Gesture based input methods for wearable devices

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Abstract— In the last few years the demand of mobile devices has changed significantly and new requirements were defined. For example, now it is very important for social acceptance that the interaction with the device happens with attracting as less attention as possible. So a new trend has been discovered: wearable devices. With this invention an incredible number of new types for input and feedback methods apart from the common touch systems have been developed. In this paper different concepts of gesture based input are introduced, concentrating on wearable devices other than tablets or mobile phones. The concepts can be subdivided into two categories: gesture based input methods using hands or fingers and other methods without using them. These categories are each illustrated by a few real world examples. In addition the trade-offs between the proposed solutions are presented. At the beginning of the paper you get a short overview of the important qualities a good device must have, a subdivision of input methods in hands-free and eyes-free interaction and the benefits of wearable devices.

Index Terms—gesture based input, microinteraction, wearable computing

1 Introduction

Since Apple introduced the first iPhone in 2007 [9] most people can't even imagine a world without smartphones anymore. But actually there is a new trend, which may one day disrupt the supremacy of current mobile devices like mobile phones and tablets. Meant are wearable devices. Nowadays, people are permanently online and want to get news and notifications round the clock, seven days a week. On the contrary it is not possible to check or interact with smartphones or tablets in several situations, like a meeting, a conversation or at work. That's the reason why the interaction with the device and the product itself has to be very inconspicuous. Obviously, wearable computing solves this problem. The fact that it can be worn directly on the body gives new opportunities for input and feedback methods, so that the interaction happens much more discretely. Furthermore, common mobile devices are quite nonfunctional, because there are many occlusion problems, i.e. the fat-finger problem and additionally the traditional touchscreen doesn't work in several cases, e.g. when it's raining. Based on these facts software engineers concluded that a device which can be worn on the body would be quite advantageous and due to these aspects they developed many different input solutions based on gesture sets, which will be discussed in the following.

2 Important Basic Knowledge

In the following section I will give a short overview of the definition of different interaction categories, benefits of wearable devices and the reason why they are so popular.

2.1 Benefits of wearable devices in everyday life

The technology of wearable computing may change our lives and the common lifestyle in many different circumstances. In the health care system it can help to detect and prevent diseases, improve the independence and everyday life of disabled or ill persons by offering new input methods, or just help everybody to get a better and healthier lifestyle. Another issue is the influence in the sport sector. To give an example, wearable computing enables persons to better supervise their body when they are doing workout or help them tracking their movements. Furthermore such products just simplify and improve the everyday lifestyle, by giving aid in countless situations [2]. In *figure 1* you can see a summary of possible use cases.

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- *This research paper was written for the Media Informatics Proseminar on "Interactive Surfaces", 2015.*

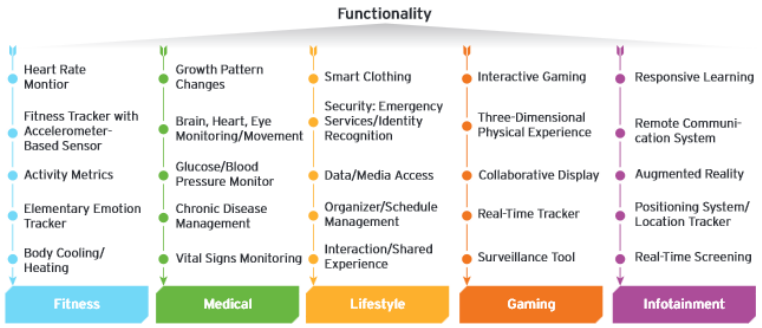

Figure 1. Overview of possible use cases for wearable devices [2]

2.2 Characteristics of popular devices

Successful devices have to fulfill certain characteristics to become and stay popular, because today people have a precise idea of how their devices have to work. Otherwise it would definitely influence the buying behavior and frequency of use in a negative way. People only use devices regularly when they fulfill the following basic criteria. Being always reliable, socially accepted and available is as important as the interface being simple, so that people enjoy using it. The last important point is durability constrained by the battery's lifespan [7].

2.3 Definition of hands-free and eyes-free interaction

Input methods using gesture sets for interaction with devices can be subdivided into two categories: hands-free and eyes-free interaction. Hands-free interaction is an input method which uses gestures executed by the hands or other parts of the body, but without having equipment in the hands, in order to leave them empty. That's a huge advantage, because with empty hands the user can instantly return to the primary task, if it is needed, which highly increases the security [5]. Eyes-free interaction requires minimal visual cost, which means that the focus of the user is not taken away from the physical world. That is very important, because otherwise it may create dangerous situations by distracting the visual focus [6]. Due to that fact it is important to use tactile feedback methods which can be performed by appealing the human senses, for example by using pressure, temperature or sounds [7]. The best interaction solution is a combination of hands- and eyes-free methods to have the lowest visual, cognitive and physical distraction [7].

3 Gesture based input for wearable devices

Until now audio input is the most common interaction method for wearable devices, beside the usual touchscreen interaction. But speech

control is still quite associated with disadvantages and problems, e.g. reliability problems in noisy environments or the revealing interaction, because it can't happen in private [7]. Obviously gesture based input methods don't have these kind of problems.

3.1 Gesture based input methods with hands or fingers

The reason for the popularity of finger based input is the high level of sensitivity in the area of palms and fingers. Additionally, hand gestures can be effectively learned and remembered [10], which enhances simplicity and the joy of use.

