PROTOTYPE WIRELESS PUSH-TO-TALK GLOVE

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Keywords: automotive, speech user interface, PTT

Abstract

In-car speech user interfaces play an increasingly significant role in vehicles and they use push-to-talk (PTT) buttons to allow the user to signal voice activity. We explore the differences in usage of a fixed location PTT button and a wireless PTT glove which allows a less restrictive field of operation. Our pilot study indicates that reducing the restriction on the location of the PTT button may make using the PTT button more comfortable compared to a fixed-location PTT button. Further studies are needed to evaluate the impact of the PTT glove on driving performance.

1 Introduction

Speech interaction is gaining a foothold in vehicle applications. One reason for this is that governments around the world have been enacting legislation requiring hands-free kits for cell phones in cars. These kits use speech as the interaction modality [4]. Another application of speech interfaces in vehicles is in controlling entertainment devices. Such systems have recently become standard equipment in some commercially available vehicles (see Sync Technology by Microsoft).

Speech is also used in situations when trained personnel have to interact with in-car devices while driving. Our group at UNH has developed and deployed the Project54 system that integrates all the electronic devices in a police cruiser (radar, radio, lights, sirens, etc.) into a single system [5]. The devices can be accessed either by the integrated touch screen interface or using a speech interface. The speech interface is activated by pressing a push-to-talk (PTT) button which is fixed to the crossbar of the steering wheel. This location was chosen such that the button is under the driver's thumb when driving straight.

The question that motivates this research is: how does the location of the PTT button influence driving performance? This is a relevant question, since speech recognizers are likely to require a PTT button for the foreseeable future. We hypothesize that a PTT button with a "floating" location will degrade driving performance less than a fixed-location PTT button. In order to test our hypothesis we have designed a PTT glove.

2 Background

Using in-car devices while driving may result in the increase of driver distraction. Sometimes, driver distraction can lead to accidents [8]. Distraction is closely related to driver workload. Angell et al. [1] define driver workload as "the competition in driver resources (perceptual, cognitive, physical) between the driving task and a concurrent subsidiary task."

We expect that speech interfaces will introduce less of a workload than visual-manual interfaces while driving. This is the expected result of applying the multiple resource theory by Wickens [11], which argues that tasks that require similar resources will interfere with each other more than tasks that require dissimilar resources. Speech interfaces allow drivers (consumers, police officers, etc.) to keep their hands on the wheel and eyes on the road when driving and simultaneously operating in-car devices, thus leaving resources related to vision and manual activity, which are needed for driving, significantly less taxed than they would be by complicated manual-visual interfaces. The expected outcome is that speech user interfaces will result in better driving performance than manual-visual interfaces.

A good topic review of using speech interfaces while driving can be found in [2]. This publication concludes that in the experiments reported on in the literature, driving performance was generally better and driver workload was lower when using speech interfaces compared to manual ones. Still many open questions remain. One problem is that the relationship between the characteristics of the speech user interface, the level of cognitive load caused by different road conditions, the psychological state of the driver and the resulting driving performance are not very well understood.

The characteristic of the speech interface that we focus on here is the position of the PTT button. In previous research [6] we have compared in-car speech interaction when using a PTT button and when speech commands are automatically recognized (no PTT). We found that having to use a PTT button can negatively influence driving performance when the recognition rate is low.

Sensored gloves have been used in a variety of applications. The most popular use of them is in gesture tracking and reading [12]. This technology uses bending sensors. Others published work on tracking the position of the hand using markers [10]. Gloves are also used to measure gripping forces by attaching force sensors on the palm and fingers [3;9]. We are not aware of any publications on using a glove for push-to-talk activation. This usage is explored in this paper.

2 The glove

The system is based on a general purpose glove. We installed two commercially available momentary pushbutton switches into its fabric, one under the tip of the index finger and the other under the thumb. The two buttons allow investigating the effects of using different fingers for PTT operation. By virtue of their mechanical design, the buttons provide tactile and audible feedback when pressed. The buttons are connected to an RF transmitter which wirelessly transmits button presses to a relay-station. This relay can be connected to the Project54 system to provide its PTT input. Figure 1 shows the locations of the most important elements of the system. In the middle (the blown-up circle), the tip of the index finger is shown with the pushbutton revealed. When used, the button is tucked back, inside the fabric of the glove.

Figure 1 The wireless PTT glove

The switches can be operated by pushing a finger against any firm surface. The surface is usually the steering wheel itself. With this design the PPT can be operated anytime without regard to curves or turns, because the push-buttons are literally under the driver's fingertips at all times. In this sense the operation space of the PTT is expanded to the whole surface of the steering wheel.

