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FACILITATING INDEPENDENCE FOR PHOTO TAKING AND BROWSING FOR BLIND PERSONS

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Table of Contents

List of Figures and Tables

Abstract

Facilitating Independence for Photo Taking and Browsing for Blind Persons

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Photography is a visual way to capture a moment in time, used for artistic expression, and to document significant events. Even though photography is an inherently visual endeavor, several studies, supported by our own investigations, have shown that many people in the blind community take pleasure and find use in photography.

Because taking, organizing and sharing photos traditionally requires visual information, people with no or limited sight can have problems with these activities. People without sight must process chunks of information sequentially as opposed to globally (as is the case with sighted people). This nuance in information process adds to the difficulty of processing a photo album for people without sight.

Previous work has made photo capturing without sight easier, such as Bigham's work with VizWiz, and Jayant et al's work with photography among people who are blind [12,23]. These researchers design systems to help someone who is blind aim a camera and capture a "good" photograph. But there is little work that makes photo browsing and sharing accessible for people who are blind. My dissertation research aims to facilitate independence for blind persons to locate and browse photos in a sequential manner, as opposed to global. This is done through user-centered development of a smartphone application that can be used without sight.

The work begins with an investigation of current practices of blind persons in these activities, by conducting an in-depth survey and interviews among people who are blind, investigating their current photography preferences and practices. The survey and interviews informed the design of an iPhone app, called VizSnap, which is a blind-friendly app to help photographers sequentially organize a photo album by attaching time, date, location, and audio to the photographs to enhance memory retrieval of the photographs.

VizSnap was distributed among 13 blind people for two months; their usage of VizSnap was monitored by gathering their photos and the photos' accompanying metadata (time, date, location, audio recordings). A user study was also conducted every two weeks with each participant. The photos taken by the participants were analyzed for type of photo and quality of photo. The participants' usage of VizSnap was also analyzed to determine the viability of attaching audio, time, date, and location to a photograph, in a sequentially organized photo album, to enhance memory retrieval of the moment in which the photograph was taken.

The ultimate goal of this research is to encourage and challenge modern developers to create their technology with Universal Access at the forefront of each stage of development. VizSnap attempts to achieve Universal Access by appealing to both people who are blind and sighted people. This will greatly improve the overall design and general enjoyment of the product by all members of the community. Not all people use technology in the same way, and without thoughtful design, certain groups

may be excluded from using mainstream technology when their usage is not considered.

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Chapter 1

Introduction

Photography is a visual way to capture a moment in time. A photograph can have many uses – to help with remembering significant events, to express oneself artistically, to represent oneself on social media, to sell merchandise online – to name a few. While photography is an inherently visual activity, there are numerous published manuscripts that show many blind people value having a photographic memento of a moment, a place, or an event, and take much enjoyment in photography [37,38,39,40,41].

Blind people face many issues when capturing photos and when dealing with photos they have captured. Aside from the technical challenge of capturing an "acceptable" photograph (typically regarding such aspects as framing, lighting and focus) on their own, there is the challenge of managing the captured photographs without being able to visually inspect them to distinguish one from another. There is also the challenge of recollecting the circumstance under which a photograph was taken without the benefit of the detailed visual cues present in the photograph. People who are blind should be able to capture, browse, organize and share photos just like their sighted counterparts.

There has been a decent amount of work on making photo capturing without sight easier. Such as the work done by Bigham et al., in which they developed VizWiz, an app allows users to ask a verbal question about a photograph and receive an answer in almost real time. There is also the work done by Jayant et al., in which they developed a system to assist blind photographers with aiming a camera to produce a "good" photograph. Vazquez et al. developed a similar application to assist blind photographers with aiming a camera to take a well-framed photograph. Still, there is little work that tries to help blind people deal with the photographs they have captured; that is, there is little to no work on helping blind people with browsing, organizing, locating, or sharing the photographs they have taken. This is the subject on which my dissertation research has been based; that is, my dissertation research aims to help blind photographers capture, browse, organize and share photos by enabling them to attach non-visual cues to the photographs they take.

The advent and ubiquity of smartphones provide a customizable framework that can help people who are blind capture, organize, browse, and share photos. There are currently different methods for associating some sort of photo description with its corresponding photograph (e.g. associating text or audio with the photo); however, many of these methods are not designed with the blind user in mind, and thus are often times difficult or impossible to use by users who require a layer assistive technology to use the application. By understanding the current photo browsing, organizing, and sharing practices of blind people, as well as the shortcomings of the

current photography tools is use, better tools can be designed to cater to their photography needs. One product of my research is an iPhone application, called VizSnap, which is designed to help people who are blind with locating and experiencing their photographs. VizSnap also gives users options to share via Facebook or email.

Vecchi et al. have shown that, in general, sighted people process a bundle of information (such as a textual list) globally, and sequentially by blind people [31]. This can be inferred to mean that blindness forces sequential information processing onto many processes where sighted people use parallel processing, such as when scanning a wall of pictures, or a page looking for particular words to pop out.

Media affordance theories (media resource theories) suggest strategies people (sighted or not) can use effectively when visual information is not present. In regards to people without sight scanning a list of information conveyed aurally (in their case search engine results), Leporini et al. have shown that properly designed, blind-accessible interfaces can allow users to scan information sequentially with success [30].

When scanning a digital photo album, a sighted person has the luxury of looking at all of the photos almost simultaneously to locate the photo they are looking for [8]. Conversely, someone who is blind must traverse this photo album sequentially,

consuming the non-visual information of each photograph one-by-one until they reach the photo they are looking for.

Part of my research will involve conveying a chunk of information to a blind person sequentially, using aural cues. This will manifest itself in a blind-accessible photo album on a smartphone that conveys information about each photograph, sequentially, using sound.

My dissertation research involves investigating photography practices by blind people, and using that information to inform the design of a smartphone application to assist blind users in capturing, organizing, and sharing photographs. A long-term user study was performed among people who are blind using VizSnap for two months to determine whether VizSnap achieves what it is set out to achieve – to be a blind-friendly tool to assist with locating and experiencing photographs.

The research begins with a survey targeted to blind people who take photos. 54 people who are blind participated in the survey, and answered various questions about their photography practices, providing both qualitative and quantitative data. The results of this survey are used to inform the features of the smartphone application.

To replicate the data informing the application's features, we conducted interviews among 11 blind photographers investigating their photography preferences to inform

another a set of design features for a blind-friendly smartphone application. These two sets of features were used to build the blind-friendly iPhone app, VizSnap. VizSnap is an app designed to assist blind people in organizing and browsing a photo library without sight, which records audio while the user is aiming the camera, and allows an optional voice memo to be recorded, to allow the user to give custom information to accompany the photo, as well as capturing time, date, and location the photo was taken. All this information is available to the user when browsing through VizSnap's photo library.

I am also interested in finding out the types of photos (e.g. photos of groups, photos of animals), as well as the quality (such as whether the photograph is blurry or out of focus), taken by blind photographers. To investigate this, we began by analyzing photos taken by blind people among a Flick forum, all photos of which were taken by photographers who are blind, as well as forum threads. We distilled the types of photos taken, patterns of problems, and photo quality among the photographs; we distilled common obstacles, techniques for taking photos, personal reflection, and common technological help sought out from the forum threads.

A long-term study of blind users using VizSnap was performed to learn about the general usability of VizSnap in a long-term setting. We also sought to build a corpus of photos taken solely by blind photographers to try to replicate the findings of the Flickr analyses. The user study aimed to determine whether accompanying audio,

time, date, and location metadata assists in memory retrieval of photos by blind people. We found that in general, both ambient audio and voice memo are considered most helpful for memory retrieval, which are what make VizSnap unique.

1.1 Related Work

1.1.1 Blind Photography

A number of published manuscripts suggest that those with no or limited vision perform photography-related activities [37,38,39,40,41]. These people take photographs for pleasure and artistic expression, [7,10,11,14,18,19] as well as for more functional reasons, such as to assist in identifying grocery labels while shopping [23]. However, blind photographers often run into issues when taking and organizing their photos because of the visual nature of photography [1,22]. There are currently several photography aids that help out with different aspects of photography, such as aiming, verifying resolution and brightness, and recognizing a photo within a photo album, which are discussed more in detail below.

Because of accessibility features such as VoiceOver for iOS [35], and TalkBack for Android [46], adoption of smart phones is becoming wider among those with limited vision [18]. Smart phone apps to help with photography-related tasks without vision are starting to become widely available. Examples include using a camera to assist users to “view” the environment around them. VizWiz::LocateIt is a smartphone application that locates objects within a user’s environment using the smartphone’s

camera, and with feedback provided by the application, visually impaired users are much more likely to locate a specific object than without it [12]. VizWiz, which utilizes VizWiz::LocateIt's object location techniques, allows users to snap a photo of their environment, and returns a textual description of that photo in almost real-time. This allows users to assess their environment without having to see it. oMoby [42] is an application similar to VizWiz; computer vision techniques first try to identify the contents of the photo, and if unsuccessful, the photo is crowdsourced to identify the contents.

Jayant et al. developed a system that helps visually impaired people aim a camera. They showed that certain cues provided by the smart phone can increase the quality and accuracy of the photo taken [22]. This system provides non-visual identification cues for the photo for future retrieval in an accessible photo album.

Vázquez and Steinfeld's work assists in aiming a camera by suggesting a region of interest (ROI) - the suggested center - in the camera frame through a choice of three feedback modes: speech, tone, or silent feedback. Once the new ROI is suggested, the user is directed to the new ROI via the feedback modes previously mentioned. Developers of this system also provide a blur detection mechanism to improve overall quality of the photo [29].

EasySnap is an iPhone application that provides a framework for users to receive real-time aural feedback about blur and darkness, camera tilt, and location and size of peoples' faces within the camera frame [33]. EasySnap has three modes, "Freestyle," which functions like a normal camera, providing no feedback, "People," which tells the user whether there is a face in the camera, its location, and size, and "Object," which allows the user to take a photo of the object up close, then instructs the user to whether the object is still in the frame as the user moves the camera back. Even though these technologies have been shown to improve framing, lighting, and focus of photographs, many visually impaired people who wish to take picture still do not do so because of accessibility problems of mainstream cameras.

PortraitFramer is an Android application that assists people with visual impairment capture a "well-framed" photograph [29]. While EasySnap is designed for one person, PortraitFramer is specifically designed for groups of people. The user begins by taking a preliminary photo of the group of people, and after receiving aural and tactile feedback about the frame, the user is able to readjust and take a more "well-framed" photograph.

Ahmed et al. [6] has shown that blind people taking photos are hesitant to share photos without knowing whether the photograph is "good," or acceptable to the user. This shows a necessity to help people who are blind with taking a good or at least acceptable photo. Balata et al. describes a system that helps blind people aim a

camera to achieve the Golden Ratio (which is a design principle roughly based on the ratio of 1 to 1.618) using vibration from a smartphone [9].

Up till now, most of the work discussed so far in this section deals with helping blind photographers take a "good" photograph, however, we have not discussed any resources that help blind photographers organize or share photos. While there has been very little work in the area of blind photographers organizing photographs, there has been a decent amount of work investigating whether and how blind photographers share photographs online. Understanding how blind photographers share their photographs may not solve the problem of how they best organize a photo library, it will give good insight.

1.1.2 Visual Impairment and Social Networking

Hewett and Douglas from the Royal Institute for the Blind in the United Kingdom ran a survey investigating social networking habits and mobile phone usage among teenagers with visual impairment aged 14-17 years old [19]. This research shows that the level of visual impairment among participants in the study does not impact their opportunities to spend time with their peers outside of school. Sixty nine out of 70 participants claim to own or have access to a mobile phone. Seventy five percent use smartphones. Interestingly, one common activity with the mobile phone was taking photos (65%). Most participants (54%) have used accessibility features on their phone, such as changing font size/style and using zoom functions. The most

significant findings proposed here is that a higher proportion of visually impaired people have set up their own social networking profile (91%) than the general population of young people.

El-Gayyar et al. propose a framework for a social networking service to connect those with hearing and visual impairment in the Arabic world [15]. One such system would be considered, only under the lens of a smartphone application, as well as in English.

Brady analyzes perception of use comfort for asking questions for help from those with low vision [13]. The questions being asked by users with low vision range from identifying home addresses, medicine bottle, and credit card number from photographs. Since questions often bare personal and sensitive information, it will be necessary to incorporate Brady's findings when building my own application.

Voykinska et al. conducted interviews with 11 blind people and conduct a survey among 60 blind people investigating blind people's interaction with photos on social media [32]. They found that most participants in their study use social networking services for the same reasons sighted people do, and 100% of their survey respondents use Facebook. While many of their totally blind participants face many accessibility challenges, there were plenty of participants who were engaged with visual content on Facebook, such as photos. However, the researchers reported that this often times required sighted help. They also reported only 23% of participants

post photos on Facebook, mainly because of the difficulty associated with taking a "good" photo, and selecting the correct (or desired) photo from their photo album.

Wu et al. ran a study with 50,000 blind or visually impaired Facebook users to investigate general Facebook usage and problems faced by visually impaired users, compared with a random sample of 160,000 Facebook users [34]. The researchers discovered that comparing the "amount of photos that are produced and shared to Facebook" of the visually impaired group compared to the random sample, the difference is statistically significant for a Wilcoxon rank sum test on the difference in medians (p-value < 1.2 x 10-14). They do, however, report that users of the visually impaired sample do upload slightly fewer photos than the random sample, despite this statistical significance regarding "the amount of photos that are produced and shared to Facebook."

