FacialMarionette: An On-Skin Interface for Controlling Facial Expressions and its Applications

Figure1: FacialMarionette

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Abstract
In this research, we propose a wearable device named "FacialMarionette", which moves the user's face skin physically and controls his/her facial expressions. In our system, strings are attached above the user's eyebrows and are pulled with motors to control their location and movement. By using this device, we propose several methods to augment/share our facial expressions. In this paper, we describe the design and implementation of this tool and application scenarios.

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Wearable device; Facial expressions; Face-to-Face communication.

ACM Classification Keywords
H.5.2 [User Interfaces]: Input devices and strategies.

Introduction
Facial expressions are a form of nonverbal communication. They play important roles in conveying social information with others. Although our basic facial expressions are innate, we need to learn how to manage expressions for better social communication.

In this research, we propose a novel wearable device named FacialMarionette. This device controls a movement of eyebrows that is important for showing emotions [1]. Although several related works have been proposed with EMS (electro muscle stimulation)-based technologies, our device utilizes a mechanical approach to provide a better wearable feeling and a natural setting. By attaching kinetic structures on our forehead, our system can move our eyebrows mechanically and manage our facial expressions interactively (see Figure 1). In this paper, we describe the design and the implementation, and show some application scenarios.

Figure 2: Prototype System.

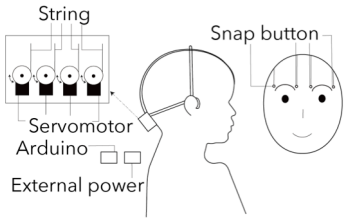

Figure 3: System configuration of FacialMarionette.

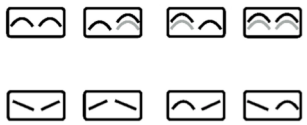

Figure 4. Screenshot of the Application.

Basic Design of FacialMarionette

FacialMarionette is a wearable device that manages facial expressions of the wearers. To control facial expressions, we adopted a mechanical approach. Figure 2 shows a prototype device of FacialMarionette.

The user puts tiny buttons, which are connected to strings, just above his/her eyebrows. Like a marionette, FacialMarionette controls the facial parts by pulling the strings. By controlling multiple strings, which are connected to different positions on the forehead independently, the system can change the position and the tilt of eyebrows dynamically.

Figure 3 shows a system configuration of the FacialMarionette. The device consists of three components. The first component is a button part. We attached semi-transparent buttons on our skin just above eyebrows. Each buttons (diameter 5mm) are tied with string and covered with beige bandages (diameter 6mm). We use four buttons attached above inner and outer tip of right and left eyebrow. The second component is a headband located on the top of head. This part has small holes to pass the string so that the button part can be moved up and down. The third component is located at the back of neck. This part has servomotors with bobbins. Each string is connected to the bobbin and changes its length according the motor rotation. The user can hang this component using his/her ears. To control the position and the tilt of eyebrows, we use Arduino to manipulate each servomotor independently.

In this device, we used four servomotor (SSCI-016582). The size of this motor is 32mm x 11.5mm x 24 mm. The weight is 8.5g. It takes 0.12 sec for rotating 60 degrees. The torque is 1.5 kg cm.

Application Scenario

We propose three application scenarios using FacialMarionette devices.

Scenario1: Programmable Facial Expressions
In a presentation, we need to manage our facial expressions to show confidence and familiarity. In other cases, for actors and actresses, making attractive facial expressions is necessary. Singers lift up their eyebrows to generate high notes. Although experts might be able to do this naturally, it can be said to be usually hard for others. By using the FacialMarionette, the user can change her facial appearance automatically. In the application on a smartphone, she can select positions of eyebrows from a preset menu. According to schedules, situations, conditions, she can determine her facial appearance like selecting clothes. (See Figure 6)

Scenario2: Sharing Facial Expressions with Others
In this scenario, the user can record her facial expression to the system. By using an image-based facial recognition technique, the system captures the face. Then, the user can add the expression onto the list so that the she can replay the expression later by using the FacialMarionette. By using this function, we can also copy the facial expression to other person's face. For example, we can "wear" facial expressions of favorite actors/actresses on our face. (See Figure 7)

Scenario3: Viewing Contents with Controlled Facial Expressions

Figure 5. Face changes according to data.

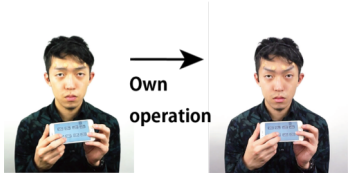

Figure 6.control eyebrows movement by application.

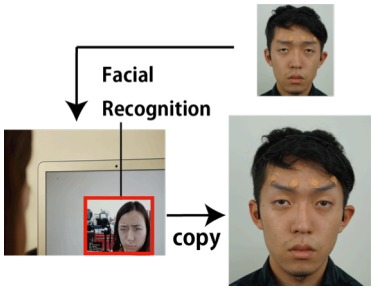

Figure 7. Sharing facial expressions with others.

