User Expectations on Touchless Gestures in Vehicles

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Abstract

Gestures are part of the interaction between humans and are currently getting more and more popular in the field of Human-Machine Interaction (HMI). First systems with mid-air gesture control are available in the automotive field of application. But it is still an open question which gestures are intuitive for the users, standards do not exist. In this paper we present a 2-step user study on expectations on touchless gestures in vehicles as part of a participatory design process.

1 Introduction

Touchless gestures as a new input modality for automotive HMI have been discussed more and more intensively during the course of the last years. Manufacturers like BMW and Volkswagen recently presented first systems using this means of interaction. The aim of introducing mid-air gestures in the vehicle is to reduce driver distraction, as it allows some gestures known from touchscreen systems (such as smartphones) in combination with displays mounted close to the windscreen. Typical touchscreen systems are mounted in a lower position to be reachable by the driver and therefore the user needs to look downwards, away from the driving scene. The benefits were shown in several studies, e.g. (Döring et al 2005, Loehmann et al. 2013, Pickering et al. 2007, Riener 2012).

Another kind of gestures works without relation to screen content. In these cases, it will not be possible to include hints on the display to increase affordance for the interaction. In this paper we present a two-step investigation on user expectations on mid-air gestures without screen display. This research is part of a participative design process (see e.g. (Muller 2003)) for gesture-based user interfaces in vehicles with the target to design highly intuitive systems. As gestures without screen indication are a "hidden interaction feature" intuitiveness mainly consists of the question, which gestures users would perform without learning. Including users in defining the vocabulary of gestures is also recommended by Nielsen et al. They propose the following principles to "facilitate Learnability and Memorability, and minimize the chance for Error":

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- Easy to perform and remember
- Intuitive
- Metaphorically and iconically logical towards functionality
- Ergonomic; not physically stressing when used often" (Nielsen et al. 2004).

2 Related Work

Currently there exists no standard or best-practice for mid-air gestures in vehicles. Moreover, scientific research does not answer the question on intuitiveness of different gestures for this field of application. Following Jef Raskin intuition is mainly based on familiarity (Raskin 1994). As mid-air gestures are relatively new in all fields of application (incl. home entertainment) for the customers there is no clear analogy, but similarities to touchscreen gestures known from smartphones are potentially helpful.

A gesture-based system for medical images is discussed in (Soutschek et al. 2008), but the choice of gestures is not discussed. In (Zobl et al. 2001) a usability study for touchless gestures in vehicles is described. The main difference to our approach is that this study is related to a graphical user interface. Additionally, this study is 15 years old, within this time touchscreen gestures have become very popular and may have had influence on the expectations on the gesture vocabulary.

Riener et al. present results of a study on preferred functions for gesture control and different locations for gestures in vehicles (Riener et al. 2013). Some features such as location and duration were automatically measured, but the evaluation of a task-to-gesture mapping is not the aim of this work. However, a high variety was observed.

Angelini et al. developed a gesture taxonomy with user centered methods (Angelini et al. 2014). Differently from this study, the gestures are not contactless, hands need to be placed on the steering wheel.

3 Usability study for touchless gestures

We conducted a user study in order to determine the easiest and most intuitive touchless gestures in the automobile. This study was divided into two phases, a prestudy and a main study. The following chapters will explain the approach of each phase as well as the results of the evaluation.

3.1 Phase 1: Prestudy

The prestudy was executed in 21 face-to-face interviews in a dummy-environment in which participants were asked to show touchless gestures for previously selected functions. The selection of functions was chosen due to different aspects. The first group was the standard control of multimedia content like adjusting volume or skipping to next track. The second

group were functions that would normally require a complex interaction for example activating the rear window defogger or navigating to your home address. Lastly we wanted to investigate how participants would react to gestures that control driving relevant functions like changing gear or indicating a turn. In an interview the participant was explained she/he should assume a flawless system being able to recognize every gesture at any location. This study was realized without a User Interface which had to be imagined. This phase of the survey served to presort the functions which would then be evaluated.

