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An Inventory of Voice Input Commands for Users with Visual Impairments and Assistive Smartglasses Applications

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***Abstract*—We present an inventory of voice commands to control assistive vision features on smartglasses. Toward this goal, we review 13 smartglasses prototypes designed for users with visual impairments, which we identified from a survey of more than 500 scientific papers and a survey of commercial smartglasses. We perform a meta-analysis of our findings according to a set of eleven categories of commands to effect for assistive smartglasses applications. Our results are useful to researchers and practitioners to inform design of voice input commands for smartglasses and users with visual impairments.**

Keywords— visual impairments, smartglasses, accessible computing, survey, voice input, voice commands, inventory.

I. INTRODUCTION

Assistive smartglasses applications can improve the quality of life for people with visual impairments [1-3] by making visual search tasks more efficient via augmented vision [4] and by providing vision rehabilitation in the form of mediated vision [5,6,7]. Unlike other types of wearable computing devices used to implement assistive technology, smartglasses can deliver visual feedback that is aligned with the visual perception of the physical world, which makes them well positioned to implement assistive vision and vision rehabilitation for people with various visual disorders. The fact that visual disorders impact the quality of life has been well documented, and the magnitude of the impact is related to the type and severity of the visual impairment [8-12]. WHO has proposed an operational taxonomy of visual disorders according to visual acuity [13], *e.g.*, low vision denotes visual disorders for which visual acuity is less than 6/18 but better than 3/60, and blindness refers to conditions where visual acuity is less than 3/60; the term visual impairments encompasses both low vision and blindness.

The literature on accessible computing and assistive technology has focused on smartglasses to assist and improve vision functioning and, consequently, to increase life quality for people with visual impairments, including low vision [4-7,14-20] and people who are blind [21-26]. Various input modalities, including voice, touch, free-hand, and mid-air gestures, have been implemented for effective input on smartglasses and Head-Mounted Displays (HMDs) in the Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR) communities, including interaction techniques specifically designed for users with visual impairments [4-7,14-26]. Among these input modalities, voice commands present the advantage of natural communication with a computer system in the context of Natural Language Processing and Conversational User Interfaces implemented in the form of voice assistants, such as Amazon's Alexa, Apple's Siri, Microsoft's Cortana, or the Google Assistant available on many devices and platforms. In this paper, we conduct a survey of the scientific literature on voice input for assistive applications for smartglasses. Motivated by a recent examination [27] of the gestures proposed by people with visual impairments for smartphones and tangible user interfaces, we contribute with an inventory of voice input commands to interact with smartglasses for assistive vision applications and users with visual impairments. We believe that our inventory will be useful to researchers and practitioners interested in implementing voice input commands into their prototypes, applications, and interactive systems to effect assistive vision functions.

II. RELATED WORK

There is a wide range of assistive applications for smartglasses and people with visual impairments, including low vision [4-6,14-19,28-32] and people who are blind [21-26] for various types of visual disorders, *e.g.*, color blindness [7,20]. These applications recognize voice commands [5-7,14,28-30,32], touch input [20,31], or gestures [16,17], and some enable multimodal interactions [6,7,28-30]. Feedback is delivered to users visually [4-7,14-16,18-20,28,29], aurally [14,17,21,22,25,26,19], and via haptics [23].

A. Assistive Smartglasses Applications for Users with Visual Impairments

Smartglasses applications have been implemented to assist people with visual impairments in performing everyday tasks. For instance, upon successful identification of a physical obstacle, an application can trigger an audio alert in the form of a sound effect [21], 3-D binaural sound [22], or stereosonic vision [25]. Massiceti et al. [25] explored the efficiency of a

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visual-to-audio mapping system for people who are blind, in which information about the physical space was rendered by means of distance-dependent modulation of audio feedback. Moreover, audio feedback can be enriched with visual cues, *e.g.*, distance to nearby objects via brightness levels by [18,19]. Prior work addressing users with visual impairments has implemented many vision assistive techniques, such as magnification [4-6,14,16,17,28,29,31], contrast and edge enhancement [4-7,14,16,17,29,31], text-to-speech [5,6,14,17, 28,30,31], face recognition [30], detection of public signs [26], object recognition [4,14], and bar code QR scanning [29,30]. Specific features have been implemented for specific visual disorders, such as recoloring for color blindness [7,20], night vision enhancement for nyctalopia [33], and projecting images directly onto the retina for retinitis pigmentosa [34]. Other specific features include product identification [4], reading text [16] and traffic signs [26], and emotion recognition [24].

