GuideCall: Affordable and Trustworthy Video Call-Based Remote Assistance for People with Visual Impairments

ABSTRACT

Blind or Visually Impaired (BVI) individuals often face many challenges while performing daily tasks or exploring new places. Assistive technologies can help a BVI individual to be independent by addressing some of these challenges, but there remain many tasks that still require some sort of human assistance. Given that human assistance from someone nearby is not always possible or preferable, there is an increasing trend of using video-calls to receive assistance from a human remotely. To better understand how well current remote video-calling applications serve the needs of BVI individuals, this work conducts an online user study with 55 participants. The responses received suggest that the current approaches to provide remote assistance through video calls are either too expensive or do not use helpers whom a BVI individual can fully trust. This work presents a smartphone application called GuideCall that enables BVI individuals to draw assistance through a video call with a single volunteer helper selected from one of many pre-constructed situation-appropriate groups of trusted individuals. GuideCall provides a unique combination of features not present in commodity video-calling applications and is specifically built to meet the needs of BVI individuals. Preliminary evaluations show GuideCall to be fairly effective in many daily tasks BVI individuals encounter, potentially proving to be an inexpensive option for receiving assistance while being more confident about the quality of assistance, privacy, and safety.

ACM Classification Keywords

K.4.2. Computers and Society: Social Issues; Assistive Technologies for Persons with Disabilities

Author Keywords

Assistive Technologies; Blindness or Visual Impairment; Video Streaming; Mobile Technologies

INTRODUCTION

Visual perception plays a central role in completing many tasks of our daily routine, such as indoor and outdoor wayfinding, locating items of interest at a store or office, comprehending visual signs and printed text, and getting a general sense of the current state of the surroundings. These tasks can pose great challenges for blind or visually impaired (BVI) individuals leading to the need to spend significant amount of additional time and effort (compared to sighted users) to complete these tasks (if they can be completed at all), potentially taking on undue physical risks in some cases.

There has, thus, been prior research to overcome these challenges. For example, there has been a lot of work in the area of indoor and outdoor wayfinding through the use of global-positioning systems (GPS), computer vision and artificial intelligence (AI), and wireless technologies to provide location and associated contextual information for BVI users (for example, [1, 12, 16]). Even with these emerging advancements, there will continue to be many instances when the limitations of these solutions (such as lack of infrastructure or conditions unsuitable for the technology to work) will result in a BVI user not fully being confident in relying on them. In such cases, it always helps to be able to rely on another human's assistance to bridge the gap and provide the necessary assistance. Unfortunately, there are many situations where a BVI person may be alone with no one present in spatial proximity to provide assistance upon request.

There has thus been a growing trend of BVI individuals resorting to remote assistance from others by transmitting real-time images or videos [3, 4]. The remote sighted assistant or "helper" comprehends the received images visually and passes along any information gleaned to the BVI user, thereby "filling in" any of the latter's information gaps towards completion of the task. These systems, unfortunately, are either expensive to use due to high labor costs of the helpers (in the case of Aira [3]), or untrustworthy due to the use of unknown and typically untrained volunteers (in the case of BeMyEyes [4]). Additionally, contacting outside help may be restricted in situations that involve the workplace. Personal video calls through applications like FaceTime are common, serving as an inexpensive, trustworthy option utilizing known helpers. Finding someone to help in a hurry may not be easy with such commodity applications intended primarily to connect with a single person at a time, and they were never designed to serve BVI user needs.

This paper presents the GuideCall remote video-based assistance system that allows a BVI user to seek and get assistance from a trusted set of known individuals through a free smartphone-based application. GuideCall allows the user to populate and create trusted groups for specific life scenarios (such as work, personal) and reach out simultaneously to all members of a group when assistance is needed. The first person to accept the call takes on the assistant's role with all others notified that assistance is no longer needed. Beyond a simple video call interface that is designed to be BVI-friendly, GuideCall provides tools for a remote assistant to (i) control the BVI user's smartphone to better assist them, and (ii) see

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real-time location information in embedded maps as a user moves around utilizing GPS or other indoor positioning information available. Such a unique combination of features (see discussion on uniqueness in Section 3) are designed to make GuideCall to be more effective in completing the daily tasks when assistance is needed. Results of an evaluation study establish the efficacy of GuideCall in facilitating typically challenging tasks for BVI users. A systematic study is subsequently performed to better understand whether the options GuideCall provides will prove practical and useful to BVI individuals. Although applications like Aira and BeMyEyes have been around for a while, we believe this paper presents the first systematic study to understand who BVI individuals trust to provide assistance in various situations of work, home, and outside of work and home.

The major contributions of this paper can be enumerated as the following:

1. A literature review of the various options to receive remote assistance through smartphones to accomplish various daily tasks for BVI individuals, and identification of areas of improvement with respect to the existing options

2. A user study of 55 BVI individuals posing questions about habits and preferences of using remote video-based assistance and ascertaining who they trust in various life and work situations, helping establish appropriate motivations towards designing GuideCall

3. A detailed description of the design and implementation of the proposed GuideCall app and its unique features such as customized group-calling, indoor wayfinding capabilities, and tools for helpers

4. An extensive evaluation of the effectiveness of GuideCall (and remote video-based assistance in general) in completing challenging tasks for BVI individuals and its current limitations

RELATED WORK

Numerous assistive technologies have been developed over the years to assist BVI persons with daily tasks. With the advent of GPS-based positioning, outdoor wayfinding has become easier using mapping software from Google, Apple, Microsoft, MapQuest, OpenStreetMap and others. However, indoor wayfinding had still remained a big challenge. There have been many recent efforts in the area utilizing wireless devices or computer vision to provide location information and context within indoor spaces [14, 11, 20, 12, 1, 2]. In addition to the application to wayfinding, the use of computer vision promises to serve as the "artificial eye" allowing a BVI person to capture and analyze images using a smartphone and identify text and objects around them as captured within images [16]. This has resulted in many applications emerging such as CamFind [10], TapTapSee [13], KNFB [15], BeSpecular [5] and SeeingAI [18], or something as simple as an app for magnification [19]. Other advances have been in the area of web accessibility and screen readers allowing BVI persons to participate in today's increasingly digital society.

