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‚Skweezee-mote: A case-study of a gesture-based tangible product design for a television remote control

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Abstract: Skweezees are soft objects filled with conductive padding, which are capable of detecting different squeeze gestures using electrodes dispersed all over the object. This paper presents a case-study on the design and development of a tangible product based on the Skweezee system, namely a cushion remote. Squeeze-based gestures for soft user interfaces have rarely been explored. Therefore, we have worked on establishing squeeze-based gestures for a soft cushion interface for controlling a television, by means of a user-centered approach. The user study has brought out appropriate gestures for controlling a cushion remote. A prototype was designed using these gestures. The end result is a cushion remote that uses the Skweezee system and a gesture set for a Skweezee-based cushion remote control.

Keywords*: Soft-User Interface, Tangible User Interface, Gestural Study, User-Centered Design*

1 Introduction

Tangible user interfaces are becoming part of our life with the emergence of wearable computing and the internet of things. Tangible User Interfaces give us the power to alter the coupling between physical and digital data [1] i.e. input and output can be computationally coupled. When a computer acts as a mediator between input and output, a wide array of input-output coupling are possible. Having the freedom to choose the input and coupling gives designers flexibility to generate a wide variety of interaction styles or gestures for product interaction. While this might be an opportunity for designers, the effort required from users while interacting with everyday products can be enormous. This brings forth an inherent need to design gestures in such a way that it reduces cognitive effort of the user.

Kirk et al. [2] highlight that the kinesthetic memory of moving a tangible object can help in reducing the risk of mode errors by increasing the awareness of performed actions. Gestures add a benefit of reduced cognition [3] to 3D manipulation of a tangible object [2]. However, Norman [4] points out that, using gestures can have side effects such as misrecognition and poor designs of the gesture-to-function mapping. To counter poor designs of the gesture-to-function mapping, it is paramount to adhere to a user-centered design process. In this paper we provide a case study where we designed gestures for a cushion remote based on the users' previous interaction with the product (in this case a cushion).

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In this study, gesture detection for cushion-remote was achieved using the Skweezee system [Figure 1]. Skweezees [5, 6] are soft objects that are programmed to recognize specific shape deformations. They are filled with conductive padding and can be deformed or squeezed by applying pressure. They have electrodes dispersed all over their surface and they detect the gesture or shape change by measuring the changing resistance between every possible pair of electrodes. The authors of the Skweezee system were curious about the different application areas of the Skweezee system, and what type of squeeze-based tangible interface could be built with the technology. To address this question, we followed a product design approach. In this paper we discuss this approach and the result, namely the cushion remote.

Figure 1 Squeezing the Skweezee object [5]

We will first discuss related work with respect to squeeze-based gestures and highlight why we opted for a cushion remote. Next we will present our user-centered approach for studying the diverse gestures for interacting with the cushion remote. A Wizard of Oz technique [7] was employed to conduct this empirical study during which users were asked to control their television by means of the cushion remote. Next, a video analysis of gestures was conducted to identify the most appropriate gestures for the "Skweezee System". The gestures of all the users were screened and it was investigated which gestures were enacted by multiple users. These repetitive gestural interactions formed the basic repository for a gesture set for a cushion remote. They were coded into the form and the interaction of our "Skweezee System". Finally, a Skweezee Cushion Remote was prototyped using these set of gestures.

2 Related Work And Probable Application Areas

The product design phase started with analyzing products similar to the Skweezee system. These products were then grouped according to similarity. These groups formed probable application areas for the Skweezee system. Thereafter, mind mapping was employed to identify the possible application area. We here discuss the applications that we believe are most relevant to the Skweezee system i.e. rehabilitation products, interactive and programmable soft toys and remote controls for house appliances.

