Follow the Leader: Examining Real and Augmented Reality Lead Vehicles as Driving Navigational Aids

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ABSTRACT

Two studies investigated the concept of following a lead vehicle as a navigational aid. The first video-based study (n=34) considered how drivers might use a real-world lead vehicle as a navigational aid, whilst the second simulator-based study (n=22) explored how an Augmented Reality (AR) virtual car, presented on a head-up display (HUD), may aid navigation around a complex junction. Study 1 indicated that a lead vehicle is most valued as a navigation aid just before/during a required maneuver. During the second study the dynamic virtual car (which behaved like a real vehicle) resulted in greater confidence and lower workload than a static virtual car that “waits” at the correct junction exit, but resulted in more gaze concentration. It is concluded that a virtual car may be a valuable element of a navigation system, in combination with other forms of information, to completely fulfil all a driver’s navigational task requirements.

KEYWORDS

Augmented Reality, Heads-Up Display, Navigation, Virtual Car

INTRODUCTION

The rapid development of head-up displays (HUDs) is reducing the limitations on how navigational aids may function within vehicles. At present, information can be layered over the driver’s view of the road environment (Gabbard et al., 2014), potentially reducing the need to look away from the road scene for gathering display information (cf. Victor, 2005). Hence, augmentation of the road environment poses a tempting opportunity to better provide the driver with information, as many have started to investigate (e.g. Tonnis, Sandor, Klinker, Lange, & Bubb, 2005). Currently, novel augmented reality (AR) HUD concepts are highlighting hazards in real time to encourage the driver’s attention to safety critical information (Park, Park, Won, Kim, & Jung, 2013). Others are aiding navigation by highlighting relevant road signs (Chu, Brewer, & Joseph, 2008) or superimposing paper airplanes on to the road environment, which act as arrows to indicate a direction (Bark, Tran, Fujimura, & Ng-Thow-Hing, 2014). A study investigating AR navigation systems highlighting relevant landmarks...

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found that these landmark cues required less visual attention than conventional cues (Bolton et al., 2015). The present work investigates a novel approach to aiding navigation using an AR HUD.

Using a ‘front’ vehicle as a navigational aid may be considered a broadly familiar experience: A driver who is aware of a route may lead another, unaware driver in a separate vehicle who follows behind. Although work has examined car-following behaviours extensively from the perspective of general traffic behaviours, with consideration of driver behaviours (Ranney, 1999), minimal research has actually investigated car following for navigational purposes (McNabb, Kuzel, & Gray, 2017).

This work aims to clarify how drivers use a lead vehicle as a navigational aid in this manner, how this lead vehicle affects visual behaviour (eye-movement) since driving is a predominantly visual task (Foley, 2009), and then examine how an AR version of this concept may perform within a specific navigational example.

The Navigational Task

In order to appreciate how navigational information is used whilst driving and during car following scenarios, it is first vital to understand the typical structure of the navigational task (see Figure 1). Burnett (1998) developed a framework based on interviews and a direction-giving study that considers the navigational task a continuous process; making it ideal for the current application. According to Burnett (1998), before setting off, drivers will usually go through some form of “Trip planning” stage, where they establish a route, and then there are 5 subsequent stages of the navigational task that occur whilst driving.

The stages of navigation are distinguished by the different aims or goals a driver is trying to achieve. Each of these different goals requires or benefits from different types of navigational information. The first three stages are described in relation to a manoeuvre the driver is required to make to stay on the correct route. The driver first goes through the “Preview” stage, where they aim to gather information in order to anticipate the upcoming manoeuvre. The “Identify” stage then occurs, where the driver will attempt to apprehend the precise speed, direction and road positioning required for the upcoming manoeuvre. Next, the “Confirm” stage occurs just before and after the manoeuvre; during this stage the driver searches for indications that the correct manoeuvre is being performed or occurred.

Two further stages are described by (Burnett, 1998) which can take place at any point during the navigational task. The “Confidence” stage occurs when a driver is aiming to gain reassurance that they are on the correct route or gain reassurance that the method they are using to navigate is functioning as it should. Finally, the “Orientation” stage describes a point in the navigation task where a driver aims to identify their overall direction in relation to their destination and the surrounding environment.

This definition of the navigation task in the driving context has been used by others (e.g. Lee, Forlizzi, & Hudson, 2008) – since the thorough and continuous depiction of the task makes evaluating information from a navigational system simpler to analyse. Therefore, it forms an ideal framework to evaluate lead vehicles (whether real or as an AR implementation) as navigational aids.

Our Studies

Two studies were conducted. The first study aimed to establish how drivers use different types of visual and auditory information to navigate during a short journey with several different junctions and manoeuvres. Specifically, the work focused on how drivers, who are following another vehicle for navigational purposes, use the lead vehicle as an aid for navigation. The second study, conducted within a simulator environment, used the information gathered during the initial investigation to explore how an AR lead vehicle, presented on a HUD, could be used as an element within a vehicle navigation system.
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