E-Gaze Glasses: Simulating Natural Gazes for Blind People

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Abstract
Gaze and eye contact are frequently in social occasions used among sighted people. Gaze is considered as a predictor of attention and engagement between interlocutors in conversations. However, gaze signals from the sighted are not accessible for the blind person in face-to-face communication. In this paper, we present functional work-in-progress prototype, E-Gaze glasses, an assistive device based on an eye tracking system. E-Gaze simulates natural gaze for blind people, especially establishing the "eye contact" between blind and sighted people to enhance their engagement in face-to-face conversations. The gaze behavior is designed based on a turn-taking model, which interprets the corresponding relationship between the conclusive gaze behavior and the interlocutors' conversation flow.

Author Keywords
Social interaction; eye tracking; visual impairments

ACM Classification Keywords
H.5.2. [Information interfaces and presentation]: User Interface, K.4.2 [Computers and Security]: Social Issues – Assistive technologies for persons with disabilities.

Introduction

Gaze and mutual gaze are important in the development of trust and deeper relationships [2]. McNeill emphasizes that nonverbal cues such as gazes are integral to a conversation and that ignoring them means ignoring part of the conversation [10]. A common face-to-face conversation can contain a wealth of gazes and eye contacts, which the sighed people take for granted in their daily routines. For example, a sighted speaker consciously or unconsciously uses gaze or eye contact to communicate with the conversation partner. Through the conversation partner's eyes, she can sense interest, engagement, happiness etc. Gaze signals, frequently used by the sighted in social interactions, are visual cues. Blind people have limited or no access to gaze signals in face-to-face communication. They often feel difficult to meet people, because they could not see and make eye contacts with the sighted people.

In this paper, we present E-Gaze glasses, a wearable device based on an eye tracking system. It simulates natural gazes for people with visual disability, especially establishing the "eye contact" between blind and sighted people to enhance the engagement in face-to-face communication. The natural gazes are designed based on a turn-taking model, which links the conclusive gaze behavior with the interlocutors' conversation flow.

Related Work

This research draws on theories of gaze behavior and related research on turn-taking gaze behavior of agents or avatars.

Gaze and turn-taking

A number of studies have investigated gaze and turn-taking behavior of sighted people in social occasions. Argyle studied that in dyadic (two-person) conversations, about 75% of the time people are listening, which coincides with gazing at the speaker[1]. Goodwin explained the role of gaze in turn-taking by considering the gaze interaction between hearers and speakers. He claimed that the speaker's look away at the beginning of turns occurs to avoid overloading information in the planning of an utterance [7]. Kendon suggested that seeking or avoiding looking at the face of the conversation partner has important function to regulate the flow of conversation in dyadic conversations and to ensure smooth turn-taking [9]. Vertegaal et al. demonstrated a linear relation between the amount of gazes perceived by subjects and the number of speaking turns taken by subjects during three-person conversations. Lack of gaze can decrease the turn-taking efficiency of multiparty mediated system by 25% [15].

Turn-taking strategies in agents or avatars

Gaze and turn-taking strategies applied in agents or avatars systems indicate noticeable effects on human-agent or human-avatar communication. Cassell et al. proposed a new approach to design conversational agents that exhibit appropriate gaze behavior. In this approach, the exchange of looks between participants was related to both information threads and the exchange of turns during the flow of conversation [5]. Dirk Heylen et al. reported a pilot experiment that investigated the effects of different eye gaze behaviors of a cartoon-like talking face on the quality of human-agent dialogues. The result demonstrated that the gaze strategy using turn-taking model significantly affects

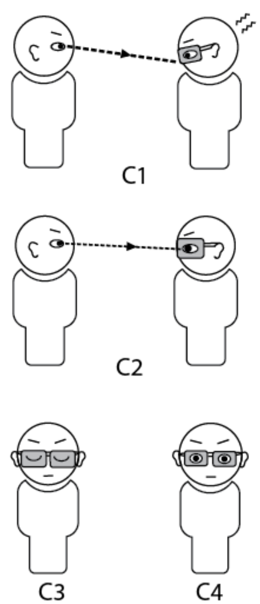

Figure 1. E-Gaze: (C1) gaze detection; (C2) eye contact simulation; (C3) avoiding state; (C4) attention state.