3 The fixed push-to-talk button

The current Project54 system uses a fixed PTT switch. In our experiments, and in some of the police cruisers using the Project54 system, we implement the PTT button using a commercially available AirClick remote control device located on the crossbar of the steering wheel as shown in Figure 2. AirClick has a radio frequency connection to the Project54 computer. All five of the buttons perform the same operation: they activate the speech recognizer while a button is held down. Usually the top left button is used since it is at the most convenient location for the driver when driving straight. This button is fixed at about a 75º angle compared to the vertical axis, as shown in Figure 2.

The operation of the AirClick is constrained to situations when driving straight or in a slight curve, when the hands are still at a convenient position. In sharper curves or in turns, the PTT slides away from the user's grasp. In this sense the operational field of this solution is more limited than it is for the glove.

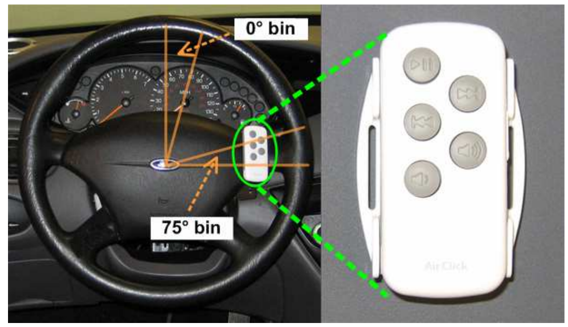

Figure 2 The fixed PTT setup and the AirClick device

4 Experiment

We conducted a pilot study to investigate the usability of the new glove solution.[1] In this experiment the PTT button type was a within-subjects variable, i.e. the subjects repeated the same driving scenario using the fixed and the glove PTT consecutively.

The experiments were conducted in a high-fidelity driving simulator with a 180º field of view, a car cab and a motion base to simulate acceleration and deceleration tilt. The simulator is shown in Figure 3.

Figure 3 The driving simulator

The simulation presented a 3.6 m wide, two-lane city road in daylight, with straight sections, intersections and curves. The map of the simulation scenario can be seen in Figure 4. The drivers were guided through the given route using traffic signs. These included one-way, no left or right turn, work zone directions and other signs that gave the driver a clear indication which road to take.

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1 A video presentation of the glove and experiment can be found at: http://www.youtube.com/watch?v=9UeEMWCnq4o.

During the scenario, Project54 voice commands appeared on the simulator screen at pseudo-random times. Participants were instructed to push the PTT button, say the command they saw on the screen (e.g. "lights and siren"), and then release the PTT button. In the experiment, recognition accuracy was close to 100%. Each subject received about 5 minutes of training on using the simulator and the glove. Each of the two experiments also took about 5 minutes. Participants pressed the PTT button (fixed or glove) about 20 times in each of the runs. The experiment was completed by five male UNH students, between 23 and 25 years of age. Their average annual miles driven was around 12000.

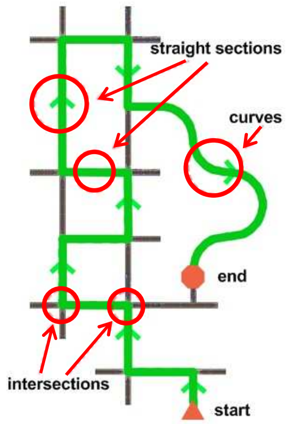

Figure 4 The driving scenario

We videotaped experiments and for the runs with the glove we hand-coded the location of participants' index fingers or thumbs when they depressed a switch. Our coding used 15º wide bins as shown in Figure 2.

For experiments with the fixed PTT button, the location of the button, and thus the location of a participants' finger, was calculated by adding 75º to the steering wheel angle. We recorded lane positions and steering wheel angles from the simulator. A higher variance of lane position or steering wheel angle represents worse driving performance [2]. We also recorded the times when the PTT button was pressed (fixed and glove) from the Project54 system.

5 Results and Discussion

Figure 5 shows the histograms of finger positions (using 15º bins) for the five participants when operating the PTT buttons.

For the fixed PTT button, clicks in the 75° bin were most common. This tells us that subjects most often operated the fixed PTT button when driving on straight segments of the road. Reviewing steering wheel angle and PTT timing data shows that the glove buttons were also predominantly operated on straight road segments. However, the histogram for the glove PTT buttons shows that, when given the choice, participants preferred to push the button in positions other than that provided by the fixed PTT button, and that they experimented with a variety of positions.

