Come alive! Augmented Mobile Interaction with Smart Hair

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ABSTRACT

Many research and products have augmented mobile interaction by integrating shape changing interface to overcome limited interaction space. However, most of these control systems tend to be complex and hard to configure due to the mechanical limitations of the actuators. Furthermore there are a few studies about using a shape changing I/O integrated interface with mobile technology. Therefore, we introduce a way to augment interaction on mobile phones with shape changing interface called "Smart Hair". The "Smart Hair" is a sensor integrated actuator that curves its shape according to the intensity of light. This simple system enables the users to implement physical interaction that is synchronized with the mobile phone. Different from previous works of the research, we developed the input method for mobile use. This study describes the development of the shape changing interface on mobile phones and discusses the practical use of the developed interface. As an application example, we developed physical body of smart phone which behaves as if it is an interactive robot. In addition, we evaluated how people perceive the motion of the interface. The result showed that the behavior of the actuator could evoke subtle emotion to the users.

This paper consists of three parts. First the augmentation methods are described. Then the applications are evaluated by the users and finally the possibilities and limitations of the study are discussed.

Author Keywords

Smart hair, Hairlytop Interface, Mobile Interaction, Animacy, Tangible, Augmentation.

ACM Classification Keywords

H5.2 [**Information interfaces and presentation**]: User Interfaces – *Interaction styles*

1. INTRODUCTION

Augmentation of the mobile interaction is to establish new communication channel between user and device. The augmentation has been developed increasingly in the HCI field recently. This is primarily because of the two reasons. One is the limited interaction space on the mobile devices, and the other is the bias of communication channel to interact with the users. For example, the users input information mainly with a touch display and tiny buttons. As a result, the mobile device requires user's

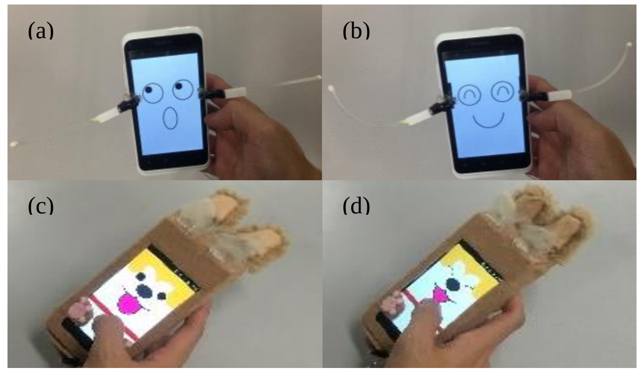

Figure 1 An example of augmented mobile interaction

visual attention too much. Thus, various sensing technologies with integrated sensors have been developed to improve the way to input information [17]. Meanwhile, most of the output channels are composed of visual display, speakers, vibrator and specially designed shape changing interfaces. Such interfaces have been developed to enrich physical communication with the users. Consequently, current researches have been trying to configure more context-aware interaction of the mobile device. However, conventional studies of the mobile shape changing interface require complex and large mechanics. Furthermore, there are few I/O integrated interfaces which could give less cognitive load to the user. Based on this background, there is a demand for mobile shape changing interface which provides easy implementation and simple control system.

In our previous study, we proposed a novel way to augment mobile interaction with hair-like shape changing interface named "smart hair (formerly Hairlytop Interface)" [20]. The series of the research aimed to contributes this field according to those points listed below [16], which are not still fully covered yet.

Flexibility in configuration

Previous studies of mobile shape changing interface mainly change its body shape with motor mechanics. As a result, this augmentation method requires complex hardware and control system. Therefore, there is a demand for simple system of shape changing interface to augment mobile device.

Real-time Control

Besides the flexibility in configuration, it is also required that the delay time in actuating should be independent on the number of interfaces. Smart Hair also contributes for real-time control since the interface is controlled by the light intensity. This enables mobile device to control each actuator independently by use of display light.

Based on these conditions and unique motion of Smart Hair, we have developed an application which adds physical interaction to mobile devices. At the same time, we ran an experiment to evaluate how people were affected by the simple kinetic motion.

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By integrating both the application and the experiment result, we discuss the possibilities of the proposed augmentation method.

2. RELATED WORKS

Most of the cases which augment mobile interaction aim to increase communication vocabulary between human and device by adding new function to sense and express information. In this section, we introduce previous researches about augmentation of mobile interaction to sharpen the contribution of our work.