the dialogue quality [8]. Garau et al. described an experiment to investigate the importance of eye gaze between humans in four mediated conditions: video, audio-only, random-gaze avatars and inferred-gaze avatars. In inferred-gaze, gaze was tied to turn taking in the conversation. The result showed that the inferred-gaze avatar significantly outperformed the random-gaze model and also outperformed audio-only on several response measures [6].

Conceptual Design in User Study

In a prior user study, a conceptual design of E-Gaze glasses was proposed, to create gaze communication between blind and sighted people in face-to-face conversations. E-Gaze has two main functions: to help blind people access gaze signals and to help them react to the sighted by displaying eye gestures. Based on these two functions, four features of E-Gaze (Figure 1) were proposed: C1) *gaze detection*, slight vibrations from E-Gaze indicate gazes from the sighted conversation partner; C2) *eye contact simulation*, when the sighted looks at E-Gaze, E-Gaze also looks back to establish "eye contact"; C3) *avoiding state*, if the sighted gazes long enough, E-Gaze looks away to avoid the long gaze; C4) *attention state*, the simulated eyes in E-Gaze open bigger when the heartrate of the blind person increased, indicating an "attention state". In the interviews, we explained to participants four features of E-Gaze using persona and scenarios, which aimed to arouse participants' past experiences and memories to help them envision the use:

> *The example scenario*
>
> *Jack is 19 years old, a senior high school student. He was born blind… Jack feels a slight vibration from E-Gaze on the right forehead. His head turns right and wants to know who is looking at him. After a short while, his classmate Jim comes to say: "I see you see me and it reminds me of asking you a question." In this scenario, E-Gaze has two functions: (1) the slight vibration of E-Gaze indicates gazes from the sighted and (2) when the sighted looks at E-Gaze, E-Gaze also looks back to establish "eye contact".*

After explaining the use scenario of each of the four features, we asked participants: "*What do you think of the idea? Imagine that you are Jack in this scenario.*" Twenty participants evaluated each feature based on three dimensions: usefulness, efficiency and interest. More relevant results about this user study are reported at a conference [12]. In this working-progress paper, we refine two design features in E-Gaze system: (C2) eye contact simulation and (C3) avoiding state based on turn-taking gaze model.

Turn-taking Gaze Model

In human-human and face-to-face conversations, typical patterns have been observed in the way interlocutors make eye contact or look away [4]. We start from simulating these two typical gaze patterns in our E-Gaze system. Since the patterns of gaze behaviors, turn taking and information structure are correlated [13], we are interested in linking gaze patterns with the conversation flow by the turn-taking strategy. In general, a speaker will often avert the eyes from the listener when she starts to speak (to concentrate on what she is going to say). At the end of the turn, the speaker will typically direct to the listener again, in order to signal the end of the turn and indicate the hearer to take the turn [14].

In our design, E-Gaze is a wearable device, worn by the blind person as glasses. It displays two basic gaze

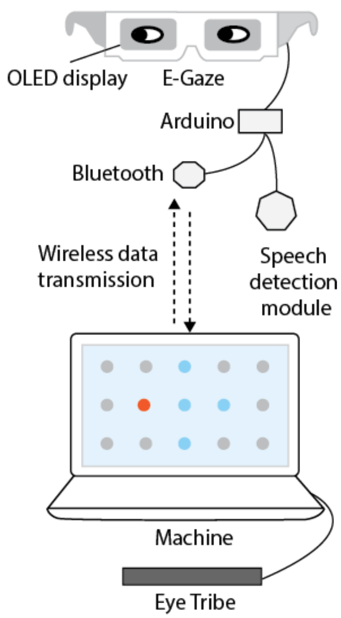

Figure 2. Overview of the E-Gaze system

patterns: "look at" and "look away" from the sighted based on whether the blind person is talking. When she starts talking, E-Gaze will "look away" from the sighted to concentrate on what she is going to say; when she ends talking, E-Gaze will "look at" the sighted to establish the "eye contact" when giving the sighted an opportunity to take the turn. If the sighted stares at E-Gaze, E-Gaze will "look away" to avoid her long gaze.