B. Voice Input Commands for Smartglasses Applications and Users with Visual Impairments

ForeSee [5], ForeSee++ [6], and SeeingVR [14] are systems that considered voice input to control various accessibility tools, such as magnification, contrast and edge enhancement, black and white reversal, text extraction, object recognition, and recoloring. Chroma [7] is a system that enables people with color blindness to distinguish more colors by means of recoloring, highlighting, and contrast enhancement; Chroma runs on Google Glass and is launched with the voice command *"Ok Glass, Start Chroma."* The IrisVision Assistant [28] enables switching between different tools and operation modes, such as volume adjustment, brightness control, magnification, and photo capture via voice input. NuEyes Pro [29] has a small set of voice commands prefixed by the word *"glasses," e.g.*, *"Glasses, freeze image," "Glasses, start recording,"* and *"Glasses, capture image."* The OrCam MyEye [30] conveys visual information aurally to users with visual impairments by reading text, identifying products, banknotes, barcodes, and by recognizing faces; overall, it exposes more than twenty distinct voice and hand gesture commands. Aira [32] offers remote assistance to people with visual impairments: when help is needed, a human agent is contacted via the voice commands *"make an Aira video call"* and *"make an Aira audio call."* Cyber Eyez [35] is an application for the Vuzix M100/M300 smartglasses that provides magnification and text and object recognition features; for example, voice commands employed to navigate through menus are *"move left," "move in," "scroll down," "go back," "go home," "quit," "Okay," "confirm,"* and *"next."* Some prototypes targeted specific needs, *e.g.*, navigating unfamiliar environments. Tian *et al.* [36], Ran *et al.* [37], and Zhao *et al.* [38] proposed such prototypes to assist navigation, and implemented voice input and feedback delivered aurally.

III. A Set of Voice Commands for Smartglasses Input

A. Methodology

We conducted a survey of the scientific literature to identify smartglasses applications designed for users with visual impairments controlled via voice input. We employed seven survey papers [1-3,6,12,40-41] published between 2014 and 2019 on the topic of mobile and wearable devices with applications for users with visual impairments, from which we identified and analyzed (the titles and abstracts of) more than 500 distinct papers available in the lists of references of the seven surveys. From those, we found 60 papers on the topic of smartglasses/HMDs for users with visual impairments, of which only 8 papers (13.3%) actually implemented voice input commands. We also conducted a survey of several commercial smartglasses (by performing a Google search) for users with visual impairments, from which we identified 5 that met our criterion for voice input.

B. Results

We grouped prior work according to the nature of their voice input commands into 11 categories (see also Table 1):

C1. *Start/stop functions*, including initialization, resetting, and ending of sessions or tasks; *e.g.*, to avoid false positives, several systems expect specific words, such as *"Glasses," "OrCam please,"* or *"Okay Google."*

C2. *System information request*. Users obtain information about the functionality of the device, access tutorials, and ask about the status of the device, such as battery level, Internet and Bluetooth connections, etc.

C3. *Magnification features* implement zooming in and out. Some commands perform a zoom of the entire scene, others of the objects from the center of the visual field.

C4. *Visual enhancement functions*. Besides magnification, other type of image processing techniques are useful to deliver a better understanding of the visual world to people with visual impairments, *e.g.*, brightness and contrast adjustment, image freeze, television mode, adjusting the field of view for the retinitis pigmentosa and glaucoma conditions, etc.

C5. *Application navigation functions* address operation of the application user interface, such as selecting items from menus, navigating back and forward in lists, performing selection, confirmation, cancellation, etc.

C6. *Sound and voice settings* to customizing aural feedback.

C7. *System settings* regard other types of customization, *e.g.*, setting the current time, activating Bluetooth, etc.

C8. *Text recognition and enhancement functions*. Reading printed text is challenging for people with low vision and impossible for people who are blind. While the former user category can benefit from contrast image processing, the latter needs text recognition assistance.

C9. *Object and face recognition functions*. Commands from this category trigger recognition of various objects of interest, such as doors, traffic signs, human faces, etc.

C10. *Multimedia recording and play*. This set of voice input commands addresses multimedia content.

C11. *Communications*. Users can initiate audio and/or video sessions with remote assistants.

TABLE I. AN INVENTORY OF VOICE INPUT COMMANDS FOR ASSISTIVE APPLICATIONS ON SMARTGLASSES AND USERS WITH VISUAL IMPAIRMENTS

