Using Dual Eye Tracking to Investigate Real Time Social Interactions

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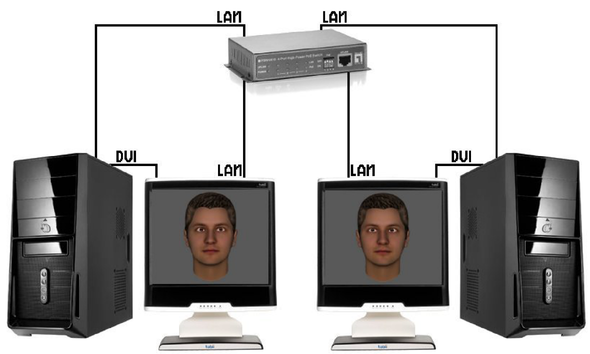

Figure 1: Dual eye tracking setup.

CHI 2013 Workshop on "Gaze Interaction in the Post-WIMP World", April 27, 2013, Paris, France.

Abstract

Commercially available eye tracking solutions are designed to monitor one person at a time. Increasing interest in the interpersonal functions of gaze in social neuroscience has brought up the question of how to analyse gaze behaviour in ongoing social interactions and how to create gaze-contingent social stimuli [6]. In the current paper we present the implementation of a dual eye tracking system which allows to simultaneously measure two participants, engaged in gaze-based interactions while providing full experimental real time control over the behavioural data.

Author Keywords

Eye tracking, dual eye tracking, social interaction, gaze

ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction

Human gaze is a crucial non-verbal communication channel. It contains a wealth of socially relevant information. Mutual gaze plays a critical role in regulating social interactions by providing information and expressing emotions. Gaze behaviour is a good indicator of social rejection, acceptance, trustworthiness, attractiveness, interest and cooperation[1, 11, 5].

Most experimental paradigms regarding gaze productions and gaze perception in the past have relied on testing individual persons in isolation. While we have learned a lot from these paradigms, we have not understood how people experience others' reactions to their own gaze. To create a paradigm that actively engages participants, advancements in eye tracking technologies have enabled interactive setups in which gaze is used to control contingent behaviour of anthropomorphic virtual characters, creating the illusion of real time interaction.

In order to explore the reciprocity inherent to social interaction[9], a different experimental setup is needed. A truly interactive platform must enable participants to respond to each other's actions and behaviour in an unrestricted fashion, compared to the preprogrammed reactions contingent upon individual's behaviour. The current literature proposes two solutions in order to ensure the required social reciprocity.

One approach, often used in developmental studies, is based on video-based interaction paradigms with a recent trend towards bi-directional real time video streams as a stimulus for joint attention research[7][8]. The first problem with this setup is the inability to interfere with an interaction, except for substituting or delaying the real time video stream. It is impossible to control for judgements based on facial features such as likability, or to create a virtual environment in which both participants may or may not experience the same context.

We favour a second approach of a dual eye tracking setup enabling reciprocity. Eye tracking has been utilised in order to study visual attention during joint action[4] or coordination of cognition[3]. However, none of these have used dual eye tracking in combination with interaction with another agent in a virtual world - an agent representing the other, even though it was demonstrated that such setup is possible[2].

We developed a dual eye tracking system that enables real time social interaction of two individuals represented by virtual characters. We set out to build a modular platform that will allow for an arbitrary number of users, and diverse types of stimuli. Also, for the purpose of quantification of interaction parameters, it was crucial that our platform allowed for a very fine-grained behaviour measurement. We wanted to be able to describe interactive gaze not only in terms of directional contingency, but also the scanpath length and area, number of saccades and fixations, fixation duration, saccade velocity, regions of interest, etc. Our virtual environment and avatars can be fully controlled in their outer appearance and behaviour. In our setup the eye gaze can be either an active part of the task, or it can be a dependent measure that we can correlate with other target behaviour.