3.1.1 Hand gesture measured by camera

There are different possibilities to measure hand and finger motions. The most frequently-used option is using a camera, which is fixated on the body. The positions differentiate extremely between the solutions. The developers of "PinchWatch", a one-handed device, decided to attach the camera at the chest to register pinching, for example pressing the thumb against finger or palm [5]. Another solution is "ShoeSense", where the camera is fixed at the shoe to measure performed hand and finger gestures [1].

3.1.2 Hand gesture measured by accelerometer

Accelerometers are also a good opportunity to register hand activities. These devices measure the acceleration of an object. Fixated on the wrist, taking a bracelet as example, they can easily recognize simple hand movements, but complex movements are often misinterpreted by accelerometers [4].

3.1.3 Finger gesture

Using fingers is still the most common method for gesture interaction basing on the huge number of alternative finger gestures, which can be executed by human beings. The thumb enables people to perform gestures, which vary from pointing to pinching up to touch movements. Again, these gestures can be detected by different tools. In the example of "WatchIt", four potentiometers are installed in the wristband of a watch measuring different pointing and sliding motions on the band, to avoid occlusion of the screen [12]. Potentiometers measure the electrical potential, for example caused by the contact of skin.

3.2 Gesture based input methods without hands or fingers

Until now the most common input method for mobile devices is to hold the device in the hand and use the fingers for the input, but in many situations the hands are needed for a primary task, whose execution will be interrupted when using the device like that. In some situations it can be even very dangerous to do that, like taking the hand off the steering wheel while driving. That's why new methods were developed to let the user's hands empty.

3.2.1 Electromyography - Muscle activity

A quite trendsetting input solution is the use of Electromyography to measure the electrical activity of the muscles and interact with a device that way. „Electromyography (EMG) is defined as the study of the muscular function through the analysis of the generated electric signals during muscular contractions“ [3]. So if the user performs a gesture, electrodes at the skin, which are integrated in the device, register the muscle activity and control the device through that. A huge advantage is that the interaction happens with attracting very low attention, which is conducive for social acceptance. But the most important benefit is the possibility for quadriplegic people to get back their independence, if the device is worn at the neck [3]. A good and successful example for a device using Electromyography is "Myo - Gesture Control Armband" [11].

3.2.2 Head gesture

An other option for fully hands-free and eyes-free interaction is using movements of the head, eyelids or ears. The detection of head-movements is often realized by using a gyroscope or accelerometer, which is installed in a device mounted on the head. In the example of "InEar BioFeedController" a gyroscope is integrated in an inear-headset, which detects nodding as "Yes" and head shaking as "No" [6]. Using this input method it is important to ignore gestures which are executed too fast or too slowly, because the input has to be distinguished from the general head movements which are made thousandfold a day. An extraordinary benefit is the fully hands-free and eyes-free interaction, which enables the user to concentrate on his real world tasks, because it requires neither visual nor tactile contact. In addition the size and inconspicuousness of the device is a great advantage, because it looks like a usual headset. A negative point is the problem of possible misinterpretation of the normal movements, which may cause wrong input.

3.2.3 Foot gesture

Feet movements are a further possible gesture interaction method. Sensors in the shoes enable to track and evaluate movement based pressure to generate the input. In the example of "ShoeSoleSense" this was realized by several sensors implemented in the insole of a shoe, which can detect almost every movement of the feet from normal steps over pressure-shifting up to little toe movements. Based on the different anatomies of feet, everybody has it's individual footprint, which enables personalized analysis and authentication purposes. It is also beneficial, that the sensors are implemented in the shoe, so that they can't get damaged. [8]

3.3 Trade-offs

3.3.1 Advantages and disadvantages of hand gestures

There are a few disparities between input methods based on gesture sets using hand movements and those, who use other parts of the body. The advantages of using hand and finger gesture sets are the good characteristics of the interaction with the device. The input can happen very accurately, is often unambiguous, which prevents misinterpretation and is, in addition, easy to learn. One of the problems of using hands for input is the increased risk of accidents caused by the occupation of the hand. If the hands are occupied, it is more difficult to react fast enough in certain situations, like absorbing a fall when being stumbled.

3.3.2 Advantages and disadvantages of gestures without hands

The biggest advantage of interaction without hands is definitely the improved security, which will among others reduce the increased number of car accidents caused by using mobile devices [13]. Due to the certain fixing-positions on the body, which are often covered by clothes, other people don't realize the interaction with the device and the input can happen by the way. Additionally quadriplegic people can use those devices without help, if they can be mounted at the neck or head, so they can get back a little self-dependence. Prejudicially is, that the everyday movements can easily be misinterpreted by the devices and may cause wrong input, just as the fact, that they are harder to learn and remember.

4 Conclusion

In this paper different methods of gesture based input methods have been discussed. On the basis of the trade-offs you can see that both interaction solutions, referring to the different gesture sets, namely the use of hands or not, both have benefits and disadvantages. The market will continue to enhance the concentration on wearable devices, but the design and development will be more influenced by the question, if a device can be used hands-free and eyes-free, to improve the security when being mobile. Additionally, the method of giving feedback and therefore the question of the best sense being appealed to recognize the feedback, is also a very interesting field of research.

These new developed input and output methods in combination with wearable devices will one day revolutionize the world market.

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