
On-Wheel vs. Mid-Air Haptics: Where is Best for In-Car Interaction?

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Abstract

The availability of ultrasonic haptic feedback devices has opened up new possibilities for in-car interaction, shifting away from featureless and attention-diverting touchscreens towards feedback-enabled eyes-free gesture interfaces. However, this method necessarily requires that a hand be removed from controlling the steering wheel to gesture near a sensor, potentially decreasing safety. The PRESTIGE project is developing richer tactile feedback presented from printed actuators in a steering wheel, to improve interaction and keep hands in control of the vehicle. Input could come from buttons, on-wheel touch sensors or on-wheel micro-gestures. Our intentions for the workshop are to discuss under what circumstances each technology can be best utilised: what interactions, and balance of utility and safety, does each offer?

Author Keywords

Haptic feedback; in-car interaction; steering wheel.

ACM Classification Keywords

H.5.2. Information interfaces and presentation (e.g., HCI): Haptic I/O.

Conventional In-Car Interfaces

Decades of research has sought to improve driving safety or interaction with infotainment systems by augmenting the driving cabin with alternative control

and feedback methods. Physical buttons are reliable in activation and inherently provide tactile feedback about which button was pressed (shape, indentation) and whether it was pressed (depression and release). However, to reduce manufacturing cost and complexity, and expand input diversity, physical buttons have increasingly been replaced by touchscreen interfaces [1], so that any number of control configurations can be provided to the driver with no increase in cost/complexity.

Touchscreens are known to suffer from a lack of tactile feedback [7], making interaction more uncertain, challenging and frustrating, which could have a negative impact on driving performance, as more visual attention and cognitive resources are being diverted from driving [6]. Buttons may also require visual attention, especially if placed in the centre stack. Finally, the spatial layout of touchscreens and physical inputs may mean the driver is reaching for varying and physically inconvenient distances.

Mid-Air Haptic Feedback

Ultrasonic haptic feedback, combined with a depth-sensing camera, has been pursued by researchers [4,12] and car manufacturers [10,11] as a potential solution to some of these problems. It is an eyes-free input method: the driver keeps his/her eyes on the road while the hand receives feedback concerning input. The haptic feedback also improves over featureless touchscreens, as it can provide complex spatial and temporal patterns. Finally, gesturing above a sensor positioned close to the driver provides a less physically demanding interaction.

However, this approach retains some limitations of older interfaces, and also introduces new issues. The driver must still take one hand off the steering wheel to interact, potentially reducing the control they have over the vehicle. Also, while gesture recognisers can be robust, they are generally less reliable than physical buttons or touchscreens, due to the complex spatiotemporal nature of hand movements. Therefore, input may be more inaccurate or frustrating than physical devices.

Richer On-Wheel Feedback

Steering wheels have been augmented with vibrotactile feedback in research [9] and commercial cars [5]. While beneficial over audio or visual feedback alone, the feedback is generally only used for notifications, such as lane deviation [5], automated hand-over requests [3] or navigation [8], and not user input. Also, many devices vibrate only one small part of a wheel or the whole wheel [5], leaving little opportunity for richer spatiotemporal feedback. The PRESTIGE project is developing printed vibrotactile actuators to be placed inside the steering wheel, providing highly localised and texturally rich tactile feedback for user input. Input could be from physical buttons, on-wheel touch input [2] or a gesture-sensing camera positioned in the driving column, to detect micro-gestures from the fingers [13].

Which is Better? Is One Better?

Ultrasonic haptic feedback and PRESTIGE on-wheel feedback each have their potential benefits and limitations, and it is important to discuss where the different technologies can best be deployed. Under which circumstances does each approach provide the better user experience and task performance?

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