Dual eye tracking

The dual eye tracking system consists of two Tobii T60 60 Hz eye trackers for gaze recording. For stimulus delivery, a build-in 17" TFT screen was used with screen resolution set to 1024x768 pixels and refresh rate set to 60 Hz. For stimulus presentation and data collection, two PCs with dual-core processor and a GeForce 2 MX graphics card and two network cards were used. Both desktops are running the same software configuration, which consists of Windows XP, Python 2.7 and Vizard 3.0. In order to make the setup as independent from commercial software as possible, we used the Microsoft Component Object Model (COM) to start the processes which control the calibration and data retrieval. Eye trackers and computers were isolated from the rest of the network and connected

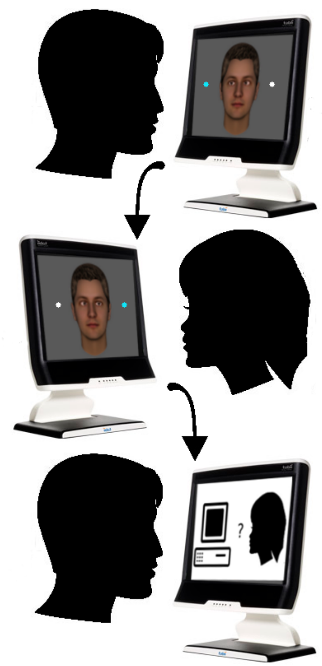

Figure 2: Turing test experiment flow. Judge selects one of the objects on the screen, and follower reacts to judge's gaze. After 6 trials, judge decides if the interaction was with a human or with a computer generated gaze.

to a switch. In order to minimise the traffic on the network, we arranged communication so that every computer collects data from its respective eye tracker and exchanges it over the network. Data transmission delay is negligible compared to the data collection rate of 60 Hz.

Modularity
The system was designed for an arbitrary number of users. It consists of one server module and arbitrarily many client modules. Data exchange is possible between the server and every client, and if needed, between clients.

Stimulus diversity
To present stimuli, we used Vizard, a commercial Python module. While the module is neither open-source nor free, we believe it offers the biggest flexibility for displaying 2D and 3D interactive stimuli, including virtual environments, avatars, video, images, etc. Vizard can be replaced by free modules such as Visual or Pygame.

Gaze parametrization
Since all collected gaze data is available for immediate use, many gaze parameters, such as scanpath length and area, number of fixations, fixation duration, regions of interest, etc., can be utilised in our dual eye tracking paradigms. All parameters are also available for the post-experiment analysis. It is important to note, that these parameters are not simply available for each participant individually, but that, apart from within-participant variance, between-participant (or dyadic) variance can also be used to explain behavioral outcomes of individual participants and/or of the dyad.

Possibility of interaction interference
What makes our system unique is the possibility of influencing communication in real time. Since all the gaze parameters are available instantly, it is possible to manipulate any or all of them in real time. Therefore it is possible to create contingent stimuli that depend on the behaviour of one or more participants, or any combination or relationship between participants behaviour, but without restraining the communication the way other current interactive paradigms do.

Turing test
In order to demonstrate the usability of the system, we have selected the interactive paradigm known as the "non-verbal Turing test" and expanded it. As in the original experiment, the goal was to study which parameters of gaze-based interactions influence subsequent humanness ratings of the avatars in a forced choice task[6]. This test was proposed[10] in order to address the question of "thinking machines", i.e., whether or under which circumstances humans would ascribe human-like intelligence to machines. In order to address this question Turing suggested various experiments, one of which became known as the standard Turing test: a participant engages in a conversation via a computer screen either with another human or a computer located in a separate room and has to judge with whom he is interacting[10]. If the participant cannot reliably distinguish between the human and the computer, the machine is said to have passed the test. The rationale of this paradigm was used in the study to investigate humanness ascriptions during interaction[6]. Participants were told that the avatar's behaviour was controlled either by the other person in the room (a confederate seated at a fake eye tracker), or by a computer program and their task was to indicate who controls the avatar's gaze behaviour. In fact, they always interacted with the computer. Results showed that people consistently rate avatars exhibiting more positively contingent gaze as more human. In our experiment, participants were paired with a real human