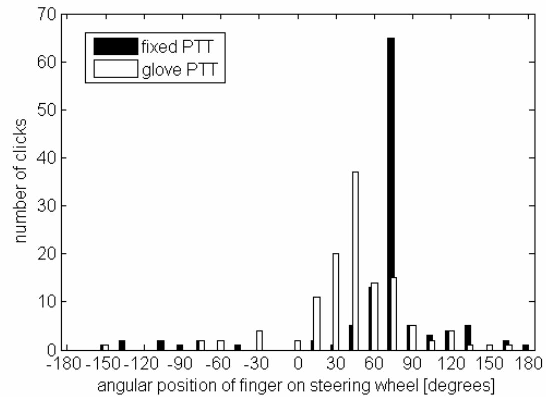

Figure 5 Angular position histograms

We also found that the push-button under the thumb was more frequently operated (around 80%) than the one under the index finger. Since the fixed PTT button is also operated using the thumb this aspect of its design was validated by our initial data.

The average lane position variance for both fixed and glove PTT buttons was around 0.3 m^2. This is consistent with lane position variances we measured in previous speech interaction experiments and indicates that, at the very least, using the glove did not result in a deterioration of driving performance.

While turning at intersections, the average steering wheel angle variance was lower when participants used the glove. ANOVA analysis reported no statistical significance. However, in intersections each participant had lower steering wheel angle variance with the glove. This may indicate that using the glove requires less effort than using the fixed PTT button when the driving task is very demanding.

Furthermore, the reaction times of the subjects were measured (see Figure 6). We defined reaction time as the interval between the appearance of the command text on the simulator screen and the activation of the appropriate PTT button.

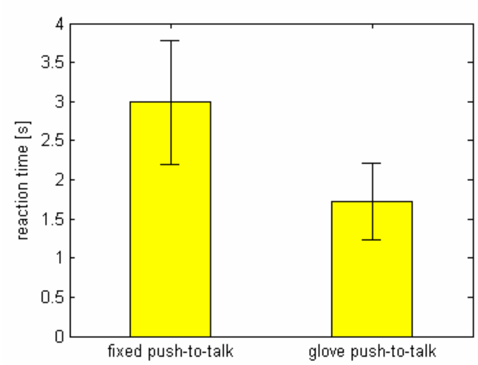

Figure 6 Reaction time while taking turns

We hypothesized that the reaction time for the glove would be shorter since the activation button was always under the tip of the finger and because the fixed PTT can drift away from reach when taking turns. The collected data did not show any significant difference for straight road and curve driving, but when taking turns, the reaction times differed noticeably, as Figure 6 shows. Using ANOVA the difference was found to be statistically significant with $p<0.0001$. This result supports our hypothesis, that easier access to the PTT will shorten the reaction time.

6 Conclusion and Future Directions

In this paper we describe the experimental investigation of a wireless PTT glove used while operating a simulated vehicle. We found that lane position variance was very similar for both the glove and a fixed-location PTT buttons. Average steering wheel angle variance was lower when using the glove for one demanding driving task (turning at intersections), although the difference was not significant. Reaction times were found to be significantly shorter while using the glove in turns compared to using the fixed PTT button. We also found that participants operated the glove in a variety of positions around the steering wheel which may be an indication that using the glove is more comfortable than using a fixed-position PTT button. This conclusion is also supported by the results of the post-experiment questionnaire, in which participants gave the glove higher grades for efficiency and ease of use. Overall, our findings suggest that a PTT glove, or a PTT button with a “floating” location, may make performing speech tasks more comfortable and less distracting while driving, than a fixed PTT button would.

The above data does not tell us under what circumstances it is safe for drivers to be performing a secondary speech task while underway. To answer this question, we are investigating the influence of performing speech tasks on driving performance as e.g. in [7]. Further studies are needed to improve understanding of the interactions between the driving task, characteristics of the speech user interface, such as the PTT button type, the psychological state of the driver, and driving performance. E.g. in this experiment, participants spent most of their time on city roads. We need to explore driver performance on other types of roads (highways, rural roads, etc). We also intend to explore the use of an instrumented wheel which users could tap to indicate the start and end of an utterance. Finally, we have to quantify potential drawbacks to the glove, such as accidental PTT triggering.

On a different note, we will experiment with using the wireless PTT glove with a handheld computer. Handhelds are becoming powerful enough to provide a speech interface to in-car devices. They will also likely be used for other tasks outside the vehicle. The wireless PTT glove could help provide a continuous user experience in and outside the car. We expect that the availability of such a continuous user experience would entice some users, e.g. police officers, to use a PTT glove.

7 Acknowledgements

This work was supported by the US Department of Justice under grants 2005CKWX0426 and 2006DDBXK099.

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