Qiu et al. conducted interviews and observations with six blind and visually impaired people to investigate their use of social media on mobile devices, in Hong Kong [26]. Some of their participants in the study have expressed desire for "real-time acoustic information of scenarios (record the synchronous sound when taking the photo), and acoustic description of photo contents (such as information of object, location, and color), " within the social media apps. One of VizSnap's purposes is to provide the user with both of these aforementioned features, through ambient audio and voice memo, respectively. However, the audio information is not currently targeted to be

integrated with social media applications; they exist within VizSnap simply to enhance the user's memory of photographs.

Ahmed et al. conducted a user study with 14 visually impaired people to investigate the privacy concerns of visually impaired people, how visually impaired people manage their privacy, and which new technologies could offer enhanced privacy for visually impaired users [6]. They found that visually impaired users of social networking services are often concerned about the privacy of their personal content, including photos, on those social networking services. Participants also noted being concerned about strangers eavesdropping on audio played from a screen reader of the visually impaired person's mobile device. Many of their participants reported using headphones as a way to keep audio private.

1.1.3 Blind Photography Corpora

Analyzing many photographs taken by blind photographers gives insight into the kinds of photographs they regularly take. By understanding what kinds of photographs blind photographers often take, we can understand better how to cater to their needs of experiencing a visual photograph. For example, if we find that the majority of photographs being taken are of people, then we will need to incorporate face detection with the photograph to convey to the user whether there are faces in the photograph, as they review their photos.

Bigham et al. have developed a smartphone application to assist blind users in assessing their environment by giving almost real time feedback on how to aim their camera at certain objects around them [11]. Similarly, Brady et al. report on the analysis of tens of thousands of photos from thousands of users of VizWiz with audio questions (i.e. “what color shirt is in this photograph?”) being asked about them to assist blind users in assessing their environment [14].

1.1.4 Life-Logging

One of the ways I will be testing the theories of how to make photographs more accessible to people who have no sight will be recording sound while the photographer is capturing the photograph. This will capture a non-visual aspect of the moment in which the photograph was taken to attempt to give the user a way to experience that moment which was captured. The following work has shown how audio recordings accompanying photographs (and other mementos) enhance the experience of experiencing that object. While it is clear to me that understanding how sighted people consume this information will not be the same as how someone who is blind may consume this information, it will at least give a jumping off point as to with which concepts to begin.

Frohlich and Murphy developed a system such that souvenirs of the users’ lives are kept in a box and sounds associate with the souvenir are played to enhance the reminiscing experience [17]. The participants in their user study expressed generally

positive feelings toward the system of associating sound with souvenirs. In particular, women and children seemed to enjoy the system more than men. This kind of finding may necessitate development of my own application being targeted not only to appeal to women and children, but to men as well.

An audiophotograph is a medium that combines a photograph with associated audio recording as a single unit [16]. The type and method of audio capture can range from recording ambient audio the moment the photo was taken, to adding a voice commentary, voiceover or associated music afterwards. Even though the audiophotograph is not a medium that was devised specifically for people with visual impairments, it does provide a convenient mechanism for capturing, organizing, and sharing captured moments among both sighted and visually impaired people. While it may seem that an audiophotograph is similar in nature to video, there are certain notable differences. We do not discount the utility of video as a capturing medium, but it does have certain properties that make it less ideal for visually impaired users. For instance, the nature of video capture makes it such that the user would have to hold the camera steadily pointing at the target of interest while s/he records the ambient sound or memo audio, a task that may be particularly difficult for a blind person compared to snapping a photo and then recording the audio without worrying about where the camera is pointing.

Bachianni et al. demonstrate a system similar to voicemail, however, once the voicemail is recorded, users are able to navigate content by speech recognition, information retrieval, information extraction and human-computer interaction [7]. This means users can jump to a specific point in a large group of voice mails by giving a few pieces of spoken information. This system is useful in my own application of giving users the capability to search through a group of audiophotographs by easily inputting information designed for a user with low vision.

FM Radio [27] focuses on audio as a means for reminiscing pleasant memories. The families tested in this study expressed extensive laughter using an application that uses audio to remind them of vacation events, expressing the memories to be vivid. If sighted people find enjoyment in recalling memories through audio, then we conjecture so will blind people, which motivates us to consider audio as a means for not only giving useful information about a photo, but pleasure as well. There is interesting work being done in Audio Lifelogging that can be applied to our current interface technique.

Chapter 2

Photography Preferences Survey

We conducted an online survey in the summer of 2012 to investigate various photography trends by visually impaired people, including photo capturing, organizing/browsing, and sharing. By analyzing the results of this survey, several striking points were revealed that motivated the design and implementation of an iPhone application to facilitate photography for blind people. We learned most blind people would like to be able to capture, organize, or share their photos independently, however, as we predicted, there are currently limited blind-accessible services to assist in the photography needs of visually impaired people.

Based on our literature survey, we argue that if we are to develop a blind-friendly application that can facilitate photography (taking pictures, recognizing them and sharing them through mainstream social networking tools) for those without or with limited sight, we need to first understand the photography habits, needs and preferences of blind persons. To do this, we ran an online survey among those who are totally blind, with light perception, and legally blind on Survey Monkey for a month in September 2012. Before we launched the survey, we tested our survey with two of the most common screen readers, JAWS and Window Eyes, to make sure the survey is accessible when read through a screen reader. We received 54 valid

responses. Two $20 Amazon gift certificates were offered as incentives through a random draw.

2.1 Design

The first set of questions was informed by the survey conducted by Jayant et al. that investigated how visually impaired people aim a camera [22]. We then added questions to include photo sharing and browsing rather than just photo capturing.

2.1.1 Demographics

The survey starts with demographics questions: age, gender, visual impairment level (legally blind, light perception, totally blind), and how long they had the visual impairment. If the respondent is legally blind, the survey asks for his/her visual acuity (they can answer they do not know or leave the answer blank). It then moved to a question about problems in general with photography-related activities.

2.1.2 Photography Behavior

The next set of questions asked about their photo taking behavior, followed by photo sharing behavior. The list of questions includes whether they had ever taken (or are interested in taking) pictures independently, whether they had ever had (or are interested in having) someone else take a photo for them, and whether they had ever shared (or are interested in sharing) photos online. They were also asked about the

devices and services that they used for these activities if they had done so. For those who had not done so or are not interested in these activities, we asked why in open-ended format.

2.1.3 Photography Satisfaction

A series of Likert-scale questions were used to assess, for those who had done photo taking, recognizing and sharing, how satisfied they were with their current photo taking, recognizing and sharing methods and tools. These then led to open-ended questions to suggest design improvements or a wish list. For those who had not done these activities, we still asked them for their wish list.

2.2 Survey Results

2.2.1 Demographics Data

Our respondents ranged from 18 to 78 years old of age (mean = 47.6, S.D. = 18.79 years). There were 37 females and 17 males. Thirty-three were legally blind, nine with light perception, and 10 were totally blind. For those who were legally blind, their acuity ranges from 20/200 (the starting point of being considered legally blind) to 20/2400 although there were some special cases such as some respondents who were blind in one eye and legally blind in the good eye or those who had a varying condition from legally blind to light perception on good/bad days. Thirty seven respondents had their visual impairments all their lives (as indicated in answers that include “since/from birth”, “all my life”, “congenital” or “lifelong”). The rest varies

but the shortest (time from the moment they started having their visual impairment) was 3 years.

2.2.2 Independent Photography-Related Activities

The next set of questions aimed to understand whether blind persons perform photography-related activities independently, for if we are to find that a very small percentage of blind persons perform these activities independently, we will have to re-think our idea of designing a tool to help photography without sight (and instead either design an educational tool to train blind persons to become independent photographers or a tool for sighted persons to help blind persons perform photography-related activities, independently). These questions investigate current photography behavior. Twelve (22%) respondents had not taken a picture independently. Ten (19%) had never asked somebody else to take a picture for them. Twenty (37%) had never shared their pictures online.

Only two respondents (both are males, one legally blind and one totally blind) had never done any of these three activities. To make sure that these two respondents did not randomly answer the survey, we analyzed the reasons why they did not perform these activities (especially as for those who answered "no" to all these three activities, the only data left to analyze was the reason for not doing these activities). The legally blind participant stated, "*While I'd like a good photo of myself that I could post on Linked-in and perhaps other social network sites, I don't have much interest in*

photography because I can't see the pictures." We found this comment interesting as this person participated in social networking, and is interested in making use of a "good" photo. The totally blind participant stated that the reason he was not interested in taking picture on his own was because he "*[was] not able to see at all and don't really know what I'm doing at all or really how to point and shoot with the vision required camera*" We also found this comment interesting as it indicates that if we could help blind persons understand how to point and shoot a camera, we could perhaps persuade more blind persons to try to take pictures independently.

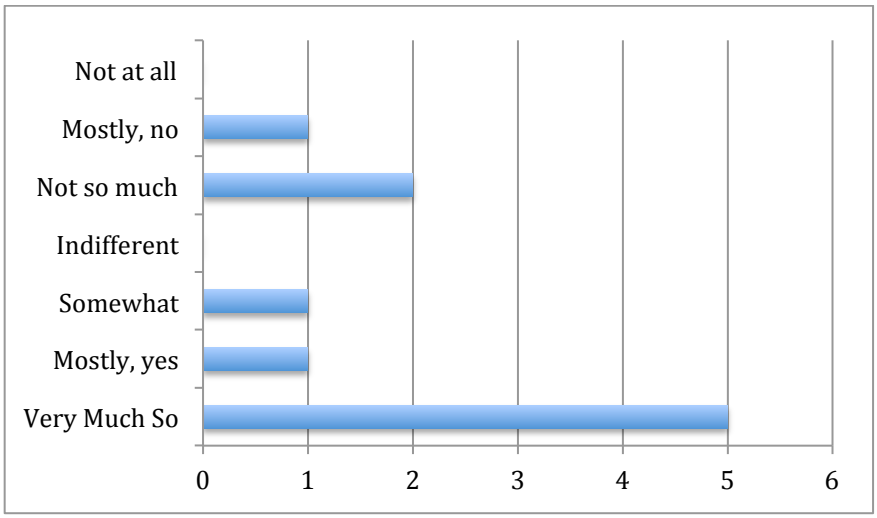

Figure 1. The distribution of desire to take photos on their own (without help) for those who had not done so.

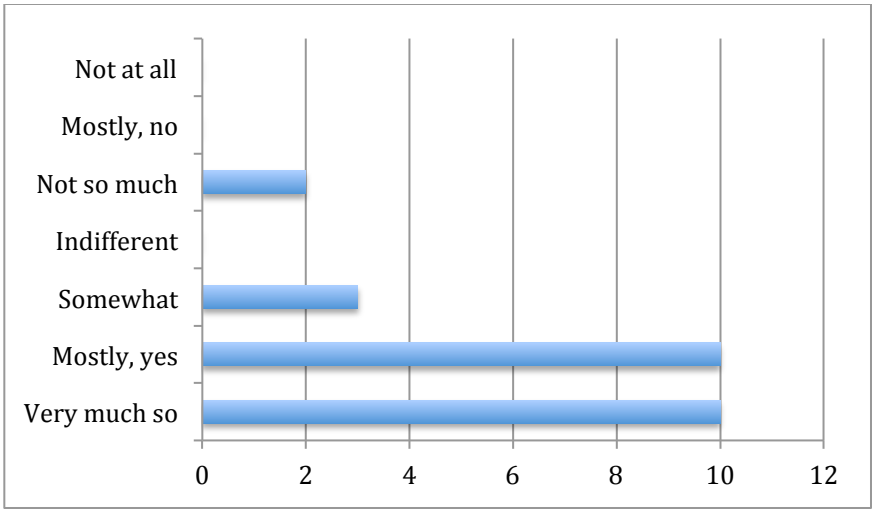

Figure 2. The distribution of desire to take photos on their own (without help) for those who had done so but have also had someone else do it for them.

We asked respondents whether they wished they could take photos on their own. Ten out of the twelve respondents who had not taken photos on their own (without help) provided an answer. Figure 1 shows the distribution of the answers. As Figure 1 shows, only five out of 37 answered negatively. Likewise, 25 out of the 34 respondents that answered that they had taken photos by themselves (without help) and that they have had someone take photos for them provided an answer. Figure 2 shows the distribution of the answers. As Figure 2 shows, only two out of 25 answered negatively. Both of these indicate that there is a need to help those with no or limited vision to take their own photos as there is a significant interest in being able to take their own pictures in blind and visually impaired community.

The respondents were asked in an open-ended fashion how they shared their pictures (they can list as many ways of sharing as they wish). Thirty-two respondents provided

answers. Twelve attached the pictures on their email, 22 posted them on Facebook. Four mentioned Twitter and some used photo-sharing services such as Photobucket and Flickr.

2.2.3 Problems with General Photography-Related Activities

To inform the design of the functionalities of the application, we need to understand, in general, problems that blind and visually impaired persons have with photography-related activities, and therefore this question just asked in general about obstacles that they face in doing these activities. We asked this question to both those who have taken photos on their own (without help) and have shared photos, and those who have only taken photos on their own (without help). This is an optional question, and we received 38 responses. Three coders coded the open-ended answers into themes, and the following are the themes that emerged, organized by photo taking, sharing, and organizing and editing categories, and within each category, listed by frequency. Please note that some respondents listed multiple problems that fell into more than one category.

