Bimodal Feedback for In-Car Mid-Air Gesture Interaction

Gözel Shakeri
Glasgow Interactive Systems Section
University of Glasgow
School of Computing Science
Glasgow, United Kingdom
g.shakeri.1@research.gla.ac.uk

John H. Williamson
Glasgow Interactive Systems Section
University of Glasgow
School of Computing Science
Glasgow, United Kingdom
johnh.williamson@glasgow.ac.uk

Stephen A. Brewster
Glasgow Interactive Systems Section
University of Glasgow
School of Computing Science
Glasgow, United Kingdom
stephen.brewster@glasgow.ac.uk

ABSTRACT

This demonstration showcases novel multimodal feedback designs for in-car mid-air gesture interaction. It explores the potential of multimodal feedback types for mid-air gestures in cars and how these can reduce eyes-off-the-road time thus make driving safer. We will show four different bimodal feedback combinations to provide effective information about interaction with systems in a car. These feedback techniques are visual-auditory, auditory-ambient (peripheral vision), ambient-tactile, and tactile-auditory. Users can interact with the system after a short introduction, creating an exciting opportunity to deploy these displays in cars in the future.

CCS CONCEPTS

• **Human-centered computing** → **Haptic devices**; **Auditory feedback**; **Gestural input**;

KEYWORDS

feedback; auditory; cutaneous push; peripheral lights; in-car interaction; mid-air gestures;

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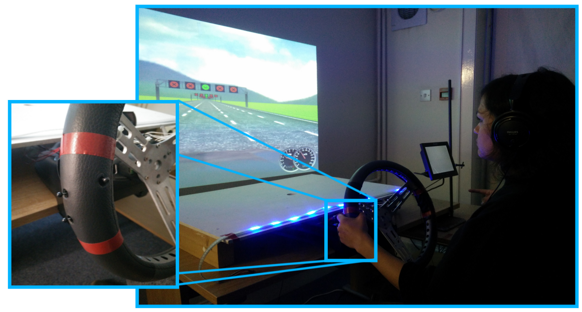

Figure 1: Multimodal feedback for mid-air gestures in a simulated driving scenario. Feedback types are 1) visual, 2) auditory, 3) ambient lights, and 4) cutaneous push.

1 INTRODUCTION

Users need feedback to support their interaction with mid-air gesture systems and to know whether their gestures were recognised by the system to complete the intended task. Feedback can address this problems and improve the usability of gesture systems. In cars that currently use in-air gestures, such as the BMW 5 and 7 series, feedback is mainly visual. However, when driving, a drivers' visual attention is occupied and on-screen feedback is not appropriate due to increased visual distraction.

Visual distraction has been shown to contribute to around 60% of crashes and near crash incidents [3]. To mitigate the effects of visual distraction, the Multiple Resource Theory [9] suggests a distribution of secondary task information to modalities not used in the primary one. Sensory channels for this potential information distribution are auditory, tactile, and peripheral vision (ambient).

This demonstration explores visual-auditory, auditory-ambient, ambient-tactile, and tactile-auditory feedback techniques for mid-air gesture interaction with an in-car infotainment system. Users can interact with our system and get better acquainted with mid-air gestures in a simulated driving situation and determine for themselves which feedback technique they prefer. Our findings can help understand the effects of mid-air gestures on driving performance, visual attention, and mental workload. This is particularly important since car manufacturers such as BMW, VW, Cadillac and Hyundai, who are investing in mid-air gesture systems, see a potential for its in-car use.

2 RELATED WORK

Feedback is necessary to help users understand mid-air gesture sensing systems [1]. Users need to be informed whether their gesture had the intended effect. Research has looked into ways of providing non-visual feedback for in-car interaction, however this limits itself mainly to auditory and vibrotactile feedback. Vibrations on the steering wheel, for example, can reduce reaction time and are easily implemented, but they can be mistaken for natural in-car vibrations [2]. Auditory feedback is often perceived as disruptive during conversations.

For these reasons, recent work has looked into alternative feedback modalities such as peripheral lights [4] and cutaneous push [6]. In a driving situation, traditional visual feedback is located in an eyes-off-the-road position whereas peripheral feedback can be perceived whilst looking ahead. Peripheral feedback has been shown to decrease eyes-off-the-road time compared to traditional visual feedback for mid-air gesture interaction [8]. Cutaneous push feedback on the steering wheel can be presented to the steering

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hand when gesturing. Patterns presented with cutaneous push have a recognition accuracy of 88.7% which can be utilised to give gesture specific feedback.

In a previous study on unimodal feedback for mid-air gestures [8], we investigated the effectiveness of visual, auditory, cutaneous push, and peripheral lights feedback for mid-air gestures in cars (see Figure 1). We found that providing non-visual feedback decreased eyes-off-the-road time significantly, however mental demand was higher in the non-visual conditions. Multimodal feedback has shown to not increase mental demand in a driving situation [5]. Therefore, we designed a bimodal feedback study for mid-air gestures in cars to determine which modality combination causes the least mental demand and the least visual distraction from the driving task.

3 BIMODAL FEEDBACK FOR MID-AIR GESTURES IN CARS

The demonstration will entail 1) a computer, on which the OpenDS driving simulator will be run, 2) a 24 inch screen on which the driving simulator will be displayed, 3) an 8 inch screen to the right of the driver mimicking a car's centre console screen, 4) a Leap Motion tracker to sense the user's gesturing hand, 5) a Logitech webcam located on top of the main screen, 6) three solenoid powered pins protruding from the steering wheel providing feedback to the driver's left palm [7], 7) a capacitive sensor attached to the steering wheel under the driver's right hand, and 8) a 107 cm long LED light strip (see Figure 1). The placements of the individual devices were guided by the measurements of a Jaguar Land Rover Discovery Sport. The Leap Motion device, which we use to track user input, will be placed where the gear stick would be such that the interaction area is a cube on the right of the steering wheel, above the gear stick. This ensures that the gesture execution area is close to the steering wheel and gear shift. The measurements of the interaction box are smaller than the Leap Motion's default settings: width: 235.24 mm, height: 235.24 mm, and depth: 147.75 mm.

We use OpenDS Version 3[1] to simulate a lane-changing driving scenario. Participants will have to follow easy to see instructions on the bridge panels above the motorway.

The demonstration will present bimodal feedback for each input gesture executed by the driver.

4 CONCLUSION

This demonstration presents bimodal feedback types for in-car mid-air gesture interaction. With mid-air gestures, users can manipulate the in-car infotainment system. The feedback techniques reduce eyes-off-the-road time but do not increase mental demand. This can make driving safer.

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