	Category of commands	Count[1]	Examples of voice input commands
C1	**Start/Stop**	5	*Ok Glass, Start Chroma [7], Okay Google…, Go to sleep, Shut down, Close, Open [28], Go to sleep, Hello Vuzix, Stop, Quit [35], System restart, Turn off system, Abort current task [36], System restart, Turn off system, Stop function [39], Glasses <command> [29], OrCam, please <command> [30], How are you? [37]*
C2	**System information request**	4	*Help, Info [28], Check Internet connectivity, Tell build, Tell battery status, Tell time, Tell date, Tell vocal commands [30], Help [36,39]*
C3	**Magnification**	7	*Make it larger [5,6], Glasses make bigger, Glasses make smaller [29], Bioptic, Set zoom <number>, Max zoom, Reset zoom, Zoom in, Zoom out, Scene, Scene with bubble [28]*
C4	**Visual enhancement**	6	*Glasses freeze image [29], Okay Google: RP, Increase brightness, Decrease brightness, Max brightness, Min brightness, Set brightness <number>, Okay Google: Television [28]*
C5	**Application navigation**	5	*Move the window down [5,6], Glasses go back [29], Next, Back [28], Move left | right | up | down | in | out | forward | back, Scroll left | right | up | down, Go left | right | up | down | in | out | forward | back | home, Select this, Pick this, Okay, Confirm, Next, Previous, Cancel, Show menu [35], Enter user menu, Enter tutorial [30]*
C6	**Sound and voice settings**	7	*Glasses voice off [29], Louder, Quieter, Slower, Faster [39], Louder, Quieter, Slower, Faster [36], Disable reading navigation, Enable reading navigation, Change voice, Speak faster, Speak slower [30], Enable voice prompts, Disable voice prompts, Set volume <number>, Increase volume, Decrease volume, Max volume, Min volume [28], Voice off [35]*
C7	**System settings**	4	*Torch on, Flashlight on, Light on, Torch off, Flashlight off, Light off [35], Change auto suspend time, Change face repetition time, Connect to Bluetooth audio device, Disable auto flash, Enable auto flash, Set time, Clear user settings [30]*
C8	**Text recognition and enhancement**	7	*Okay Google: Iris Reader, Okay Google: Reading Line, Okay Google: Reading yellow, Okay Google: Reading green, Okay Google: Reading inverted [28]*
C9	**Object and face recognition**	7	*Find exit door, Find room <number> [36], Read QR code, Disable face recognition, Set face recognition to auto, Set face recognition to manual, Remove all learned faces, Remove all learned products [30], Indoor, Outdoor, What we have?, Where am I?, Sofa, Prompt [37], Up/down stairs, 30 feet to…, Turn left [38]*
C10	**Multimedia recording & play**	4	*Glasses start recording, Glasses capture image [29], Take photo, Next photo, Previous photo, Exit photo, Next video, Previous video, Play video, Photo gallery, Video player [28]*
C11	**Communications**	1	*Make an Aira video call, Make an Aira audio call [32]*

[1] Number of prototypes and commercial products (out of the 13 examined in this work) that implemented this category.

Table 1, shown on the next page, presents a classification of the prior work identified in our survey (13 out of the 60 papers addressing users with visual impairments) according to these categories of commands. Results show that the implementations of commands are unequally distributed across the prototypes and commercial products we examined. For instance, the most frequently implemented categories of commands are sound and voice settings (C6), magnification (C3), text recognition and enhancement (C8), and object and face recognition (C9), each with a frequency of 7 out of 13 (53.8%). While magnification is useful to users with low vision, text and object recognition are especially valuable to people who are blind. The high frequency that we observed for these categories of commands is explained by the fact that there are many scenarios that require the ability to understand text or to identify objects. Six out of the 13 prototypes (46.2%) implemented voice commands from the visual enhancement category (C4). The rest of the categories were implemented by at most 5 of the 13 systems examined in this work. Note that this finding does not necessarily mean that other features are not available; in some cases, other features do exist but are not controlled via voice commands. Figure 1 illustrates the frequency of the words employed for the voice commands listed in Table 1. We believe that enabling access to this information is useful to practitioners to inform the design of voice commands for assistive vision prototypes (*e.g.*, there is a wide selection of voice input commands for magnification features and smartglasses; see the third row of Table 1) as well as for researchers to inform further examination of commands little explored before.

Fig. 1. Word cloud produced from all the voice input commands identified in this work and listed in Table 1. *Note:* the word cloud was generated using https://www.wordclouds.com.

IV. CONCLUSION AND FUTURE WORK

We inventoried in this paper smartglasses-based assistive applications designed for people with visual impairments. From our literature survey of more than 500 papers, we identified 13 research prototypes and commercial products that implemented voice input. From these, we extracted mappings between voice commands and system functions and features, and we analyzed their frequency. Our work implements an important step to integrate smartglasses with voice input in ecosystems of smart devices [42-45] and to inform future designs of voice input commands for assistive applications for smartglasses. For example, future work will address implementation of a selection of these commands for smartglasses prototypes delivering assistive vision as well as multimodal input by incorporating gestures defined by people with visual impairments [27]. Integrating voice and gesture input for smartglasses into other wearables, such as smart rings, might be interesting as well; for example, the study participants from [46] proposed voice commands in conjunction with smart ring gestures, *e.g.*, raise the hand wearing the ring and say "player" or placing the smart ring next to the mouth and blowing on it. Explorations of these ideas will lead to new designs of voice input for smart glasses, assistive vision, and users with visual impairments.

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