StopFinder: Improving the Experience of Blind Public Transit Riders with Crowdsourcing

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The usability of the public transit system is of crucial importance to blind people in their daily lives. One major challenge blind people experience when using public transportation is finding the exact location of bus stops. Our work focuses on alleviating this challenge to improve overall public transit usability. We built StopFinder, a system that uses crowdsourcing to provide information about non-visual landmarks around bus stops to enable blind people to find them more easily. The crowdsourced information includes which street has the bus stop, which direction the user must walk to reach the bus stop from the intersection, and what objects are at the stop (e.g., shelters, garbage cans, and benches). Users interact with the StopFinder iPhone application, which is optimized for the built-in text-to-speech engine on iOS devices.

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1. Introduction

People with severe visual impairments cannot drive, so they often rely on public transit. The usability of the public transit system is, therefore, of crucial importance to blind people. One major challenge blind people experience when using public transportation is finding the exact location of bus stops. Our work focuses on alleviating this challenge to improve overall public transit usability.

We use the technique of crowdsourcing to provide information about non-visual landmarks around bus stops to enable blind public transit riders to find the stops more easily when navigating with a cane or a guide dog. Crowdsourcing is a technique that involves outsourcing tasks to a network of people, also known as the crowd, in our case being the public transit riders. The crowdsourced information includes which street/avenue has the bus stop, which direction to walk to reach the bus stop once you arrive at the intersection and what to expect once you arrive at the bus stop like the presence of shelters, garbage cans, benches etc. Since we are using crowdsourcing for getting information, we provide an option to rate the entry, which is used for the purpose of reliability. In addition to accessing and rating information about a bus stop, blind people can also contribute information through a non-graphical interface.

We have developed StopFinder, a system that uses crowdsourcing to provide information about non-visual landmarks around bus stops to enable blind people to find them more easily. Since one of our primary foci has been the ease of using Stopfinder, we conducted interviews with blind people that informed the design of the application. The interface consists of mostly multiple-choice questions that are convenient to fill in a short time while waiting for a bus. StopFinder users can use the built-in text-to-speech on an iPhone to interact with the application.

This paper will next include a brief background about blind people, technologies that blind people use, and related work on public transit usability. It will then describe our system, StopFinder, and how it improves the public transit experience for blind people. For this research project, I conducted user studies and worked on iOS implementation. My research mentor Shiri and I worked together on design iterations, and Shiri worked on server side implementation.

2. Background

Blind people use technology just like sighted people on a daily basis. Blind people use cell phones to make calls, GPS systems to keep track of their location, computers to surf the web, send emails etc. The only difference is that blind people require an additional tool to use this technology, which is known as access technology. Some examples of such tools that are used by research projects like GoBraille discussed later in this paper are as follows:
2 a. BrailleSense

The BrailleSense [1] is a type of Braille note-taker for blind people with a Braille keyboard (also known as a Perkins keyboard) and a 32-cell refreshable Braille display. It is portable and has the capabilities of a word processor, web browser, schedule manager, and media player, for use at work, home or school. The best parts of using Braille note-taker for blind people are the ability to read at their own pace. Also it is more secure to use a Braille note-taker to access a website that requires login.

2 b. iPhone VoiceOver

Another assistive technology used by blind iPhone users is VoiceOver [2]. VoiceOver is a screen reader built into iOS, the operating system on Apple’s mobile devices. With VoiceOver, someone with a visual impairment can use a few simple hand gestures like single or double finger flicks, taps etc. to hear aloud what is displayed on the screen. This technology helps blind people use various mainstream applications available in the iOS Marketplace. Since VoiceOver is built into iOS, there is no additional cost to using access technology as in the case of other smart phones.

3. Related Work

There are various research projects that aim to improve public transportation usability. Here we will describe three projects: OneBusAway, GoBraille and StopFindera (by Deeplocal). OneBusAway and StopFinder are designed without much consideration to accessibility whereas GoBraille is developed for blind and deaf-blind public transit riders.

