On the Relevance of Freehand Gestures for Peripheral Interaction

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Abstract. Interactions in the visual and attentional periphery can help to perform secondary tasks without an attention shift away from the primary task. In this paper, I define freehand gestures as imprecise moments towards any device or object in the periphery of a user. This kind of gesture can be interpreted by the device and understood as an attempt for activation or deactivation. The interaction can be performed eyes-free, which is an advantage compared to controlling haptic elements such as buttons. The paper will provide example use-cases, advantages and constraints of the approach as well as issues I would like to discuss at the workshop with experts on the field of peripheral interaction.
Keywords: peripheral interaction, freehand gestures, eyes-free interaction, workshop

1 Introduction

While working on this paper for a workshop on peripheral interaction, I direct my full attention to the display standing on my desk. On the screen, multiple windows are open at the same time such as a browser, Word and a PDF viewer showing all the related work. As if the task of writing this paper would not be difficult enough, little but necessary interactions with other devices on my desk distract me from my main task. The deadline is approaching, which increases my stress level. The music, which is usually very welcome while I am sitting on my desk, suddenly becomes rather annoying. I reach for the speaker to find the on/off button, which I am not able to find right away. I need to look at the speaker, push the button and get back to work. How was I going to finish the paragraph again? An hour later, the sun just disappeared from the sky, it gets too dark to see the notes I wrote on a piece of paper. I reach to the left to find the light switch for the reading light on my desk. Where did it go? I look to the left to find the switch and reach for it to turn on the light. I turn my head back to the screen. Which sentence was I working on again?

Of course, these are only exemplary but also well known situations. In both cases, it would have been helpful to succeed in my first attempts without having to look at the devices I was going to activate. The attention shifts away from the screen towards other devices on my desk interrupted my concentration and cost me valuable time in a stressful situation.

But, what if both devices, speaker and reading light, would have been able to interpret the movement of my hand towards them and to guess my intention to deactivate or activate them? My imprecise gestures would have been sufficient to fulfill my tasks, there would have been no need to look at the devices to find the one button I was looking for and I would have been able to keep concentrated on my paper.

The purpose of this paper is to point out a characteristic of simple freehand gestures: Hand and arm movements can be performed in a rather vague way compared to the interaction with ordinary haptic control elements such as buttons or switches. We should try to make use of this advantage in the field of eyes-free interaction in order to allow the control of devices in the visual and attentional periphery [5]. In the following paragraphs, I will provide some exemplary use-cases, advantages as well as possible drawbacks and constraints of this approach. Furthermore, I will report on an experiment from the automotive context, were eyes-free interaction is even more critical. Twenty drivers used a simple gesture to deactivate certain functionalities while driving and received positive quantitative and qualitative feedback.

2 Freehand Gestures

I define freehand gestures as movements of the hand and the arm in order to interact with a digital application without the need to touch a device or other physical representation. As sensors such as Microsoft Kinect or LEAP Motion provide a cheap and relatively easy way to track gestures, their importance in the field of Human-Computer-Interaction has increased. In the automotive context, studies involving freehand gestures have shown their ability to decrease visual distraction [2], helping the driver to better focus on traffic. Thus, gestures have a great potential to enable eyes-free interaction [9]. One reason is that movements performed by hands and arms can be monitored via the kinesthetic sense due to the feedback from muscles and joints. Because of this inherent feedback, visual attention or additional artificial feedback is not needed during the interaction itself. Therefore, freehand gestures can be used for research in the area of peripheral interaction [1, 6].

Though, the design of gestural interactions has a strong influence on their applicability for peripheral interaction. A gesture performed in the periphery without an attention shift away from the primary task is only possible if its naturalness can be maintained. E.g. a rather large or arbitrary gesture set works against the advantage of natural interaction [8]. Gestures need to be learned and remembered and thus using the right gesture for a certain action requires additional attention, which is a problem for peripheral interaction. For this reason, required movements should be kept simple.