2.2.3.1 Photo Taking

1. Aiming, focusing and positioning, framing (12 counts). Example sentence: "*Since I have no vision, I don't know if I am focused correctly when taking the picture. I often take pictures and they do not come out because I am not focused properly.*"

2. Need sighted help (6 counts). Example sentence: "*If I am in a group, I usually have someone advise me on the camera placement even if I take the picture myself.*"
3. Device (4 counts). Example sentence: "*Unable to distinguish what buttons on camera are for unless I pull out my hand magnifier.*"
4. Photo quality (3 counts). Example sentence: "*Things like detecting whether a whole person is in the picture or whether sunlight is obstructing the view would be good information.*"
5. Lighting and pose (1 counts). Example sentence: "*Through experience, I have gotten better at properly placing cameras, but every situation is so different due to lighting, the way people are posing, etc.*"

2.2.3.2 Photo Organizing and Editing

1. Identifying photo (16 counts). Example sentence: "*My phone will not let me rename photos so I can't remember which ones are which*."
2. Label (12 counts). Example sentence: *"…need a way to give longer description than title to photo for later 'viewing'*."
3. Device (8 counts). Example sentence: "*Since most photos are organized by numbers on phones/cameras, it's hard to know which photo is which..."*
4. Photo quality (6 counts). Example sentence: "*Identifying which photo is which; which takes are the best shots; which photos are doubles/blurry, etc*."

5. Accessibility issues (5 counts). Example sentence: "*photo editing programs don't talk with JAWS; same for organizing*."
6. Need sighted help (4 counts). Example sentence: "*I have to have friends/fam, mainly my BF, go through photos with me so I know what they are, which takes are good, and label them before upl[oa]ding*."
7. Manipulation (3 counts). Example sentence: "*I have had some trouble seeing to edit and crop.*"

2.2.3.3 Photo Sharing

1. Need sighted help (3 counts). Example sentence: "*i can never post a picture on my own, i have to ask for help because i can post the wrong picture on facebook or internet, , etc. i have done it in the past.*"
2. Accessibility issue (3 counts). Example sentence: "*I can successfully upload photos from my iPhone to Facebook, but if I want to create an album, I have to go through the website 1 By framing, we mean determining what is in the frame. on a computer, and I have to use the "classic" way of uploading 5 pictures at a time rather than the newer version which consists of flash content so I cannot access any of the browse or upload features with my screen reader JAWS.*"
3. Photo quality (2 counts). Example sentence: "*I don't know which ones are good enough to share.*"

4. Don't know how (2 counts). Example sentence: "*eyesight getting worse and not really having the hang yet of filing photos and then dropping into docs or emails*."

In general, it appears that most of the problems are to do with making sure that the pictures taken are of good quality (i.e. by providing help in aiming, focusing, ensuring good lighting, etc.) and that the process for organizing and sharing is easy for interaction without sight (e.g., by allowing easy renaming of pictures). We took these findings into consideration when it was time for us to start designing the mobile application to help with blind photography.

2.2.4 Photo Sharing Behavior

Through our literature survey, we found that photo sharing behavior of those with limited or no vision is not as extensively studied as photo-taking behavior is. Hence, the next set of questions in our survey aims to get a better understanding at photo sharing behavior. These questions aim to identify requirements for a future (improved) application.

The first question that we asked for those who shared their photos online was "How satisfied are you with your current method of sharing photos online?" Thirty-three respondents answered this question (please note that there are only 34 respondents that had shared their pictures online). Figure 3 shows the distribution of the answers.

As Figure 3 shows, nobody answered that they were completely satisfied or completely dissatisfied with their current method. However, only 10 out of 33 respondents were either somewhat satisfied or mostly satisfied with their current method.

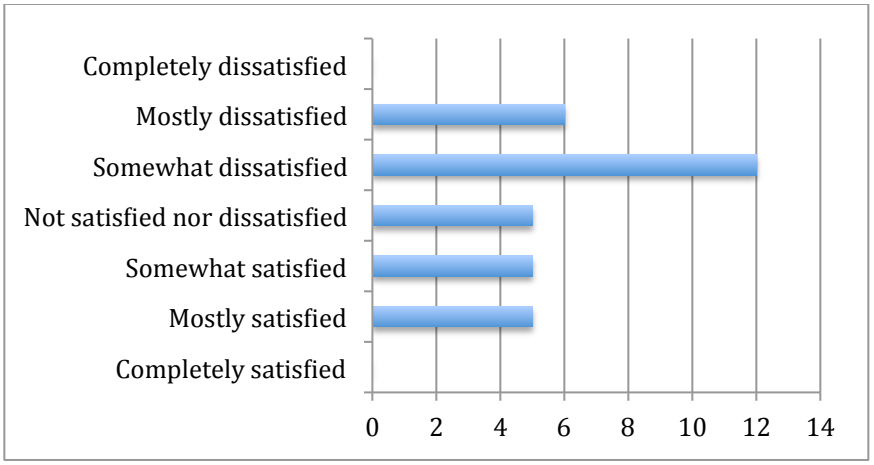

Figure 3. The distribution of respondent satisfaction with their current method of sharing photos online.

We also asked them the question of "Do you wish you could share photos online?" regardless of whether the respondents had shared their photos online or not. Forty one respondents answered this question. Figure 4 shows the distribution of the answers. As Figure 4 shows, only six out of 41 respondents answered negatively about sharing photos online, providing us with a confirmation that there is a desire among blind photographers to share their photos online.

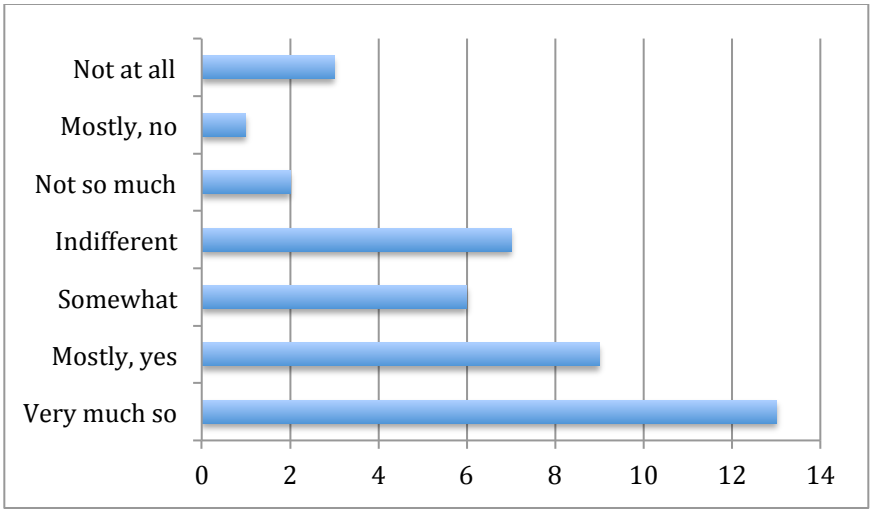

Figure 4. The distribution of desire to share photos online.

To understand better these opinions, we looked at the qualitative data, i.e., the answers to the open-ended questions about the problems they faced with sharing photos online (for those who share) or why they have not shared their photos online (for those who have not shared). This is an optional question, and 28 respondents provided an explanation (mostly those who had not shared their photos online). To categorize the answers, three coders coded the data into themes. Below are the themes that emerged, in the order of frequency. Please note that some respondents have more than one theme in their answers (e.g., "Don't know which are good; process getting difficult for me").

1. Don't know/forget how (8 counts). Example sentence: *"[I] was 5 years ago; didn't know how to send.*"
2. Unsure about the quality of the photo (7 counts). Example sentence: "*mostly because my photos have not come out good. If they do come out good, I do share them.*"

3. Current sharing process (3 counts). Example sentence: "*process to post to FB changes too often.*"
4. Privacy (3 counts). Example sentence: "*I photograph for individual people, events, schools. These are private customers*."
5. Lack of time (2 counts). Example sentence: "*lack of time to learn more ways to do so.*"
6. Need sighted help (2 counts). Example sentence: "*I do not have enough confidence in my judgment to do it without someone sighted reviewing them first, and I am ok with that. However, even with the best technology, I will probably always seek sighted assistance, because I feel that a person who I know will have a better idea of what I consider to be an acceptable picture than any computer program.*"
7. Not interested in sharing (2 counts). Example sentence: "*Not interested in sharing, just taking practice photos.*"
8. Not an option with the current camera (1 count). The sentence was exactly that.

From these answers, it was apparent that the two major issues here were that the respondents did not know how to share and they were unsure about the quality of the pictures that they took. If we were to design an application to help them, these would be two major requirements that we need to consider, especially as these two issues appeared in respondents' comments related to various photography-related activities.

2.2.5 Features of the Application

We also collected the open-ended answers that referred to the features of a blind-friendly tool that can help take, recognize/organize or share picture. The following are the features suggested, with the original sentences from the respondents:

1. "*Having a way to name and place a pic after shooting*."
2. "*It would be great to confidently access time/date and description of photo or circumstance*."
3. "*If I could attach a verbal description to the shot, that would at least give me the feedback I need when sharing in person or online" or "being able to record a small sound byte for some pics*."
4. Information about "*how much distance to put between the lens and the object*."
5. "*a way to quantify ways to detect whether a picture is good, it would be cool if I could be advised whether a picture is good or whether it should be retaken*."
6. "*detecting whether a whole person is in the picture or whether sunlight is obstructing the view*."
7. "*making labels appear universally, no matter how you access your photos*."
8. "*vocal assistance with anything having to do with pictures*."
9. "*more accessible ways to take, store, and upload photos*."
10. "*need to be able to know whether the lighting is right for our photos*."

11. "*need to know how to get the photos from our camera or phone onto our computers and onto eBay or social networking sites or to send them as at[t]achments in emails.*"
12. "*a 'low vision tool' to 'see' things (enlarged) that I otherwise can't clearly see" or "The ability to magnify the view screen on digital camera*"
13. "*getting the ones I don't want deleted and out of my way" or "programs could at least weed out the really bad pictures to save time.*"

In general, in line with the open-ended answers from other questions, the features for this application seem to relate to helping ensure a good quality picture (i.e., vocal assistance to ensure good lighting, pose and focus; and weeding out bad pictures) in an easy/accessible way, followed by an easy way to add verbal information about the picture (which can be date/time, place or other information) for easier identification, and an easy, accessible way to share the pictures.

2.2.6 Significant Differences for those who are Legally and Totally Blind

In the area of assistive technology for people with visual impairment, there is a significant difference between applications built for those who are legally blind (but can still see with some degree of magnification and image enhancement) and for those who are totally blind (including those who only have light perception). Therefore, we took a second look at our data to see if there are significant differences

between any aspects of our survey between those who are legally blind and totally blind.

We ran One-way ANOVA analysis between the visual impairment level of the participant and the Likert-scale questions regarding attitudes toward photography and online photo sharing. People who are legally blind are more likely to have taken photos themselves (with no help) than people who are totally blind ($n=55$; $p=.004$). Analyzing the qualitative answers of these two groups, it was apparent that those who were totally blind made more comments that relate to lack of confidence about the quality of their photos or not knowing how to take their own pictures, something that we also had to address in the design of our photography helper.

2.3 Photography Application

Based on the analyses results from the aforementioned survey, an iPhone application was created to assist users with limited or no vision in capturing a photo and browsing their photos through an accessible photo album. iPhone already has a face detection feature that can help center a face, so we took advantage of this feature and embed it into our application. Several applications that we reviewed in the Related Work section are also available to help aim and focus. Therefore, we decided that while our application also helps in aiming the camera as the user requirements indicated as an area of importance, it adds some features on helping those without or

with limited sight browse the pictures after the photos are taken. A full description of the technical details and functionality of the application can be found in [18].

As the survey indicated, the most common obstacles in photography without sight after the photos are taken are remembering the content of the photo at a later date and lack of capability to assign verbal information to the photo for future reference. For this reason, the tool is equipped with the ability to include machine-mined information with each photograph to assist the user to remember the content of the photo, namely the date and time as well as the location of the picture based on GPS information (translated into the name of the city or a much more detailed information (e.g., the name of a district or neighborhood) if available). While the photo is being taken, the application also records ambient audio, and right after the picture is taken, the users are provided with an option to add a voice memo. In addition, to make finding what is in the picture easier, the information tagged to the photo (audio sound byte, time, date, and location) is easily accessible while browsing photos. Figure 5 shows the wireframe of the application.

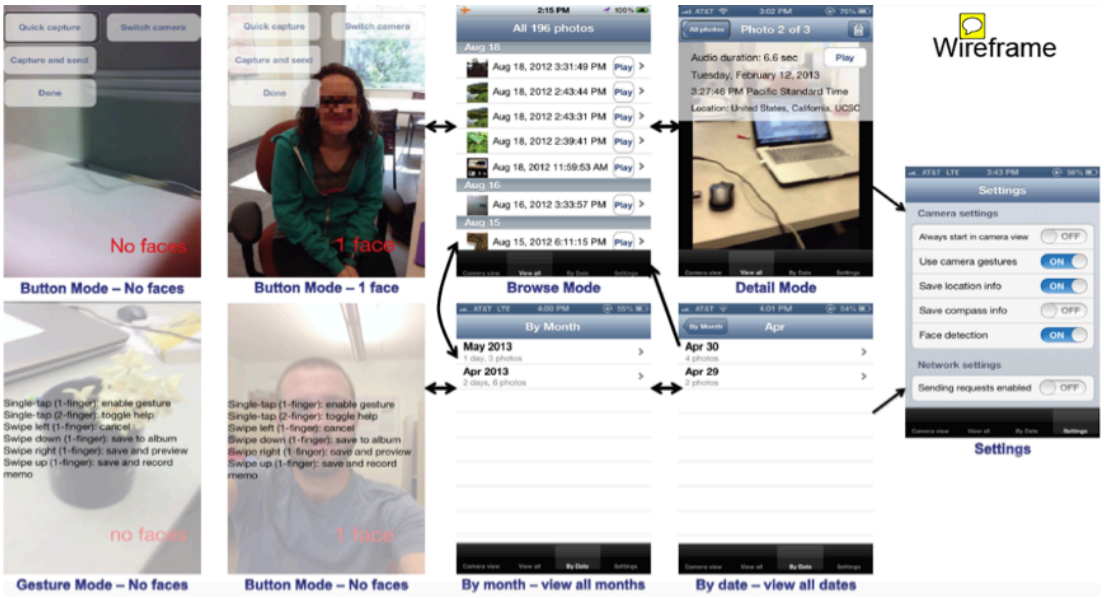

Figure 5. Wireframe of VizSnap

2.3.1 Application Details – Camera Mode

When the application opens, the user is presented with a camera view, shown in Figure 5, which is the Camera Mode. The camera view has six functions: Enable gesture, Toggle help (displays and hides help menu), Save to album, Save and preview, and Save and record memo.