The various assistive technologies mentioned above have limitations, however. GPS location accuracy isn't always good enough to guide BVI users on walkways. There are many outdoor locations with poor line of sight, such as around skyscrapers, where GPS accuracy is very poor to be even used for even approximate positioning. For indoor wayfinding, the use of wireless communication devices presents challenges in terms of interference with other wireless signals and fading. Providing such an infrastructure of wireless devices within indoor spaces is in itself a large undertaking and it may not be economically feasible to adopt everywhere at adequate densities. Computer vision-based approaches have limitations in terms of how well (angle, lighting, etc.) a BVI person can capture images for analysis in addition to being able to pose and receive meaningful queries and responses. Web and computer screen accessibility technologies can fail periodically due to inadequate conformity to standards by content designers or device resource limitations. In general, assistive technologies can fail due to software or hardware malfunctions or incorrect usage by the human involved. Keeping a human in the loop to correct or overcome limitations of any assistive technology being used provides greater peace of mind to a BVI user and encourages adoption and use towards overcoming daily visual challenges and/or breaking down social accessibility barriers. The evolution of self-driving or autonomous cars provides a similar case-in-point. Even with many advances in the technology, a need to keep a human in the loop for assistance has been felt. As a result, humans are likely to be involved from within these cars or from a remote location, to provide assistance for unanticipated situations. Such remote human involvement for rare corner cases allows technology offerings to be possibly provided earlier and at a lower cost to users than if full automation were desired. For BVI users, access to technology for independent living cannot come soon enough.

Given that on-call human involvement can be important to provide BVI users the confidence to meet many daily challenges, it is natural that there have been efforts to facilitate such involvement through the use of technology. It can be challenging to find human assistance in the geographic vicinity of a BVI user when the need arises. Thus, most approaches have focused on remote assistance from someone that is expecting such a request and prepared to assist. BVI users can make individual calls and share image or live video from smartphones through apps like Skype, FaceTime, etc., but it may take a while before someone accepts to assist given the sequential nature of finding such a person. Group calls on the other hand do not easily allow selecting one user and continuing a call with them for further assistance. These commercial collaboration services were also never designed keeping in mind the needs of a BVI user and to serve as an assistive technology with a remote person helping another for visual tasks and wayfinding. VizWiz was introduced a way for a BVI user to pose questions about their environment to remote crowdworkers who could look at shared images and answer questions [6]. Aira is a successful commercial venture that allows the BVI user to call in to a dedicated number and receive assistance from a trained orientation and mobility specialist [3]. The BVI person can use a smartphone or an extra-cost eyeglass device that provides images to the remote helper to look at

and provide assistance. BeMyEyes is a similar service to Aira but is based on the use of a smartphone app and relies on unpaid volunteers to serve as assistants [4]. All three of these approaches have limitations. Both VizWiz and BeMyEyes provide assistance from people who have not established trust with the BVI user. This is a very important factor for a BVI user to feel confident about the assistance they are receiving (see Section 3 for details). A trusted helper can potentially alleviate privacy concerns of the BVI user and allow images to be shared that may contain potentially sensitive financial, personal, or corporate information. Previous work has also identified safety as a factor to consider due to incidents where a BeMyEyes volunteer attempted to come to the geographic vicinity of the BVI user to provide assistance [9]. Because Aira uses trained employees, there is likely to be greater trust established with those providing assistance. But because these agents work for Aira, sensitive corporate information from a BVI employee could be transmitted outside the premises. The biggest disadvantage with Aira is the high cost of the service, which runs at about $1/minute and can easily add upto hundreds of dollars a month for a BVI user.

GuideCall as a system attempts to provide the level of quality of assistance BVI users receive from Aira but at a much lower cost or for free. It is built as a smartphone app that a BVI person uses to request assistance from a trusted group. Because assistance is sought from a chosen group simultaneously (in parallel), the delay in getting someone to help is likely to be much shorter than sequential calls for assistance (such as with Skype or FaceTime). Multiple groups can be configured for various assistance-requiring scenarios, be it at work, home, or somewhere else. At work, where sensitive corporate information may not be shared with an outside person, a group could be created comprising only of co-workers. At home, trusted friends and relatives could provide assistance in finding documents or objects. Each potential helper can be labeled with trust levels. A BVI user only needs a smartphone with access to WiFi and/or data service from a cellular network. GuideCall provides real-time location updates for helpers using embedded maps allowing them to provide more knowledgeable assistance, not just in GPS-covered satellite locations, but also indoor locations that are so provisioned.

There have been other work in peripheral areas that are related to this work. The work in [8] investigated the appropriateness of social network question asking as a resource for blind users using VizWiz Social. HintMe [17] is another Q & A posing tool developed for BVI users utilizing their smartphones. Prior research has generally identified various tasks that BVI individuals require assistance with and are amenable to seeking remote-assistance [7]. The main difference of this work with such prior work is that GuideCall seeks assistance through video calls. A video call has the potential to help accomplish a different set of tasks than what an app built to pose queries was designed to do. This brings forth its own system design challenges along with the need to consider multimodal interactions with a remote helper. The fact that applications such as Aira and BeMyEyes are very commonly used (as will be discussed in the following section), suggests that this mode of seeking assistance is a very important area to consider for research.

USER STUDY MOTIVATING GUIDECALL

Although FaceTime, Skype, Aira, BeMyEyes and other similar video-calling applications have been around for a while and known to be used by BVI individuals, little is known about how often such applications are used and in what situations they are used. In order to better understand the role these apps play, their benefits, and their limitations, an online survey was created to gather responses from BVI individuals. The results of this study will be used as motivation for the design and implementation of the GuideCall app to be presented later in Section 4.