3 Approach

For the reasons stated in the previous chapter, I would like to stress the importance of a certain property of freehand gestures: Compared to the usage of haptic control elements, where the movements to and the activation of the button needs to be very precise, a gesture can be performed in a rather vague way using imprecise movements. Considering the exemplary use-cases described in the introduction of this paper, a simple gesture can replace the interaction with the on/off button of the speaker to turn off the volume and the actuation of a switch to turn on the reading light (see Fig. 1).

In general, each movement of a hand close to a certain device could be interpreted by this device. In our case, the system can 'see' how a hand reaches towards it and interprets this movement as an attempt to being activated or deactivated.

The tracking of the hand and its movements can be realized by using infrared distance sensors, which are integrated in each device in a reachable distance to the user. By interpreting the values of all active sensors, the system is able to detect the single device a user is reaching for.

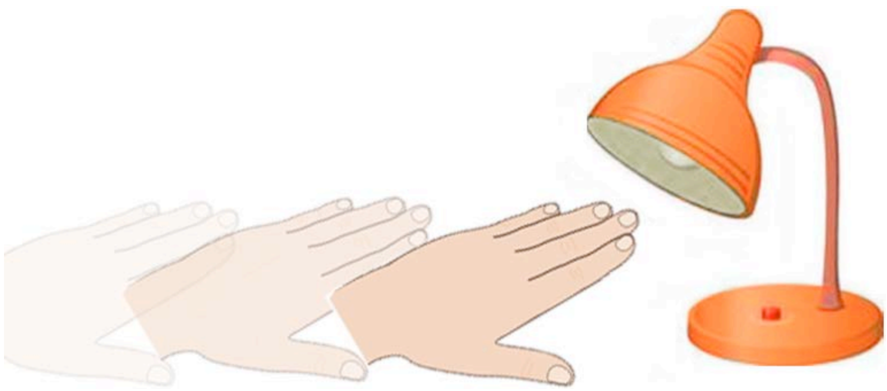

Fig. 1: Turning on the light by simply reaching towards the lamp

4 Prototype

Visual distraction of the driver is a critical issue in the automotive context. Controlling e.g. the infotainment system via a touchscreen or a number of haptic controls is already a difficult task itself. To accomplish this task while concentrating on the primary driving task produces an even higher amount of cognitive load. Therefore, my colleagues and I implemented a prototype [7] enabling a simple freehand gesture to control certain functions while driving in city traffic for about 15 minutes.

Twenty drivers were able to use the stop-gesture (approaching a device with the whole hand, see Fig. 2) to turn of the ventilation of the air conditioning (AC), mute the volume of the radio and stop the route guidance of the navigation system. In order to recognize the hand of the driver, we attached two distance sensors, one below and one above, to each of the three devices (see Fig. 2).

To be able to gain realistic insights into this kind of gestural interaction, we chose a between-subjects design, where each driver used haptic controls in one round of driving, the stop-gesture in the other round of driving and had the choice of using either type of interaction in the last round of driving. To avoid order effects, half of the participants started with gestures and the other half with haptic controls.

The quantitative results of an AttrakDiff2 questionnaire, which all participants filled out after each round, show that gestural as well as haptic interaction has a high pragmatic quality. At the same time, gestures have a higher hedonic quality, meaning that the use of the stop gesture did not only fulfill the purpose of deactivating certain functions, but also was considered to be the more attractive type of interaction.

Qualitative results from interviews after all three driving rounds show that 14 out of 20 participants favored the gesture over haptic controls. In the third round, when drivers were allowed to use either type of interaction, they chose the gesture for 91 out of 120 tasks (76%). 16 out of 20 drivers stated that the use of the gesture helped them to better focus on traffic, which is especially relevant for peripheral interaction. One driver stated that "turning off the radio is especially helpful in stressful situation, just like when I am entering a crowded parking garage to find a parking spot, where I usually switch of my radio to be able to concentrate better".