Figure 5 shows the case when there is no face detected, as well as when the camera detects one face. This textual message is spoken out loud by VoiceOver allowing blind users to know how many faces were detected.

As soon as Camera Mode is opened or after a photo has just been taken, the device begins recording ambient audio up to a maximum of 30s – which can be restarted at any time by double tapping the screen – which is associated with the photo once

saved. By using a single swipe up gesture, the user snaps a photo. Once the photo is captured, the user has the option of recording a voice memo, by tapping and holding, waiting for one second (after which a confirmation sound indicates voice memo recording has begun). Upon releasing hold, voice memo recording stops and the voice memo is automatically replayed. At this point, the user may re-record the voice memo, or if they are happy with the memo, single-finger swipe down to save the photo, ambient audio, and voice memo into the photo album.

The album mode is depicted in Figure 6. In this particular screenshot, the album is organized by the date the pictures were taken. As shown by Bailes to be an important factor in traversing a chunk of information for blind people, the user is conveyed information of the photo album sequentially [8]. The tab view shown in each screen in Figure 5 is an easy way to go back and forth between various functions, which are: Camera view, View all [pictures], By Date and Settings.

The user may access the photo album by using left-swipe gesture in Camera Mode (please refer back to Figure 5). When the photo album is grouped and sorted by days, the user swipes left or right to access an earlier or later date, respectively. Once the user arrives at a desired date, they can access a time-wise sorted list of all photos taken on that date by double tapping. While accessing the list of photos, the user may swipe left or right to access each individual photo, giving it focus.

When the user highlights a photo, the memo audio is played, followed by the reading of the time, date, and location the photo was taken via iOS VoiceOver. Double tapping the photo changes the screen to the detailed view screen.

2.3.2 Application Details – Album Mode

In this screen, the photo is shown in full screen, referred to as Detail Mode in Figure 5, partially covered by a textual overlay with the information about the photo, which includes the duration of the voice memo, the dates and local times and the location of the photo. Upon loading this screen, the voice memo followed by ambient audio (which was recorded while the user was aiming the camera) is played. Once ambient audio stops, the orientation of the photo is announced, i.e. “Landscape” or “Clockwise,” to indicate how to properly show the photo to a sighted person. The user may three-finger swipe left or right to navigate to other photos from this screen. The top of the screen indicates how many photos were in that album.

2.4 Discussion

This chapter reports a largely qualitative analysis of a survey that aims at understanding the requirements among blind and visually impaired persons regarding independent photo taking and sharing activities. The results of the survey informed the features of the mobile application that we developed, that we then tested with five persons, also in a largely qualitative user evaluation method; the results of this user study can be found in [18].

Several features of the application that were motivated by the results of our survey were:

- Provides both magnification and voice outputs: The application must be accessible by visually impaired and blind users, which means that not only must the interface be magnified for those with low vision, but also interact aurally for those with light perception or no vision.
- Gesture Modes: As some of the respondents in the survey complained about the complexity of the operations to take and share pictures of the existing applications, we developed a series of Gesture Modes that allows for very minimal steps to do these activities. More specifically, these gestures allow users to toggle a help menu, save a photo with audio to the album, save and preview the photo with audio, and save photo and video and record voice memo – all with just various swiping motions without necessitating them to listen to menus.
- Time, date, and location metadata: As the survey indicated that identifying the contexts of the pictures is problematic, the application must assist users in locating the photo at a later time, such as by saving metadata automatically.
- Ambient audio: In the same light as above, to assist users in identifying the photo at a later time, and to enhance the non-visual experience of the photo, our application also allows recording of ambient audio of where and when the photo was taken.

- Voice memo: Finally, again to help users identify the photo at a later time, our application also allows users to record voice memo.
- Various grouping options: When a large number of pictures are taken, there is a need to have folders that either are automatically assigned by the system or defined by the users. Our application allows both options.
- Face detection: As the survey indicated, many users are concerned about focusing and aiming the camera. By taking advantage of the face detection feature that the iPhone has, our application helps in focusing and aiming the camera in relation to faces.

Through the analysis of a survey conducted among 54 totally blind, with light perception, and legally blind participants investigating photography trends, we have shown the need of a mobile application to assist those with limited or no sight with capturing, organizing, and sharing photos. As noted, the application was tested on five low-vision (including totally blind) participants with mostly positive results, detailed in [18].

It should be noted that the medium through which the survey was conducted, the Internet, suggests the sample of participants in this survey is more tech savvy than the general population of people with low vision. It will be necessary in the future to complement this survey through telephone surveys and visits to centers for orientation and mobility for blind persons.

While the survey revealed many important aspects of low-vision photography, as is the nature of the survey, we cannot really observe the actual practices of these people when they take and share pictures beyond the five people we interacted closely when they tested our application. In addition, the survey did not include a way to get a glimpse into the pictures that blind persons took and shared. We plan to follow up the survey with a series of interviews and focus groups to gather this information. This will allow us to verify the respondents' perceptions about the quality of their pictures, given that this theme appeared many times.

From the application development side, our future work will build on work done by Jayant et al. [22], Vazquez and Steinfeld [29], and our own work [18]. We plan to investigate the different photo capturing methods low-vision people are currently using and whether we can create a way to customize our application to match their preferred method. We also plan to follow in the footsteps of Swanson et al., who developed a game, Panorama, which investigates visual composition preferences using photography composition rules (such as balance, thirds alignment, symmetry, and spacing) [28]. The game automatically scores screen shots' composition quality. Swanson et al. obtained pairwise ranking scores of the images through crowdsourcing, and compared the scores given by Panorama and those given by the crowd, and showed that the game is mostly accurate in personal preference and general composition preferences. The algorithms used in this game will be distilled

and tested in our future study of how to assist visually impaired people to capture a "good" photograph.

Even though we already started inquiring about how low-vision people organize their photos or maintain a photo album, there is a lot to be done to really look into their organization method for a variety of media files. We plan to develop a customizable organizational method within the next generation of our application to account for individual differences in organizational preferences. We anticipate utilizing principles to sonify images proposed by [10] to design such an organization scheme, such that users are able to interpret the content of a photo by interacting with the photo through a touch-screen interface.

Finally, we had only touched upon the differences between those with some residual vision and those with no vision. We plan to investigate more deeply their preferences, to see both the commonalities and differences between these two user groups.

Having listed the limitations of the study, we believe that our study is unique in its contributions, in that it presents an extensive survey about photo taking and sharing issues among those with limited and no vision. Although some research groups have developed a variety of photographic aid for this user group, our application is unique in having its features informed by the needs and concerns of our user group as stated in the survey, and in having the features that make photo taking and sharing easier for

this user group. There are a lot of pending questions and ideas that we need to implement in the next generation of our application, but we believe that this study is a first step in the right direction to helping those with limited or no vision to be able to take and share their pictures independently.

The technological value of the future of this work lies in the novel methods for i) computer vision algorithm to improve photo taking without sight; ii) audio life-logging to retrieve from large amounts of audio data. This work will also provide a deep understanding of how visually impaired people take, organize and share pictures. This research will produce a technological artifact that turns a smartphone into a photo-taking aid without sight.

Chapter 3

Interviewing Blind Photographers: Design Insights for a Smartphone Application

3.1 The Interview

We interviewed people with low to no vision, who have taken photographs, in order to inform the design of application for blind photography, as well attempt to replicate the data from the survey described in the previous chapter. The results of the survey being reinforced by replicated data from these interviews will confirm their practicality.

The interview was conducted both through telephone, Skype and email. We chose different media to conduct the interview for the purpose of diversifying our sample. Those who were given the interview via telephone and Skype were asked the same questions as those completing the interview via email.

3.1.1 Interview Questions

The first set of questions asked the participants about demographic info. The next set of questions had to do with how exactly participants take their photos. The third set of questions had to do with how participants organize their own photos and view others' photos. The final set of questions had to do with sharing photos.

3.2 Results

3 researchers analyzed the interviews using open-coding, and extracted themes in the categories of Taking Photos, Organizing Photos, and Sharing Photos.

3.2.1 Taking Photos

The following were the most common subjects of the participants' photos (in the order of frequencies):

1. Natural scenery
2. Hobbies or items of personal interest
3. Pets or animals
4. Social scenes

The most frequently mentioned type of camera used is their cell phone's camera, more commonly the iPhone's camera. This could mean if we want to create an application to assist with blind photography, a cellular device could be a good choice.

The following are the most common methods people used to take photos, excluding using sighted help:

1. Simple point and shoot.
2. Get close, touch the object, then move away and take photo.
3. Take several photos then weed them out.

We also asked what they liked best about taking photos, the following were the most common responses:

1. Share with friends
2. Virtual memory or record keeping
3. Visual art or self expression

The following two high-level themes were the most common issues the participants ran into while taking, organizing, or sharing photos:

1. Focusing/blur. Example sentence: "*I often do not realize the shot is blurry until I review it on the computer screen*." A common way these individuals will try to eliminate this issue is by taking multiple shots of the same scene or to get a second opinion from a person with normal vision.
2. Photo organization. Example sentence: "*I usually rely on memory and people's descriptions to help remind me what is in the photos; sometimes it is not obvious or I forget certain events.*" This issue is also directly related to participants' feelings toward uploading photos; they are often wary of uploading the wrong photo.

3.2.2 Organizing Photos

The most common method for organizing photos (excluding using sighted help) was renaming the photo file to something more descriptive ("*mom*" instead of

"*img_1001*") and/or placing photos into descriptively named folders. In general, most participants cited using sighted help to determine whether their photos are of acceptable quality when going back through them.

3.2.3 Sharing Photos

Nine out of 11 participants said they use Facebook or some other social networking website. Most participants (four out of six) claimed they do not normally "view" others' photos, however, six out of 10 mention sharing photos with friends as one of the best things about taking a picture. This suggests participants are more likely to show their photos as opposed to view others' photos. Furthermore, four out of six participants who responded only view photos if they are captioned. This means the photos need to be captioned or annotated if the photographer wants people with limited vision to view their photos.

3.2.4 Application Features

Based on the interview results, we built the iPhone app, the details of which can be found in [18]. The application was built on the iOS platform, and assists users with limited vision take and organize photos by using iOS's built in face detection API to give some, although limited, assistance with aiming the camera. The app also uses time, date, and location metadata of the photo, as well as ambient audio and a voice memo, given by the user, to assist with browsing photos.

3.3 Discussion

We have shown the need for certain features for an application to assist blind and visually impaired people capture photographs with a smartphone by conducting interviews and analyzing the responses. The analyses were transformed into features for a smartphone application to be integrated into an already existing application. In the future, we plan to add the following features:

1. Search function – Annotate users' photos to roughly describe what is going on in the photo, using IQEngines API [45]. The voice memo that is recorded with the photo will also be transcribed using speech-to-text engine. The user can query for key words associated with the photos.
2. Photo weeder – The user aims the camera in the general desired direction, several photos are automatically captured, one photo is chosen using machine learning algorithms proposed by [28].
3. Blur detection – Also noted by Jayant et al. [22] and Vazquez et al. [29], users desire a way to detect whether the photo is blurry, out of focus, or with poor lighting.

Chapter 4

Implementation of VizSnap

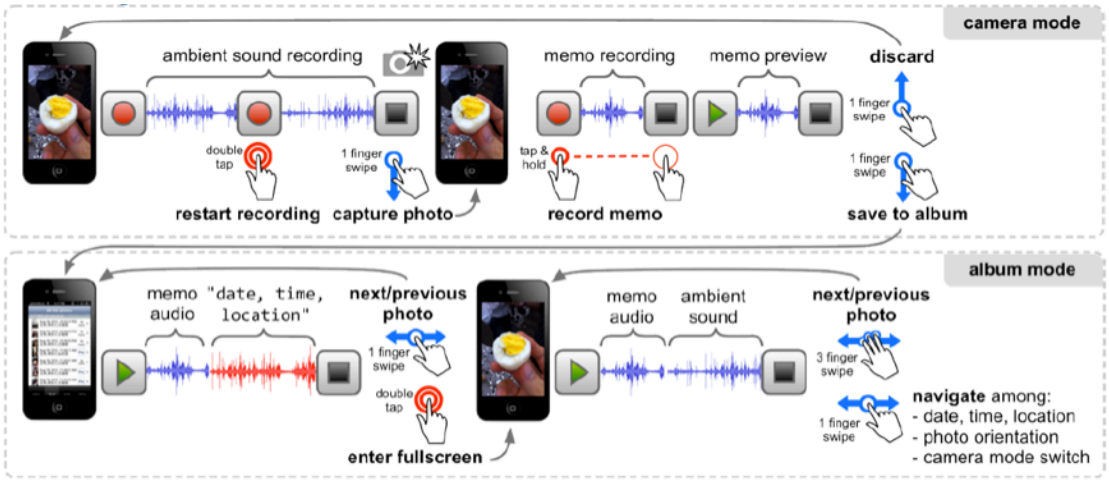

Figure 6. VizSnap storyboard with VoiceOver

I developed an iPhone application that enables the user to capture a photo and augment it with an audio memo recording as well as a recording of the ambient sound. The app was designed to be blind-accessible and optimized for operation via the built-in VoiceOver screen reader functionality of the iOS, so that a visually impaired user can use it without needing to see what is on the screen. The key functions were designed to be accessible through the various touch-screen gestures. Figure 6 provides an overview of the functionality and interaction made available by our iPhone app. The app consists of two main modes: camera mode, and album mode. As soon as the app is launched, it enters the camera mode and ambient sound recording is started. The user can explicitly restart the ambient sound recording by double tapping on the screen. The user can capture a photo by performing a single-

finger swipe-down gesture. While ideally we would have liked to utilize the physical volume button as a shutter, we encountered technical issues in implementing such a feature in conjunction with the audio recording capabilities, thereby resorting to using a gesture. Full detail of the application can be found in [18].