Method

An online survey was created using Google Forms and distributed via email after gathering appropriate IRB approvals. Emails were sent to all known prior participants (about 25) we had engaged with over the past 2-3 years for other studies. In addition, the survey was distributed to a mailing list associated with the American Council of the Blind (ACB). No compensation was offered for participating in the study, and the survey took between 10-15 minutes to complete. Participants were required to be blind or low vision to be eligible and at least 18 years of age. All responses were collected anonymously without any identifying information.

Survey Structure

The survey had two main parts. The first one was mainly collecting demographic information such as age, gender, vision category (blind, low vision, neither), and comfort with using smartphone apps.

The second part asked questions about the situations in remote video-based assistance was typically sought, how often, and who was considered the most trusted to offer such assistance in each situation. Participants were also asked what apps they commonly use for remote video-based assistance.

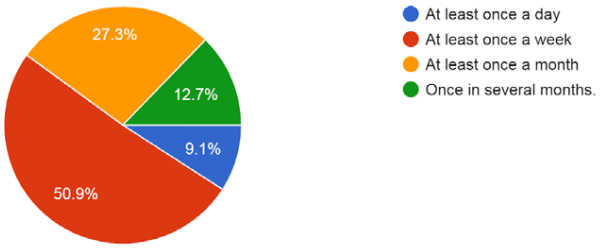
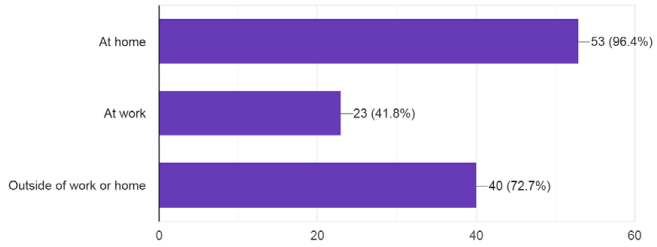


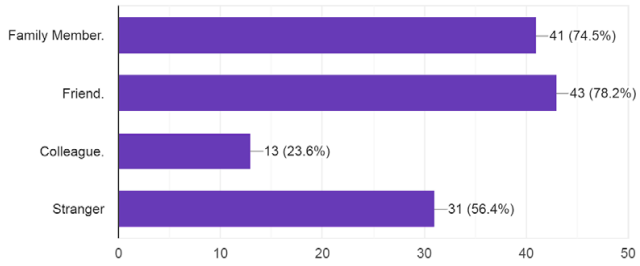
Figure 1: How often do you request remote, video-based assistance?

Results

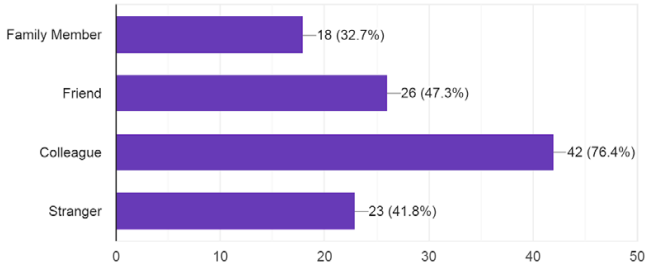
A total of 55 responses were received. Participant age fell mainly (and almost evenly spread) in the 29-69 age group, with only 15% total for the ranges 18-29 and beyond 70. Almost all participants identified as being regular users of smartphones



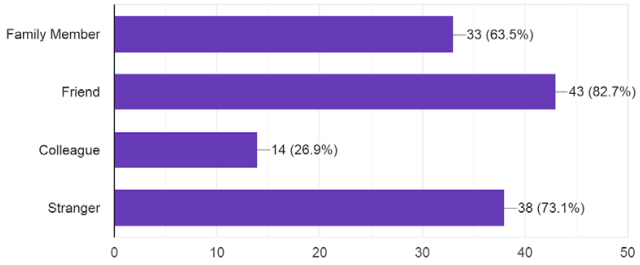
(a) Where have you requested remote video-based assistance from someone in the past?



(b) Who do you trust as a remote, video-based sighted assistant for situations arising at home?



(c) Who do you trust as a remote, video-based sighted assistant for situations arising at work?



(d) Who do you trust as a remote, video-based sighted assistant for situations arising outside of work or home?

Figure 2: Results from a survey of BVI participants seeking to understand how often, where and how they seek remote video-based assistance.

and various apps. Participant responses to the specific questions about using remote video-based calling are summarized in Figures 1 and 2.

The result in Figure 1 that remote video-based calling is used very frequently, with 60% using it at least once a week, supports the premise of the paper that this is an important area to add new options for users to consider, including low-cost ones.

For the question of what situations remote video-based assistance has been sought in the past, respondents identified (Figure 2a) home as the scenario where they have used help the most (96%), followed by outside work or home (72%), with work being the situation where they sought least help (41%). Part of this result is explained by the fact that some of the respondents indicated through comments that they are retired or not employed at the moment.

For the question of who BVI users trusted to provide remote video-based assistance at home, respondents identified (Figure 2b) friends (78%) and then family members (74%) as the most trusted with strangers (56%) to a lesser extent followed by colleagues (24%) as the least trusted. User comments indicated that when sensitive information, documents, selection of something for the home, etc. are involved, they trusted a stranger less. On the other hand strangers were preferred when it was perceived that a friend or family member is not needed, putting less burden on the latter set. Colleagues naturally are not thought of for help at home, unless a close friendship exists with someone.

For the question of who BVI users trusted to provide remote video-based assistance at work, respondents identified (Figure 2c) colleagues as the most trusted (76%) followed by friends (47%), with strangers (41%) and family members (32%) to a lesser extent. User comments indicated that wariness of revealing sensitive information to people outside made colleagues the most trusted choice. Friends were thought of as an in-between trusted partner if colleagues were not available. Complete strangers and family members were not thought of as good choices in work situations with documents or computer tasks.