3.1.1 Preparation

An Audi A6 was used as a test environment. Two cameras were installed in the car which should record the movements of the participant. One of the cameras was placed in the backseat and recorded the central stack, the second camera was positioned in the legroom of the passenger seat and filmed the rear of the participant (Fig. 1).

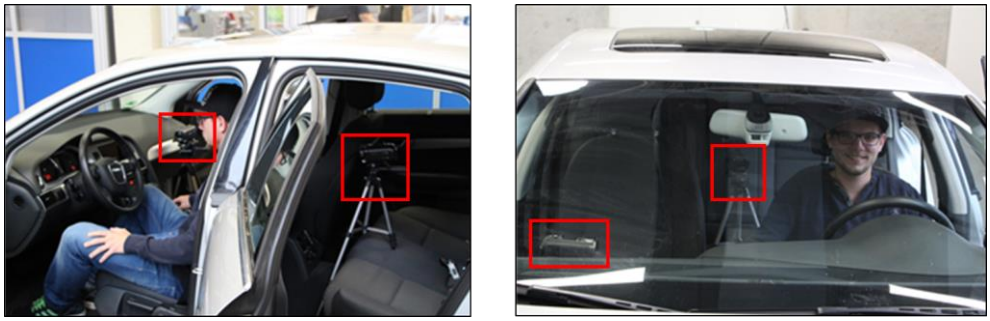

Figure 1: Test environment from side and front (cameras on the rear and the passenger's seat)

The proband was asked to show the first touchless gesture, for a preselected function, which came to his mind. The functions were selected from the secondary and tertiary driving tasks. For example 'change a music track', 'open a window', 'change your gear' or 'indicate'.

From the 21 participants 38% were female and 62% were male. More than half of the participants were student. A small amount of participants had some preknowledge with touch-less gestures, but most of them did not have knowledge about this topic. Furthermore, the requirement to participate was that no one had a system to recognize touchless gestures in their own automobile.

3.1.2 Evaluation

A selected number of functions and the determined touchless gestures will be presented in this part of the contribution. To this end, functions from the secondary and tertiary driving tasks were chosen.

Change to the next music track

Most of the participants suggested a swiping gesture to change to the next music title. However, most of the swiping gestures are differentiated to each other by how many fingers were

used or by the swiping direction. An interesting observation is that most people swiped from left to right instead of the other way around, which is known from using devices such as smartphones. Some made the gesture with one or two fingers but some used the whole hand.

Indicate your turn

Most people had an aversion of steering their vehicle with touchless gestures. This was accounted for by the absent haptic feedback. Therefore it was difficult for some of the participants to think of an appropriate gesture.

Other participants however found the idea of steering your vehicle by touchless gesture interesting and had multiple ideas for this function.

The most common answer was that you should point out your limbs in the direction you want to turn to. The variation between the gestures was merely what limb you point out, an index finger, a thumb or your complete hand.

Navigate to home address

Another function evaluated in the prestudy was to trigger the navigation system and let it navigate to your home address. Almost every participant noted that they would like to trig-ger this function by voice commands instead of pointing out a touchless gesture. Therefore the shown gestures were much too complicated and abstract so that they were no longer a part of the following main study. It stood to reason that functions like these are likely to be performed with voice or text commands.

3.1.3 Consequences for the main study

After the prestudy was evaluated some of the tested functions were dropped and some of them showed to be interesting for further investigation. Therefore the gestures for these func-tions were renovated for the following online survey.

To work off the touchless gestures they were filmed anew in a driving simulator. Afterwards these videos were compressed and converted into .gif file.

Tertiary driving tasks present the most interesting area of investigation. Therefore, most functions asked for in the survey are based around these. Functions of the secondary driving tasks brought the assumption that they are poorly to operate with by touchless gestures. But the interest in steering your vehicle with touchless gesture is significant. Also, technology realizing touchless gestures is not yet well developed, which is a reason to conduct further research in this direction. The tertiary driving tasks appealed to the participants which is the reason to direct the interest of the main study towards them.

