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Emotion Sensitive Active Surfaces

Larissa Müller[1], Arne Bernin[1,4], Svenja Keune[2], and Florian Vogt[1,3]

[1] Department Informatik, University of Applied Sciences (HAW) Hamburg, Germany
[2] Department Design, University of Applied Sciences Hamburg (HAW) , Germany
[3] Innovations Kontakt Stelle (IKS) Hamburg , TuTech Innovation GmbH, Germany
[4] School of Computing, University of the West of Scotland (UWS), UK

Abstract. In this work we introduce a new user interface design that maps sensed emotions to an abstract device. This abstract display allows the exploring of emotional expressions avoiding anthropomorphisms caused by human or animal like designs. The presented interface senses emotions by facial video analysis. The device is implemented as an actuated surface that expresses emotions by changing its physical attributes. This change is triggered by sensed emotions via a behavioral mapping. The surface design, including texture, form of expression and dynamics, is a result of an iterative design process involving interdisciplinary participants. Finally, results of informal evaluations of the device during audience exhibits are presented.

1 Introduction

Computer interfaces have evolved over many years into various shapes and forms. The main focus of interface development has been on rational control paradigms using mental models such as *tools* or *request response behaviors*. In contrast, humans communicate on an emotional as well as a rational level. Emotional interactions with computers have not yet become widespread in computer interfaces, although research is developing this field in areas such as computer linguistics, affective computing, and human robotics. Building computer interfaces based on human to human communication is challenging and complex, since humans simultaneously process on both levels and integrate different modalities. Our approach is to disambiguate these two levels of processing with a *divide and conquer* strategy by building an interface that suppresses the rational level and emphasizes the emotional level.

For this purpose we chose an abstract surface design, since associations of anthropomorphism are less pronounced and there are no direct links to humans or animals. Otherwise, anthropomorphism could lead to misunderstandings and false expectations. The research by Gaver et al. [6] has found cases of frustration when user expectations are not met by the abilities of computer interfaces; this is also supported by the work of Höök [7]. In our user interface design we exclude any rational controls such as buttons or position sensors and deploy emotion sensors based on facial expression.

A purely emotional interface allows us to evaluate interaction patterns such as the *emotion mirror*, an interface which mirrors the emotion displayed by the user. *Provoking/reacting* is another pattern where an expressed emotion is mapped to a different displayed emotion thereby creating a character behavior. The basis of this work is to investigate if an interface has the ability to: 1. express emotions, 2. engage in an emotional dialog, and 3. create an emotional binding with users.

1.1 Related Work

Physical user interfaces of computers and machines have greatly evolved since the introduction of personal computers and have become more diverse in form and function. In particular, robotic interfaces have taken a lead role to include emotional qualities in interfaces. These are categorized by two properties: The similarity to living beings including human or animal and The type of interface both physical and virtual. The following table shows the categorization of related work:

Interface model	**Physical**	**Virtual**
Human	Geminoid HI-1 [11]	Max [4], facial animations [9, 3]
Animal	Haptic creature [13], Kismet [5]	Nintendodogs [1]

Table 1: Examples of different types of emotion based interfaces

While the works above translate the behavior and character of living beings, our active surface exhibits abstract behavior, which makes it free of preconceptions.

2 Concept

The design process in our work is based on Mitch Resnick's ideas of a *Lifelong Kindergarten* [12]. Our fast prototyping is achieved in an iterative process using the steps of *imagine*, *create*, *play*, *share* and *reflect*. This fast prototyping offers the possibility of creative idea development in teams. Our short design and implementation cycle also includes informal feedback given by observers and focus groups. This enables us to perform integrated testing of the concepts of the emotional interface and avoids that observers misinterpret or do not perceive the displayed emotions.

We applied this design method with an interdisciplinary team consisting of computer scientists and designers. Multiple design evaluations with reflection and feedback from visitors of exhibitions have led to a number of designs. The final results are presented in this work.

2.1 Physical Design Concept

The active surface consists of a sense and a display module. The display module can change surface properties to provoke reactions from visitors. The behavioral patterns are triggered based on the presence and facial expressions shown by visitors.

The surface design consists of repeating basic elements, constituting colonies or swarm configuration. This concept was inspired by living organisms and natural elements, each having limited complexity but together having the ability to exhibit complex and engaging behavior.

Our final design resulted in an active surface which is made of fabric covered shell elements, as shown in Fig. 1. A group of these base elements are connected to servo motors to display movement. These servo motors are controlled by a microcontroller, connected to the displaying module.

The active surface works with four degrees of freedom to express emotions: speed of movements, intensity of movements, size, and position of the moving area. Since the different areas of the surface do not symbolize special meanings such as face or body parts, we discarded the position of the moving parts as a degree of freedom; instead we combined the size and position of movement, reducing to three degrees of freedom.