For the question of who BVI users trusted to provide remote video-based assistance outside of work and home, respondents identified (Figure 2d) friends (82%) closely followed by strangers (73%) and then family members (63%) followed by colleagues (26%) as the least trusted. User comments indicated that when sensitive information is not involved, friends were most trusted, and usage of strangers were fine too if safety and/or privacy was not important. Colleagues were again not thought of as ideal helpers for this situation.

Selected Comments

In this paper we do not go into all the qualitative aspects of this study due to space constraints; however, a few user comments are presented verbatim below to provide an idea

of user experiences and thoughts about current remote video-calling options.

AIRA is sometimes financially difficult for many people. So users do not use the number of hours they would like to. In the Be My Eyes app, sometimes it is difficult to reach a volunteer. Sometimes the volunteers don't have much time or skill.

Be My Eyes is not always answered. AIRA is expensive. The call is sometimes dropped. The equipment is complicated to learn.

I have serious privacy concerns/I'm not sure any of these applications are taking privacy as seriously as they should.

Price for AIRA and lack of volunteers for be my eyes who can do longer tasks.

Be My Eyes, sometimes long waits for help and having to work with people I don't know. FaceTime: not always having a friend or family available who also has access to FaceTime. AIRA: the cost of the service and the effort of setup.

Discussion

Analysis of the survey data collected from BVI respondents revealed some useful insights regarding their preferences for remote, video-based sighted assistance. Firstly, it is true that strangers can prove to be ideal helpers in some situations, and can even be more preferable in reducing burden on friends an family. However, this was not a very strong or overwhelming feeling within the community and when costs (for example that of Aira) are factored in, friends and family can be equally if not more appealing as helpers. When asked what apps they mostly use, they mentioned Aira and BeMyEyes, with FaceTime, SeeingAI, BeSpecular, and Skype to a much lesser extent. The descriptive responses suggested that BeMyEyes has issues of trust, while Aira is more trustworthy, but not in all settings. Aira's costs were considered very high making users want an in-between option. In summary, the study identifies a need for an affordable and trustworthy remote video-calling application with features that are comparable or exceed that of existing options. We believe GuideCall fits this space very well and can be an option that best balances safety, privacy, convenience, functionality, and cost.

	Video Calling (eg., FaceTime)	BeMyEyes	Aira	GuideCall
Direct calls	X	X	X	X
Group calls	X	X	X	X
Outdoor location tracking		X	X	X
Indoor location tracking			X	X
Remote control of user smartphone		X	X	X
Fast assistance response		X	X	X
Trusted helpers	X		X	X
O & M trained helpers			X	
Inexpensive	X	X		X
Sensitive information preservation				X

Figure 3: GuideCall comparison with other existing options.

Table 3 provides a comparison of the features of the current remote smartphone video-calling applications available to BVI individuals and how GuideCall fits in. It can be seen that GuideCall provides all the features that Aira provides except that of assistance from orientation and mobility (O & M) trained professionals. Instead, it relies on groups consisting of trusted friends, family, or colleagues only. This, however, allows GuideCall to be affordable and also meet corporate guidelines by utilizing colleague work groups in work situations. GuideCall stands out from other free applications such as BeMyEyes by having the capability to integrate real-time indoor positioning technologies in addition to getting assistance from trusted individuals.

GUIDECALL SYSTEM

After laying out the motivation for building an application such as GuideCall in the previous section, this section provides some details about the system architecture of the designed GuideCall application and its various components. Designed as a single smartphone application, it operates in two modes: BVI user and Helper. An overview of system architecture is shown in Fig 4.

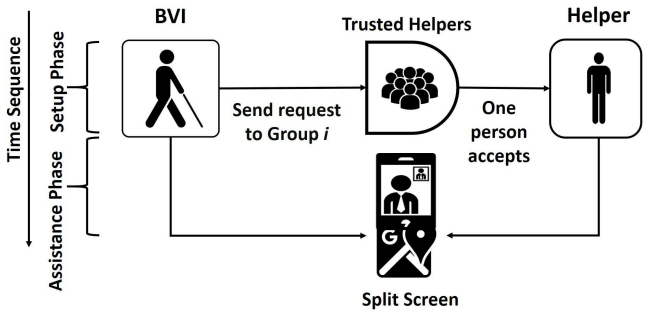


Figure 4: GuideCall System Concept

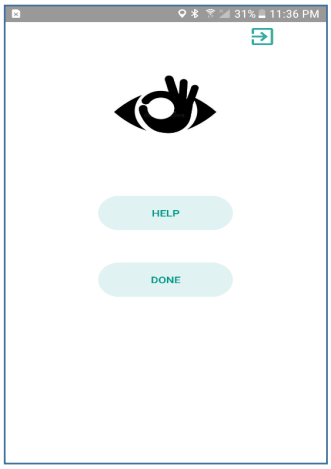
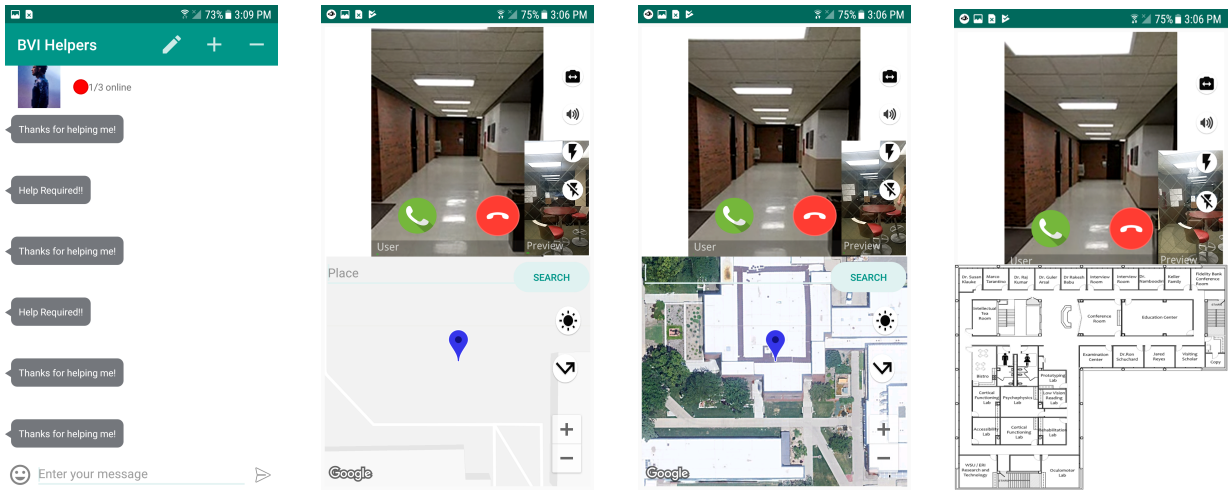


