USING IN-VEHICLE AVATARS TO PREVENT ROAD VIOLENCE

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Abstract

The physical difficulty of conveying appropriate social interactions between drivers expresses itself in aggression, selfish driving and anti-social behaviour. By building computers that convey/understand social cues/context, technologists can dramatically improve collective decision making. Existing research on Intelligent Transport Systems (ITS) has not capitalised on recent advances in social computing. Eye gaze is a social cue affecting collective decision making which could contribute substantially to safe driving. This preliminary study proposes a new unobtrusive in-vehicle system to communicate drivers' intentions and increase social awareness via eye gaze. There has been little research into the role of social cues to improve driving behaviour. The overall objective of this research programme is to improve drivers' social awareness by breaking the "shielded space" with the use of an avatar with eye gaze movements. The avatar is designed to maximize a sense of social presence by reducing anonymity and increasing intimacy and immediacy. Participants were asked to drive through different types of intersections, in a driving simulator. An avatar representing the head of the other driver was displayed and driver behaviour was analysed. The result has shown significant difference in terms of eye gaze pattern when an avatar is displayed. No changes have been observed in terms of speed. This approach has the potential to improve social interactions between drivers, allow clearer collective decision making between road users and reduce the incidence of antisocial.

1. Introduction

This research uses in-vehicle technology such as eye tracker and peer to peer wireless networks to mediate the social power of mutual gazes between road users to reduce road crashes. The technology mediates the subjective experience of being observed and sharing the road, even when the driver is physically and psychologically isolated in a vehicle. The driver is expected to change attitudes on his/her own to fulfil social norms (conformity theory [3]). Social norms are explicit or unspoken rules about how we ought to behave. The social impact of eye contact on human behaviour has been documented in the literature:

- **Eye contact is a major social cue to driving safely:** Argyle [1] has estimated that when two people converse, only 30% of the communication process is verbal, the other 70% is a result of indirect or nonverbal communication. Eye gaze direction plays a crucial role in the initiation and regulation of social encounters [9]. Being able to make eye contact is arguably one of the major foundations of social skills. Driving is a public and social behaviour where eye contact is a crucial cue enabling social awareness. Adopting a pro-social behaviour is considered a good driving practice [8].
- **Eye contact breaks drivers' anonymity:** The distance between drivers, the physical and psychological constraints imposed to perform the driving task safely, and vehicle design (metal frames, tinted windows) prevent drivers from exchanging clear and unambiguous social cues [13]. This hinders eye contact, isolates, provides a feeling of anonymity, and reduces drivers' social awareness. Individuals in anonymous situations often lose respect for themselves as well

as others (disinhibition effect). Eye contact regulates social interactions and expresses a sense of intimacy [1]. It breaks anonymity, brings about self awareness and creates a feeling of immediacy and produces greater perception of closeness between individuals [4]. Research on immediacy and arousal has shown that eye contact causes the receiver to reciprocate positively with intimacy [13].