2.1 Rehabilitation Product for Children

When suffering from chronic pain, it is hard to interact with hard objects. Nevertheless, this might be necessary for physical therapy. Children like plush toys, particularly if they seem alive by means of sound or movement [8]. Thus using a soft user interface for children suffering from chronic pain can be easier to interact with, along with being more likeable. The soft object can be used to attract children in interacting (squeezing, pulling, pinching, picking, etc.) with objects thereby promoting physical rehabilitation. Researchers from the Pain Medicine Care Complex [9] have employed games as a way to collect data from children suffering from chronic pain. Christian Schönauer et. al. [10] used serious games with multimodal input for facilitating rehabilitation for chronic patients. Coupling the soft input from the Skweezee system with output in form of movement of a soft object can increase interaction with an object supporting rehabilitation among children. The natural benefit of the soft object designed with the Skweezee system can be that it is easy to interact with, and merging it with games can provide a motivational factor for children.

2.2 Interactive and programmable soft toy

Pinoky [11] used a wireless-ring like device to animate a plush toy by moving its limbs. Storytelling Agent Generation Environment is an authoring tool by Marina Umaschi [12] that allows children to design their own wise storytellers to interact with. Using the gesture learning capability of the Skweezee system, an interactive toy companion can be designed such that it can be programmed by children. A normal toy can be augmented to an interactive toy by using the Skweezee system. For example, they can tell the teddy bear to produce a particular sound when they move the hand in particular way, or produce a certain sound when they hug them or squeeze their paws or ears. Another alternative version could be in a form of puppets. So a certain gesture can be associated in a form of certain sound or activity.

2.3 Cushion Remote

Researchers have employed various techniques for redesigning conventional remotes like using gesture-based interaction [13-15], smart phones [15], video game controllers [16] and even a cushion as a remote [17-19]. Vatavu [13] has used a set of referents containing frequently used commands for controlling the TV set: Starting-Up and Shutting-Down the TV, Next and Previous Channel, Increasing and decreasing the volume, Mute, Opening and Closing Menu, Accepting and Rejecting Option and Help. Bernhaupt [20] said that although many buttons are included in today's remote controls, they just lead to puzzling effect. Vatavu [13] posits that this has led to new and shorter versions of the remote like the Pal Simple Remote or the Flipper [21], featuring 6 frequently-used buttons only (power, channel +/-, volume +/-, mute).

Although there have attempts [17-19] in re-designing present day remote controls into a cushion remote, none of them have employed a user-centered methodology to

come up with gestures for the soft remote. Rather, they assigned different locations of the cushion as pressable locations without working out appropriate gestures for them.

Based on the preliminary findings, the "cushion remote" was found to be the most promising application area wherein the "Skweezee System" can be embedded, at least for this study. Remote controls have been there for a long time and have not changed much. The present design of remote is easily lost among cushions of sofa. Adding to it the hard feel of the plastic casing in present designs, this does not fit the comfortable environment (sofa, cushion and soft lights) of living room.

Therefore, it was decided to merge a TV remote with a soft sofa cushion and redesign its interaction based on user-designed gestures. We put forward the concept of the "cushion-remote" in which the cushion of your sofa would act as a remote control for the television. In this manner, the new cushion remote would have the added benefit of not getting lost in some corner of your living room as classical remote controls, but always be there conveniently located on your sofa.

3 User Study

As aforementioned, a user-centered approach was followed which involved users designing the interaction and look of the cushion. The aim of the study was to figure out the optimal gestures for the users, to investigate what kind of cushion, users would relate to and to understand how users' interaction with the cushion remote would change when the user is not looking on the cushion. 'Not-looking' was an extra condition put forward on the basis of the assumption that it would be an additional benefit if users could control the television, without having to look at the remote, but instead be able to focus on the television screen. 20 users participated in the activity, of which 10 users performed the activity with blindfold and 10 users performed the activity without blindfold.

A "Wizard of OZ" technique was employed for this user study. These 20 users were given a cushion and asked to perform various gestures related to some selected functions of the TV remote. Upon their gestures, the television magically responded as if the cushion remote truly worked. In reality, the researcher controlled the television.

All participants (both with and without blindfold) were asked to perform the gestures. Next, they were asked to participate in the design activity during which they designed the look of the cushion remote that can facilitate the gestures performed by them. Video recording was done for all the users while performing the tasks to facilitate later analysis.