Figure 5: Initial screen on BVI side.

System Workflow

Whenever the BVI user needs assistance, the following steps will be followed through the application:



(a) Help request received as a chat notification

(b) Outdoor default map view

(c) Outdoor satellite view

(d) Indoor wayfinding view

Figure 6: Potential stages as seen on the helper side of GuideCall

Step 1: The BVI user opens the GuideCall app; if already signed in, the BVI mode screen activity will be displayed.

Step 2: Utilizing native accessibility features on the smartphone OS, (Google Talkback) the buttons and images inside the activity will be read to the user.

Step 3: To receive assistance, the BVI user selects a Help button. This triggers a notification "Help Required" to be sent to the smartphones of all potential helpers through a group chat application that contains all potential helpers within the selected group i ($i = 1 \cdots n$).

Step 4: One of the trusted helpers (who elects to provide assistance) will select the received message and click a Call option that becomes available. This will result in a video call to be connected between this helper and the BVI user and a notification to be sent to all other helper candidates in the chat that a helper is connected successfully with the BVI user. This will assure other potential helpers that someone has accepted to be a helper for providing assistance.

Step 5: When the call is connected, a video stream of the BVI user will be shared with the helper so that they can be the "eyes" of the BVI user in assisting with visual perception. To assist effectively, a helper user can access features of the BVI user's phone such as cameras (front and back), flash light, and microphone (to switch the speaker on if necessary). The video call can be viewed in full screen by double tapping on the frame and allows pinching by the helper to zoom in and out. Along with the video call, Google Maps is integrated into the application to assist BVI users in outdoor environments. This allows the helper to study both the default view and the satellite view and understand the BVI user's location and orientation and guide them towards the destination. Incorporation of indoor maps is a unique feature for GuideCall. In locations provisioned with an accessible indoor wayfinding system such as NavCog [1] or GuideBeacon [12], real-time location updates of the user walking can be shown on an image of the floorplan. This feature allows a helper to continuously learn about the context surrounding the BVI user and incorporate that in their instructions.

Step 6: Once a BVI user has got the assistance they need from a helper, they can end the call by clicking a Done button. This button will send a message of "Thanks for helping me" to the group chat and enables others to understand that the BVI user was successfully assisted.

The simple start screen on the BVI user's side is shown in Figure 5. A sequence of snapshots of the app on the helper side is shown in Figure 6. although not shown in the paper, the helper side app does not necessarily have to be run on a smartphone; it can also be run on a desktop or laptop providing another convenient option for a helper. To provide ease of access to users, there are some additional features to each of the messages sent or received by any user. A user can call any user inside the application by clicking a Call button. When there is a need of assistance for a BVI user, this feature is used by a helper to make a dedicated call to the BVI user. Each group chat has a capacity of 100 participants. When the capacity of a group reaches maximum, the user can create another group to add new users to and link the two groups if they choose to in order to create a virtual larger group. This linkage allows both the groups to receive the alert message whenever there is a need for assistance. GuideCall allows a BVI user to create different groups like Work group, Relatives group, Friends group, etc. Users can decide to which group the alert message should be sent in the application. Situations at work that involve sensitive documents or images can rely on the Work group, while personal situations may rely on one of the other groups.

Label	Participant characteristics	Test pattern
A	Blind, cane user	All tasks without and then with GuideCall
B	Light perception (LP) only, cane user	Only GuideCall
C	20/500 one eye, LP other, cane user	All tasks without then with GuideCall
D	20/150 both eyes, <20° visual field, cane user	Only GuideCall
E	Blind one eye, 20/800 other, dog user	All tasks without and then with GuideCall
F	Blind, cane user, speech impairment too	Only GuideCall except indoor wayfinding also without GuideCall
G	LP, cane user	Only GuideCall except indoor wayfinding also without GuideCall

Table 1: Participant labels and characteristics.

Implementation

Different services were used to implement the application and provide back-end support. The cloud communication service Quickblox that supports video calling, instant messaging, and push notifications was used to provide back-end support to GuideCall implemented as an Android app. While Quickblox was used to store user account information and group chats, Apache Maven, an automation tool that is used to build Java applications was used to create repositories. Vidyo, a software-based visual collaboration technology provider, was used to integrate video calling features in GuideCall. As the video call requires scarce mobile CPU, data, and memory, codecs designed deliberately for smart phone devices were used. Google Firebase was used to provide store all information about a BVI user's location updates. Helpers can use this information to track the BVI user's location on Google Maps (with adequate permissions set), even if they are not actively assisting through a video call. This may provide an additional layer of safety on the background for a BVI user. Indoor floor plans and BLE beacon-based localization was used to track user locations indoors as they moved, with the potential to add other open-source indoor mapping and tracking applications as they become available; this distinguishes GuideCall from the proprietary indoor positioning that Aira uses currently.

