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

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ABSTRACT

Blind or Visually Impaired (BVI) individuals often face many challenges while performing daily tasks or exploring new places. Assistive technologies can help independently address some of these challenges, but there remain many tasks that still require some sort of human assistance. Some 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 develops an Android 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 many 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 and safety.

CCS Concepts

•Human-centered computing → Accessibility; *Accessibility systems and tools;* Accessibility technologies; Interaction design;

Keywords

Accessibility; visual impairments; alternative input.

1. 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 a lot of 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, [10, 13, 15]). 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, increasing automation has led to a decrease in the number of human personnel used in various occupations; such personnel in the past would have been able to anticipate the special needs of BVI persons and 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 [1, 2]. 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 [1]), or untrustworthy due to the use of unknown and typically untrained volunteers (in the case of BeMyEyes [2]). 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, and they were never designed to serve BVI user needs.

This paper presents the GuideCall remote video-based as-

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sistance 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 real-time location information in embedded maps as a user moves around utilizing GPS or other indoor positioning information available. Such unique features are designed to make GuideCall to be more effective in completing the daily tasks where they need assistance. Results of an evaluation study establish efficacy of GuideCall in facilitating typically challenging tasks for BVI users.

2. RELATED WORK

Numerous assistive technologies have been developed over the years to assist BVI persons with daily tasks. in addition to GPS-based solutions for outdoors, there have been many recent efforts in the area of indoor wayfinding utilizing wireless devices such as Bluetooth Low-Energy (BLE) beacons or computer vision to provide location information and context within indoor spaces [14, 9, 13, 10]. In addition to its use for wayfinding, 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 [15] resulting in many applications emerging such as CamFind [4], TapTapSee [8], KNFB [5], BeSpecular [3] and SeeingAI [6], or something as simple as an app for magnification [7]. Other advances have been in the area of web accessibility and screen readers allowing BVI persons to participate in today's increasingly cyber-enabled society. However, all these assistive technologies have limitations; they can fail due to software or hardware malfunctions or incorrect usage by the human involved and keeping a human in the loop can be less stressful towards overcoming daily visual challenges and/or breaking down social accessibility barriers.

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 images or live video from smartphones through apps like Skype, FaceTime, etc., but it may take a while before someone accepts to assist given the unannounced nature of the request and the sequential nature of finding such a person. Group calls on these applications, the faster option, 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 and in some cases having the ability to control smartphone functions of a remote user. VizWiz was introduced as a way for a BVI user to pose questions about their environment to remote crowdworkers who could look at shared images and answer questions [11]. 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 [1]. 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 [2]. 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. 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 [12]. Because Aira uses trained employees, there is likely to be greater trust established with those providing assistance. Because helpers in systems such as Aira, BeMyEyes, and VizWiz are employees of another organization or outside volunteers, 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 $0.50/minute and can easily add upto hundreds of dollars a month for a user.

GuideCall 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 of potential helpers who, over time, may become adept at knowing how to help a BVI user. 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. Multiple groups can be configured for various assistance-requiring scenarios, including 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 coworkers. At home, trusted friends could provide assistance in finding documents or objects. Each potential helper can be labeled with trust levels. 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.

3. GUIDECALL SYSTEM

This section provides some details about the system architecture of the GuideCall application and its various components. Designed as a single smartphone application, it operates in two modes: BVI user and Helper. The overview of system architecture is shown in Fig 1.

3.1 System Workflow

Whenever the BVI user needs assistance, the following steps will be followed through the application:
Step 1: The BVI user opens 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.

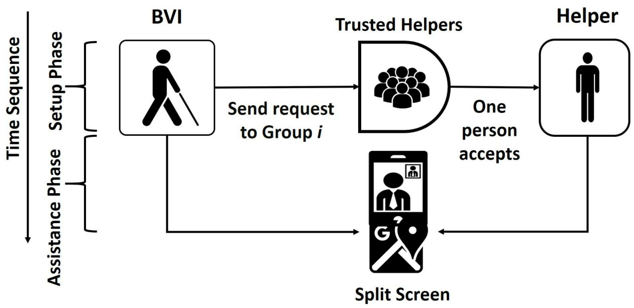

Figure 1: GuideCall System Concept

Step 3: To receive assistance, the BVI user selects a Help button. This triggers a message "Help Required" to be sent to a group chat application that contains all group users from the selected group i $(i = 1 \cdots n)$ who are potential helpers as notification to their smartphone.
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 video call to be connected between this user and the BVI user and a notification to be sent to all other users 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 GuideBeacon [13], 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.