4.1 User Study

To evaluate the effectiveness of the application and to observe the actual practice of taking and sharing photos by visually impaired users, we conducted a user study with blind and partially sighted participants who expressed interest in the idea of taking and sharing photos. More specifically, the goals of the user study were as follows:

1. To answer the following questions about whether our application was able to meet our goal:
    (a) Did the app enable the user to quickly capture photographs along with memo and ambient audio recordings?
    (b) Did our app enable the user to quickly browse through the photo collection and grasp the content of each photo?
    (c) Did our app enable the user to take the lead during the activity of sharing their experience through the photos with a sighted person?
2. To gain insights about future design considerations for making the photo sharing experience more accessible and inclusive, by observing visually impaired people engaged in the end-to end process of photo capturing, browsing and sharing of their photographs.

	Age	Gender	Visual impairment	Have taken photo on their own?	Have shared photos?
P1	25	Female	Left eye: hand-movement (since birth) Right eye: finger count (since age 15)	Yes (mobile phone camera)	Yes (show on phone, e-mail)
P2	34	Male	No light perception (since birth)	No	Yes, others' photos (e-mail)
P3	35	Male	No light perception (since birth)	No	No
P4	34	Female	Left eye: hand-movement (since age 4) Right eye: no light perception (since age 4)	Yes (mobile phone camera)	Yes, experimentally (e-mail, blog)
P5	36	Male	No light perception (since age 21)	Yes (mobile phone camera)	Yes (show on phone, e-mail)

Figure 7. Summary of background information about the user study participants

Five participants (three males and two females ranging in age from 25 to 36) took part in our user study as paid volunteers, with each participant taking part in a full-day evaluation session. Information about each participant is summarized in Figure 7, with details presented in the following section.

4.2 Results

The results from the study are first summarized in the context of the application design goals. Given that the focus of our study was more towards observing the end-to-end user experience of photo capturing and sharing rather than on conducting controlled lab experiments, I have chosen to evaluate whether or not our goals were met based on the responses by our participants to my qualitative questionnaire.

1. Did my app enable the user to quickly capture photographs along with memo and ambient audio recordings?

While only P3 had prior experience with the VoiceOver functionality of iOS mobile devices, all participants were able to grasp the basic gestures involved in using our app within the introductory session.

	Photo-capturing session locations	Photos captured
P1	Major waterfront leisure area with shopping malls and attractions	17
P2	Major landmark tower and major waterfront leisure area	18
P3	Wine import store and major waterfront leisure area	20
P4	Historic site and adjacent park	13
P5	Chinatown and uptown shopping mall	15

Figure 8. Summary of background information about our user study participants.

Each participant captured between 13 and 20 photos during the photo-capturing session over the period of approximately five hours (Figure 8). In response to the statement "taking photos was easy" to which the participants responded on a 7-point Likert-scale with 1 being "strongly disagree" and 7 being "strongly agree," two participants responded with a 7, and the others responded with a 5 (Figure 8). Responses to the statement "recording memo was easy" included two 7s, two 6s and a 5.

For the three participants who had previous experience with capturing photos on their camera phones (P1, P4, P5), I also asked them to rate their agreement with the

statements comparing the ease, speed, and level of detail of the memo recording using our app versus their previous methods. Across all three questions, all participants rated my app as being easier and faster in assigning memos to photos, and as enabling recording of more detailed memos.

2. Did my app enable the user to quickly browse through the photo collection and grasp the content of each photo?

All the participants quickly familiarized themselves with the basic gestures for flipping through the full-screen photos, controlling the audio playback, and determining the correct orientation of the photograph. All five participants were able to recall and identify the content of every photo, except for two photos that were unable to be distinguished by one of the participants (P2). The photo that led to the ambiguity was a photo of the participant captured by the experimenter, taken from knee height pointing upwards with the landmark tower in the background soaring behind the participant. The memo description that the participant had recorded for the photo was "tried taking a photo of the landmark tower looking directly down upon it." Upon hearing the memo during the photo sharing session, P2 became confused, given that the preceding photo was also of the landmark tower but one which the participant himself had taken, with the memo description "tried taking the landmark tower. Unfortunately we couldn't go up to the observation deck, so looking up at it from below." Aside from this one instance, all participants were able to advance

through the photos using the three-finger flick gesture and after hearing the few seconds of the recorded audio memo for a particular photograph, begin recounting its context without any prompt from the viewer.

3. Did my app enable the user to take the lead during the activity of sharing their experience through the photos with a sighted person?

In response to the questionnaire statement "felt able to play a proactive role during the photo sharing session," all but one participant (P2) replied agree or strongly agree. P2 described the reason why he felt neutral about this statement as being due to the one pair of photographs that he was unable to successfully distinguish, as mentioned above. While it is difficult to gauge how much that particular experience may have skewed his assessment of the experience over the entire set of photos, based on our observation, he was able to accurately recount the contents of all other photos without any problem.

4.2 Discussion

We created an accessible smartphone application that enables people with visual impairment to capture audio recordings along with photographs and to peruse them at a later time. Through the use of such audio recordings, a user can associate a spoken memo describing the particular photograph, along with any ambient sound that may aid in recalling the photo later. Our user study with five visually impaired participants

in naturalistic settings revealed that our approach is a viable solution to overcome the barrier faced by blind and partially sighted users in sharing their photos. Based on our observations of visually impaired people engaged in the end-to-end process of capturing, browsing, and sharing photographs, we presented a set of insights about future design considerations for making the photo sharing experience more accessible and inclusive.

Chapter 5

A Picture's Worth a Thousand Words: Analyzing Photographs Taken by Blind Photographers

As noted by [1,18], many people with low vision (including blind) enjoy the pastime of photography, however, run into various problems while taking, browsing, or sharing photos. By understanding photo browsing, organizing, and sharing practices of those with limited vision, as well as the shortcomings of the current photography tools they use, tools can be designed to cater to their photography needs. Our first attempt to understand some of these activities is by looking at postings in forums of blind photographers. One particular forum discussion and uploaded photos were analyzed: a Flickr [44] group called "Blind Photographers". A qualitative analysis was performed for the forum postings and two other co-authors for the photos.

5.1 Blind Photographers' Forum

We analyzed the forum postings and photos of a group on Flickr called "Blind Photographers." The group restricts the uploaded photos to those taken by visually impaired photographers. Please note that the members are self-proclaimed to be visually impaired, there is no test or verification done by the forum administration.

This forum is very active and some of the members posted hundreds of pictures to the forum. The five most active contributors, for example, contributed 2,851, 977, 614, 573 and 562 photos since they became members, respectively.

We distilled the types of photos taken, patterns of problems, and photo quality among the photographs; we distilled common obstacles, techniques for taking photos, personal reflection, and common technological help sought out from the forum threads.

The first thing that we observed was that there is a wide range of photography skill levels, ranging from novices who take pictures as a hobby all the way to paid professionals.

We also observed that most photographers in these groups feel that they should be held to the same standards as sighted photographers, and they should not be excluded from the photography community just because they are blind. Some topics that were discussed within these forums suggest that some blind photography (as in photos taken by blind persons) is often seen as "outside art", and every blind photographer who voiced an opinion in this particular discussion did not like this particular "categorization".

5.1.1 Analysis of the Forum Posts

We coded the forum posts into themes, and the following are the themes that emerged, organized by obstacles and solutions regarding photo taking, sharing, and organizing and editing.

5.1.1.1 Obstacles

1. Some programs are hard to use or not accessible. Example sentence: "*I can still see reasonably well enough with high magnification - but editing software is pretty frustrating when used in this way.*"
2. Framing. Example sentence: "*I'm using a Canon Powershot G9 which is necessary due to the difficulty framing shots through the viewfinders of SLR's (especially in low-light).*"
3. Determining quality and processing (i.e., editing) them. Example sentence: "*One common reaction I've had towards my photos seems to be 'how do you know which of your pictures are good... how do you process them...' along those lines. The thing is, I don't.*"

5.1.1.2 Technique for Taking Photos

1. Taking a lot of photos, then weeding out or editing the low quality ones. Example sentence: "*I build up an 'appetite' (nicely put) for photography over some length of time, take a bunch of photos, try to edit (i.e. salvage) them, find a few I like*"

2. Point and shoot. Example sentence: "*I'm totally blind and just point and shoot…*"

5.1.1.3 Self Reflection

1. Reading books about photography techniques (hints and tricks). Example sentence: "*In my never-ending quest to take better pics, I have turned to my usual helper, books*."
2. Reviewing their pictures to make notes on how they can take better pictures. Example sentence: "*A large part of the creative process for me is iteration. Shooting, reviewing the results, and changing the way I shoot based on that review.*"
3. Pay closer attention to the surrounding (e.g., time of day, color, form or geometry or shape, light, sounds etc.). Example sentence: "*I have taken a few scenic pictures that seem to work for others...they were all some place that I could walk into and around first. I got a better sense of the place and the space. I then had a more informed intuition for framing the shot*."
4. Plan ahead. Example sentence: *"...perhaps you can retrain to think of yourself as an early photographer. You need to plan out your image in advance completely, as they did, making their own luck in getting a good image.*"

5.1.1.4 Technological Help

1. Using special camera equipment (e.g., long range lenses, short focal length lenses, accessible interface). Example sentence: *"...with short focal length lenses, I can guess distance and use the distance and DOF scale on the lens and get usable results most of the time.*"
2. Using auto-focus. Example sentence: "*A lot of what I shoot (all the telephoto work for instance) would be impossible without auto-focus*."

Some members of this group were taking photos to assess their surroundings, capturing a photo and zooming in, and using Optical Character Recognition (OCR) software to read labels.

5.1.2 Analysis of the Photos

Categories	Percentage(%)
No Object	8.8
Out of Focus	20.2
Cut-off	26.8
Not enough light	10.2
Too much light	1
Tilted	3.4
"Photoshopped"	5.6
Low Resolution	13
No Problem at all	38.4

Table 1. Percentage of Photos Falling into these Categories

In addition to analyzing the forum posting, we also analyzed the uploaded photos to see if there is any pattern of problems. It should be noted that many of these pictures are actually of high quality and if we did not know that we were analyzing pictures taken by blind persons, we would not have suspected that those pictures were taken by someone with a visual impairment.

500 photos were randomly chosen. Two researchers used stratified random sampling by photographer and by the photographs that were analyzed. The researchers

randomly chose 10 photographers, and then randomly chose 50 photos from each of the photographers' photo stream. The two researchers independently reviewed the photos and then came to a mutual agreement about the following common themes:

- Out of focus or blurry: We discarded photos that were made specifically blurry for artistic purposes.
- Cut-off: photos are cropped in a way that they leave out important content.
- Too much or too little light: the photo is under or over exposed.
- Low resolution: the photos are pixelated.
- Tilted: the photos are tilted, including 90 degrees tilted.
- Photoshopped: this is not necessarily a quality problem, as the photos can be photoshopped for artistic purposes or to fix quality problems, and we have no way to know the real purpose.

Some pictures could also have more than one problem (e.g., out of focus and cut-off). Analyzing the forum posts and the photos by those posting to the forums (as seen in Table 1) reveal that there are some similarities between what the blind photographers stated as obstacles and the resulting photos (e.g., focus) but there were a lot of differences between the subjective and objective difficulties, indicating a need to design a system that can inform blind photographers the quality issues with their photos and assure them when no quality issue is detected.

5.1.3 Analysis of the Tagged Photos

Lastly, in addition to analyzing the forum and photographs, we conducted a third analysis to gain insight of the certain categories blind photographers use to tag their uploaded photos as solutions for various categories already exist technically (e.g., face detection is a common feature in many phone or digital cameras, scenery quality control is not very common). Categories of tagged photographs were chosen by randomly viewing over 500 photographs. One researcher used random sampling and analyzed 225 photographs that were tagged. The following categories were found (with examples). These categories were then verified by another researcher:

- People: Person or persons are the main focus of the photograph and the tagged category.
- Animals: Animals or pet(s) are the main focus of the photograph and the tagged category.
- Nature: Nature photographs with nature-related tagged category.
- Architecture: Buildings, structures, and statues with related tagged category.
- Abstract: Abstract tags such as "*Have pride*," when the photograph displays an animal for example.
- Travel: Photographs captured from cars, or planes, and the tagged category related to traveling such as "*One hundred miles to go*."

Tagged Categories	Percentage(%)
People	32.9
Animals	15.5
Nature	21.8
Architecture	17.8
Abstract	4.4
Travel	7.6

Table 2. Percentages of the Photos Falling into the Tagged Categories

Table 2 summarizes the percentages of the photographs tags analyzed with the above categories.