3 a. OneBusAway

OneBusAway [3] is an application developed at the University of Washington by Brian Ferris. This application provides easy access to real-time arrival information for a number of transit agencies in the Puget Sound region. It has approximately 100,000 weekly users as of March

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a Our application is called StopFinder too. We plan to name it different before deployment. Everywhere else except Related Work section, StopFinder refers to our system.
Information can be accessed in a number of ways: through a website, a phone number you can call, a text messaging interface, and smartphone applications.

Many blind people use this application for the real time information and find it useful. However, it is not fully accessible, as it was not designed with blind population in mind as you can see from Figure 3a.

Figure 3 a. iPhone version of OneBusAway

3 b. GoBraille

Before this research project, we developed GoBraille [5]. GoBraille includes two related Braille-based applications that provide information about buses and bus stops where we implemented a primitive system for crowdsourcing landmarks. GoBraille consisted of a Braille note-taker that used the capabilities of an Android phone to provide the information about bus stops. The system was able to display information on a Braille display as well as in speech, depending on the preference of the user. The 3G net of an Android phone was
used to provide Internet connection to the BrailleSense to display information about buses and bus stops to the Braille display.

In that work [5], we conducted interviews with blind and deaf-blind people to understand how they use the public transit system, and what information is useful for them to enhance their safety and independence. Through user studies, we discovered that one of the biggest problems for them while using public transit is to find the exact location of bus stops. Usually, blind people use various landmarks like garbage can or sound of fountain etc to guide them to reach the stop. Thus, the access to reliable, accurate and concise information about various landmarks to reach to the proper bus stop is very crucial to blind and deaf-blind public transit riders. The participants loved their ability to read the information at their own pace using the Braille display. However, there was concern related to the cost of a Braille note-taker. And since not all blind people are Braille literate, this made the system limited only to people who know Braille. Furthermore, it is not always convenient to carry a Braille note-taker, especially for people who prefer traveling lightly.

3 c. StopFinder by DeepCool

StopFinder[^1] [6] is an application that uses augmented reality to help locate bus stops from over 100 transit agencies. The downside to it, as you can see from the image below, is that it is visual. And since visual cues are not useful for blind people, this system would be difficult for blind people to use as clear from Figure 3c.

![Figure 3c. Screen shot of StopFinder](image)

[^1]: Our application is called StopFinder too. We plan to name it different before deployment. Everywhere else except this section, StopFinder refers to our system.
4. Our StopFinder Application

As described above in Related Work, there are a lot of applications that improve the public transit experience for the user, but most of these applications are not accessible to blind people. They also don’t alleviate many challenges that blind people face. Thus, our system, StopFinder is developed with an emphasis on providing useful information in an easy to use interface for blind people. It is a crowdsourcing application to access landmarks information around the bus stops using VoiceOver on an iPhone.

4 a. System overview

Based on the interviews and studies with GoBraille, we developed an idea of providing landmarks information to blind people using only an iPhone. This would enable blind users to get this information on their smartphone and don’t require them to possess a Braille note-taker. In order to obtain large coverage, we are using the iPhone platform, which is the most widely used smartphone among blind people. Another reason for using the iPhone is to avoid having to carry a Braille note-taker, which will make travel much lighter. Furthermore, the cost of Braille note-taker is very high compared to using iPhone and also not all blind people are Braille literate. Thus, iPhone is the most viable option to make the system usable for larger blind population.

There are various landmarks around bus stops. Some of those landmarks are: shelter, bench, garbage can, concrete texture of street, grass, location of the pole, presence of coffee shops, restrooms nearby etc. Figure 4 shows some of those landmarks.

Since there are a lot of landmarks, it is important to figure out what are the most important
pieces of information among all available choices so that we can provide users with the most concise, yet useful information. This way, they are not over-whelmed with a lot of information. Another important concern was with the design of the system. We have to make the interface easy and fast to use as they will be using it on the go while walking or waiting for the bus. Furthermore, we also needed to assure that it worked with VoiceOver, the text-to-speech feature of iPhone.