Fig. 1: Lomelia interface: A group of shells is connected to one of ten servo motors. To optimize detection of facial expressions, a frontal image is required, therefor a camera is mounted next to the pink flower acting as an eye catcher.

2.2 Software Architecture

The software design consists of two modules, loosely coupled through a message broker, implementing a publish-subscribe pattern. One module performs the emotion sensing, while the second module controls the active surface. Loose coupling was chosen for maximum flexibility in extending the setup with additional input and output. In order to sense emotions, a camera is mounted on top of the surface, taking pictures of visitors' faces in front of it.

These pictures are algorithmically searched for facial expressions and are processed by the SHORE library of the Fraunhofer Institute for Integrated Circuits (IIS) [8] to produce emotion estimates. If an emotion is sensed, it is sent to the message broker. The control module receives the published message and reacts according to a predefined mapping of emotions (see Fig. 2). It creates different surface movements.

2.3 Emotion mapping

We apply a state-based emotional model consisting of the emotions *angry*, *sad*, *surprised* and *happy*. These emotions are determined by the SHORE library. The movements of the shells display the

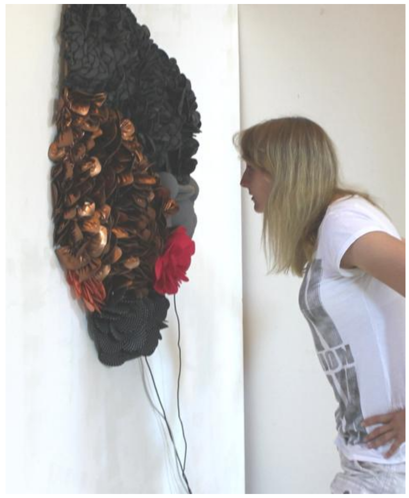

Fig. 2: Communication with our active surface interface

following emotions: *happy*, *angry*, *relaxed*, *excited*. The current mapping of emotions is shown in Table 2.

A salient part of the surface is the red flower in the center. This surface part provides an engaging focus by displaying happiness.

SHORE	**Lomelia**	**Expression**
happy	happy	rhythmic dance movement
sad	angry	jitter movement
angry	relaxed	breathing movement
suprised	excited	erratic movement

Table 2: Mapping of emotions: - recognized emotions of the interface (SHORE). These emotions are mapped to states of the active surface (Lomelia), which triggers particular movements (Expression).

2.4 Informal Evaluation

Informal evaluations took place during the DMY Berlin 2012 (see Fig. 3, [2]), an international design festival, with more than 2000 exhibition visitors , as well as during the Open House 2012 of the HAW Hamburg with more then 1000 exhibition guests. We observed the visitor interaction with our surface prototypes at the exhibits. In interviews the observers answered questions about their expectations and experiences regarding the emotional dialogue and engagements.

Recognizing the emotional state *sad* leads the surface interface to display *angry* which may trigger a feeling of discomfort in some observers. The visitors do not normally associate intention.

Fig. 3: Visitors at the DMY 2012 interacting with three different versions of the active surface

The fast movements were in most cases distinguished as *happiness* instead of *angry*. Recognition Rates of the SHORE Library varied for the different emotions, *happy* was recognized with the highest rate. *Surprised* and *angry* had a lower recognition rate, followed by *sad*.

A smiling person in front of the surface interface triggers a happy response. In most cases, observers recognized the interface as happy. Some of them compared the interface with a dog wagging its tail. Others made associations with coming home and finding a friend to share their happiness. Looking angry into the camera provoked a relaxed response from the interface. Slow movements were associated with a relaxed state. A surprised facial expression triggers a very fast movement. The aim was to show excited emotions. In most cases different movements while smiling and looking angry led to a lot of excitement. People laughed and had a lot of fun to trigger the emotions of the interface. They spend significant time playing with the interface, Lomelia. Some visitors were shocked by the movement. They did not expect the surface to react when they moved closer. Some screamed in surprise.

The acceptance of our idea to establish an emotional dialogue between an observer and an interactive textile surface interface was very high amongst exhibition visitors. The enthusiasm of the audiance was supported by the receipt of the audience award at the DMY Berlin 2012.

3 Summary

With this work we present our design of an emotion sensitive active device. We developed a physical abstract surface interface with the ability to sense the emotional states of observers and react by expressing emotions. We focused exclusively on the emotional aspects of the interaction, leaving rational input aside.

Our preliminary findings are based on observation and informal interviews from two exhibitions. Visitors were able to recognize different displayed emotions of our abstract surface. Furthermore many visitors engaged in an emotional dialogue by playing with Lomelia several times in `provoke response cycles`. In several instances we observed personal bindings, since visitors returned multiple times to interact with the active surface and shared their experience with friends and family. While the sensing module could be improved to include a wider range of emotion enabling an enriched dialogue, we think emotional interfaces have further far reaching computer applications in entertainment and computer interfaces.

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