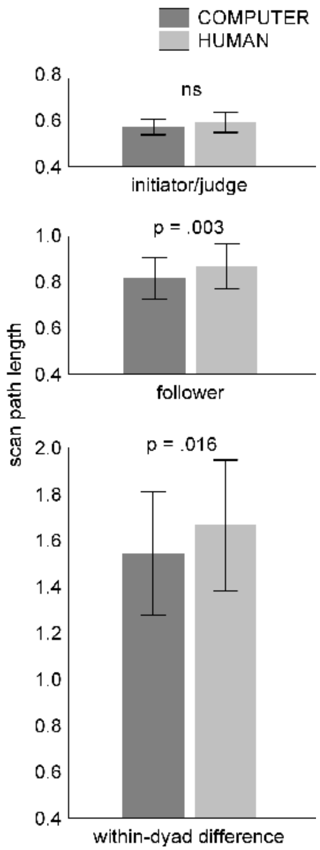

Figure 3: Results. Mean scan path length for interaction blocks judged "computer" vs. "human". No correlation between initiator/judge and other measures; .95 correlation between follower and within-dyad difference. Only C-H differences in within-dyad difference depend on dyad (interaction p=.042). Vertical bars denote 0.95 confidence intervals.

partner. One participant played the role of the judge, the other was called follower and had the task of reacting to the judge's initial gaze. We allowed participants the full freedom of actions, provided that, at the end, they selected one of the items presented on the screen.

In preliminary results on 14 participants, we did not find an increased humanness rating with increased contingency[6] as humanness ratings were overall very high, possibly due to s ceiling effect based on the additional information that natural gaze contains. The additional biological jitter that real gaze conveys, made even gaze aversion appear human. Specifically, longer scan paths were associated with increased humanness ratings, as were greater differences between judge and follower scan paths. Thus, greater dyadic variance resulted in a stronger experience of humanness.

Future work

The current results are exploratory in that they seek to expand on the non-verbal Turing test as it was originally operationalised in a non-dyadic context, by looking at what information real interaction with another human can add. Next, we will systematically vary how gaze behaviour is presented to both participants and refine measures of interpersonal coupling.

References

[1] Bayliss, A., and Tipper, S. Predictive gaze cues and personality judgments: Should eye trust you? *Psychol Sci 17*, 6 (2006), 514–20.

[2] Bente, G., Eschenburg, F., and Krämer, N. Virtual gaze. a pilot study on the effects of computer simulated gaze in avatar-based conversations. In *Virtual Reality*, vol. 4563 of *Lecture Notes in Computer Science*. 2007, 185–194.

[3] Brennan, S. E., Chen, X., Dickinson, C. A., Neider, M. B., and Zelinsky, G. J. Coordinating cognition: The costs and benefits of shared gaze during collaborative search. *Cognition 106*, 3 (2008).

[4] Carletta, J., Hill, R., Nicol, C., Taylor, T., Ruiter, J., and Bard, E. Eyetracking for two-person tasks with manipulation of a virtual world. *Behavior Research Methods 42*, 1 (2010), 254–265.

[5] Mason, M., Tatkow, E., and Macrae, C. The look of love: gaze shifts and person perception. *Psychol Sci 16*, 3 (2005), 236–9.

[6] Pfeiffer, U. J., Timmermans, B., Bente, G., Vogeley, K., and Schilbach, L. A non-verbal turing test: Differentiating mind from machine in gaze-based social interaction. *PLoS ONE 6* (2011).

[7] Redcay, E., Dodell-Feder, D., Pearrow, M. J., Mavros, P. L., Kleiner, M., Gabrieli, J. D., and Saxe, R. Live face-to-face interaction during fmri: A new tool for social cognitive neuroscience. *NeuroImage 50*, 4 (2010), 1639 – 1647.

[8] Saito, D. N., Tanabe, H. C., Izuma, K., Hayashi, M. J., Morito, Y., Komeda, H., Uchiyama, H., Kosaka, H., Okazawa, H., Fujibayashi, Y., and Sadato, N. Stay tuned: Inter-individual neural synchronization during mutual gaze and joint attention. *Frontiers in Integrative Neuroscience 4*, 127 (2010).

[9] Schilbach, L., Timmermans, B., Reddy, V., Costall, A., Bente, G., Schlicht, T., and Vogeley, K. Toward a second-person neuroscience. *BBS Journal* (in press).

[10] Turing, A. Computing machinery and intelligence. *Mind 59*, 236 (1950), 433–460.

[11] Wirth, J., Sacco, D., Hugenberg, K., and Williams, K. Eye gaze as relational evaluation: averted eye gaze leads to feelings of ostracism and relational devaluation. *Pers Soc Psychol Bull 36*, 7 (2010), 869–82.