3.2 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 maps and BLE beacon-based localization was used to track user locations indoors as they moved, with the potential to add other indoor mapping and tracking applications as they become available.

4. 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 independently challenging, were chosen.

4.1 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 a nearby (about 400 ft away using shortest path) building unfamiliar to them. The paths 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.

For all tasks, participants were allowed to use assistive technologies they would generally use to complete tasks.

4.2 Methodology

Eight BVI subjects with varying level of visual impairments (see Table 1) were recruited. Each participant was paid \$50 to complete the four challenge tasks. Results from

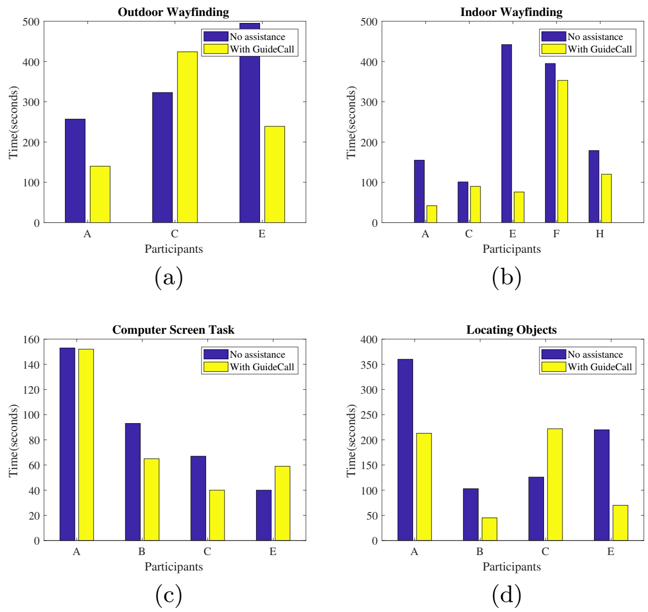

Figure 2: Completion time for the four challenge tasks

only those participants who completed tasks without and then with GuideCall are shown in this paper. Some participants were unable to complete some of the tasks due to weather (outdoor wayfinding), or not having any mechanism to complete the task without GuideCall or due to lack of time. Effectiveness of GuideCall is measured using only the metric of task completion time in this paper; consideration of other quantitative and qualitative metrics will be explored in future work. For participants A,B, D, and F, the helper used to provide assistance was very familiar with GuideCall and its features. For participants C, F, and H helpers had no prior experience in using GuideCall.

Label	Participant characteristics
A	Blind, cane user
B	Light perception (LP) only, cane user
C	20/500 one eye, LP other, cane user
D	20/150 both eyes, $<20^\circ$ visual field, cane user
E	Blind one eye, 20/800 other, dog user
F	Blind, cane user, speech impairment too
G	LP only, mobility impairment too, used walker
H	LP, cane user

Table 1: Participant labels and characteristics.

4.3 Results

Task completion times without and then with GuideCall are shown in Figures 2.

For the outdoor wayfinding task, results 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 slightly more time with GuideCall than without; this was due to the use of a helper that was new to GuideCall and its features.

The biggest benefits were seen for the indoor wayfinding task. There were significant benefits in using GuideCall, except for participants C and F. We believe this 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.

For the comprehending the computer screen task, those who had no way of identifying what is on screen were excluded from these results; GuideCall would have provided more benefits for such users. GuideCall still was typically better at interpreting screen information; the results for participant E was the only anomaly,. This was due to the user being very adept at using the KNFB app [5].

Finally, for the locating an object (document) task, 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.

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