E-Gaze System Design

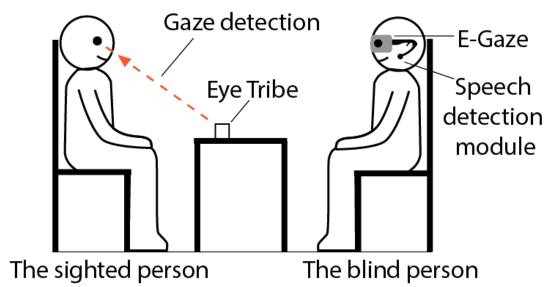

Figure 3. A dyadic-conversation scenario between the sighted and the blind people

The initial version of E-Gaze is the AgencyGlass based on a C++ program in Visual Studio 2012 [11]. AgencyGlass was designed for the sighted and it used a connected keyboard to control displaying basic gaze animations. It was designed to decrease the emotional workload of the sighted people by simulating eye gestures. In our research, we introduce AgencyGlass design into E-Gaze system to provide means for the blind person to react to the sighted by displaying natural eye gestures based on the conversation flow. In a dyadic-conversation scenario, an Eye Tribe Tracker [1] is placed in front of the sighted, detecting her gaze coordinates. The blind person sits face-to-face with the sighted and wears E-Gaze (Figure 3). We also envision an overview of E-Gaze system in Figure 2. In the system, the eye animations displaying on E-Gaze are driven by the speech detection module based on "while speaking" and "while listening" modes.

"While speaking" mode

If the blind person starts a conversation with the sighted, the speech detection module recognizes the turn taking states and creates corresponding commands. If the blind person starts talking, the Arduino board controls the OLED module to display a "look away" eye gaze. When the blind person stops talking, the OLED display shows eye gaze that look towards the sighted as an indication that it is the turn of the sighted to continue the conversation.

"While listening" mode

In the "while listening" mode, if the gaze coordinates from the sighted match the area of the E-Gaze, it indicates that the sighted is looking towards the blind person and trying to establish an eye contact. Once Arduino retrieves this coordinate, it sends a message to E-Gaze. After receiving the message, the OLED module displays eye gaze that looks towards the sighted. At times, E-Gaze displays a "look away" eye gaze while the sighted is still talking and looking at E-Gaze. We expect that this would make the conversation become more comfortable, since there should be an equilibrium level of eye contact for a person in a social conversation with the second person. If eye contact rises above that amount, it can be anxiety-arousing [3].

1 https://theeyetribe.com/

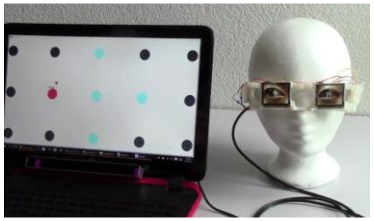

Figure 5. A simple graphical user interface (GUI) with 15 point of gaze is created to detect the eye gaze from the sighted using the Eye Tribe Tracker.

