Body-Centric Interaction Design Approaches for Large Displays

Elisaveta Karypidou

Abstract— Getting to know what our bodies can do is becoming more and more important in this era since large displays and multi-surface environments are on the rise. We cannot use traditional interaction modalities like mice and keyboards anymore since we are now dependent on our entire body. There are different body-centric approaches that the designer of such environments has to consider: the location of the body while performing and how the user gets feedback of his actions. We will take a look at different approaches for interactive body-centric techniques which allow our bodies to be usable interactive input devices.

Index Terms—body-centric, multi-surface environments, whole-body interaction

1 Introduction

In multi-surface environments users are obligated to interact with their body, whether it is using their hands to accomplish tasks by touching the screen or using their entire body by walking in front of the screen[4], enabling new opportunities for interaction designers. We have to forget the traditional techniques for interacting with mice and keyboards since they are not usable for such large displays[2]. Using the body as an input instead of a hand-held device can be strange at first but since our brains are filled with great learning potential,[1] we can quickly adapt to the new environments with a little exercise. But what is this so called body-centric interaction approach? It means using your body for interacting without any kind of hand-held devices. The movements and the position of the bodyparts are the main input types: mid-air pointing, on-body touch or making body movements in front of the screen whether it is dancing or jumping.

Throughout the years, improvement in sensor and actuator technology has made a lot of whole-body interaction techniques possible. But still, any interaction technique which should be widely adopted in the long term has to implement some essential requirements, as Shoemaker et al. mentioned in his work, the technique must be practicable at any distance from the display, the technique must provide rich awareness information to users, collaborators, and observers, and the technique has to provide a body-centered interaction experience.[2] The latter is our main topic in this research paper: what is our body, regarding interaction with large displays, capable of doing? This paper discusses the different body-centric techniques that our body has to offer and how these techniques contribute to helping interaction designers of large displays in their work space.

2 Getting to know body interaction

The human brain is filled with more knowledge than we think. As Klemmer et al.'s bicycle example shows, this knowledge combined with the human's good understanding is able to do more than one thing at once: navigating, balancing, steering, and pedaling.[1] Transferring this example to our graphical user interfaces, we also need this coordination of simultaneous actions even for simple tasks like e.g. writing an email: typing, spelling, using the mouse of the computer, fading down the influences of the environment, etc.

Innovations from every point of view are not a big challenge for the average human. By learning through doing, we have accomplished new tasks since our childhood. Back then the challenge was to learn how to walk and talk. Nowadays, the challenge in using interactive devices is learning how to use them. For interaction designers this is a very important point. They don't have to concentrate on just easy interaction techniques but can also include tasks that are rather complicated, because the human will learn performing these tasks by trying them out.

You usually use your smartphone, and not a large display, for interacting at home. The only reason why hand-held devices are more distributed than large displays is that shops don't offer many of them, and if they do they are very pricy.[3] So in conclusion, most interacting devices are hand-held devices, even if our body as a whole has a lot of usable movement abilities to offer. The first design to use the whole body as an interaction technique is Krueger et al.'s VIDEOPLACE. The user has to stand or walk in front of a big display while pointing to it.[4] As for interactions with large displays in the context of public displays, you can either interact with a hand-held device or you can use your whole body to perform tasks. Holding a device in front of a large display contributes to a tired arm and has less interaction opportunities than whole-body interaction.[4] With a hand-held device you can either point to the display or click on buttons of the device, but with your body you can perform much more techniques such as touching the display, drawing in the air or using movements of more body parts at once.

3 Complexity of Design Alternatives for Public Displays/Large Display Interaction

Since there will be a time when large displays will become a must-have in every household, we have to understand what our body is capable of so that the designers manage to develop practical large displays. Most display interactions are limited to just hand gestures. For large screens or multi-surface screens we have more room for more tasks and interacting with our whole body.

3.1 Interaction Technique Approaches for Interaction Designer

There are couple of techniques which are dependent on the body: shadow systems, which make use of the body contour, Strömberg et al.'s sensing users' location in a room, or Harrison et al.'s sensing technology employing a user's skin as an input surface.[3] Our input will now be the different movements of our body. We perform some movements intuitively like putting our hands on our hips. But now with our body-centric approach for large displays these motions can be interpreted as techniques and can be used for interacting with the display. Not only easy movements are used for large displays, there are also more tiring techniques that involve e.g. standing on one foot.

For the designer it's an infinite design space. Even if you think there are no other techniques that can be used, new complex techniques can be introduced through creativity like drawing a circle with your foot as an input. Some aspects have to be considered by the designer. Klemmer et al. introduced five themes that are relevant for the realization

- *Elisaveta Karypidou is studying Media Informatics at the University of Munich, Germany, E-mail: e.karypidou@campus.lmu.de*
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of interactive systems: *thinking through doing* as mentioned before, *performance*, *visibilitiy*, *risk* and *thick practice*[1]. The designer has to think as a human and not as an engineer and consider the following aspects: what possibilities does my body have to interact with that large screen in front of me? How can I design the display so it can get the most out of my body's abilities? The approach for designing large display interactions is very different in comparison to designing hand-held devices like smartphones. Now the user's abilities for interacting aren't limited to just hand gestures anymore but the designer has to consider the body from head to toe.

