A Tactile Interaction Concept for In-Car Passenger Infotainment Systems

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A Tactile Interaction Concept for In-Car Passenger Infotainment Systems

Figure 1: A passenger uses the remote for absolute indirect touch interaction with the in-vehicle infotainment system.

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Abstract

Many modern cars offer in-vehicle infotainment systems to enable information and entertainment features. Often, these systems use touchscreen-based interaction concepts, which can be tedious (holding the arm) and imprecise due to the mobile context. In addition, most systems are driver-targeted and neglect the interaction by passengers. In this paper, we therefore investigate the use of an absolute indirect touch interaction concept with tactile feedback to enable passenger interaction with an infotainment system with the goal to ease screen navigation and improve user experience. Results from an experiment (N=18) reveal that this approach performs well regarding usability and user experience for both entertainment and infotainment functions.

Author Keywords

Remote touch interaction; absolute indirect touch input; automotive user interfaces; passenger infotainment system.

CCS Concepts

•Human-centered computing → Haptic devices; Interaction techniques;

Introduction

The act of driving is more than going to a defined place, transporting people, or carrying goods [15]. While interactions inside of the very first cars were limited to maneu-

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Figure 2: Absolute Indirect Touch (AIT) deployed through a remote control: The grid on the remote (bottom) has the same resolution as the on-screen grid (top). In this example, the user touches the bottom right field on the remote to select the corresponding item at the bottom right of the screen (highlighted in green).

Figure 3: Study setup: Installation of the displays for front seat and rear seat passenger.

vering the car (using pedals and steering wheel), there are much more opportunities nowadays. Equipped with a multitude of features and functions, modern cars combine technical innovations with functional and personal belongings [1, 10]. Mostly offered through an in-vehicle infotainment system (IVIS), the driver can use entertainment, comfort, and assistance functions with a variety of interaction mechanism to enable a safe, pleasant, and enjoyable ride [9, 11, 12]. Due to these innovations, inside actual cars more than 100 different input and output modalities do exist [9]. Most of them are related to non-driving related tasks [14] like touchscreens which provide drivers with infotainment and entertainment functions [9, 19].

If input on touch screens – also known as absolute direct touch (ADT) [16] – is used in a safety-critical context like driving a car, it should be ensured that the display location is within arm's reach [6]. While most IVIS are driver-targeted, passengers are only incidental users who might perceive less information and can use less functions inside a car [8], for instance when the display is aligned toward the driver. However, for some collaborative activities the front-seat passenger can provide valuable support with co-driver tasks such as entering a destination to the navigation system [8]. Up to now, only selected premium cars¹ are equipped with passenger-targeted systems, e.g., rear seat entertainment systems. As a consequence, many passengers prefer to use smart phones or tablets inside a car to avoid boredom during a ride [8, 20].

The use of touch screens (either mounted into the car or on mobile devices) can create several ergonomic issues. Interacting with integrated touchscreens can be tedious due to the need of raising the arm. Moreover, mobile devices can lead to motion sickness when users look down onto the

screen instead of looking in the direction of movement [5]. Furthermore, the use of direct touch in a car can reduce accuracy [13], needs more eye-glances [4], and increases task completion times compared to traditional buttons [13]. For the driver, this also negatively affects vehicle guidance and driving safety while interacting with the system [18].

The usage of touch pads inside a car – decoupled from the screen – requires less eye-glances and reduces task completion times [17]. In addition, absolute indirect touch interaction (AIT) can improve eyes-free tapping and accuracy by using additional haptic marks for a landmark-based target selection [4]. Such haptic feedback positively affects usability and user experience (UX) [2].

As a summary, we see the concept of absolute indirect touch interaction as a viable solution to improve usability and UX for interacting with IVIS in the car. The contribution of this paper is an exploration of this concept for passenger interactions with infotainment and entertainment functions in the car by means of a first user study (N=18).

Concept

Our concept addresses two in-vehicle interface aspects: First, we implemented an IVIS for passengers, while the majority of current IVIS rather targets at drivers. Addressing the specific needs of passengers will gain even more importance when the driver's role changes into being a passenger in automated cars. Second, we address usability and ergonomic issues which often occur with touch screens in cars: a) the position of touch screens is often limited to be within arm's reach of the user, b) interacting with out-stretched arms can be tiring, c) interacting with hand-held devices on the user's lap can induce motion sickness, and d) pointing precision suffers due to the motion of the car. We also consider the social context of riding with multiple

¹e.g., BMW 7 series, www.bmw.de/7er, last accessed: 2019-06-20

Figure 4: Home screen of the developed infotainment and entertainment system.

Figure 5: Passenger collaboration: A received item is displayed as pop-up notification. The user can accept or deny such message.

Figure 6: Detailed information for one specific recommendation with sharing possibility by pressing the displayed sharing button (middle, lower position)

passengers in the car by means of enabling information sharing between these passengers.

To overcome the named limitations of in-car touch screens, we designed an interaction concept that uses AIT in combination with tactile feedback in order to improve accuracy, task completion time as well as in-car usability and UX.

