Meet me halfway: Eye Behaviour as an expression of Robot Language

Patrícia Alves-Oliveira, Eugenio Di Tullio, Tiago Ribeiro and Ana Paiva
INESC-ID & Instituto Superior Técnico, Universidade de Lisboa, Portugal

Abstract

Eye contact is a crucial behaviour in human communication and therefore an essencial feature in human-robot interaction. A study regarding the development of an eye behaviour model for a robotic tutor in a task-oriented environment is presented, along with a description of how our proposed model is being used to implement an autonomous robot in the EMOTE project.

From Sci Fi movies and books, robots are becoming a real part of human lives. The field of robotics is widespreading and new forms of robots are being designed and created to interact with people everyday in our society, forcing to consider its social status. Nowadays, different types of robots are becoming real. According to a recent survey of The United Nations, robots can be grouped into three major categories: industrial robots, professional service robots, and personal service robots (Bartneck et al. 2007), accommodating several human requirements in various environments such as factories, battlefield, home, school, and so on. This way, according to the desired environment for the robot, different types of artificial intelligence (AI) are developed in order to express different types of behaviours and communication attending to the robot embodiment and perceptive capacities (e.g., industrial robots, contrary to social robots, do not interact with people and mostly serve to do heavy work in a factory). Since gaze is literally the first contact with another being, the exchange that takes place will often determine the first impression and play a role on the interaction flow (Collier 1985). In human-robot interaction (HRI) the head is implicitly the primary place for social interaction, and the eyes are an important communication feature, having a pragmatic design goal (DiSalvo et al. 2002). This has been leading most robot manufacturers to include eyes in the robots' design. Thus, this paper focuses on eye behaviour as a feature of Robot Language and its implication in HRI.

The eyes are the mirror of the soul

Eye behaviour (EB) is one of the first most meaningful and critical non-verbal behaviour for social interaction (Cassell et al. 1994) and is indeed a crucial communication cue when looking at HRI (Mutlu, Shiwa, and Kanda 2009). As humans and robots will share their physical space, EB emerges as a way of narrowing this communication, making the interaction seem more natural, intuitive, and engaging. In general terms, research shows that there are different types of EB (Lance and Marsella 2007) that comprise a set of properties (Lee et al. 2007) to serve different functions in the social interaction (Argyle et al. 1973). In this sense, the EB is interrelated with a context and has a role in cognitive, communicative and affective face-to-face interactions, where different EB patterns can emerge (Lee et al. 2007). Thereafter, EB can be of different types: there is a distinction between eye gaze (looking at the eyes of someone) and eye contact (establishing gaze that does not necessarily target eyes), that can also happen during mutual EB (Collier 1985) (see Fig.1a, 1b). On the other hand, when we intentionally redirect our gaze away from a face, we are performing gaze aversion which in the social context is related with cognitive, intimacy-modulating, and floor management functions (Andrist et al. 2014). Timing is also essential to interpret EB (Collier 1985).

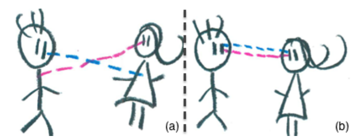

Figure 1: (a)Mutual Eye Contact - (b)Mutual Eye Gaze

This literature serves to show the complexity of EB and the inherent challenges that the HRI field still needs to overcome to achieve a truly positive social interaction between a human and a robot. To achieve this stand, we propose a different perspective regarding robot's communicative and expressive behaviour: since robots have different embodiments that constrain their expressive modalities, they should have a specific language that is adequate for their expression. We believe that by providing robots with their own communicative and expressive language, they will not be seen as "limited humans", but rather as different entities. Being EB the modality that most stands out in any type of social interaction, this type of behaviour has become our starting point.

