

Time-Critical Supportive Augmented Reality – Issues on Cognitive Capture and Perceptual Tunnelling

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1 INTRODUCTION

Augmented Reality (AR) enables user-centred applications. The user can use additional information to execute his work.

But in case of time critical tasks, supplementary information can become a drawback. Such tasks, as driving a car or performing a surgery, require the full attention of the user. Any supplementary information can probably gather the user's attention too long, generating the risk of causing serious harm. In the two given examples, accidents can occur or an artery, for instance, could lose too much blood.

This effect is not only based on the additional information in general, but on two special factors [4]: *Perceptual Tunnelling* and *Cognitive Capture*.

Perceptual tunnelling (PT) is a phenomenon that originally comes from aviation and in which an individual becomes focused on one stimulus, like a flashing warning signal and neglects to attend to other important tasks/information such as driving the car.

Cognitive capture (CC) refers to the situation where the driver may be totally "lost in thought," a condition which, in particular, could impair situational awareness. Where emotional content (i.e., personal involvement) in a conversation is high, such as arguing with someone over the phone, the likelihood of cognitive capture is increased. Instruments that require some level of cognitive involvement and thereby could lead to a loss of situational awareness are viewed as increasing the risk of a crash.

To know about the factors that contribute to distraction can facilitate designers of AR systems to minimize distractive effects.

The issue of distraction is crucial for my work, as I try to enable AR for car driver assistance. Here, I present my most critical application and some work that works on the subject of measuring such effects. I present the approach, I am going to use to analyse for PT and CC in a driving simulator and want the approach to be discussed in the AR community in order to determine suitable solutions for testing AR systems on that kind of distraction in general.

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2 LONGITUDINAL AND LATERAL CAR DRIVER ASSISTANCE

Indicating where a car is heading and where it would come to a halt intends to reduce the amount of accidents. An AR-based bar floating in the Head-Up Display in front of the car visualizes the actual braking point. Lines attached to the corners of the bar, connecting them to the front corners of the car indicate the traversed drive-path and can intend to support curve estimation. Figure 1 shows a screenshot from the driving simulator where the visualization is currently under research [5].



Figure 1: Screenshot from the AR-based Lateral and Longitudinal Assistance

Due to its ongoing animation and presence, this visual tool enforces analysis on perceptual tunnelling and cognitive capture.

3 MEASURING MENTAL EFFECTS

There are two main classes of objective tests to measure PT and CC. First, subjects are requested to execute tertiary tasks and their response time and accuracy is monitored. Second, glance behaviour can detect changes in eye movement behaviour and therefore reveal dependent factors to PT and CC.

The first class of tests uses tertiary tasks, in general computation tasks that must be executed in conjunction and in parallel to the primary task and perception of the AR information, i.e. the secondary task. For instance, during the execution of the primary task, a subject has to repeatedly subtract 7 from a given three digit starting number. Recording the results can determine computational errors as well as slower response times.

The second approach is given by Praxenthaler [3], who reported on the effect of perceptual tunnelling and advises glance tracking as indicator. But head-mounted systems alter head-movement and therefore make it more difficult to transfer results into real world application domains. Outside-in systems on the other hand are difficult to handle, because eye-tracking is not as accurate due to the distance of the cameras.

Subjective Measurements can be used as well to determine the cognitive impact of AR support. The SAGAT method [1] for instance breaks execution of all procedures executed in the experiment, freezes the scenery and allows for short questionnaires about situational awareness. For instance in a driving simulator test, subjects are asked to name traffic relevant objects or to paint them into an empty screenshot. The NASA task load index (TLX) [2] furthermore computes an Overall Workload Index out of several questions, where a subject has to mark his own subjective opinion about his mental workload on a scale between 0 and 100.

4 PROPOSED APPROACH

Due to the fact, that an automotive environment does not allow mobile devices inside of the car, AR has to use the Head-up Display (HUD) to present visual information. Therefore the user's eyes are visible. Furthermore, the volume, within a driver's head can move, is very small, because the driver sits on the driver's seat and wears the seat-belt.

Both factors enable car-fixed camera based eye-tracking systems. Such a system can monitor various factors of eye-movement:

- Non-traffic relevant glances (Clouds, Advertisements, Buildings, ...): In comparison to
- Pupil activity: The lower this activity, the higher the possibility for PT and CC
- Amount and angle of saccades: Again, the lower this activity, the higher the possibility for PT or CC
- Fixation to infinity: In closed environments, this effect can reveal, that a person is lost in thought, which contributes to CC

Experiments should use a within subject design with a recorded baseline, so that the differences to normal, not AR supported activities can be measured.

In addition, driving performance data, such as the capability of keeping speed and lane can show, if a driver was distracted at a certain moment. For instance, the steering wheel reversal rate which indicates, that the driver was absent minded for a relative long time and therefore has to perform an unexpected large steering wheel correction, can indicate such absence. Analysing the glance behaviour at this moment in time can enable to determine, which kind of distraction occurred.

Finally, the NASA TLX is intended to give a subjective opinion of the driver.

5 CONCLUSION

For my application I currently realize an outside-in tracking system with two cameras mounted on the upper border of the windshield. This approach is based on Active Appearance Models for non-rigid face tracking [6]. The eye tracking system is connected to the computer generated virtual environment and therefore allows for detection of virtual objects, such as flying balloons and other environmental objects along the driver's foveal cone of sight.

I hope to determine reduced eye-movement only in the very first minutes, during which the driver gets familiar to the new support system. Afterwards he should be used to that kind of support and get back to normal behaviour. If not, I will analyse the situations, where the driver was distracted to find out if he looked more onto the bar or the drive-path and therefore will remove the path indication or modify the appearance of the bar.

For automotive environments, the users environmental constraints keep me in perfect condition for such test, because I can

use outside-in tracking. This might not be possible for every kind of AR-based systems. In general, when a Head-mounted Display is used, outside-in tracking with environmentally mounted cameras is not possible, but a camera could be attached to the Head-mounted Display, recording the eye directly.

Furthermore, interruptive tests, like the SAGAT method are surely not applicable for AR based systems, where the user cannot exactly hold his position during the questionnaire.

In discussion with the AR community, I hope to find alternative ways to measure the cause for distraction by AR systems. Digging into the detail instead of just knowing, that the user is distracted, can surely help developers and designers to generate less distractive systems.

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