EVALUATIONS

The primary objective in evaluating GuideCall was to measure its efficacy for tasks that prove challenging for BVI persons to accomplish independently. Four different tasks, that were identified through discussions with BVI individuals as challenging to accomplish independently, were chosen.

Challenge Scenarios as Tasks

Outdoor Wayfinding: To locate and navigate to any unfamiliar outdoor location, BVI users typically employ a GPS-based application. Unfortunately, the instructions from such mapping applications may not be fine-grained enough for BVI pedestrian navigation. Additionally, real-time information such as safety in crossing streets (especially those without any crosswalks and traffic lights) is lacking. For this task, we ask a BVI participant to walk to the entrance of a nearby (about 400 ft away using shortest path) building unfamiliar to them. Any path taken require crossing a street without crosswalks or signals.

Indoor Wayfinding: Upon entry into any unfamiliar space, finding a specific destination within that space is always challenging. Without anyone to ask around, feeling around the entire space with hands is the only option currently if no other indoor wayfinding system for BVI users is present (as is typical). For this task, a participant is asked to locate a laboratory (about 100 ft away on the shortest path) from the entrance lobby of a floor.

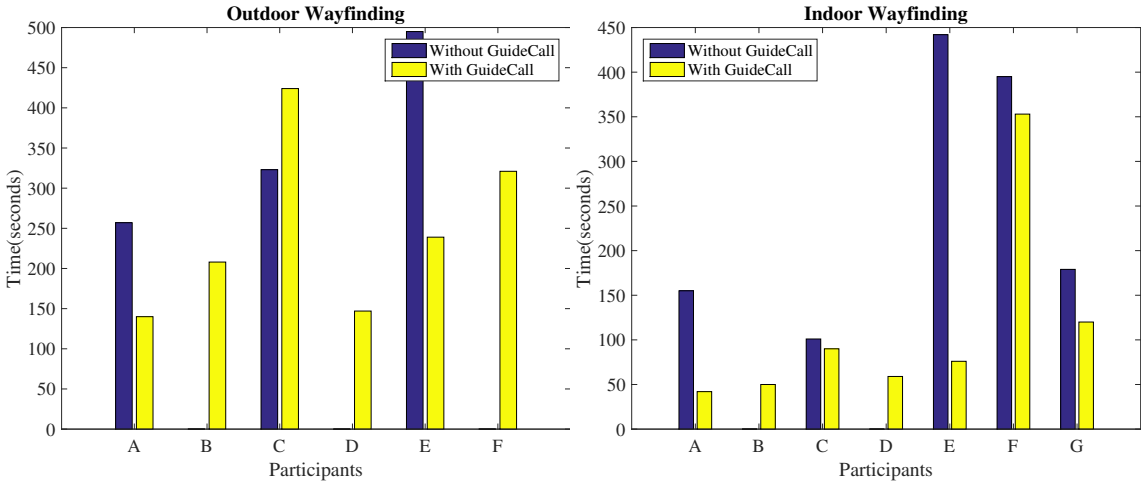
Computer Screen Task: BVI individuals heavily depend on a screen reader to interpret textual information on a computer screen. In instances where a screen reader does not work (frozen computer screen, image on screen instead of text), help is necessary. In this task, a computer screen with an image mimicking a frozen screen with error message is displayed and BVI users are asked to comprehend the situation.

Locating Objects: A common challenge is that of locating an item. Such situations arise in locating documents or objects within offices or homes especially if misplaced. In this task, BVI individuals are asked to find a misplaced handout document on an office desk kept second to last with seven other documents in the pile.

Method

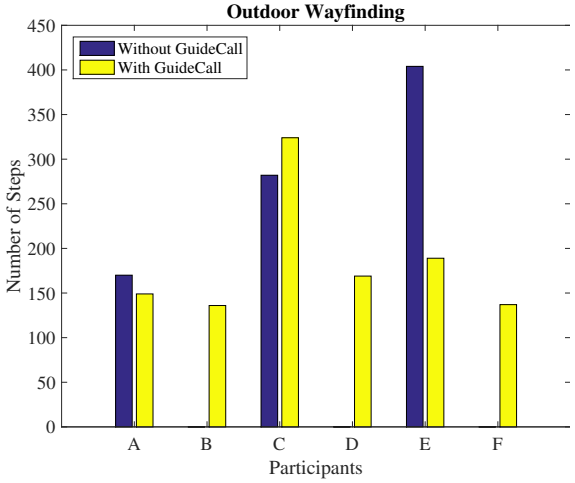
Seven BVI subjects (A-G) with varying level of visual impairments (see Table 1) were recruited. Given that this was a system evaluation and took considerable time from each participant (60 to 90 minutes), we believe the number of subjects chosen is adequate and in line with other assistive technology system evaluations. Each participant was paid $50 to complete the four challenge tasks. As a counter-balancing step, some participants were asked to only use GuideCall to understand if doing tasks without GuideCall first were positively impacting results for those that who utilize GuideCall later. Some of the participants were more used to relying on spatially available human helpers or not doing the task at all, while some were very used to utilizing various smartphone apps to accomplish similar tasks as best as they could. Given that the ability to track user location indoors is a significant feature of GuideCall, that task was the most extensively tested (in terms of number of participants) without and then with GuideCall.