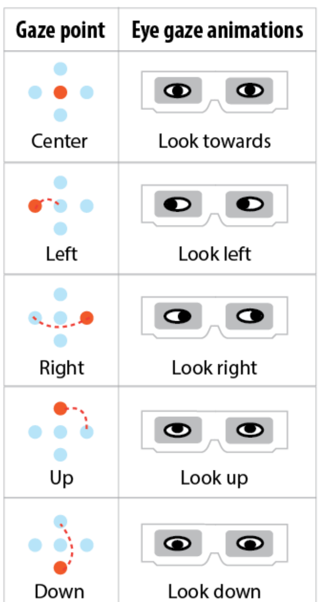

Figure 6. Gaze points on GUI and corresponding eye gaze animations of E-Gaze

System Implementation

We currently focus on connecting the Eye Tribe tracking platform with the corresponding gaze animations of E-Gaze. The speech detection model of E-Gaze system is unfinished, so we leave the turn-taking gaze behavior for the later report. We implement that E-Gaze can follow the gaze behavior of the sighted in the working-progress system. If the sighted looks towards E-Gaze, E-Gaze looks at the sighted; if the sighted looks left, E-Gaze also looks left. We test the E-Gaze worn by a dummy rather than the blind person.

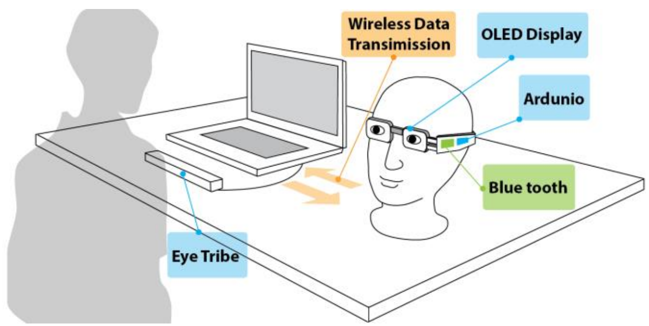

Figure 4. Setup of E-Gaze system

In the E-Gaze system, an Eye Tribe Tracker is used to calculate the location of the gaze point by extracting information from the camera images of the person's face and eyes. The supporting software can measure the person's eye gaze defined by a pair of (x, y) coordinates with an average efficiency of 0.5 to 1° of visual angle. It enables the client applications interact with the underlying tracker server to obtain gaze data both in raw and smoothed forms based on an open Application Program Interface (API). A computer acting as a server extracts the data gathered by the Eye Tribe Tracker. E-Gaze system also consists of an Arduino microcontroller, a bluetooth module, two uOLED-160-G2 display modules with an embedded GOLDELOX graphics processor and a physical glasses-shaped prototype fabricated using a 3D printer. The setup of the system is shown in Figure 4. E-Gaze is programmed in Java based on Eclipse Integrated Development Environment (IDE). A graphical user interface (GUI) with 15 point of gaze is created to detect the eye gaze from the sighted using the Eye Tribe (Figure 5). Particularly, central five points with the blue color can be activated in gaze detection. Whenever the sighted is focusing on any gaze point among the five, it will highlight that point and trigger the corresponding eye gaze animation on OLED displays. For example: if the sighted focuses on the left gaze point on GUI, E-Gaze will display a "look left" eye gaze (Figure 6). The eye gaze animations use the real eye gaze video, which is helpful to simulate the natural gaze.

Towards the development of a fully functional prototype, one technical solution is under investigation. Now a sighted person needs to look at the evaluation window on a computer screen (Figure 7(a)) to manipulate the eye gaze animation of E-Gaze. Ideally, we expect the sighted person to look towards the E-Gaze glasses to control the corresponding eye gaze animation. In our proposal, we will still use the gaze on the evaluation window, but we will depict the GUI from the evaluation window and transfer it on the virtual plane as shown in Figure 7(b). It is important to ensure the position of the Eye Tribe Tracker to face towards the sighted person's face for maximum tracking ability. The facial area of the blind person (wearing E-Gaze) is also crucial and must be within the virtual plane area. When the sighted person is gazing on the virtual plane, the Eye Tribe Tracker will detect the gaze and compare it to the nearest point of interest (Figure 7(c)). Then, the