3.1 Task 1

A cushion was kept on sofa which was placed facing the TV. Figure 2 shows users carrying out a gesture corresponding to the selected functions of a classical remote, however this time using the cushion. A plain white square (50X50cm) cushion was given to them to accomplish the task. The functions that users were asked to accomplish were Start TV, Stop TV, Volume Up, Volume Down, Next Channel, Previous Channel, Menu Open and Menu Exit.

Figure 2 Users performing tasks of controlling a television by interacting with a cushion, without blindfold (Left) and with blindfold (Right).

The first user group consisted of users without blindfold. This was done to investigate what gestures users would perceive as natural while interacting with a cushion. In this the users were allowed to see while performing the gestures. The second user group consisted of users who were blindfolded while performing the tasks. The blindfolded condition was introduced to understand what gestures were perceived as natural without looking at the cushion. Users were not allowed to see what gestures they were performing and so they were blindfolded.

3.1 Task 2

Figure 3 Users crafting visual look of the cushion remote after performing 'Task 1'.

After task 1, users were asked to modify the plain white cushion using markers, colored papers and other basic arts, crafts and stitching material as shown in Figure 3. Although they were given as much time as they needed to modify the cushion, most of these activities lasted for 15 to 20 minutes. This task was given to the users to learn about most common/ dominant visual metaphors in the context of a TV remote (for given functions).

4 Analysis

Visually, many of the cushions borrowed looks from the existing TV remote control interface as apparent from figure 4. Many cushions consisted of a button in the center with four arrows pointing outside from the center in each direction (top, bottom, left and right), or some variant of this design. Even during performing gestures most of the gestures performed by users were somehow associated with the position of them on the remote. However, 6 out of 20 users used gestures that took advantage of a cushion like twisting, pulling, pressing, squeezing, etc.

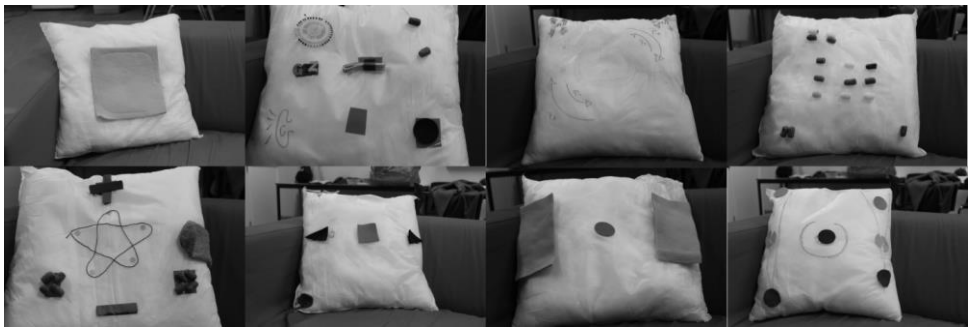

Figure 4 Few outcomes of creation activity

Thus, it seems that the metaphor of a remote is printed strongly into the users' brain. Furthermore, analysis was conducted to identify the gestures deemed most appropriate by our users. Video of each user was broken down to keep only the 8 gestures of each user. This was followed by open coding; the gestures from the video were described on the basis of what we observed. Then these open codes were coded again (axial coding) to find the relationship between the task and the location of gesture, direction of gesture, and type of gesture. Within the scope of this paper we cannot discuss all three characteristics, but we will present the location of gesture in relation to the task being carried out.

Figure 5 shows that the center of the cushion was most preferred for opening the menu (9 out of 16) and an equal number of users preferred the center as an option for closing the menu. So the center of the cushion can act as toggle for opening and closing menu. 6 out of 14 users preferred using the Middle Left for going to previous channel, whereas the opposite end of it (i.e. Middle Right) was mostly preferred for going to the next channel. The bottom-center and top-center can act as target location for decreasing and increasing volume, despite having low agreeability on that as a location for performing gesture. The volume down button is the bottom-most button as compared to other functions (next channel, previous channel and volume up) in a conventional remote. This trend can be continued to the cushion remote by fixing the location of volume down gesture to bottom of cushion.

Either the television system can be in "On state" or "Off state" thus a common gesture like squeezing all of cushion can be used to toggle between these states.