3.2 Phase 2: Main study

3.2.1 Preparation

After the gestures were converted into .gif files, a questionnaire was created on SoSci Survey, (www.soscisurvey.de) a website for online studies. Due to limited file upload size, the ‘gifs’

were reduced to 128 x 96 pixels. Each gesture was shown to the participants on a single page, along with a scale from 1 to 5, to avoid a ranking between the gestures. The gestures were rated from 'not intuitive' (1) to 'very intuitive' (5). After the preparation of the study, it was shared on Facebook in a group dedicated to online surveys prepared by students.

3.2.2 Evaluation

The study was accessible for 33 days. During this time, a total of 58 participants completed the survey. Their average age was 29.5 years, with the youngest being 19 and the oldest being 61 years old. All results have a very high standard deviation. We assume that this is due to a split of acceptance for gestures in vehicles with some people rejecting gestures vehemently. In the following the results for selected functions will be presented.

Change to the next music track

The first result we want to show is the assessment for gestures for changing to the next music track (Fig. 2). The lowest scoring gesture was the swipe from left to right, shown in green, similar to the gesture you would use to operate a cover flow on a touch device. One possible explanation is that our participants have a different mental model, maybe because they don't have touch screens in their cars. The length of the gesture could be another possibility of its low ranking. The longer execution time could distract more from the main driving task. The other gestures do not differ much in terms of execution time and rating, with the highest rank being the swipe from left to right. We think it scores highest since you don't need to turn your wrist to execute this gesture.

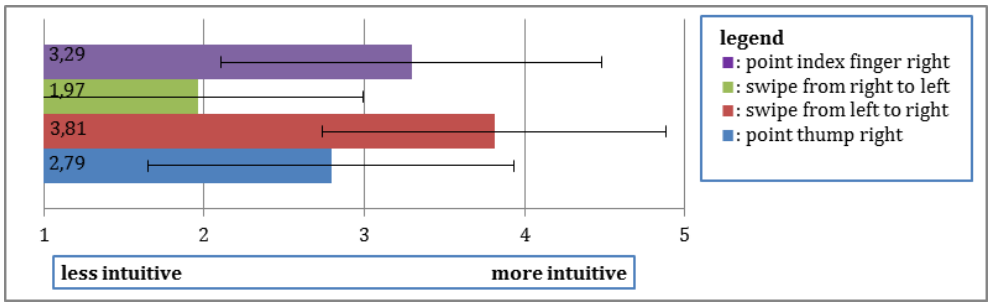

*Figure 2: Average rating and standard deviation of **'Change to the next music track**' gestures*

Muting

Another common task that could be controlled with a gesture is to mute the radio or media player. We extracted three gestures from our prestudy. The first is a slicing hand motion in front of the center stack display; the second is the same motion only in front of the user's neck. Both are metaphoric gestures for signaling someone to stop talking. The third gesture is a stop motion often used in traffic or even as a pictogram on hazard signs. After the evaluation it appears that the participants favored the gestures with short execution time and low movement complexity. The cutting gesture in front of the display, shown in orange, is scoring highest (Fig. 3).