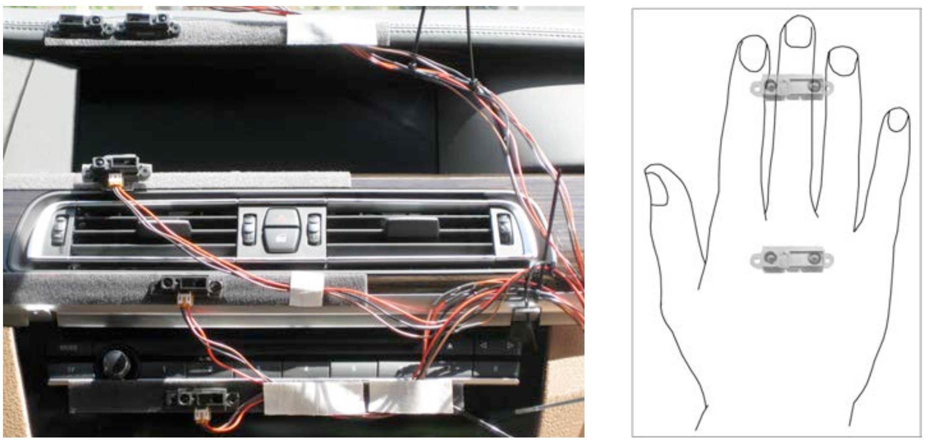

Fig. 2: Distance Sensors on the Dashboard of a car (left) detecting a Stop-Gesture (right) [7]

All in all, the results of the study allow us to draw conclusions, which are interesting for the field of peripheral interaction. The application of a simple stop-gesture, which basically describes the movement of the hand towards a certain device to deactivate its functionality, has proven to be pragmatic and attractive to the drivers in real driving situations. One reason for drivers choosing gestural over haptic interaction was the feeling that it helped them to better focus on traffic while performing a secondary task. Considering the use-cases described in the introduction, this approach can be transferred to the desktop, where secondary tasks like turning on the light while focusing on the computer screen are performed on a regular basis.

5 Outlook

To provide a natural way of peripheral interaction with a system via gestures, it is important to keep the set of possible gestures rather small. The need to think about the correct gesture in a certain use case would hurt the principles of eyes-free and therefore peripheral interaction. On the other hand, a small gesture set limits the number of possible interactions with a certain application. Considering the use-case of interacting with the audio-player [5] of a desktop computer, users will probably ask for more detailed controls. A possible step towards this need is the mapping of the distance of the hand to the speaker: the closer the hand, i.e. the smaller the distance between the hand and the speaker, the quieter the music, and vice versa. How far this additional possibility still meets the requirements for peripheral interaction, needs to be studied in future experiments. The workshop on peripheral interactions offers a great opportunity to discuss the issue of how the number and kind of gestures influence their applicability for eyes-free interaction without shifting attention to this secondary task.

Furthermore, there is a possible conflict between the needed impreciseness of the movements and the segmentation issue of gesture tracking. E.g. if I only move my hand to grab an apple laying next to the lamp on my desk, the light should not be activated. This case of a false positive gesture recognition would result in confusion about the accidental interaction. An attention shift to the lamp and an interruption of the primary task of writing the paper would be inevitable. When designing for peripheral interactions using gestures, the trade-off between the advantages of vague moments and the resulting problems for gesture tracking need to be taken into account.

Another issue, which needs to be considered during the design of peripheral gestural interaction, is the type of feedback given to confirm the success of the performed action. As mentioned above, kinesthetic feedback is directly given by muscles and joints while moving hand and arm. While muting an audio-player or turning on the light without paying visual attention, functional feedback [10] is given by the corresponding device itself: I can hear that no music is being played anymore and I notice that the room is not dark anymore without a shift of my visual attention towards the lamp or its light bulb. With other functionalities, such as disabling notifications from a messenger such as Skype, direct functional feedback is not perceivable. Therefore, when gesturing towards a physical representation of Skype, such as the StaTube [4], the device needs to provide an additional artificial feedback. A possible solution is the changing color of the StaTube, indicating the success of my action in an ambient way.

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