Integrating a Touchless UI in the Automotive Environment

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Abstract
In this paper we introduce the usage of a touchless sensor device in the automotive environment, in particular we discuss how its integration in an infotainment system could change the interaction between the driver and the car.

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Car, optical sensor, infotainment, UX, touchless.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

Introduction
In the last years the automotive market has launched a lot of infotainment systems that have changed the habits of drivers.

Although these systems made it possible to increase the activities inside the vehicle, integrating the personal settings of the driver through the connection to the smartphone, they have failed to create a system fully suitable for the automotive environment.

In fact they have tried to exploit the technology of smartphones on voice control, that still has some limitations such as the lack of supported languages. For

Figure 1 Testing the sensor's detection of the gestures

example at the moment on Android systems the accepted languages are only English, French, German, Italian, Japanese, Korean, Russian, Spanish and Brazilian [1], but not for all these languages are supported all commands. Moreover, the systems are not able to recognize the origin of the voice, creating errors in situations like a crowded car, where every passenger can control the system.

Instead the usage of physical buttons or touch screen requires the driver's attention, so the user must stop looking at the road, even for a short time, reducing his safety [2]. For this reason we studied alternative methods for using these infotainment systems.

After some initial tests we chose to experiment with the optical sensors to create a touchless control (Figure 1). Past studies showed that the number of eye glances at the screen is lower with a gesture control compared with the touch controls and the physical buttons [3].

The sensor

The sensor that we chose is the Leap Motion, that works through an infrared camera and two red leds (Figure 2).

Figure 2 Leap Motion

The infrared camera detects better the image than a regular camera because it reduces the environment lights, that generate noise in the information.

The sensor can detect the hands and recognizes each finger and every bones of the hand through an elaboration of the images. It is also able to detect the forearm with the data of the position and the rotation of the palm. The Leap Motion works on several platforms and with many libraries, so it could be used for different applications.

To interact with the infotainment systems that are in the market is necessary to use the iOS or Android libraries, because the main infotainment systems are developed for iOS, like the CarPlay, or for Android.

At the moment the Android SDK is available only in private alpha version, as it is not yet ready to be shared with the broader developer community. We tested this version and it is quite unstable. But the potential of this library is very huge, because it can integrate the sensor inside the mobile devices environment and also in the most of the infotainment systems.

Waiting the official version of the Android SDK, we developed a demonstrator in JavaScript that simulates the standard operations of an infotainment system.

The test sessions

To interact with a generic infotainment system, we defined several gestures that correspond to specific commands.

There are four main gestures and they are used to navigate inside the menus:

- Swipe left
- Swipe right
- Key tap
- Anticlockwise circle

The swipe is a fast movement of the hand towards a specific direction. In our project the swipe left and the

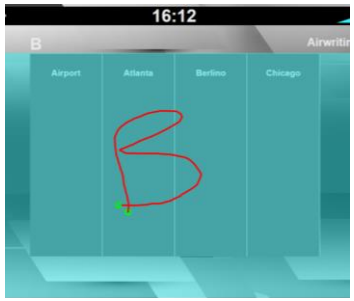

Figure 3 Screenshot of the air writing in the navigator

Figure 4 Mouse 3D that we integrated in the system

swipe right are used to move the selection to the left or to the right within the menu.

The key tap gesture instead is recognized when the tip of a finger rotates down toward the palm and then returns back to approximately the original position, as if tapping. This movement determines the confirmation of a selection.

The anticlockwise circle is a anticlockwise rotation with the open hand and it is used to come back to the previous page.

We experimented also specific gestures that control some specific settings.

If the driver closes his hand at the left of the sensor can change the value of the temperature of the driver's spot with a hand movement up or down. The same gesture made at the right of the sensor changes the temperature of the passenger's spot.

With a clockwise rotation of one finger it is possible to increase the volume of the car stereo, and to decrease it with an anticlockwise rotation.

In some specific pages there are also other gestures. In the contacts page the rotation of two fingers changes the letter of the index.

Moreover in the maps page it's possible to write the destination through a specific gesture called "air writing" (Figure 3). It is a movement of the index finger along the X axis and Y axis. The driver can write the letters using his finger like a pen on an invisible whiteboard positioned in front of him.

To improve the air writing we added a sound feedback that notified when the finger is detected on the invisible whiteboard and, then, when it is possible to start to write.

The audio feedback is implemented in every part of the system, with proper sounds for swipes, confirmation and back actions. A female voice reads the menu item currently selected by the user, so that the usage of the infotainment system does not need the driver's look. Moreover the system gives an audio feedback when the hand goes inside or outside the detection field of the sensor [4].

The last feature that we added was the possibility of the driver to go directly on a specific part of the system, that could be the most used pages. We created three shortcuts, programming the sensor to detect when specific fingers are extended for more than three seconds.

At last we decided to add another control device to improve the user experience. In fact the most important issue of the touchless control is the detection of the unwanted gesture if the driver moves his hand accidentally over the sensor. To avoid this situation we added a knob between the seats.

In our tests the knob is a common 3D mouse (Figure 4) and can be used for navigating the system like a joystick or to use its buttons to pause the music or come back to the home, but there is another feature that is the real purpose of this device in our set. The knob can be used like a button whose pressure enables and disables the sensor. Moreover even the sensor can turn off itself if it does not detect any hand for a while.

In this way if the driver moves his hand over the Leap Motion, the gestures are not detected until the sensor will be enabled again through the knob.

Our touchless control was tested during the development in a simulation environment. Then it was tested inside a real car; this test was focused on the understanding of the real dimensions with the obstacles of the car, like the handbreak or the gear shift. The tests are qualitative, we have already planned future tests, that will be done with a quantitative approach.

The results of these preliminary tests show that the volume control, the back gesture and the shortcuts are easily performed by the testers. Other gestures like the climate control create some errors because sometimes the driver puts the hand in the wrong position along the horizontal axis. The swipes (left or right) generate some errors because sometimes the driver makes a gesture with a speed or a rotation not understood by the sensor.

Further tests will be done in an enriched simulated environment and during driving sessions.

Conclusion

Our tests show how an optical sensor can be used in the automotive environment.

The potential of the touchless interaction is very huge because allows the driver to control the car and keep looking the road at the same time. We tried to mitigate the typical problems encountered in the development of a touchless interface introducing other input/output elements like the button to activate/deactivate the sensor, or the voice feedback.

We think the study can be further developed, testing other elements, like on-steering wheel controls, to find the best integration of a 'hand gesture' sensor within the car environment.

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