw a path from the user's current location to the accessible facility. In order to be most useful, this improvement would require a connection to a service that continually updates information about the possible route. For example, if a road is closed for construction, the system would be able to update N-S Ā F and then N-S Ā F in turn would adjust the route accordingly. The intent is that N-S Ā F will be more context-aware and provide the user with near real-time routing.

Another improvement involves further adaptation of N-S Ā F for the visually impaired. This may include audio (sound) and tactile (vibration) cues. Additionally, the integration of an obstacle detector with N-S Ā F could be used to determine the safest route to an accessible facility avoiding obstacles along the way.

Conclusion

Individuals with disabilities continue to be challenged when navigating many urban areas. The rapid deployment of inexpensive wireless APs, coupled with non-intrusive applications like N-S Ā F, can show a user an estimate of his current location on a map with indications of accessible facilities both indoors and outdoors. N-S Ā F displays a marker for the facility, an estimated distance, and changes color as the user moves closer to the facility. Inexpensive tools such as N-S Ā F are the first of many steps toward providing support, reassurance and independence to new students on this University's campus.

References

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