StopFinder uses the idea of crowdsourcing where the information comes from public transit riders. There are mainly three parts to the system in terms of its usage:

1. Getting various landmarks information around bus stops.
2. Rating information given by the system to increase reliability of the given information.
3. Adding information for other users to use.

4 b. System Architecture

StopFinder has three different components:

1. A StopFinder iPhone application, which allows blind users to get, rate and add information
2. An extension to OneBusAway, which allows current OneBusAway users to add information for StopFinder users to use
3. A server, which stores information obtained from both StopFinder and OneBusAway

We plan to extend the OneBusAway system to allow current OneBusAway users to add information for blind people to access using our new system, StopFinder. Both the components will provide information about the landmarks around the bus stop, which will be stored in the common database. All of these components will be discussed more in details later in the paper.

Whenever a blind user requests information about a particular bus stop using StopFinder, the system will give two sets of entries for that stop: highly rated and most recently entered. A set of entry is the list of all landmarks information about a stop added by a user during one use of the application. The reason for having two sets of entries is to help foster reliability through highly rated entries and also make sure to update the user about any changes to the route cause by construction etc though the newly entered entries. Once blind users get the information, they have an option to rate it as helpful, or not helpful, which will contribute to increased reliability using the rating system. Figure 4b shows the integration of the various parts of the system and how they interact each other.
4 c. StopFinder Application

For blind users, we created a system that enables them to get landmark information around the nearby bus stops from an iPhone. In addition to this, blind people can also provide information about landmarks through a non-graphical interface. Since one of our primary foci has been the ease of using the system, the application is designed based on interviews with blind people. Thus, the interface consists of mostly multiple-choice questions that are convenient for them to select and submit in a short time while waiting for their buses. Along with landmark information, the system provides blind users nearby bus stops and direction of selected bus stops from the intersection. They can use the built-in text-to-speech on an iPhone to access the interface of our application.

The application starts with the screen with options to either get the information or add the information as you can see in Figure 4c. Once you select either one, it will list out all the nearby bus stops. StopFinder uses the OneBusAway API to get the nearby bus stops using the GPS feature of the iPhone.
4 c 1. Getting Information

Once the user selects the bus stop of interest, the application lists two entries with one being highly rated and the other being the most recently added.
As noted previously the reasons for having two sets of entries are:

1. Highly rated entries help ensure reliable information and
2. The most recently added entries keep track of any unexpected change in the bus stop because of various reasons like construction, sports games etc.

After getting the information about the bus stop, the user can rate each entry for being useful or not. This is used as a measure to increase the reliability of information provided by the system.

4 c 2. Adding Information

Once users select the “Add Information” button and the stop of interest, it takes them to the screen with a brief description of how they need to enter information.

Figure 4 c 2. Transition from one question to another

Below is the list of questions used by the system:

1. Where is the bus stop?
2. Which direction is the bus stop from the intersection?
3. Is the bus stop close to the intersection?
4. Where is the pole?
5. Is there a shelter?
6. Is there a bench?
7. Is there a garbage can?
8. Additional Comments

All of these questions from 1 to 7 are provided with a set of possible answers including “not sure” option, which the users select based on their knowledge of the bus stop. Question 8 gives an option for the user to add anything specific related to the bus stop. For example, a user may comment that there is a coffee shop nearby, a restroom etc. There is one question per page and selection of answer takes them to the question in the next page and so on. At the last page, the user can submit the information about the stop.

4 d. OneBusAway Extension

Providing the information about the landmarks around bus stops requires a lot of data. Therefore, we decided to extend the already existing application OneBusAway [3] to provide information for blind users to use. This will help us cover large number of bus stops around Seattle area. We have developed an interface for the users of OneBusAway to use while waiting for their buses to provide information about non-visual landmarks for StopFinder users. Considering the limited time they will have to fill in the information, it is a short questionnaire with answers to select from and an additional text box if they want to add any specific information about that particular bus stop.