5.2 Discussion

From the forum postings and the analysis of photos for quality problems, we found several problems (although we should note that a third of the photos analyzed do not have any obvious problems we can pinpoint). The two biggest problems (combined made up almost half of the problems) are the photos being obviously cut off or out of focus. While better and better features are available in terms of helping photographer focuses their cameras, fewer technique is available to help avoid cut- off photos (e.g., a person with missing top part of the face/head). This suggests that there is a need to design a system that can inform the users about whether the object of interest is captured in its entirety.

The forum postings were more varied, there were no single problems that showed up more times than others, and our sense from the analysis of the forum postings is that there is a general need for support in various aspects of photo taking, although one thing that we noticed is that the blind photography forum is already quite established in helping each other.

Finally, the photo tag analysis revealed that the number one object taken was of people, in which, as we stated previously, there exists good support already in terms of face detection (although not so much in making sure that the head is not cut off). The second most frequent tag, nature, is more difficult to support in terms of ensuring good quality photos, opening opportunities to think of an interactive system that can help in this kind of photographed object.

We have analyzed thousands of forum posts by tens of thousands of users with limited vision as well as photos posted by these users and concluded with the most common obstacles, techniques for taking photos, personal reflection, and common technological help sought out. We should note that the analysis was done on a forum in which the photographers posted their photos, perhaps indicating that they have a certain level of confidence to show their photos to the general public (although the forum postings were also populated by those who are just beginning to take photos and are seeking help). By understanding the photography needs of blind

photographers, hopefully technologies and techniques can be built to address those needs.

Chapter 6

Blind Photographers and VizSnap: A Long-term Study

Blind people often face challenges when accessing photographs that have already been taken and are stored in a photo library [1]. Since photography is inherently a visual undertaking, photographs often times only contain visual information. With the advent and recent ubiquity of smartphones, photographs can be complemented with other information (such as time, date, and location information).

Some researchers have made an application to make photographs more accessible to people who are blind by adding location (using reverse geo-coded GPS information) and general, nonspecific information about what is in a photograph (such as IQEngines [45]) to help users browse and navigate a photo album without sight [22]. However, little research has been done to assess whether audio recorded while the photograph was taken, as well as a custom, spoken, voice memo to accompany the photograph could be used to help browse and navigate a photo album without sight.

This chapter reports on a long-term user study that aims to investigate whether accompanying audio to a photograph enhances memory retrieval of an event for people who are blind, in addition to time, date, and location information, which are

already available with the default photo album with iPhone. With the default iPhone photo album, time, date, and location are information given to the user through VoiceOver. Through VoiceOver, the iPhone user is also able to give a custom tag of the photo, once they have located it in the photo library (which is not available upon taking the photo – it must be done afterwards in the photo library), which may be a daunting task for someone who is unable to see the photograph. Giving a custom label in text is a multi-stage and sometimes time consuming process, meaning several gestures are required in order to open up the label creator, and typing with VoiceOver on requires three times as many gestures as it would without VoiceOver.

6.1 Method

As the first step of understanding the problems that blind photographers face, we analyzed thousands of forum posts by tens of thousands of users with limited vision as well as photos posted by these users and concluded with the most common obstacles, techniques for taking photos, personal reflection, and common technological help sought out. These photographs came from a Flickr group called Blind Photographers, which can be referred to in Chapter 5.

6.1.1 Research Questions

Based on our analysis, the primary research questions of the user study reported in this chapter are:

1. What kind of photographs do blind photographers take?

2. Do blind photographers make use of sound recordings, time, date, and location information to help them recognize their photo?
3. What are some of the issues that blind photographers face when using VizSnap?

To answer question 1, all photos taken by participants during the user study were collected and combined to form a corpus of photos. The photos were analyzed by two researchers to categorize them into meaningful groups.

To answer question 2, the participants were given the description of five photographs, and asked to retrieve the photo using only audio, time, date, and location metadata. After three minutes, if the user has not located the photo based on the description or has located a different photo, then retrieval of that photo is considered unsuccessful.

To answer question 3, participants were asked a short questionnaire during each two-week meeting about their general usage of VizSnap throughout the two-month period.

Approval from the Institutional Review Board (IRB) was obtained for this research before the study began.

6.1.2 Equipment

The main equipment for our study is an iPhone running an iPhone app we developed called VizSnap. VizSnap allows users to attach additional information to a photograph. VizSnap is available on the App Store for free. A precursor of VizSnap (called Phodio) has been documented and its user study had been published in [18]. VizSnap records ambient audio while the user is aiming the camera, then allows the user to take a picture using gestures provided by VoiceOver, and adds the option to record a VoiceMemo.

One gesture captures a photo, and one additional gesture records voice memo (fewer than the two gestures required by the built in iPhone camera app (using VoiceOver) to just take a photo). Once the user finished taking photos, they may exit the camera view (using one gesture), and are automatically taken to the photo album. In the photo album, the user uses one finger to swipe left and right to hear the voice memo, ambient audio, time, and date of earlier, and later photos, respectively. Upon hearing the desired photo, the user can use more gestures to replay the voice memo and ambient audio, and location information, as well as send the photo as an email attachment, post to Facebook, or delete the photo.

6.1.3 Participants

The users for this study are people who are totally blind or with light perception, and who need VoiceOver to use an iPhone. This user study targets both adventitiously blind and congenitally blind people. While it is intended that this app be implemented

through Android at some point, right now, it is only available for iPhone, the most commonly used smartphone by blind persons [22]. For that reason, in addition to being blind, users must also have an iPhone.

The user study involved 13 participants, aged 18-65 years old, seven females and six males. There were users from USA (11), Canada (one), and New Zealand (one). There were seven adventitiously blind participants, and six who are congenitally blind. Nine participants were totally blind, and two still had some light perception.

The user study required that participants use VizSnap for two months, taking at least five photos every two days, and meeting with us (either in person or over the network) every two weeks. The goal was to have the user take at least 30 photos in the two week period so that a legitimate assessment could be made as to whether the participant had used VizSnap sufficiently to form an opinion of the app, as well as for us to objectively assess the participant's usage of the app based on data recorded by the application. The participants were asked to upload their photos, along with all of the photos' audio, time, date, and location data to a server, to allow us to analyze the data, the day before the meeting. Please note that the VizSnap version in the app store does not require nor have the facility to upload to a server for privacy purposes.

From the data, five photos were chosen at random, and during the meeting with the participant, each photo was described to the participant, and the participant was asked

to navigate through their photo album on VizSnap and locate the photo using only the audio, time, date, and location information of the photo. The participant was also asked a short questionnaire about their general usage of VizSnap during the previous two weeks.

6.1.4 Study Procedure

Since participants of this study are located throughout the US and outside the US, the users had to download the test VizSnap app with the capability to upload their data to a server for analysis. VizSnap was made available to participants using a service called TestFlight, provided to developers by Apple.

TestFlight involves registering the build of the App, as well as the email addresses of the participants [36]. TestFlight then simply sends each participant an invitation to download the app, and the app is easily downloaded with the click of one link. The only caveat is that each build of TestFlight expires after 30 days, and since the user study lasted roughly two months, the participants had to download updates, which retains all the users' previous data of VizSnap.

The user study was conducted over four sessions, and each session is described as follows.

6.1.4.1 First Session (Introductory Session)

The introductory session involved several steps. First, making sure VizSnap downloaded successfully on the participant's iPhone. All participants had successfully downloaded VizSnap.

Next, the participants were asked the following demographics questions:

1. How old are you?
2. Since when were you blind?
3. Preferred choice of camera device.
4. Since when did you use the camera device?
5. In a typical week, how often do you take photos?
6. How often do you browse through your photos?
7. What's your strategy for taking photos?
8. What's your strategy for browsing photos?
9. What's your strategy for sharing photos with others?

Next, the participants were instructed how to use VizSnap through a step-by-step demonstration of every feature and gesture. The participants were asked to repeat the use of each feature and gesture. All participants were successful in this step.

The next step involved the explanation of the user study, which highlights that the participants were required to take at least five photos every two days, such that at least 30 photos were present for the next meeting session (occurring every two

weeks). The participants were given a $10 Amazon Gift Card for every session as long as they took at least five photos every two days prior to that session.

Finally, the consent form was read aloud to the participant, and the participant was asked if they consent to taking part in the user study and having their data used for analyses. The participants were given the consent form in advance (electronically with accessibility features) to read over if they so desired, in addition to having it read aloud do them during the meeting.

6.1.4.2 Second and Third Sessions

Sessions two and three were identical. The goal of these sessions was to assess the participants' long-term usage of VizSnap in their day-to-day life. The participants were interviewed following these guiding questions:

1. What do you think about this app VizSnap?
2. What problems have you experienced with VizSnap these last two weeks?
3. Out of the voice memo, ambient audio, time, date, and location information, which do you find the most useful in locating photos after you've taken the photo?
4. How often did you send your photos via email this last week? 0, 1-5, 6-10, more than 10?
5. How often did you post your photos on Facebook this last week? 0, 1-5, 6-10, more than 10?

6. What features do you think are missing from this app?

This was followed by a short exercise, in which we had chosen five photos, at random, prior to the meeting. We gave a short description to the participant of what was in the photograph, and asked them to locate the photo using only time, date, location, and the audio taken while the photo was captured. The participant provides the time and the date of the photo they think is correct, and we verified whether their photo matches the photo we asked them to find.

Here are some examples of the descriptions that were given to the participants:

- Photo on a sidewalk with a wooden garden in the frame.
- Photo inside a plane taking a picture out the window.
- Photo of a classic car parked in a driveway.

6.1.5 Pilot Study

Over the Summer of 2015, a pilot study was conducted with two blind participants to assess the viability of the long term user study. The two users were asked to use VizSnap in their day to day life, taking as many photos as possible, and were met with once every two weeks to assess their use of VizSnap through a short questionnaire, and to perform a short user study in which 3 photos were chosen at random, described to the participants, and the participants were asked to retrieve the photos using only the audio, time, date, and location information of the photograph.

The sessions in this stage of the user study took place in person; one participant lives in San Francisco, CA, the other participant lives in Hollister, CA. The first session began by asking the participant the same demographics questions listed in Section 6.1.4.1.

Next, the participants were shown all the features of VizSnap, including how to take a photo using gestures as well as taking photos using button mode, how to browse through their photo library, how to access the details of photos, send via email and Facebook, how to delete photos, and how to access the settings. The participants were then asked to repeat these steps to demonstrate that they understood how to use VizSnap in its entirety. Finally, the participants were taken on a small outing, in which the participant and us walked around outside of their home, taking pictures of various things in their surroundings, along with recording ambient audio and voice memos. Afterwards, we went back inside to review the photos.

The participants were encouraged to take photos in their day-to-day life, such that when the next meeting took place, they could answer a questionnaire of their general usage of VizSnap, followed by a user study. In the follow-up session, we asked the same set of guiding questions listed in Section 6.1.4.2.

Next, we chose three of their photos at random, described the photo to the participant, and asked the participant to browse through their photo album and find the photo we described, using only audio, time, date, and location information.

The participants were met with a total of three times, such that the above session described took place twice, while the initial session took place once.
Participant 1: 25 years old when the user study began. She has been blind since birth
Participant 2: 18 years old when the user study began. He has been blind since birth.

The purpose of the pilot user study was to have a run-through with only a couple participants to make sure all the steps of the user study would be necessary, no steps would be extraneous, and that necessary steps would not be left out. The most important realizations from the pilot user study came as follows:

- The user study did not need to take place in-person, it could be performed remotely, through Skype, FaceTime, or Google Hangout meetings.
- There needs to be a system in place to encourage participants to take photos.

Sometimes, the two participants took very few photos, which made the user studies of subsequent meetings unreliable. From this experience, we decided that for the real study, the participants would be paid a $10 Amazon gift card if and only if they took at least five photos every two days.

6.1.6 Sighted Users Using VizSnap

Nalini Sewak, a graduate student at UC Santa Cruz, conducted a user study among 18 sighted participants, a summary of her written report is given here. The purpose of the user study was to determine whether additional information to a photograph, namely time, date, location, ambient audio, and voice memo enhance memory retrieval of a moment in time. The theories of this study were tested using the app VizSnap, which is the same app being used to test the theories of whether these aforementioned data enhance memory retrieval with blind people. The purpose of this user study was to determine whether time, date, location, ambient audio, and voice memo enhance memory recollection in similar ways it does for blind people.

Some shortcomings of the user study as noted by Sewak were:

- Too few users participating
- A bias of photos not pertaining to real world photo taking. Participants were asked to take two photos every day, and this might be an unreasonable amount for some.
- Insufficient tutorial on using VizSnap. Some users possible never knew how to completely use VizSnap because it was up to them to learn how.

6.1.7 Results

The primary data we analyzed are the voice memos and ambient audio of the photos, time, date, and location photos were taken, participants' answers to the two different

set of questions (see Sections 6.1.4.1. and 6.1.4.2), the accuracy of photo retrieval, participants' memory elicitation of the photo described to them, and a general analysis of the types of photos that were taken by participants as well as trends with the photos.

6.1.7.1 Session One

Session one analyzes which users took part based on age, location, blindness level, since when they were blind, and their photography preferences. Participants were asked the following questions with their respective answers given:

1. How old are you?

Ages given were {18, 18, 25, 28, 34, 37, 46, 50, 52, 54, 58, 61, 65}, showing a well-represented range of ages from 18 – 65.

2. Since when were you blind?

Seven participants were adventitiously blind, while six were congenitally blind.

3. Preferred choice of camera device.

Eleven out of the 13 participants stated the iPhone was their device of choice for taking photographs. While only iPhone users participated in this study, it was still enlightening that they use a smartphone as their main camera device.