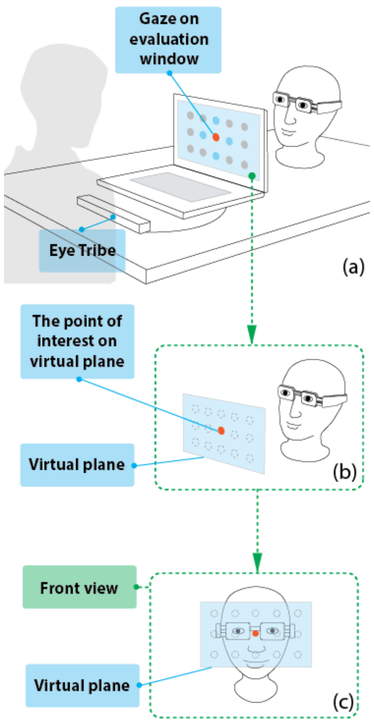

Figure 7. The sighted person looks towards the E-Gaze glasses to control the corresponding eye gaze animation.

computer will send the message to the E-Gaze and output the corresponding eye gaze animation. A small test has verified that using Eye Tribe Tracker can detect the human gaze in physical environment and produce the intended animation output.

Conclusion

We presented a functional prototype of the E-Gaze glasses based on the Eye Tribe tracking system to simulate natural gaze for blind people, to enhance their engagement in face-to-face communication. In our future work, we will develop speech detection module for E-Gaze system based on turn-taking model.

Acknowledgements

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TEI16

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TEI'16 Chairs' Welcome

Welcome to ACM TEI'16, the 10th-anniversary edition of the International Conference on Tangible, Embedded and Embodied Interaction, hosted at Eindhoven University of Technology, the Netherlands from February 14th to February 17th, 2016.

This year's conference marks TEI's tenth anniversary. We see this as a perfect opportunity for recalling some of our founding values and complementing these with contemporary values, for reemphasizing the relationship between interactive products and systems and the body, and for learning from each other's approaches and rationales. To do this, we have established the theme '**Our Body Is Our Manual**': As the interactions we propose in our products and systems are aimed to inform our embodied selves, we should also allow ourselves to be informed by our bodies when designing and researching these interactions. Through a wide palette of work ranging from highly technical to highly artistic, and from highly applied to highly conceptual or theoretical, we wish to trigger discussion and reflection, with the aim of emphasizing what binds us.

TEI'16 hosts a four-day program, starting out with the **Graduate Student Consortium** and a series of **Studio-Workshops** that embody the essence of our community by offering intellectual and practical experiences to conference attendees with diverse skills and backgrounds. The main program is kicked off by **Takeo Igarashi**, who in his opening keynote discusses computer tools that allow end users control over the design of artifacts in their lives. After the opening keynote, the Papers track commences, in a slightly different set up than before. This year we do not include Q&As in the presentations but instead wrap up each session with a reflective discussion between the presenters. The day concludes with the **Demos, Posters** and **Work-In-Progress** exhibition. From day two until day four the **Art Exhibition** questions and frames the impact of new technologies on our lives and proposes new modes of embodiment. Following day three's Papers sessions we host a full afternoon of **Studio-Workshops**, engaging all TEI attendees in active, hands-on discussions. Day four includes three Papers sessions, a lunch lecture and panel discussion, and the closing keynote by **Tom Djajadiningrat**, who reconsiders tangible interaction by discussing new technologies, illustrated through examples by Philips Design.

This year we received 178 submissions to the Papers track, which were all equally subjected to a double-blind peer review process of at least three reviewers and a meta-reviewer. A total of 45 accepted papers makes for an acceptance rate of 25%. For the Work-in-Progress track we received 100 submissions, which were subjected to a double-blind peer review process of two reviewers each. This resulted in 40 accepted submissions, making for an acceptance rate of 40%.

Of course, organizing this conference could not have been possible without the energy and commitment of many, many people. We would like to thank everyone who contributed to TEI'16: the authors for submitting their quality work to the conference, all the organizing committee chairs for managing their part of the conference, the program committee and external reviewers for safeguarding the quality of the conference, the local organizing committee, the sponsors, supporters and partners, and the TEI steering committee.

We wish you a great conference!

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