Fig 4 d. Adding Information using OneBusAway Extension: On the left screen, there will be a button above “Add to Bookmarks” which will say “Add Information about the Stop” that will bring user to the screen on the right
The information contributed from OneBusAway users will go to the same database as the information contributed from StopFinder users. Both sources will be used to provide information for StopFinder users.

4 e. Server side

We are using a database to store the information. For the purpose of adding, getting and rating information, the system has to make server requests described in details below.

a. Adding information about the stop:

The information about the bus stop entered by the user from both OneBusAway and StopFinder will be send to the server that will add the entry to the database.

b. Getting information about the stop

Every stop has a stop id. The client application makes a request to the server by giving it a stop id, which will return two entries: highly rated and most recently added and display it for the user.

c. Rating information about the stop

When the user rates each entry: highly rated and most recently added, depending on their response of neutral, helpful and not-helpful, it will make request to the server and increase the rating by 0, 1 and -1 respectively.

5. Evaluation

When we asked participants about what sort of information they use to find the stops, they mentioned using various sounds like that of fountain, texture of ground, curbs, poles etc. To understand better what information is useful for them, we conducted user studies.

5 a. Method

We evaluated StopFinder by conducting user studies with 7 blind adults (4 men, 3 women) who ride buses regularly. Four participants use iPhones on a daily basis and three have less experience with an iPhone. Each study was an hour-long and was conducted at a lab setting. After a brief explanation of the system, we gave each participant a set of tasks to complete using application followed by a semi-structured interview. Using our application StopFinder, participants were asked to do the following tasks:

1. Get the information from one of the specified nearby stops and rate that piece of information
2. Add information about one of the nearby stops

5 b. Results

The tasks were followed by an interview. The post-tasks semi-structured interview aimed to evaluate the usability of the system and also how access to this different information from StopFinder would affect a participant’s sense of independence and safety when using public transit. All participants completed the task with minimum guidance. The only guidance provided was the gestures related to VoiceOver for the people with low or no experience with iPhones. Participants found the user interface easy to use and fast to learn. Participants were highly satisfied with the system with the information provided and felt the application would enhance their sense of independence while using public transit. Mean responses from questions related to evaluating the system from 6 participants (with one of the participants, we just did the formative studies) is in Table 1 below.

Table 1. Questions and mean answers from the semi-structured interviews conducted with 6 blind people about the system.

**Instructions**: On a scale of 1 to 5, where 1 = strongly disagree, 2 = somewhat disagree, 3 = neutral, 4 = somewhat agree, and 5 = strongly agree, describe how you feel about each of these statements.

<table>
<thead>
<tr>
<th>Questions about the systems</th>
<th>Mean</th>
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<tbody>
<tr>
<td>1. The system would provide me with useful information</td>
<td>4.5</td>
</tr>
<tr>
<td>2. Getting information from the system would be faster than figuring out when reaching to the stop</td>
<td>4.3</td>
</tr>
<tr>
<td>3. I feel that the system would enable me to use public transit more independently.</td>
<td>3.8</td>
</tr>
<tr>
<td>4. Using the system would make my ride on public transit less stressful.</td>
<td>3.8</td>
</tr>
<tr>
<td>5. The system was easy to use.</td>
<td>4.3</td>
</tr>
<tr>
<td>6. It was easy to learn how to use the system.</td>
<td>4.7</td>
</tr>
<tr>
<td>7. It was easy to enter information about the stop</td>
<td>4.2</td>
</tr>
<tr>
<td>8. It was easy to rate an entry</td>
<td>4.5</td>
</tr>
<tr>
<td>9. The information provided was easy to understand /follow</td>
<td>4.8</td>
</tr>
<tr>
<td>10. Pop up for the thank you note indicates that my input is entered</td>
<td>4.8</td>
</tr>
<tr>
<td>11. It was easy to get information</td>
<td>4.7</td>
</tr>
<tr>
<td>12. I would trust that the information provided by the system would be correct.</td>
<td>3.7</td>
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Table 2: Mean value for answers about the importance of various landmarks around bus stops

