Adapting SatNav to Meet the Demands of Future Automated Vehicles

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Abstract
This paper questions whether satellite navigation systems (SatNav) in their current form will be useful in future automated vehicles. We highlight the current challenges to the design of SatNav systems and point out how aspects of these may no longer be essential during the transition towards more highly automated vehicles. Finally we pose a number of research questions that may be helpful to understand the evolution of SatNav systems in automated vehicles.

Author Keywords
Satellite Navigation Systems; Autonomous Vehicles; In-Vehicle; Auditory Displays; Multimodal Feedback; Audio; Passenger Awareness; Virtual Driving Simulator; Earcons; Auditory Icons; Speech

ACM Classification Keywords
H5.2 [Information interfaces and presentation]: User Interfaces. -User-centered design

Introduction
Automotive research and development into automated vehicles is steadily progressing from prototype to fully functioning product [14]. Their introduction may bring many benefits including improvements in road safety, traffic efficiency and enriched journey experience [4]. However, for the transition from manual to automated

driving to be seamless, a number of challenges must first be addressed. These challenges exist not only to autonomous vehicles on a collective level, where issues such as traffic management, road safety and legal concerns arise. There are also challenges concerning the control and operation of autonomous vehicles on an individual level and what impact this has on driver/vehicle interactions [12]. While it is important to understand what effect this may have on drivers in automated vehicles, it is also interesting to explore what effect a shift from manual driving to automated driving may have on current vehicular technologies such as satellite navigational systems (SatNav).

This paper explores how current system design challenges to SatNav evolve and adapt to the demands of automated vehicles. We present possible research directions investigating the presentation of alternative journey information as well as new ways to present feedback via the auditory modality.

SatNav Benefits & Limitations

SatNav systems are a widely used navigational aid in manually controlled vehicles [10]. They are most often portable dashboard based units but also feature on smart phones and tablet map applications. SatNav systems utilise positional data and maps to produce a "turn-by-turn" set of instructions presented to the driver via visual and auditory cues [3]. These systems offer benefits such as active updates during a journey and negate the need to memorise a prospective route or stop the vehicle to reference a physical map [9]. The visual and auditory feedback can be particularly useful for users with limited spatial awareness [9].

However, poorly designed SatNav systems may lead to distractions, especially if direction updates are not presented to drivers in a coherent manner. Driver safety can also be put at risk particularly when SatNav units do not provide directions that correctly correspond with the intentions of the driver [5]. Furthermore, due to the small size of SatNav displays, the impact on driver distraction and driver safety can be exacerbated [3].

SatNav in Automated Vehicles

Automated vehicles eliminate the need for the driver to actively participate in primary driving tasks. Instead, they are placed in a supervisory role where the requirement is to monitor the system performing the task of driving [15]. This switch from active to passive roles poses a number of issues to the future uses of SatNav in automated vehicles. Interestingly, the need to satisfy previous challenges to SatNav system design for use in manual vehicles becomes less important, which we highlight in the following subsections.

Reduced Risk to Driver Distraction

As pointed out by Kun et al [8], driver distraction can cause driving errors such as improper speed and direction measurements. Manual vehicle Satnav's must therefore be designed to ensure that journey information is provided to the driver with minimal distraction. In contrast, as automated vehicles operate all primary driving functions [6], the need to present information with minimal distraction is no longer imperative. Driver gaze time at visual SatNav displays can be increased without any safety critical effect on driving performance [7]. Auditory message length can also be increased as distraction to the primary driving task is no longer an essential safety concern [13].

Furthermore, it may be possible to utilise alternative sound cue types other than speech to present new forms of journey information.

Appropriate Presentation of SatNav Information
Liberating the driver from the primary driving task may call for a change in the type of information presented by current SatNav systems. Primarily, the need to present "turn-by-turn" journey information may no longer be necessary. Furthermore, as automated vehicles enable drivers to carry out non-driving tasks with minimal concerns for safety [11], presenting new information using previously restricted methods without causing distraction or risking driver safety becomes possible. One example of this is a study by Beattie et al [2] where spatialised audio was used to present primary driving sounds during simulated automated journeys. Their findings suggest that spatialisation significantly enhanced driver awareness to the intended actions of the simulated automated vehicle. They also found that when no sound was presented, drivers were significantly more distracted and awareness was greatly reduced. These findings may provide a useful insight when towards the development of SatNav for automated vehicles with respect to new feedback approaches. Furthermore, utilising spatialisation to present SatNav voice commands in automated vehicles may be a welcomed improvement and may provide a similar level of awareness enhancement as found in Beattie et al.'s [2] study.

Suggested Future Research

It is interesting to consider how the transition to highly automated modes of transport will affect current vehicular technologies. In particular, how can these technologies be adapted to provide usable information to drivers and ensure automated vehicles can provide trusted and enjoyable driving experiences [15]. In light of the discussed research, we propose the following research questions related to the appropriate presentation of SatNav information in future automated vehicles.

- *Will SatNav systems still demand active participation from drivers when used in automated vehicles?* We hypothesise that SatNav systems will shift from the requirement of presenting information that demands instructed action from drivers to presenting more passive information that may be used to enhance journey experience [3].

- *Is the current "turn-by-turn" navigational information provided by SatNav systems still useful in automated vehicles?* We hypothesise that due to the shift to a supervisory role for drivers, existing "turn-by-turn" updates may no longer be appropriate [15].

- *What new types of information can be presented via SatNav systems that are of benefit to an automated vehicle driver?* This research direction covers 3 main points. Firstly, can new information be presented in automated vehicles? Secondly, is there a requirement to do so? Thirdly, what type of new information do drivers want? Previous research suggests that drivers would like to be provided with data related to traffic and weather updates, geographical points of interests and location-based social media updates [1].

- *What new approaches to information presentation can be used by SatNav systems to effectively provide new types of information to drivers*

in automated vehicles? We hypothesise that spatialised audio may be a beneficial addition to SatNav auditory feedback which has been suggested to enhance driver awareness [2].

This paper suggests future research directions regarding the use of SatNav in future automated vehicles that may serve as useful discussion points during the workshop. By focusing on how existing vehicle technologies such as SatNav can be successfully integrated into automated vehicles may help to smooth the transition from manual to automated vehicles for drivers.

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