2.1 Shape Changing Interface on mobile

Towards more optimized communication with users, mobile shape changing interfaces have been developed. They are mostly for richer physical interaction. There are many related researches of the mobile shape changing interface, which can roughly be divided into two groups. One is to develop mobile device which changes its shape. For example, Morphees [1], MorePhone [2], AwareCover [3], Gesturing phone [10], Bendi [21], and Fabian's work [8][9] they change their shape of the body to communicate with users. While these interface have been developed, our contribution is mainly dedicated for flexible design capability. Concretely, the sensor integrated actuator could be implemented easily just by connecting to the power supply. And the delay time in actuating is independent of the number of the actuators since they are controlled by the light intensity from the mobile display. By integrating sensing technology of the device, which is currently a touch panel, the proposed way could compose additional physical I/O system. This enables users to understand information in more haptic and ambient way.

The other group is to evaluate user experience through the shape changing interface on mobile. Esben's work evaluates how people perceive mobile kinetic motion by animated mobile movies [7]. Furthermore, the purpose of kinetic motion is still unclear [13][15]. Even though previous researches have been trying to figure out the relation between kinetics and evoked impression, they still need more experiments. Based on the background of this domain, shape changing interface for mobile use should be easy to implement and enable user to make any prototype fast. Thus, there is a need for augmentation technology which has rich design capability for mobile devices.

2.2 Augmentation mobile interaction

Augmentation mobile interaction is the technology which enhances I/O channels of the device to interact with information. As an example of input, many researches have been developing novel sensing technologies. Watanabe et al. [4], Clip on gadgets [18] developed novel ways to input information into the mobile by applying new sensing technology. Meanwhile, augmentation of output mainly used shape changing interface such as Shape changing button [6], Dynamic knobs [8], Wrigglo [12]. Considering the mobile use, they should be lightweight, flexible to implement and controlled in real-time. Consequently, we propose the way to augment mobile interaction with Smart Hair.

3. IMPLEMENTATION

3.1 Smart Hair

Smart hair is haptic/visual hair-like interface. The bendable soft actuator is integrated with light sensor. The contribution of the interface is (1) Fine and lightweight, (2) Flexibility in configuration (3) Real time control. The hair interface is used to augment mobile interaction. By changing the sensor, the interface could be implemented in many different applications.

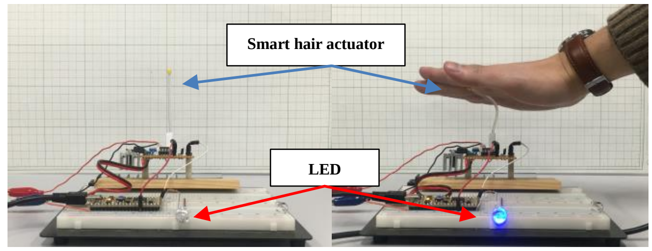

Figure 2 Touch detection by measuring the resistance of SMA

3.2 Abstract of the augmentation system

Our early prototypes are shown in Figure 1. We developed 2 types of applications to augment mobile interaction. The first prototype is a smartphone's arm, which follows characters face (Figure 1 (a)(b)). Based on the face expression on the display, smart hair draws physical gestures. The second prototype is the smart phone case to augment physical interaction (Figure 1 (c)(d)). Actuators are decollated as dog's ears in the mobile phone case. The ears follow the interaction between the user and virtual pet in the apps. For example, the ears move when user feeds the dog as an expression of 'joy' or 'fun'. Each actuator is controlled by the sound applied by the mobile device.

3.3 Touch detection

It should be considered that the current input method of the smart hair relied on the use of capacitive touch display. To cover many situations of use, the alternate input method is required. Therefore, we developed an alternate input method by applying the characteristics of the electrical resistance of Shape Memory Alloy (SMA), which is changed in response to its tension. The detect system is shown in Figure 2. Once the actuator was bent physically, the electrical resistance of the actuator is changed. In the system, the actuator is applied 121.1mA current normally to measure the change of the resistance. The resistance was reduced when the SMA bent toward lengthening, and inversed when bent shortening. The changed width was 1Ω. Towards more detailed sensing, multiple SMA should be installed to detect its deformation.

4. EVALUATION

4.1 Electric properties and performance

Besides the flexibility of the Smart Hair, mobile devices require minimum power consumption. Toward practical use of the proposed method, we evaluate power consumption and response speed of the actuator. In this evaluation, power consumption was calculated by the electric current at the maximum flexure and its resistance. The electric resistance of the sample actuator was 19.7Ω. The electric current and response time were measured by the ampere meter and video camera. The result is shown in Table 1. The result shows that the response speed becomes faster as the provided power becomes larger. At the same time the power consumption becomes bigger.

Table 1 Response time to maximum flexure

Ampere[mA]	Power consumption[W]	Time[mSec]
207.2	0.8458	540
221.1	0.9630	386
258.8	1.319	105

4.2 Heat

Due to the fact that the transformation of the actuator is driven via the Joule heat induced by electric current, this augmentation method with smart hair should be designed with the consideration of the temperature. We measured actuator temperature when its flexure was 1cm from the original state. The result is shown in Figure 3. The highest temperature was 36.6°C. This amount doesn't cause any particular damage to people, however the temperature easily goes higher if the radiation of the heat is not considered enough. Though the current drive circuits cannot control the temperature of the SMA, the addition of a resistance-feedback circuit offers a good solution [5].