**Instruction:** How important was each of the following for enabling you to feel independent while using public transit? 1 = not important 2 = somewhat unimportant, 3 = neutral 4 = important, 5 = critically important

1. Nearest bus stops 4.4
2. Direction from the intersection 4.7
3. Which street/avenue has the stop 5.0
4. shelter: 4.4
5. number of shelters: 3.6
6. bench: 4.3
7. number of benches: 3.3
8. newspaper stand: 3.0
9. bike racks: 2.7
10. restrooms: 4.1

The ratings for our system and importance of each landmark clearly show that participants believed that this system would be useful to make public transit a better experience for them.

5 c. Discussion

In addition to the rating, we asked for input from the participants on the system and the information it was providing. Participants found the interface easy to use and fast to learn. Every participant agreed that having access to this information will make using transit less stressful, and that they would be more independent riders. While observing participants entered text on the additional comments section, it was very clear that it would be difficult for blind people to enter text to the system. In that sense, having appropriate answers available to select from enabled the users to enter information in a comparatively short time. Participants also like the design of one question per page rather than having to scroll down to answer next question.

The most informative aspects of StopFinder were: which street has the bus stop, direction from intersection, presence of shelter, bench, garbage can, and location of the pole. In addition to this, many participants were interested with the points of interest such as the presence of a coffee shop or restrooms nearby. This is particularly useful if they have a long waiting time for their bus, and they want to spend their time productively. Furthermore, this will also help them get a feel for the neighborhood.

One of the participants said a benefit of the system is “Spontaneous and don’t have to wait
in the cold.” Further talking about the safety, she mentioned it is always helpful to know “what kind of neighborhood it is.” She added, “At night there may not be someone to ask on the street.” In the situation like this, the application will help them find the stop. Another participant made the similar remark about usefulness of the application at night when there are not a lot of people around.

It was equally interesting to see how the important landmarks information varied within blind population. People with guide dog felt knowing whether there was a garbage can was important since they can dispose of the waste made by a guide dog. Also they thought knowing if there is a grassy area is helpful when they have a dog. On the other hand, people using canes thought the presence of a garbage can was an important piece of information, but might not be the highest priority. However, they thought knowing texture of the ground was pretty important in case of rainy season where they can be prepared while walking, as the brick texture of street is slippery. This was not a major concern for people with a guide dog.

When asked about whether we can find the motivation among the blind population to contribute information, most participants were positive that people would very likely to add information. However, they also emphasized that the first priority would be on getting information. Thus, integrating the system to OneBusAway seemed appropriate in this regard.

As with any crowdsourcing application, the main concerns of participants regarding the system were related to the reliability of the system since the information is based on the crowd-sourced data. Thus, they strongly liked the idea of rating the entries.

6. Future work

This research project has received considerable attention from blind population as well as media and organizations working for the benefit of blind people nationally and internationally. Thus, our main focus is to deploy both the systems so that blind people can start using it to make public transit easier. We plan to deploy the OneBusAway Extension first because OneBusAway has a large number of users, so we will have data to provide for blind transit riders when they start using the application.

Another possible direction for the project is to add points of interest as many participants suggested. This might include information such as the presence of coffee shops or restaurants nearby, which would enable blind users to use the time better if they have a long wait before their buses.

7. Conclusions

Using the key considerations that are important to blind people when using public transit
that we discovered during the user study with GoBraille, we developed StopFinder to make public transit experience a better one for blind people. Using mainstream mobile devices, it reduces the additional cost for blind people to buy other devices like Braille note-taker to use the system. In addition to that, the small size of the phone makes it very easy for them to travel around. Furthermore, providing these information will help ensure less stressful travel and more confidence especially in new areas. Since a large population loses their sight with their growing age, aging populations could use such applications as well. Thus, apart from blind population, many other groups of people could benefit from accessibility tools integrated with the system.

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