The human body can be divided in 5 groups of body parts: the dominant arm, the non-dominant arm, the dominant leg, the non-dominant leg and the torso [4]. Each of these body parts include body targets enabling a high amount of different body movements which can be used as input for the interacting screen, especially for the technique *on body touch*. There are plenty of possible body motions that can be used for easy or even for complex tasks. Regarding Card et al.'s morphological analysis and Wagner et al's BodyScape, we have to focus on three aspects in order to manage the complexity of multi-surface environments: the user's body and the interactive environment relationship; the involvement of the user's body while interacting; and the combination of interaction techniques.[4]

The location of the user plays an important role for interacting with a screen. User inputs can be *relative to the body* or *fixed in the world*. The first one can be performed independent of the location of the body, whether the user stands in front of the display or sits on the other side of the room. This input is used, for example, on body touch techniques or when interacting with hand-held devices. It doesn't matter where your body is located in the room, it just matters if you touch the right part of your body or click the right button of your gadget. The second one, *fixed in the world*, implies that your body is obligated to have a certain position in the room. Mid-air pointing at a wall display applies this kind of input.[4]

Combining interaction techniques can be done in series or in parallel. The location is still a very important aspect, especially if the inputs are *fixed in the world*. Just to perform one task with two different body technique is a bad idea as the user may have to go from one side of the large screen to the other to accomplish the task. If one of the two different body techniques is *relative to the body* then it is not of a big concern. What about if both combined interaction techniques are *relative to the body*? The designer must prevent awkward situations[4], like touching your head with your left arm and simultaneously the need of touching your left knee with your right arm. Uncomfortable solutions like these should be excluded from the design of large displays for interaction.

3.2 Body-Centric Interaction Approach with Shadows

A problem that we can think of while using a large screen for interacting is that there is no feedback if you are doing the task right or if you are moving your body right, especially for large multi-surface screens, the ability of reaching every item on the screen, even if it's located above your head. Shoemaker et al. used the approach of a shadow following your gestures and movements.[2] The body is now an input and an output. For large wall displays to get to the unreachable items the user now, because of its resizable shadow, can enlarge his shadow until it is big enough to reach for example the item on top of the screen. The user seeing his shadow associates it with his body and is aware of the input he is giving to the interacting display, resulting user awareness. With the ability of resizing the shadow this technique also provides distance interaction. This aspect of distance interaction is important in a crowded room where people are not within the physical reach of a surface of interest but still have the need to interact with that surface. Shoemaker et al. call this *interaction at a distance* a *worthwhile design goal*.[2]

Of course there are other non body-centric possibilities of interacting from a distance. The user can perform tasks with a hand-held device like a laserpointer for indicating to a particular item on the screen. Our shadow approach looks redundant now for interaction at a distance. But the purpose of interacting with a shadow on the screen is that the virtual surface gets more realistic and the actions you perform are general movements that you would also do, such as when getting a book off a shelf. The more realistic the surface is, the more the user is willing to interact with it. Furthermore, interaction with a laserpointer is not always possible because the required hand-held device is not always available,[3] but your body instead is always present, as clichéd as it sounds.

3.3 Combination of Body-Centric Techniques

It is known that most body-centric interacting techniques concentrate on one body movement at a time. Wagner et al. thought beyond that and introduced with BodyScape a body-centric design space which helps to describe, classify and systematically compare multi-surface interaction techniques, whether individually or in combination.[4] With a body-centric approach, they explored the opportunities our body gives us on combining two different body movements at once, making more interaction techniques possible. They think that there is a need for a combination, in series or in parallel, for multi-surface environments. Using more body techniques at once helps to accomplish more complex tasks. In their research, they examined the effects of combining two multi-surface interaction techniques: mid-air pointing and on-body touch.

The combination of body techniques implicates that the interaction gets more complex and the user has to learn the actions in order to do them all at once. The more complex the task is, the more mistakes can be made, and the more time gets wasted for performing a task. Taking on-body touch as an example, interaction will be easier if we just use our upper body for performing tasks, because they are apparently easier to reach. Furthermore, the already performing body part shouldn't be involved in the second body technique. For example the dominant arm is pointing at the screen but the non-dominant arm has to touch the dominant upper arm. The dominant arm can get out of balance and lose the location it was pointing at the display.[4] Naturally, while performing interacting techniques the comfort of the user has to be guaranteed. No one wants to stay in a tiring position for too long.

We may think that there are plenty of easier body techniques which can be performed for interacting and why should we use more than one technique at the same time. An answer to that question may be the error rate of the display by interpreting body movements wrong. For example like above mentioned we perform some moves intuitively without thinking that this could be used as an input in the interactive display. Touching your head could cause an unwanted effect. By combining two techniques the display has to wait until the other action is done before processing the input. This can result in a clearer input technique for the screen.

4 Conclusion

The human body has the ability to perform a broad range of tasks. Whether he is using a hand-held device or using his body as an interactive input. The latter is getting more and more important in our environment since large displays will be practical and affordable in a relatively short time due to rapidly advancing computer display hardware technology. These large displays use body-centric techniques as input. But for knowing which techniques are good for these interactive screens, the designer has to consider different aspects while working. The main topics in the designer's work place are: distance of the body to the screen, possible body movements and the comfortability of the user while performing tasks. Also they have to consider different approaches like using the shadow of the body as an awareness feedback for tracking the user's actions or the possibility of combining body-centric techniques for accomplishing more complex tasks.

Since large displays are going to be of great use in the future, the body-centric approach of performance for interactive displays has to be researched well enough since the design space of such displays is massive. We also can see our body in a different way now. It doesn't just consist of bones and flesh, it can also be interpreted as another device that helps interacting with the virtual surfaces of large displays.

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