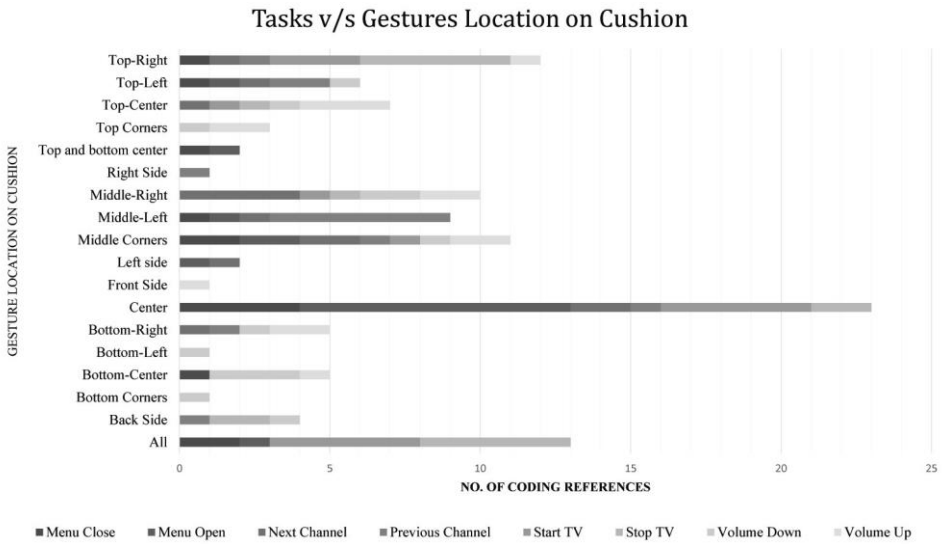

Figure 5 A graph showing the number of users that used a certain gesture location for controlling with the cushion remote.

5 Prototyping

5.1 Important Considerations for Designing Gestures

In addition to the points from the user study, the gestures were filtered based on the following points-

- The location of the gesture on cushion should be in line with the user study.
- The gestures should be designed such that unintended gesture detection is minimal, for example the channel should not change when a user puts the cushion behind his or her back.
- Gestures should be such that they can be performed easily without looking at the cushion. Additionally they should be remember-able.

Based on these considerations, eliminations were done, in order to arrive at suitable cushion design [Figure 6] and its gestures set [Figure 7].

Figure 6 Prototype of Cushion Remote

5.2 Gestures Set and Prototype

Figure 7 Gesture sets for Cushion Remote (In order from left to right: Starting and Stopping TV, Next Channel, Previous Channel, Volume Up and Volume Down).

Conductive cotton, conductive thread and conductive tape were used to make the prototype. For *starting and stopping the TV*, the gesture chosen was to squeeze the entire cushion. For *next channel*, we chose a squeeze middle-right or top-right. Top-right was included to have a clear detection, as pressing middle-right or top-right gave similar reading in the Skweezee system. The same applies for middle-left and top-left as a gesture location for *previous channel*. For *increasing the volume*, users need to pull the middle-top of the cushion away from the center, and for decreasing the volume, users need to push the middle-top of the cushion towards the center.

6 Limitations and Future Work

Our current work is limited to squeeze-based gestures for a cushion remote, a number of possibilities lie in other types of gestures, for example spatial movements of the cushion

like waving the cushion, rotating it etc. A comparison can be done to understand the performance of users when interacting with a cushion remote whose gestures are designed using user study to cushion with user designed gestures. Furthermore, a research can be instigated to see variance of preference of gestures based on age, sex, technological literacy, etc.

7 Conclusion

We have employed a user-centered methodology to establish a gesture set for 6 functions of the television remote control, namely Starting and Stopping the TV, navigating to Next or Previous Channel and Increasing or Decreasing of Volume. These gestures employ squeeze-based interaction for cushion remote control. A prototype was designed using the same gesture set.

The methodology used here can be employed while designing interaction for a soft user interface. One important factor during our process was deciding on the target location as a primary aspect to work out the gestures. Other aspects like the movement of the gesture can become important when designing for other soft user interface because of the added possibilities of pulling, pushing, twisting, etc. as a possible interaction when interacting with soft interfaces compared to hard interfaces.

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