4. Since when did you use the camera device?

Answers to this question varied from "I've rarely ever used this camera device" to the last six years. Eleven out of 13 participants stated they have been using their iPhone to take photos since at least the last two years. The other two participants stated some variation of they have rarely used the camera device.

5. In a typical week, how often do you take photos?

Seven participants stated that they take photos on a regular basis, meaning (for this user study) at least one per week.

6. How often do you browse through your photos?

Only three participants answered that they browse through their photos more than once a month. Most participants had some variation of the answer "I do not browse through my photos."

7. What's your strategy for taking photos?

Several participants stated multiple strategies for taking photos. Five participants stated using the "Point and shoot" method, such that photographers point in the general direction they know their subject is, and snap the photo. Four participants use the method of touching the subject, backing away, and then taking the photograph. Two participants stated using sighted help. Two stated utilizing face detection on the iPhone. Two stated knowing all you could about the lighting of the setting helps to

take good photographs. And one participant uses the strategy of taking lots of photos, then weeding them out later.

8. What's your strategy for browsing photos?

Several participants stated multiple strategies here as well. Four participants stated uploading to a cloud sharing service (such as Dropbox) immediately to facilitate easier browsing later on. Three participants stated using the date and time information. Two participants stated using location information. Two participants stated using labels in VoiceOver. One participant stated using sighted help, and one participant stated uploading the file the computer immediately and renaming the file.

9. What's your strategy for sharing photos with others?

Several participant stated multiple strategies here. Nine participants stated using Facebook, six through text message, three through email, two through Twitter, one through Shutterfly and one through Instagram.

6.1.7.2 Sessions Two and Three

Sessions two and three were identical in terms of what was required of the participants. Figure 9, below, shows sample photographs taken by four different participants after two weeks of use.

Figure 9. Sample photos taken by participants after two weeks of use.

6.1.7.2.1 Session Two – Part I

Thirteen participants took part in session two. There were two parts to session 2; during part I, participants were asked six questions regarding their use of VizSnap the previous two weeks, seen directly below. Part II entailed a short user study in which five of each participant's photos were chosen at random, described to the participant, and they were asked to locate the photo in their photo album using only voice memo, ambient audio, time, date, and location information.

Open-coding by three researchers was performed on the open-ended responses to the questionnaire in order to extract themes which occurred for participants' responses. The open-ended questions were questions 1, 2, and 6. Questions 3, 4, and 5 were quantitative in nature. A summary of themes (along with the number of occurrences) observed for open-ended questions and analysis of quantitative questions are given below:

1. What do you think about this app VizSnap?

There were a variety responses to this question, such that the only theme that seemed to reoccur during this question was “Getting used to the app,” which concretely occurred twice. Most users were pleased with the app, and only one participant expressed that using the app to be a negative experience, stating “I've got a couple things that I find, like, a little frustrating.”

2. What problems have you experienced with VizSnap these last two weeks?

- Performing the right gestures (4)
- Knowing the photo quality (2)
- The volume is too low (2)

3. Out of the voice memo, ambient audio, time, date, and location information, which do you find the most useful in locating photos after you’ve taken the photo?

Some participants reported two different modes of information to be the most useful for locating photos after they are taken. Seven (54%) participants reported ambient audio to be the most useful information. Five (38%) participants reported the voice memo to be the most useful information to locate photos after they have been taken. Four (31%) participants reported the date to be most useful. Three (23%) reported the time to be most useful. One (8%) participant stated that they went back to look at photos after they had been taken for the first time in that session.

This data indicates that some form of audio (which is VizSnap's novelty) recording is most useful when locating a photo after it has been taken. The next two useful modes reported were the date and time. The only piece of information that was not reported as being the most useful was the location.

4. How often did you send your photos via email this last week? 0, 1-5, 6-10, more than 10?

Only three (23%) participants reported sending photos via email. Others remarked they only felt comfortable sending photos via email if they knew the quality of the photograph beforehand. One (8%) participant noted that sending photos via email was their way of verifying the quality of the photo.

5. How often did you post your photos on Facebook this last week? 0, 1-5, 6-10, more than 10?

Only one (8%) participant reported posting photos to Facebook using VizSnap. All other participants reported not having posted any photos to Facebook using VizSnap.

6. What features do you think are missing from this app VizSnap?

- Photo quality feedback (3)
- Access to camera flash (3)
- Volume should be louder (2)
- Accessing front facing camera (2)

6.1.7.2.2 Session Two – Part II

As mentioned before, during part II, five photos from each participant was chosen at random, the contents of the photos were described to the participant, and the participant was asked to locate the photo – giving the time and date of the photo they chose in order to verify whether it was the correct photo.

The following list shows the accuracy of retrieval for each participant:

- P1: 5 out of 5 – 100%
- P2: 3 out of 4 – 75% (technical difficulties led to not assessing the fifth photo)
- P3: 5 out of 5 – 100%
- P4: 4 out of 5 – 80%
- P5: Did not take enough photos to complete Part II.
- P6: 5 out of 5 – 100%
- P7: 5 out of 5 – 100%
- P8: 4 out of 5 – 80%
- P9: 5 out of 5 – 100%
- P10: 5 out of 5 – 100%
- P11: 3 out of 5 – 60%
- P12: 5 out of 5 – 100%
- P13: Did not take enough photos to complete Part II.

Out of the 11 participants that were able to complete Part II of Session II of the user study, 49 out of 54 photos (90.7%) were identified correctly. Three out of four participants who did not identify 100% of the photos correctly were congenitally blind.

6.1.7.2.3 Session Three – Part I

Eight participants participated in session three of the user study; five had dropped out since the first two meetings due to time commitment and phone issues (not related to VizSnap). As mentioned before, the method for session three of the user study was identical to session two, consisting of a questionnaire followed by a short user study exercise (in which users retrieve the time and dates of photos described by the researcher).

A summary of themes (along with the number of occurrences) observed for open-ended questions and analysis of quantitative questions are given below:

1. What do you think about this app VizSnap?
    - Incredible/neat application (5)
    - Well organized (4)
    - Likes voice tagging/voice memos (2)

2. What problems have you experienced with VizSnap these last two weeks?

- The volume is too low (4)
- Knowing the photo quality (2)
- Issues with sound recordings (2)

3. Out of the voice memo, ambient audio, time, date, and location information, which do you find the most useful in locating photos after you've taken the photo?

Five (55%) participants reported the voice memo to be the most useful piece of information in locating photos after they are taken. Three (33%) participants reported the date to be the most useful. Two (22%) participants reported the ambient audio to be the most useful. It should be noted that one participant reported all five modes of information to be equally useful. It should also be noted that one participant who reported ambient audio to be most useful uses the ambient audio as a voice memo (sometimes with long stories accompanying photographs). This would make the number of participants who reported the voice memo as most useful actually 6 and not 5, but since the participant stated ambient audio was most useful, we interpreted her response literally.

4. How often did you send your photos via email this last week? 0, 1-5, 6-10, more than 10?

Three (33%) participants reported having used the email function to email photographs through VizSnap. This could indicate that the longer that people use VizSnap, the more comfortable they feel to sending photos through email. Many

participants stated that during the previous session, they do not feel comfortable sending photos through email because of being unsure of the quality of the photo. Since participants are sending more photographs, this could indicate that participants feel more confident in the quality of the photographs they are taking, through using VizSnap regularly.

5. How often did you post your photos on Facebook this last week? 0, 1-5, 6-10, more than 10?

Four (44%) participants reported posting photos to Facebook. Last session, only 8% of participants reported posting photos to Facebook. This could be interpreted as people are becoming more confident in their photo taking ability (as participants noted that photo quality uncertainty was the main reason participants do not share photos) the more they use VizSnap.

6. What features do you think are missing from this app VizSnap?

- Volume should be louder (2)
- Access to the camera flash (2)

6.1.7.2.4 Session Three – Part II

All nine participants had sufficient photos to take part in Part II of Session 3 of the user study. The following list shows the accuracy of retrieval for each participant:

- P1: 5 out of 5 – 100%
- P3: 3 out of 5 – 60%

- P6: 5 out of 5 – 100%
- P7: 4 out of 5 – 80%
- P8: 3 out of 5 – 60%
- P9: 5 out of 5 – 100%
- P10: 4 out of 5 – 80%
- P11: 5 out of 5 – 100%

Total retrieval accuracy for all participants for this session was 34 out of 40, 85%. Overall retrieval accuracy was less compared to the last session. One reason this could be is that the participants have twice as many photos to choose from in their photo album (at least 70 per person) than last session, thus more photos to sift through. Out of the four participants who did not get perfect retrieval, two were adventitiously blind, and two were congenitally blind.

Pearson's product-moment correlation tests was calculated for number of words in voice memo and accuracy for retrieving the photograph to determine whether there is a positive correlation between how many words the user's voice memo contains versus how accurately they locate the photograph. There were no statistically significant values based on this correlation. This means that it is not just the length of the voice memo that determines how accurately the user locates their photograph.

6.1.7.3 Session Four

The purpose of the last session was to assess whether hearing a voice memo and ambient audio from a participant's photograph would increase recall of events surrounding the moment in which the photo was taken. The first group of participants (consisting of three) was given a description of the photograph, plus the time and date the photograph was taken, and asked to describe everything they could surrounding the event in which the photograph was taken. Then the participant is played the voice memo they created for that photograph, and again, asked to describe anything extra surrounding that moment that they can. Finally, the participant is played the ambient audio that was recorded as the photograph was taken, and asked to give any additional details surrounding the moment the photograph was taken. This is done for three photographs. This process is repeated for three more photographs, only this time, the participant hears the description plus time and date, followed by the ambient audio (not the voice memo), and finally the voice memo. The purpose of changing the order is to determine whether order makes a difference. This process is done with three out of the remaining six participants.

For the second group of participants (consisting of two), the participants are given the description plus time and date the photograph was taken, and asked to give as many details as possible surrounding the moment in which the photograph was taken. They are then given the voice memo of the photograph and asked to give as many additional details as possible. The ambient audio is not given to the participants of this group. The reason being that this group of participants used the ambient audio as

a voice memo (in other words, spoke the voice memo while the ambient audio was recording) in order to reduce the amount of gestures they had to perform.

Content Analysis was performed on the participants' responses to distill a list of themes occurring throughout their responses. The themes are listed here:

- Outside/nature
- People
- Vehicle
- Geographic Region
- Work
- Home
- Place (other than work or home)
- Object
- Celebration/Party/Holiday
- Food/Drink
- Confirmation of memory
- Electronics
- Emotion

Each clause uttered by each participant is examined and assigned themes based on whether that clause references any of the themes gathered by the previous content

analysis session. Some clauses may reference multiple themes. Utterances referring to the act of taking the photograph were omitted.

The total number categories that get mentioned for Description, Ambient Audio, and Voice Memo are added up to give an overall number of how many times any category was mentioned. The total for Description is then divided by the overall total to give a percentage that tells us out of the total number of categories that were mentioned, how many of those were mentioned after being given the Description. The same is done for the Ambient Audio and Voice Memo.

Finally, we then take the averages of percentages given by Description, Ambient Audio, and Voice Memo of all six photographs to produce a graph to show which piece of information elicits the most responses from the participants.

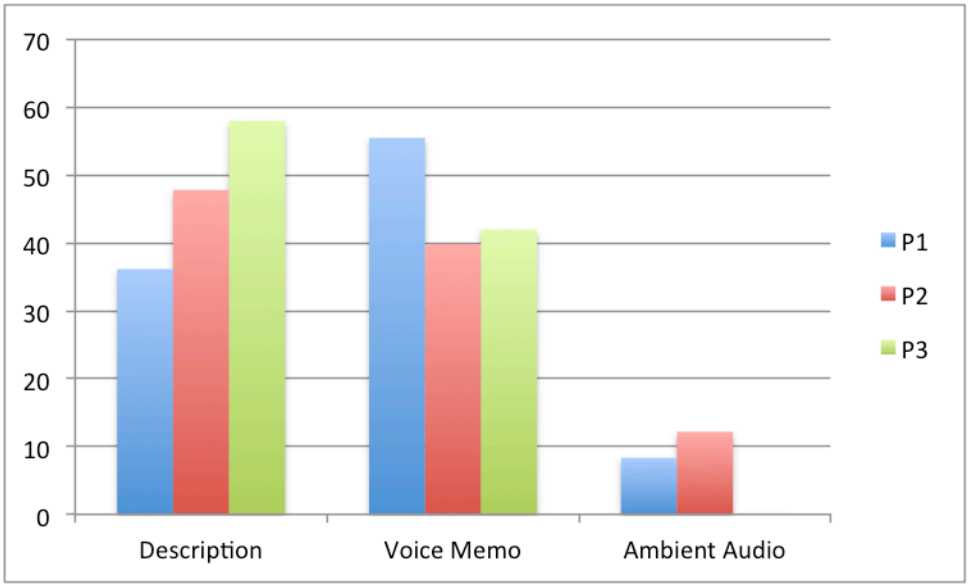

Figure 10. Percentages of Categories for the 3 types of information given for Participant 1 (P1), P2, and P3.

Figure 10 shows what percentage the categories they mentioned fell into Description, Voice Memo, or Ambient Audio for P1, P2, and P3. It may not be obvious from Figure 1, that the most categories mentioned by participants came after hearing the Description, followed by Voice Memo. We can see this by averaging all 3 participants' percentages to arrive with Description – 47.35%, Voice Memo – 45.8%, and Ambient Audio with 6.85%. This means that the Description elicits the most information out of the three pieces of information given to the participants.

Below is a short description of the session partaken by each of the first three participants'.