For all tasks, participants were allowed to use assistive technologies they would generally use (if they do) to complete tasks. These include the use of smartphone-based mapping applications for outdoor wayfinding such as Google and Apple Maps, apps like SeeingAI [18] or magnifiers like SuperVision [19]. We believe this makes for a fair comparison between a remote video-calling app versus using other means. Qualitative evaluations with each participant was used to compare against other video-calling applications (such as FaceTime,

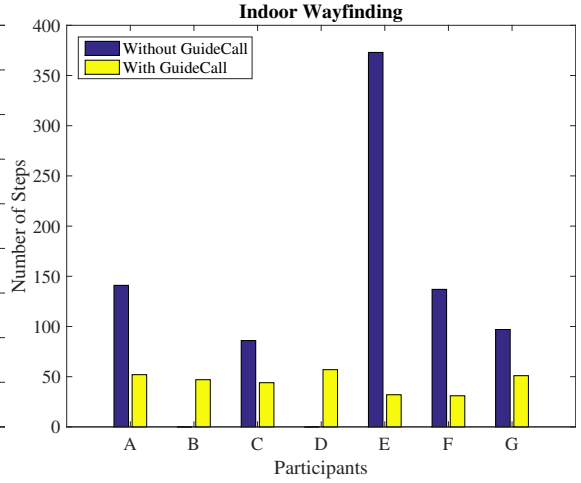


(a) Time for outdoor wayfinding

(b) Time for indoor wayfinding



(c) Steps for outdoor wayfinding



(d) Steps for indoor wayfinding

Figure 7: Task completion time and number of steps for wayfinding tasks

BeMyEyes, Aira), if they had used such other applications before.

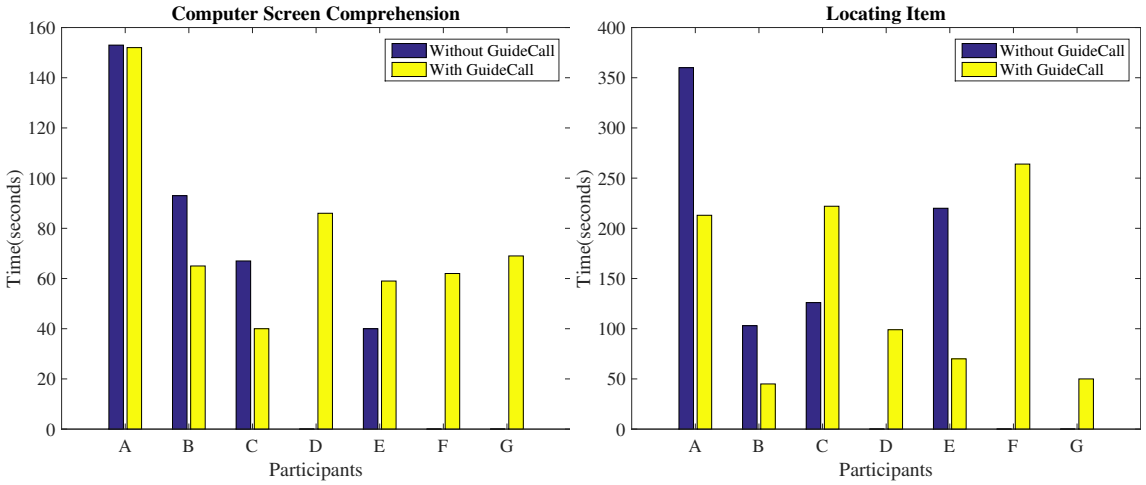
For all tasks, effectiveness of GuideCall is measured using the metric of task completion time. For wayfinding-related tasks, the metric of steps walked was also used to better drill down on why task completion took a certain amount of time (was it because of greater distances walked or just delays in receiving assistance). In addition, extensive qualitative feedback was gathered to evaluate the following: (i) the perceived effectiveness and issues in using GuideCall to a BVI user in completing tasks, (ii) the perceived strengths and weakness of using GuideCall compared to other options such as Aira and BeMyEyes to a BVI user, and (iii) the impact of a helper's familiarity to GuideCall and/or to the geographic area where assistance is sought.

The usability of the Android-based GuideCall app's user interface was not tested in detail primarily due to the fact that most of our subjects were iOS users. We have made functionality of the app the primary focus of the evaluations in this paper. Some feedback regarding usability from the perspectives of the BVI user and the helper have been captured through a user opinion survey after each user completed their allocated tasks.

Quantitative Results

Task completion times and steps taken for the wayfinding related tasks are shown without and then with GuideCall in Figures 7.

For the outdoor wayfinding task, navigation time (Figure 7a) for participants A and E show notable benefits of using a helper for guidance over Google Maps. The result for participant C showed the participant taking a lot more time with GuideCall than without; this was due to the use of a helper that was new to GuideCall and its features and had trouble determining from the outdoor satellite view where the main entrance to the target destination building was. Participants B, D, and F had



(a) Time for computer screen comprehension

(b) Time for locating item

Figure 8: Task completion time for computer screen comprehension and locating item tasks

User Label	Effectiveness Scores	Positives	Possible Improvements
A	OW = 10, IW = 10, CSC = 6, LI = 7	As an Aira and a BeMyEyes user, I can say that this will be very useful if sensitive data is involved; will be useful when danger is possible, and for subjective tasks in general; indoor wayfinding is way better than of even Aira	an iOS version is necessary; can place burden on friends and relatives
B	OW = 9, IW = 9, CSC = 9, LI = 9.5	GuideCall can be very useful to reduce my costs on Aira; did not face any lag in getting assistance when crossing street which is better than what I have faced with Aira and BeMyEyes	Camera focus seemed choppy for remote helper at first in locating item; had to ensure I keep camera steady for text based assistance
C	OW = 9, IW = 10, CSC = 9, LI = 9	Found the user interface and entire application simple to use; was nice to have someone offer assistance, will be really helpful if free to use	Need to get used to receive remote assistance for some of the tasks, where in the past I may not have attempted the task at all
D	OW = 8, IW = 7, CSC = 7, LI = 7	Does give a person confidence in maneuvering, do not have to ask a stranger, gives independence; helps find items in a pile; a human touch is better for me than just technology by itself	Helper was not able to see beforehand which direction the building entrance is; video resolution can vary with Internet connection sometimes
E	OW = 8, IW = 10, CSC = 9, LI = 9	Quick feedback, can communicate how to assist best, help them help you best; if you are lost and miserable, you are not alone; you constantly get new information both indoors and outdoors, unlike BeMyEyes; in my profession confidentiality is important a work group will be perfect	A wearable glass like Aira has will be useful at some times; cane users will enjoy this more as with a dog I have to deal with three brains (dog's, mine, and helper's)
F	OW = 6, IW = 7, CSC = 8, LI = 7	Was easy to locate document and do computer screen recognition (because I generally do not use any smartphone apps for such tasks)	Indoors it took some time for the helper to understand where I wanted to go; outdoors I was nervous crossing the street as I generally have someone go with me
G	OW = N/A; IW = 10; CSC = 10; LI = 10	Calling a group was faster and efficient in getting someone to help me; indoor navigation became very less stressful	A ringtone to say call is placed will be useful