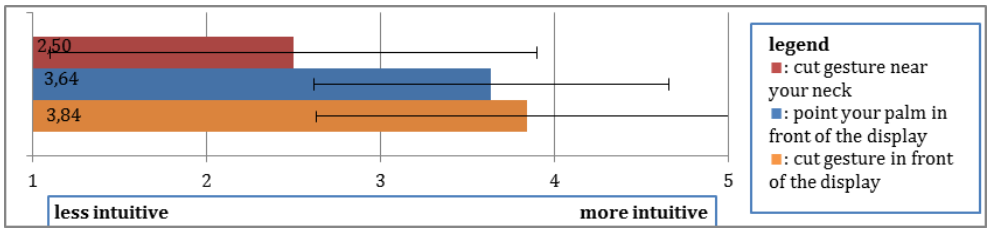

*Figure 3: Average rating and standard deviation of **'muting**' gestures*

Indicate a turn

Similar to the prestudy we evaluated how people would indicate a turn with touchless gestures. In Fig. 4 the examined gestures are shown. Moreover, the average value for the intuitiveness score and the standard deviation are shown. The most popular gesture was to point out your thumb in the direction you want to turn, shown in green, followed by pointing out two fingers (Fig. 5, left), shown in orange. The least intuitive gesture for this function was to open up and close your hands on the side of the steering wheel (Fig. 5, right). A reason for that could be that this gesture is to sophisticated. Even for these gestures the standard deviation suggests that some people are against steering their vehicle with touchless gestures and some have an interest in doing so. Therefore our observation from the prestudy was validated.

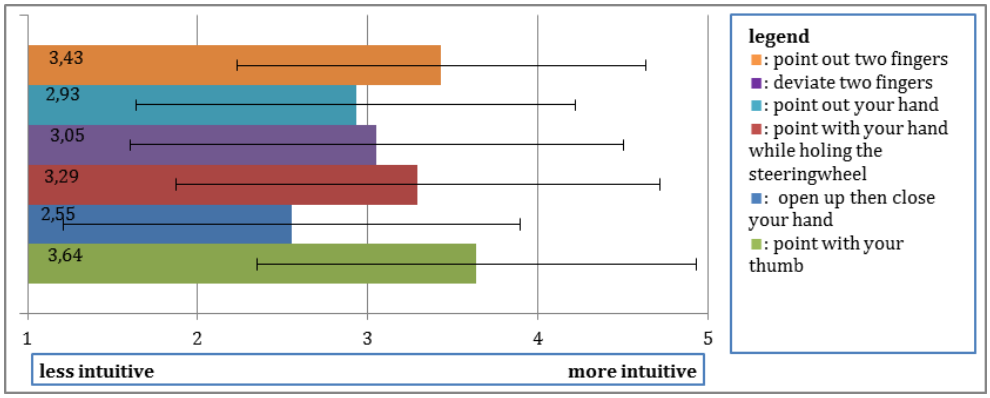

*Figure 4: Average rating and standard deviation of **'indicate a turn**' gestures*


Figure 5: Gestures for turn indication. Left: Point out two fingers. Right: Open up then close the hand.

4 Conclusion and Outlook

This contribution presents a two-stage usability study for the use of hand gestures in the context of automotive applications. Initially, the most intuitive gestures are determined in a prestudy within an automotive setting. The main findings show how participants are pre-influenced by their experiences with the usage of gestures so far, mainly derived from the context of gestural interaction from smartphone devices. Hence gestures for changing the music track in mid-air are derived from swiping through tracks within e.g. the "coverflow" context. Naturally, further correlations can therefore be found such as directional influences or the expected behavior of the system. Nevertheless, the variations in terms of duration, use and positioning of hand and fingers are still prevalent throughout the whole user base. An-other finding is that most gestures have certain limits with respect to acceptance ratings e.g. for steering a vehicle, which seems natural as this is a very safety critical situation on the one hand and it is difficult to imagine leaving such a control mechanism to a system without receiving haptic feedback.

The main study shows the acceptance ratings from a survey which show different scores for the various gestures presented due to some of them being found more intuitive than others. The interpretation of the results is somewhat difficult, but the closeness to gestures per-formed on a mobile device again seems prevalent as well as the fact that the simplicity of the gesture (in terms of duration, number of fingers, finger trajectory etc.) again seems to contribute to the intuitiveness score.

Further work will address the intuitiveness of the gestural interaction system for infotainment control developed at our institute [anon citation] and try to integrate gestures which are ranked higher regarding the acceptance scores to make the way of interacting more fluent for the users. Tests we have already conducted regarding driver distraction while simultaneously using mid-air gestures will be evaluated in the light of these findings as well as open new possibilities for further research.

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