Displays 46 (2017) 25–36

Contents lists available at ScienceDirect

Displays

journal homepage: www.elsevier.com/locate/displa

User interface for a better eye contact in videoconferencing ☆

Aleš Jaklič, Franc Solina, Luka Šajn *

Faculty of Computer and Information Science, University of Ljubljana, Večna pot 113, 1000 Ljubljana, Slovenia

ARTICLE INFO

Article history:
Received 5 June 2016
Received in revised form 17 October 2016
Accepted 16 December 2016
Available online 25 December 2016

Keywords:
Videoconferencing
Eye contact
Human-computer interface

ABSTRACT

When people talk to each other, eye contact is very important for a trustful and efficient communication. Video-conferencing systems were invented to enable such communication over large distances, recently using mostly Internet and personal computers. Despite low cost of such solutions, a broader acceptance and use of these communication means has not happened yet. One of the most important reasons for this situation is that it is almost impossible to establish eye contact between distant parties on the most common hardware configurations of such videoconferencing systems, where the camera for face capture is usually mounted above the computer monitor, where the face of the correspondent is observed. Different hardware and software solutions to this problem of missing eye contact have been proposed over the years. In this article we propose a simple solution that can improve the subjective feeling of eye contact, which is based on how people perceive 3D scenes displayed on slanted surfaces, and offer some experiments in support of the hypothesis.

1. Introduction

Videoconferencing enables people to communicate face-to-face over remote distances using video and audio telecommunication technology. First videoconferencing systems appeared already in the late 1930s when television was invented. In 1970 AT&T launched the Picturephone service convinced that a video phone would be a huge commercial success. But the Picturephone was a large customer failure due in part to dedicated big phone sets, high cost and, most of all, by making the experience uncomfortably intrusive since the Picturephone was by default always on [1]. However, teleconferencing became widespread in the 1990s with the advent of computer technology when Internet protocol-based videoconferencing made this functionality available to a much larger public as a service on existing equipment. In the 2000s free Internet videoconferencing services such as Skype became available to most users as applications on personal and laptop computers. Now, hand-held mobile devices offer similar videoconferencing services.

Videoconferencing is an important alternative to other means of interpersonal communication in many different application areas when live conversation is needed and when non-verbal or visual information is an important component of conversation. People with deafness or hearing disorder and people with speech disorders or mutism can now use videoconferencing to communicate with each other using sign language.

Despite these large technical advances, mass adoption of videoconferencing has not materialized yet, although futurists have predicted for almost a century that telephone conversations in the future will proceed as face-to-face meetings using audio and video [2]. The first reason for this conservative attitude is that voice communication is often sufficient in many situations while the second reason is that videoconferencing technology still does not offer the same experience as face-to-face communication in real, physical space. One of the major unresolved issues of videoconferencing concerning the user experience is the loss of eye contact between participants of a teleconferencing session [2–4]. The other reasons are that systems for videoconferencing are still complex and different systems are not inter-compatible. Some users are also appearance shy and being on camera hinders their communication capability. The most serious issue, however, is that it is normally very difficult if not impossible to establish eye contact between the users of a videoconferencing system.

1.1. Eye contact

People are very sensitive to the direction of the eye gaze of other people. We are able to determine very accurately if somebody is actually looking at us. Our eyes express our emotions and intentions and they help us direct attention [5]. Cultural norms in different societies dictate when, for how long and in what

☆ This paper was recommended for publication by Richard H.Y. So.

* Corresponding author.
E-mail addresses: ales.jaklic@fri.uni-lj.si (A. Jaklič), franc.solina@fri.uni-lj.si (F. Solina), luka.sajn@fri.uni-lj.si (L. Šajn).

http://dx.doi.org/10.1016/j.displa.2016.12.002
0141-9382/

situations it is appropriate to gaze into another person's eyes. In Japanese society, for example, eye contact can be considered rude, especially eye contact with a superior [6]. Eye contact plays an important role in the broader context of maintaining one's personal space, even in virtual environments [7]. Nontheless, eye contact is very important, especially in communication between individuals, because avoiding eye contact when communicating face-to-face can be associated with deception [8]. The inability of establishing and maintaining eye contact in videoconferencing systems is one of the most serious limitations of such systems [3,4] since the relationship between the ability to accurately perceive eye contact and the efficiency of communication has been firmly established [9].

Therefore, the problem of establishing eye contact may have affected a wider adoption of videoconferencing systems. Gaze patterns, which in general provide an extremely important and rich set of serial signals in face-to-face communication, should therefore be taken into account for videoconferencing design [10].