Table 2: User information and subjective scores (1-10, 10 being best) and feedback. IW and OW signify the indoor and outdoor wayfinding tasks respectively. CSC and LI signify the computer screen comprehension and locating item tasks respectively.

better outcomes with GuideCall than all participants that did not use GuideCall. The corresponding step count results in 7b show that reduction in time taken with GuideCall is primarily due to the luxury of being directed through shorter paths to

the destination and minimizing the need to exploring alternate paths.

The greatest benefits of using GuideCall were seen for the indoor wayfinding task as evidenced in Figure 7b. There were significant benefits in using GuideCall for participants A, E, and G with smaller benefits for participants C and F. The lower benefits, we believe, was due to the fact that participant C had some useful vision that was utilized in conjunction with a smartphone magnifier app to wayfind indoors. Participant F's speech impairment in addition to the unfamiliarity of the helper used for that person may have contributed to the result. Participants B and D, testing with only GuideCall, took very little time to get to their destinations. The benefits of GuideCall is greater (a roughly 50% reduction) in terms of number of steps that needed to be taken to arrive at the destination; this is because there is rarely any guidance available for indoor environments that BVI users can currently use. A system like GuideCall utilizing existing indoor wayfinding technology can make a major difference in unfamiliar environments through real-time location updates.

For the computer screen comprehension task (Figure 8a) GuideCall still seemed useful at interpreting screen information for many users, especially those that did not typically use any smartphone apps. The results for participant E was an anomaly; this was due to the user being very adept at using the KNFB app [15] which did not have the overhead of calling someone first. Participants D, F, and G used GuideCall only and completed the task fairly quickly. In general, the computer screen resolution and size as viewed through a smartphone's video camera posed some issues and the helper had to request repositioning the BVI user phone a few times.

Finally, for the locating an object (document) task (Figure 8b), only participant C was able to accomplish the tasks faster without GuideCall. This was primarily due to their residual vision which just required a magnifier to complete the task. Participants D and G accomplished their tasks fast with GuideCall but participant F had trouble accomplishing the tasks due to low video quality as result of a poor WiFi connection at the time of the test.

Qualitative Results

User feedback about their experience with GuideCall is presented in Table 2. Interesting aspects to be gleaned include comparisons to BeMyEyes and Aira from those who have used them, and overall effectiveness of GuideCall to accomplish tasks. The feedback seems to suggest that GuideCall can reduce costs on Aira, while being more trustworthy than BeMyEyes. Users even felt that for situations at work, GuideCall is a better option than Aira and BeMyEyes in using a colleagues group. Those who have not used such a remote video assistant before liked the human touch in receiving assistance and how it enabled them to complete tasks which the may not have attempted before without having someone in proximity assist them. The ability to get assistance to navigate indoors was a major feature difference with BeMyEyes; some even found wayfinding assistance in general to be easier to receive.

Helper experiences

Three different helpers were used during our evaluations; none of them had undergone any training or had experience with orientation and mobility guidance for BVI individuals. The same helper was used for participants A, B, D, E, and G and this person had used GuideCall before and was somewhat familiar with the geographic area (indoor and outdoor) we tested in. Helper for participant C knew the geographic area, but was using GuideCall for the first time. The helper for participant F was unfamiliar with both GuideCall and the geographic vicinity. From the quantitative results, it can be observed that unfamiliarity to GuideCall and its features can have some impact on the outcomes for participants; time taken to complete tasks with participants C and F could be considered as on the higher side. All helpers found GuideCall easy to use and connect to a BVI user. The second helper had some trouble determining where the entrance to a building was using just the satellite view of Google Maps. The speech impairment of participant F made the third helper's job difficult in terms of verbal communications through the app. The third helper also needed some time to learn how to use the split screen of BVI user's camera and their location. All helpers felt that poor video quality due to bad network connectivity can make it difficult to identify small fonts through the video camera. With greater familiarity to the application, due to repeated use of the same group of helpers over time, it is expected that outcomes with GuideCall will only improve. A longitudinal study of the effectiveness of friends, family, and colleagues as helpers with GuideCall is a task for future work.

CONCLUSIONS

This paper presented the GuideCall remote video-based assistance system that allows a BVI user to seek and get assistance from a trusted set of known individuals through a free smartphone-based application. GuideCall allows the user to populate and create trusted groups for specific life scenarios (such as work, personal) and reach out simultaneously to all members of a group when assistance is needed. This paper provided a detailed description of the design and implementation of the proposed GuideCall app and its unique features such as customized group-calling, indoor wayfinding capabilities, and tools for helpers. An extensive evaluation showed that GuideCall was effective in helping complete challenging tasks for BVI individuals. Additionally, a user study of BVI individuals posing questions about habits and preferences of using remote video-based assistance and ascertaining who they trust in various life and work situations, helping establish appropriate motivations towards designing GuideCall.

GuideCall is still very much a preliminary prototype. Future work with GuideCall will include developing an iOS version and integrating additional indoor wayfinding mechanisms as they become available. Releasing the app to be used more widely by the BVI population will allow gathering longitudinal data over many months of use with various helpers for different tasks, some beyond what this paper tested for. It is expected that as helpers get used to providing assistance (many of whom already do with FaceTime, Skype etc. in one-on-one sessions), they will better understand the needs of BVI individuals.

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