Prototype

We implemented our first prototypical system using Unity 3D to offer the following infotainment and entertainment functions: Users receive recommendations for points of interest (POIs) such as sights, hotels, and restaurants along the route, triggered by the position of the car. They can share these POIs with other passengers to propose and discuss route changes and potential stops, supported through a rating process. The integrated entertainment component allows users to watch TV shows and movies. Figure 4 shows the home screen of the designed application; Figure 5 presents the information sharing concept (received item). To enable AIT interaction, we used a remote control with haptic marks as shown in Figure 1 and Figure 2. This device enables users to feel the tile which is touched by the use of a one-to-one mapping between the matrix elements on the remote control and the graphical interface.

User Study

To get first insights about the implemented prototype and understand its effect on UX and usability we conducted a user study, where users had to conduct tasks in two different domains (infotainment and entertainment).

Participants

We recruited 18 participants for our user study (10 females), aged from 23 to 57 ($M = 41.1$). All participants were required to have a normal or corrected-to-normal vision.

Apparatus

We conducted the experiment inside of a parked mid-class car. Thus, we used a static set of POIs close to the parking position as a basis for user recommendations. The user interface was deployed to a 12" iPad Pro, mounted in front of the user, one at the front passenger seat and one at the rear seat as shown in Figure 1 and Figure 3. Each display was controlled by a separate remote control (Figure 1).

Method and Procedure

We used a mixed design, and let the users perform the study in nine pairs. Thus, the seat (front seat or rear seat) is the between-subject variable. The domain (entertainment or infotainment) is the within-subject variable and every participant had to perform all tasks one after another. At the beginning of the experiment, the participant pairs signed a consent form and randomly took a seat at the front and rear passenger seat. Both users performed five different tasks, one for entertainment and four for infotainment including information sharing. The experiment started with both users simultaneously finding and watching a movie (entertainment). After that, one user had to find one (or multiple) points of interests and had to share it/them with the other user by pressing the displayed sharing button (Figure 6). The other user had to deal with receiving the shared item(s) and judge them. Next, the users took turns. When the pairs started with sharing one item, this was later repeated with multiple items and vice versa.

Measures

In general we were interested if such an infotainment system with recommendations of points of interest is usable and improves UX for passengers. Further we wanted to find out if the interaction mechanism is usable inside the car due to the space constraints.

Figure 7: UX results out of the AttrakDiff questionnaire. Green marker (left): UX for infotainment functions, blue marker (right): UX for entertainment functions

As dependent variables we measured the perceived usability in terms of satisfaction using the System Usability Scale (SUS, [3]), effectiveness (error rate), efficiency (task completion time), and UX by means of aesthetic, hedonic, and pragmatic qualities using the AttrakDiff questionnaire [7]. In addition, we conducted a semi-structured interview to understand the subjective aspects of our proposed concept.

Results & Discussion

The overall usability defined by the SUS score (range: 0–100) shows high rates for both infotainment ($M = 76.4$) and entertainment functions ($M = 80.1$). According to literature, values above 70 indicate a good up to excellent usability while ratings between 60 and 70 can be interpreted as marginal up to good. Ratings lower than 60 typically indicate considerable usability problems [3].

A detailed analysis of task completion times only shows that sharing multiple items ($M = 2.08$ min, $SD = 0.91$ min) takes longer than sharing a single-item ($M = 1.03$ min, $SD = 0.45$ min; $z = -2.700$, $p = .007$). Furthermore, multi-item sharing ($Mdn = 3$) is more difficult in terms of cognitive effort (based on a scale from 1 - very easy to 5 - very difficult) than sharing a single item ($Mdn = 2$; $z = -2.145$, $p = .032$). In general, usability indicators do not show significant differences between entertainment and infotainment functions.

In terms of UX the system results in overall excellent ratings for hedonic, pragmatic, and aesthetic quality (see also Figure 7) without significant differences between infotainment and entertainment. The infotainment functions result in marginally lower pragmatic quality, which can be related to the complexity of the multi-item sharing mechanism. While our study reveals first insights regarding the user experience, the long-term UX still needs to be investigated.

The analysis of the final interview showed that two thirds of the participants would like to use the infotainment concept in their car. They could imagine using the system to retrieve information about attractions or to use the included entertainment functions. Additionally, participants mentioned positive aspects such as the consistent design and well-structured menu as well as the different available functions and a good overview about interesting attractions. This is consistent with the measured aesthetic UX dimension. In addition, the interaction with the remote control was appreciated by one third of the participants. As reasons they mentioned that the remote is easy to use after a familiarization phase and that it is better to use than standard remote controls.

Conclusion & Future Work

Our preliminary user study shows that the concept of using AIT on a remote control to interact with in-vehicle infotainment systems is a promising approach to improve passengers' UX in the car. In addition, the users appreciated both infotainment and entertainment functions the same way and they liked the remote control interaction because it was easy and comfortable to use for them.

As future work, we plan to investigate in-depth how the proposed concept performs compared to other common in-vehicle interaction concepts. Furthermore, we will explore the opportunity to embed the remote at fixed locations into the car. This will also enable to test our concept with drivers. Experiments in other domains already showed that the AIT approach reduces eye glances and improves accuracy [2, 4]. In combination with a clearly structured menu we expect a reduction of driver distraction, enhanced driving performance, and increasing driver experience.

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