4.3 Implementation evaluation

Since desirable functions are not fully implemented into our prototype, we currently could not evaluate how people interact with augmented device. However, we conducted an evaluation experiment about the affordable impression given from the kinetic movement of the smart hair. This experiment focused on the additional information which is given from the physical animation of the augmented device.

In this experiment, the subjects were asked to see two collections of the smart hair moving in different frequency at arbitrary time (Figure 5). Next, they were asked to evaluate which movement is suitable for the adjective words. 8 adjectives were evaluated: Joy, Angry, Living, Soft, Organic, Weird, Gross and Cute. The pattern frequency of the movement was between 1 - 4Hz with steps of 1Hz. The subject evaluated all 12 combinations of the patterns without touching the device. The total number of the participants was 22 (18 men, 4 women) in their twenties. All data was analyzed by the Scheffe's method of paired comparisons. In the experiment, the significant difference was obtained in two adjectives that were "joy" and "soft". Figure 4 shows the yardstick result which shows the pairwise differences. In these graphs, a positive value means to give the impression. The results met the significance level of 5%.

In the result of "joy", fast movement of the smart hair could give the impression. We therefore run the significance test between each pair of frequency. The significant difference was obtained between each pair of 1, 2, and 3Hz on the significance level of 5%. However, there was no difference obtained between 3 and 4Hz. On the other side, "soft" impression was given by slow movement. After the significance test between each frequency, the difference was obtained only between 1 and 2Hz at the significance level of 5%. This means the comparison between other frequencies did not have difference for the participants.

Unfortunately, we could not get the significant difference for the other adjectives. This may be because of the procedure of the experiment and the amount of the parameters for actuator's movement. Based on these points to improve, we continue to design the experiment with proper devices.

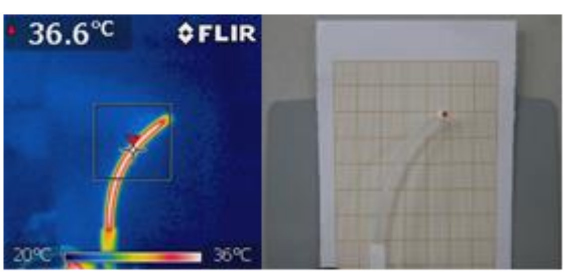

Figure 3 The actuator temperature with 1 [cm] flexure

Figure 5 Stimulation of the experiment

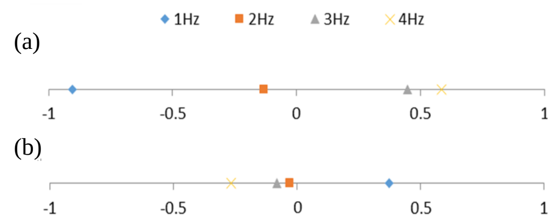

Figure 4 The result impression evaluation
(a) the result of "Joy" (b) the result of "soft"

5. FIGURES/CAPTIONS

5.1 Possibilities

Animacy

Our finding in the evaluation experiment implies that the proposed augmentation method could provide animacy to users. By virtue of Smart Hair, its unique motion could enrich mobile interaction with physical vocabulary. We will continue the evaluation with the integrated device.

Telexistence robot

By use of sophisticated technology of recent mobile devices, some researches already developed telexistence system with the combination of display and robotic body. Cally[22] and Telesarphone[19] are developed to show the existence of the person in the remote. Therefore, we believe the proposed system could express the presence of the person's existence in the suitable way for mobile devices. We will integrate the input system into Smart Hair, and connect them each other via mobile network to augment the existence of mobile devices.

5.2 Limitations

As described above, Smart Hair is suitable for the augmentation of mobile interaction. However, some hardware limitations should be considered. For example, Smart Hair cannot cover whole shape changing topologies. Although the effect of the interaction between the other topologies and users' reaction were rarely evaluated, it is required to compare them with the proposed method. Additionally, generated heat and its temperature should be carefully monitored in a design process. Furthermore, the torque of the actuator should be compared with the motors' to clear the contribution more concretely.

6. CONCLUSION

In this paper, we introduced the way to augment mobile interaction with hair-like interface named Smart Hair. We developed early prototypes and discussed the augmentation of mobile interaction. This paper presented the first prototype of the augmentation of mobile interaction. Based on the result of this paper, we will continue to develop the mobile applications and evaluate to expand our design concept beyond the mobile devices.

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