Why is the establishment of eye contact difficult over videoconferencing systems? During conversation, a person's eyes are usually directed at the center of the computer screen where the videoconferencing partner's face is displayed. The cameras for capturing the video signal, however, are usually mounted or even built-in above the display screen. Therefore, using average sized desktop computer displays at a normal viewing distances, the angle between the viewing direction and the optical axis of the camera is usually between 15 and 20 degrees [11]. If the angle between the line from the camera to the eyes and the line from the eyes to the screen is more than 5 degrees the loss of eye contact is noticeable, and in the case of 15–20 degrees the loss of eye contact is inevitable [12]. An example of this parallax in videoconferencing is shown in Figs. 1 and 2.

The same problem arises also if the face of a video conference correspondent is displayed in a smaller window on a large screen and if the angle between the correspondent's face in that window and the position of the camera is larger than 5 degrees. The problem with small handheld devices with a built-in camera is normally not as severe, since at the normal viewing distance the angle between the lines towards the image of the face and the camera is smaller than 5 degrees. Indeed, studies have shown that videoconferencing where the camera is mounted above the computer monitor, and thus disabling eye contact, is less trusted than a centrally mounted camera, where eye contact is enabled, but even less trusted than just a voice connection or email [8]. Eye contact is simply a nearly ubiquitous method of affirming trust when people communicate face to face. If several people are involved in a teleconferencing session even more issues related to communicating important non-verbal information between participants arise in comparison to a dyadic video mediated communication [2,13]. An excellent overview of gaze perception and the problem of eye contact during videoconferencing is presented by Bohannon et al. [4].

Out of this frustration with existing videoconferencing systems the idea of 3D tele-immersion has arisen [14]. Tele-immersion is an emerging technology that enables users to collaborate remotely by generating realistic 3D avatars in real time and rendering them inside a shared virtual space [15]. A tele-immersive environment thus provides a venue not only for talking between users as in tele-conferencing systems but also for collaborative work on 3D models and even remote teaching of physical activities. Such tele-immersive systems need, on the one end, 3D video capture technologies and, on the other end, a virtual reality display, making these experimental systems at present still unreachable to the general public.

In this article, we propose a solution for obtaining a better perception of establishing eye contact in a typical dyadic, video mediated face-to-face communication scenario, based on psychophysical properties of the human visual perceptual system. We have proposed this solution initially in a conference article in 2011, but without much analysis and discussion about the explanation of the observed effect [16]. We have further described this solution as one of possible applications of dynamic anamorphosis in [17]. In this article we give a broad overview of the problem of missing eye contact in videoconferencing systems and all possible solutions proposed to solve this problem. Additional experiments to illuminate and confirm our proposal are described in this article as well as a more in-depth analysis and a discussion of our proposed solution of the problem of missing eye contact in videoconferencing systems using results from psychophysical literature.

The structure of the rest of the article is as follows: Section 2 is an overview of previous attempts of solving the problem of missing eye contact in videoconferencing systems and on the background of human visual perception related to the issue of eye contact. Section 3 defines our proposal for solving the problem of missing eye contact in videoconferencing systems and describes three experiments that we made in order to back up our proposal. In Section 4 we discuss possible underlaying psychophysical mechanisms that come into play in the context of our proposal to improve the eye contact. Conclusions are in Section 5.

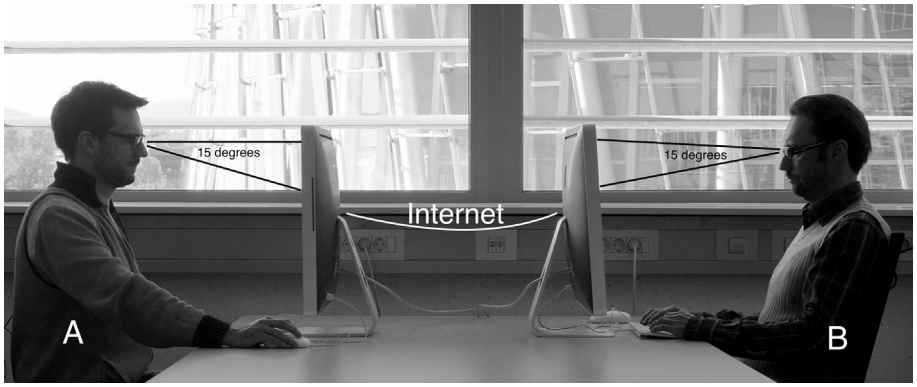

Fig. 1. A typical situation while communicating over a videoconference system over the Internet: person A is looking at the image of person B in the middle of the computer screen in front of him, while on the other end, person B is looking at the image of person A in the middle of his computer screen. Because cameras on both ends are mounted above the computer screens, the eyes of the faces imaged on both screens are looking downwards and thus the eye contact between both parties A and B cannot be established. When using a large computer monitor, the angle between the viewing direction of the user and the line between his eyes and the camera is typically about 15 degrees.