- **Eye contact communicates drivers' intentions:** Knowing the intentions of other drivers is one of the informal road rules that drivers use to avoid crashes. Eye contact is a good predictor of attentional focus [1]. Social presence, the sense of being with another, may be the by-product of reading the intentions (minds) of others [12]. Eye gaze is one of the most potent nonverbal signals humans possess [17]. The best non-verbal way to communicate intentions with other road users is to attract their attention with eye contact [6]. This is a common safe practice for cyclists and pedestrians. Eye contact could serve to show concern for the other driver. Hence, the absence of eye contact between road users may indicate a lack of awareness of the presence of other road users.
- **Absence of eye contact as a social cue contributes to road violence:** Road rage is a product of weakened social and personal controls, which can act in concert with arousal-inducing environmental circumstances, such as traffic congestion, work pressures, or family strain [13]. The inclination to undertake unsafe driving behaviour is exacerbated by the inability to perceive or express social cues when feeling anonymous. It is widely acknowledged in the road safety community that being aware of being looked at has a tremendous effect on driver behaviour [13]. Social cues are important means to assess the acceptability of our own behaviour. The "presence" of eye contact is the most efficient way to improve the feeling of self-awareness [2]. Drivers' indicating too late or failing to indicate their intentions is among the top 5 most annoying behaviours (Royal Automobile Club Australia).
- **Mediation of eye contacts with technology has positive social influence:** Mediated eye contacts influence human behaviour. The positive effects of using eye gaze in the design of human computer interfaces has been demonstrated at length in the Immersive Virtual Environment, Human Computer Interactions and Computer-Supported Cooperative Work literature [17,4,5]. It has been shown that augmenting virtual characters such as avatars with eye gaze exerts a stronger social influence on human interactants [16,17]. An avatar is a digital model representing a human whose behaviour is driven by humans in real-time. An example of avatar is depicted in Figure 1. Avatars evoke a sense of social presence especially if they are anthropomorphic (human like) [12].
- **Context awareness, mediated interactions and the driving task:** Context awareness computing can improve drivers' awareness of the driving situation. Intelligent Transport Systems (ITS) are increasingly used in vehicles to improve context awareness (e.g lane departure warning systems). Mechanisms to improve awareness of social cues such as eye gaze are increasingly used. Eye contact is a primary aid to social interactions [1,9]. Any theory or account of social behaviour that fails to include eye gaze could be suggested to lack a critical element. The social influence of avatars featuring eye gazes and head movements monitoring have been shown in desktop environments [17]. Virtual agents have been shown to make a user pay more attention [1] and elicit emotions such as embarrassment or self–awareness [15]. The presence of a human or virtual human demonstrates classic social inhibition performance impairments effects compared to those performing alone [1]

This paper focuses on the result of a pilot study examining the impacts of an avatar on driver's behaviour in a driving simulator: namely eye gaze pattern, and vehicle speed at intersections in the presence of avatars.

3. Hypothesis and experimental design

This study identifies the driving behavioural changes resulting from the presence of an avatar by comparing the behaviour of each participant in situations with and without avatars. Eye gaze and head movement patterns are the only social cues that we display on the simulator's windshield as an avatar. The avatar embodies driver's eye gaze and head movement. The realism of the avatar is critical to elicit an experience of presence or to have the sensory experience of "being looked at". The avatar's appearance is anthropomorphic, but not photorealistic, and imitates human visual behaviour..

A "looking avatar" displayed on a windshield could generate a mere curiosity and be confounded with the expecting behavioural social effects. Therefore 4 other scenarios were created to try to isolate the effect of eye gaze from other confounding factors were included in the experiment (a car with static avatar, without avatar, with a static arrow and moving arrow). This pilot study examines if the cited theory from social psychology are applicable in a driving simulator. We are testing three hypotheses:

- H_1. The presence of avatar's gaze has behavioural influences on drivers' behaviour. Thus it is predicted that gaze and vehicle speed patterns will change when an avatar is present and participants feel observed.
- H_2. Drivers are more cautious in the presence of avatar by seeking eye gaze information when it is available. It is predicted that eye gaze duration and eye glances towards the avatar will increase.
- H_3. The presence of avatar does not distract the driver. It is expected that the eye gaze duration on the avatar is below 1.6 seconds, which is the maximum allowable according to the standard in-vehicle design guidelines.

3.1 Experimental setup and scenario

12 researchers/students (8 males, 4 females, mean age 28 years) participated in the study. Participants hold a driving license and have good eye sight. They were asked to drive normally and respect road rules on the SiVIc(INRETS) driver simulator. Avatars are only displayed above other vehicles in conflict situations, i,e. where collaborative decision-making is required. Conflicts could occur on intersections. Vehicles appear from the left/right side of the intersections. Road signs indicate if participants have the right of way.

Figure 1: Driving environment with an avatar

Driver's performance related to eye gaze, vehicle's speed, and acceleration/deceleration are recorded. Driver performance was measured with driver simulator software and the FaceLab eyetracker. The road scene (13.4 km of residential roads with 96 intersections) is displayed with a projector. The participant's head is situated at a distance of approximately 150 cm from the screen (170 x 120cm). The field of view is limited to 30 degree , which coincides with the range in which the FaceLab eye tracker can detect accurately the exact eye gaze directions The vehicle is controlled with a steering wheel and pedals. Acoustical inputs are provided by Logitech G5 (5.1) speakers.