Participant 1: Specifically uses the voice memo to confirm the event for 2 out of 3 of the first photos. For 4 out of 6 photos, P1 has many new details to add to the event based on hearing the voice memo. On 5 out of 6 of the photographs, after hearing the ambient audio, the participant had no additional details to give of the event.

Participant 2: After hearing the description of one photo, P2 incorrectly thought it was referring to a different event, but after hearing the ambient audio, he was able to reassess (correctly) to which moment the photo was being described. For 4 out of 6 of the photos, the participant did not give any new information when given the ambient audio.

Participant 3: For 6 out of 6 of the photos, the ambient audio did not elicit any additional details surrounding the moment when played. For 5 out of 6 of the photos, the participant had more details to give as a result of hearing the voice memo. While VizSnap does not provide a description of the photograph, it does give the capability of attaching a VoiceMemo to the photograph.

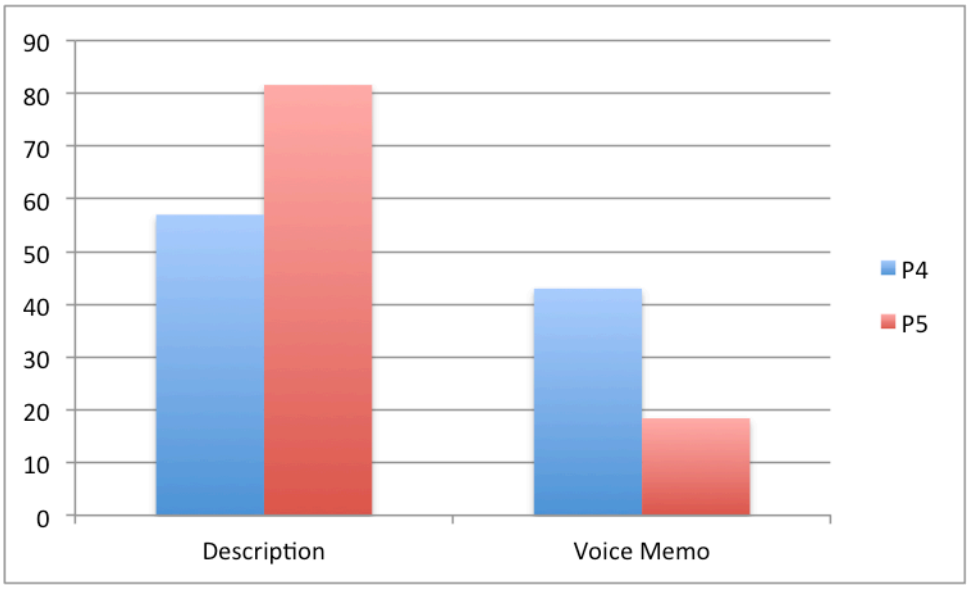

Figure 11. Percentages of Categories for the 2 types of information given for P4, and P5.

Figure 11 shows what percentage the categories they mentioned fell into Description, and Voice Memo for P4, and P5. The average for Description is 69.3%, while the average for Voice Memo is 30.3%, which means that the Description elicits more categories from these participants than the Description.

Participant 4: For 1 out of 5 of the photos, the participant corrected the memory he had being given the time, date, and description of the photographs. For the other 4

photographs, the voice memo only seemed to confirm what he originally thought being given the time, date, and description.

Participant 5: For 3 out of 5 of this participant's photos, she did not have any additional information to add after hearing the voice memo. In addition to not having anything to add, for 2 out of 3 of those photos, the participant specifically stated that she did not have anything else to add and remembered the event seemingly thoroughly. For the other 2 photos, the voice memo provided cues to elicit more memory.

Based on the results given from P1 – P5, we can see that the Description of the photograph elicits more response (in terms of categories) from the participants than the Voice Memo, and the Ambient Audio. Be that as it may, the Voice Memo, which is an essential part of VizSnap, still elicits significant responses from participants; the data verifies this.

6.1.7.4 Analysis of the Photos

There were exactly 800 photographs collected from participants throughout the user study. Two researchers came up with categories for the photos in which were agreed upon that all photos must fall into. The researchers made a first pass through the photos, came up with the initial categories, then one researcher counted how many

photos fell into each category. The categories were the following, with the number of photos falling into each category listed alongside:

- Animal/Pet - 46
- Electronics - 40
- Food/Drink - 82
- Group - 46
- Household item - 54
- Individual person - 103
- Outdoor scenery - 225
- Plant - 59
- Toy/Craft - 69
- Vehicle - 73
- Whole room - 36

It should be noted that some photos fell into multiple categories.

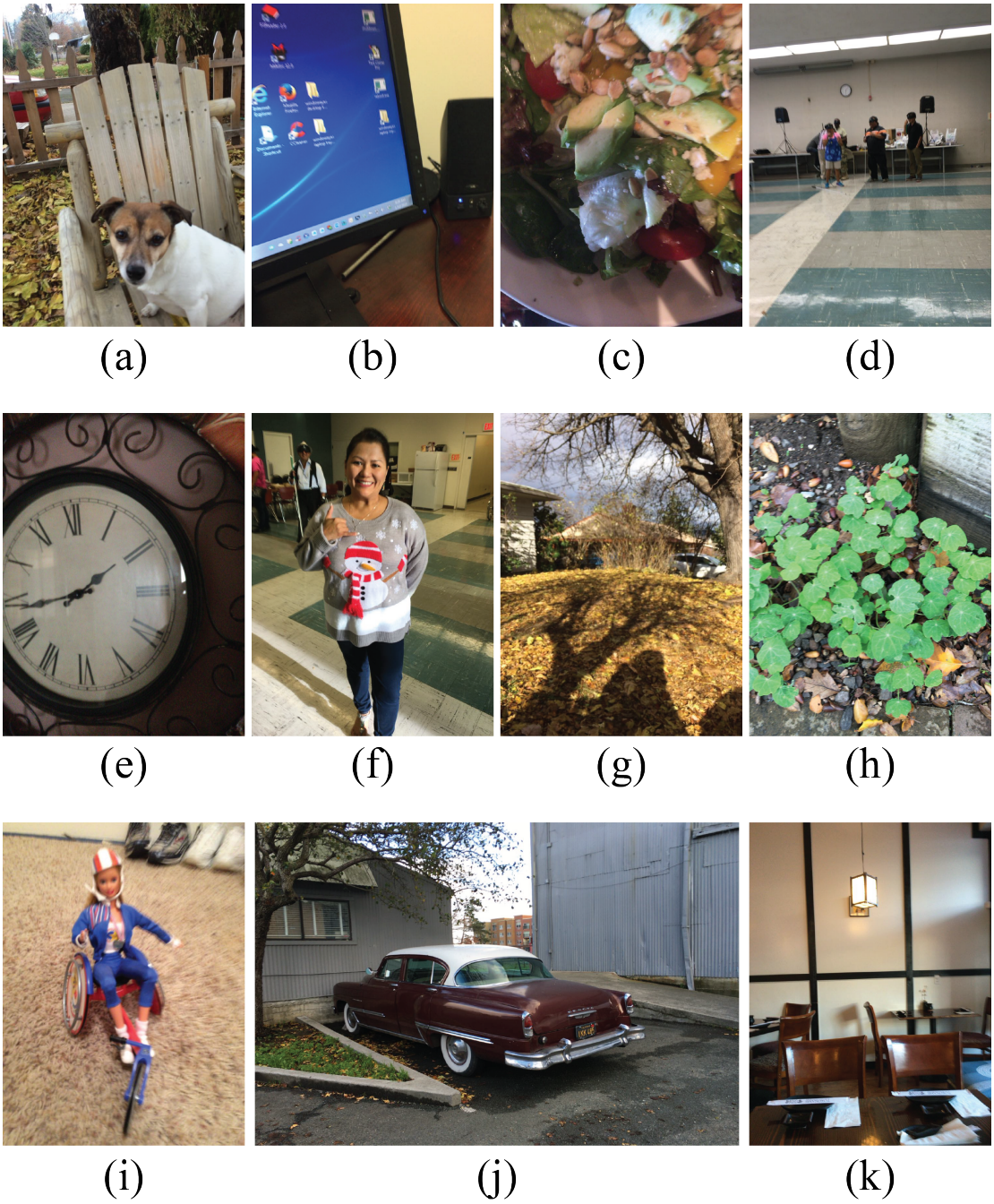

Figure 12. (a) Animal/Pet, (b) Electronics, (c) Food/Drink, (d) Group, (e) Household item, (f) Individual person, (g) Outdoor scenery, (h) Plant, (i) Toy/Craft, (j) Vehicle, (k) Whole room

Figure 12 shows a sample photograph from each category.

6.2 Discussion

This user study set out to answer these three research questions:

1. What kind of photographs do blind photographers take?
2. Do blind photographers make use of sound recordings, time, date, and location information to help them recognize their photo?
3. What are some of the issues that blind photographers face when using VizSnap?

In regards to research question 1, our analysis of the photo corpus indicated that outdoor scenery is by far the most common type of photographs blind persons take (double any other category). This is an interesting finding as there is much support for face detection that can help browsing without sight when the topic of the photograph is person(s) but not much support is available for outdoor scenery recognition.

In regards to research question 2, during session two, 54% of participants reported ambient audio to be the most useful mode of information for retrieving photos after they have been taken, while 38% of participants reported the voice memo to be the most useful. During session three, 55% of participants reported the voice memo to be the most mode of information for retrieving photos, followed by the date (33%), and finally the ambient audio (22%). We see a shift between sessions two and three from users finding the most useful mode of information when retrieving photos to go from ambient audio to voice memo. The growing number of photographs could account for

this; users rely on more specific information, i.e. a voice memo, to retrieve photos rather than the audio that is being recorded while the user aims the camera. Participants' responses indicate they do indeed make use of audio recordings, time, date, and location information when retrieving photographs.

As noted in the Results section, participants achieved an accuracy of 90.7% when retrieving photos during session 2 and 85% accuracy when retrieving photos during session 3. While we would like to see these numbers closer to 100%, they nonetheless indicate that participants retrieve photos accurately an overwhelmingly majority of the time when presented with voice memo, ambient audio, time, date, and location information.

In regards to research question 3, out of the problems that participants experienced using VizSnap, knowing the photo quality and the volume being too low seemed to persist from session two to session three. Performing the correct gestures was a theme that was observed as a problem for participants during session two, however, this theme was not observed during session three. The reason this theme disappeared could be due to the repeated use of VizSnap, thus the participants were practicing and learning the gestures and no longer found them to be a problem.

During session two, the themes that occurred when participants were asked which features they felt were missing from VizSnap were Photo quality feedback, Access to

camera flash, Volume should be louder, Accessing front facing camera. During session three, the themes that occurred when asked the same question were Volume should be louder, and Access to the camera flash. Participants no longer expressed desire for Photo quality feedback, or Accessing front facing camera. As mentioned before, more participants were sharing their photographs from session two to session three, possibly indicating they had more confidence in their photo taking ability. This could also account for the participants no longer desiring feedback of the photo's quality.

The overarching goal of this user study was to determine whether appending voice memo, ambient audio, time, date, and location information to a photograph assists blind smartphone-based in taking photos and maintaining a photo album. Observing the increased rate of sharing photos online, along with positive feedback from participants regarding their usage of VizSnap, and finally the observed lack of desire to continue having photo quality feedback from session two on to session three – signifying an increased confidence in photo quality – we believe that appending the aforementioned metadata to a photograph not only assists with organizing a photo album, but also increases confidence with taking, retrieving, and sharing photographs.

Chapter 7

Conclusion

Photography is a past-time enjoyed by sighted and blind people alike; for many reasons, including to capture a moment in time, to share with others, and to post on social media. Due to the visually oriented nature of photography, photographs can sometimes be difficult to experience or locate for people who are blind. While a decent amount of work has already been done to help people who are blind to take a photograph, there has been little work done to help people who are blind experience or locate photographs after they have already been taken.

It is necessary to understand all aspects of photography among blind people in order to assess which areas need the most work. This dissertation research has aimed at providing a deep understanding of topics in blind photography that are somewhat well understood, as well as those that have not yet been thoroughly researched. A justification has been provided of why a deeper understanding of photography among people who are blind needs to be more thoroughly understood through an exhaustive research review, as well as preliminary research. This preliminary research led to the interviews and survey, which informed the features of a blind-friendly iPhone app, called VizSnap, which facilitates independence for taking, sequential browsing browsing, and sharing photographs by utilizing audio recordings (recorded at the time of photo capture), time, date, and location the photographs are taken.

VizSnap provided a platform on which theories could be tested regarding whether adding the aforementioned metadata (audio recordings, time, date, and location) facilitates independence for taking, sequential browsing (as opposed to global browsing), and sharing photos among blind photographers. VizSnap also provided a platform to analyze the types of photographs taken, as well as the quality of photographs, by people who are blind. Alongside the analysis of photographs taken by users of VizSnap, photographs taken by members of a Flickr group called Blind Photographers, as well as their forum postings, were analyzed to extract the types and quality of photographs taken by blind photographers, as well as common problems experienced in the practice.

The contributions of this dissertation research are as follows:

- Thorough analysis of the methods commonly used with photography among people who are blind.
- Thorough analysis of the types of photographs captured by blind people.
- iPhone application (VizSnap, currently available on the app store for free) to help facilitate independence with photography among people who are blind.
- Short-term, as well as long-term, user studies with VizSnap to assess its viability.
- Motivation for developers to take up Universal Design.

The motivation behind these separate, but ultimately related studies is to contribute to the understanding of photography among people who are blind. Tools can be built to cater to the photography community that simultaneously serve both sighted and blind people. The ultimate goal behind this research is to encourage developers of technology to more frequently undertake Universal Design during the development stages, and not after the fact.

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