The third scenario is based on the facial feedback hypothesis. We assume a situation of viewing contents such as movies and dramas. The audiences wear the FacialMarionette device. In this system, according to the timeline, the device manipulates the facial expression of the audiences. For example, when the sad scene is coming, the eyebrows of audiences start to frown. Likewise, in an exciting scene, the eyebrows are raised according to the timing. (See Figure 8)

Interactions with FacialMarionette

Controlling Facial Expressions with Smartphone

For the first and the third scenario, we developed a smartphone application to control the facial expressions with a program. As shown in Figure 4, when the user select a mode, the eyebrows move according to the preset rules. Figure 5 shows the result of each mode. By using this system, the user can give facial expressions that is hard for him/her to show by him/herself.

Controlling Facial Expressions with Camera Input

For the second scenario (sending facial expressions to others), we used a webcam to recognize facial expressions of the sender who stands in front of it. By using FaceTracker, which is an addon of openframeworks, the system recognizes positions of face parts in real-time. According to the recognized data, the facial expressions on eyebrows can be shared with the receiver.

User test

We have conducted preliminary user tests using the FacialMarionette device. We focused on two points: one is emotional effect for a person who saw the wearers, the other one is effect for the wearer's emotion.

In the first test, they watched a video of a male performer singing Japanese songs with this device. We asked the performer to sing an identical song in four different conditions that are combinations of with/without putting his own emotion and with/without the assist of our device. Even in the condition that he does not use the device, he wore the device so that the participants cannot recognize the difference easily from his appearance.

Twelve people (3 males and 9 females; the average age is 27.2) participated in total and evaluated the degree of the performer's feelings put in the song on a seven-point scale (1=cannot feel emotion, 7=feel emotion strongly). When the performer sang with putting his own emotion actively, the average score was 6.2 (SD=0.75) with the device and 6.1 (SD=1.26) without a help of the device. When the performer sang with holding back his own emotion, the average score was 5.4 (SD=1.04) with the device and 3.3 (SD=0.90) without the device. We analyzed these results with T-test. In the condition that the performer put his emotions, it did not indicate a significant difference ($t(12) = 0.19$, $p > 0.05$) between conditions with/without the device. However, there was a significant difference ($t(12) = 3.81$, $p < 0.05$) between conditions with/without the device when the degree of the performer's original facial expressions was weak.

Second, we showed 9 pictures and checked the emotion of the viewer when their inner ends of eyebrows were moved up by FacialMarionette according to the timing of changing pictures. These images were pilot tested and rated by 14 people on a 3-point scale, with 1: Pleasant, 0: Neutral, and −1: Unpleasant. The nine pictures chosen here had ratings between -0.25 and

Figure 8. Controlled eyebrows according to video.

	With emotion	Without emotion
With Device	6.2	6.1
Without Device	5.4	3.3

Table1. Average score when sing with device.

	Average	SD
With Device	4.019	2.04
Without Device	3.25	0.81

Table2. Feeling when eyebrows are controlled.

0.25. This indicates the selected pictures have neutral impressions in a usual setting. As for the second test, we focused on the effect for the wearer's emotion. In this test, we basically adopted the experiment procedure of Mori's research[8].

The participants rated the impression of the pictures by marking a circle denoting "very sad"=7, "a little bit sad", "sad", "neutral", "pleasant", "a little bit pleasant", "very pleasant"=1, respectively, on the answer sheet. The average score was 4.019 (SD= 2.04) with the device and 3.25 (SD= 0.81) without the device. We analyzed this result with T-Test, and there was a significant difference ($t(56)=2.160$, $p < 0.05$). This implies that sad emotion was amplified when user's inner end of eyebrows is moved up using this device.

Related Work

In the HCI field, several wearable interfaces that control body movements have been proposed. They are designed for assisting physical skill acquiring [4] or extending the affordance of objects [9]. A unique point of our system is that we focus on augmenting facial expressions using a wearable device.

Also, there are several related works that change user's facial appearances. Some researches use display to enable users hide their actual face and show different faces on them [5,6,10]. The most relevant system with our system is Manabe's "Electric Stimulus to Face'' [2]. While Electric Stimulus to Face is an art-oriented project, we designed our FacialMarionette based on scenarios that support Face-to-Face communication. Additionally, we have to think about medical risks when we use EMS for generating haptic feedback[15].

There are some related works that utilized the string-based mechanical system for moving our bodies [13][14]. Although they focused on other body parts such as ears and arms, we used this method to control our eyebrow movements for changing facial expressions.

Conclusion

In this paper, we introduced a wearable device that can move user's eyebrows. We propose the application and describe how the facial expressions are important in our dairy life.

As for the application field of this device, many people who have experienced our device suggested that it could be applied to rehabilitation especially for people with facial paralysis. In the current implementation, the facial expressions that can be covered by the system are limited since just four points are controlled on the face. We will keep exploring the potential application fields.

In our current prototype system, the number of sticker attached on forehead is just four. But it's not enough to express all facial expressions such as micro expressions. In the near future, we plan to update the system with more points so that it can make more rich expressions on the eyebrows. Furthermore, we will also plan to extend this system to be applied to other facial parts such as eyes or mouth.

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