Figure 2: Eye Behaviour Study Setup (a - b)

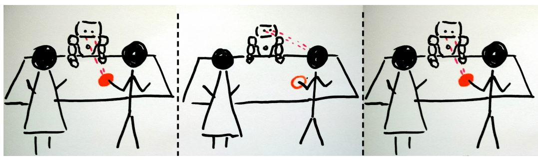

Figure 3: Example of the gaze-glance-gaze dynamic

Robot Language

When creating robots that will interact with humans in a shared physical space, it becomes crucial to develop behaviours for the robots that are readable, predictable, secure, and understandable by people. These behaviours should be developed integrating the holistic and contextualized communication of robots. Hence, Robot Language emerges as a form for robotic expression that humans should understand, but not necessarily be a replica of the human behaviour. Humans are capable of developing flexible ways of communication that are not necessarily restricted to human communication itself in order to understand other living entities (e.g., animals) or objects (e.g, personal mobile phone)(Wistort 2010). The same will happen when interacting with robots: humans will try to develop ways of communicating and understanding them. In this sense, the need to develop the Robot Language was driven by the motivation to create behaviours and in particular EB for a robotic tutor in a collaborative educational task in a classroom environment[1].

Meet me Halfway: Eye Behaviour Study

Throughout the development of this robotic tutor, we have been facing challenges to achieve the purpose of creating meaningful and life-like EB. Thereafter, we are currently trying to develop a model of EB for the robotic tutor inspired in human studies. This way, we conducted a study with a teacher (see Fig. 2(a)) and students during the same educational task that the robot would be performing (see Fig.2(b)) in a school classroom environment. One teacher and 31 students participated in the study (M*age*=14; SD=.97) and the educational task consisted in playing the Enercities game[2], a serious game for geography driven curriculum learning, wherein the main goal is to build a sustainable city. Two conditions were set: 1) two students and one teacher played Enercities, and 2) three students played the Enercities. A total of 12 sessions was performed and all data was video and audio recorded according to ethics procedures. The analysis of EB during the teacher and students interaction to inspire the model for the EB of the robot was performed with Elan Software (Wittenburg and Brugman 2006) [3]. The analysis showed that during the task-oriented interaction both teacher and students looked at the task 96% of the task time with a sustained gaze duration of M=26.58s. Also, subjects gazed at each other 2% of the total interaction time, established less than 1% of mutual gaze and the rest of the time looked elsewhere. The results fall in line with previous studies demonstrating that gaze also serves to facilitate learning and enhance task performance in collaborative environments (Bailenson, Beall, and Blascovich 2002). For this reason, EB is context dependent and regarding a task-oriented environment, subjects gaze almost always at the task in a joint attention gaze communication.

The next step we took into the development of the EB for the robot, was to combine these results with literature, considering the embodiment limitations of our robot. We are currently working with NAO Torso Robot from Aldebraran Robotics[4]. Because of its physical limitations it is impossible to have eye movements independent to the head. Therefore to achieve mutual eye-gaze and mutual eye-contact we have to move the entire head. Also, NAO has features not present in humans, such as the possibility to change the colour of the eyes. Therefore, we used a neutral eye colour that increases its intensity when a mutual eye-gaze is detected, thereby combining these aspects. This was combined with the capacity that NAO has to perform emotion eye shape (Greczek 2011). NAO's repertoire includes a wide range of behaviours (e.g., gestural animations and EB). Our current EB model is implemented as part of Skene (Ribeiro et al. 2014), which is a semi-autonomous behaviour planner that is being developed in the EMOTE project. Skene's EB state machine automates some EB (i.e., robot gazes at task-glances at student-returns to gaze at task, see Fig.3). The decision-making AI therefore deals only with selecting a target and a type of EB.

Vision

Our challenge is to develop an EB model combining three essencial aspects: literature, studies with humans, and robot's features. According to our study, context plays an important role in EB, which leads to emerging questions, such as: what stimuli do we prioritize during gaze aversion? How can this be implemented in the HRI field? How can we use Robot Language to continue developing new kinds of robot behaviours? And what impact can our EB model have when humans and robots interact?

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[1]This is part of the European EU FP7 EMOTE Project

[2]http://www.enercities.eu/

[3]http://tla.mpi.nl/tools/tla-tools/elan/citing_elan/

[4]http://www.aldebaran.com/en

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