Software was created to log and synchronise variables related to the environment, driver and road in XML. Variables include acceleration, speed, lateral and longitudinal position, track curvature at the current position of the car, current 3D position of the icons and the crossing car in a camera-related coordinate frame, the object the avatar is gazing at, track index of the current position of the

crossing car, speed of the crossing car, time of the encounter, the parameters of the current encounter (priority, side and type of icon), participant's eye gaze direction (relative to the scene and icons).

The residential roads have a width of 5 m in total. The roadway is composed of straight road modules featuring intersections separated by curves. The basic structure is repeated 32 times, providing for 96 intersections. Intersections create conflict situations. Conflict situations are defined as instances of time in which two vehicles are bound to collide if they continue driving at their current speeds in their current directions of motion. The encounter zone covers approximately 30 meters before the end of each intersection. Drivers are driving on the left side of the road as shown in Figure 1.

4. RESULTS

Factorial analysis of variance (Factorial ANOVA) is the statistical methods used to analyse the dependency of the variables such as speed, eye glances, eye gaze durations and type of displayed icon during encounters. Due to space limitation we only summarize the results:

- **Average speed relative to encounters:** The average speed of the participants when approaching and crossing the intersections were measured before comparing the average speed in the presence of an avatar or another type of icons. The speed of the participants when presented with different icons did not show significant statistical difference.
- **Detection time and gaze duration:** The detection time indicates the time taken to notice the crossing car. The gaze duration is the total time the subject's eyes dwell inside the detection window during the encounter. The analysis of variance found 18.0% variation in detection time and 17.6% on gaze duration. Therefore the presence of avatar doesn't have any effects on detection time or gaze duration.
- **Number of glances:** The number of glances, i.e. the number of separate periods of time where the subject's gaze dwells inside the detection window featuring the vehicle and icon, has been included in the evaluation. The type of the displayed icon has no significant effect on number of glances (18.2% variability). Such finding supports the H_3 hypothesis as it indicates that the display of an avatar does not "disturb" the glance pattern.
- **Glance Duration:** The majority of all glances are shorter than one second, the average being of 691 ms, below the threshold of 1.6s formulated in the Battelle Guidelines for on-road use of in-vehicle devices. The maximum glance duration of 2s postulated by the BSI guidelines is only exceeded by 2.32% of all glances, and a negligible fraction of 0.325% falls above 3s. Therewith, we consider the avatar safe for on-road use, since they do not form a classical in-vehicle device requiring the driver to avert their gaze from the road when operating it.

5. CONCLUSION

27% of crashes in the US occur on intersections. 80% of them are due to human errors where (i) lack of awareness of the presence of others or (ii) lack of knowledge of the others intentions are contributing factors. We introduced new techniques for conveying social/intentional information through avatars with the view to improve situational awareness and decision making. This preliminary study laid the basis for such future study. It showed the 3 hypotheses are verified.

H_1: The presence of avatar's gaze has behavioural influences on drivers' behaviour.

- A longer gaze durations to looking avatars are coherent with the assumption of the existence of eye contacts. The perception of being looked at was reported by a majority of participants supports this assumption.

H_2: Drivers are more cautious in the presence of avatar by seeking eye gaze information when it is available

- There is no indication showing that drivers slow down in the presence of avatar. However there are some indications showing that drivers refer to the avatar when needing information on the intention of others.

H_3: The presence of avatar does not distract the driver

- The number of glances and time spent gazing at the avatar does not indicate an unsafe distraction by standards of in-vehicle device design and is not expected to increase driver's workload.
- Avatars seem to be consulted primarily in less demanding driving situations, which underlines their non-distractive nature.

This driving simulator study is a simplified version of the complex real world situation. It lacks the social context provided by a naturalistic condition. Therefore caution should be taken in extrapolating the validity of this preliminary study to real driving conditions.

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