FX e-Makeup for Muscle Based Interaction

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Abstract. Our aim with Beauty Technology is to transform our body in an interactive platform by hiding technology into beauty products for creating muscle based interfaces that don't give the wearer a cyborg look. FX e-makeup is a Beauty Technology prototype that applies FX makeup materials embedded with electronics for sensing the face's muscles. This work presents Winkymote and Kinisi as proof of concept of the FX e-makeup.

Keywords: Wearable Computers, Beauty Technology, Electronic Makeup, Muscle Based Interface.

1 Introduction

Beauty Technology transforms our body in an interactive platform by making use of makeup that stealthily integrates technology on the body. FX e-makeup is a new Beauty Technology prototype that makes use of special effects makeup that hides electronic components and is applied to the face for sensing its muscles, acting as a second skin. Two applications will be presented, namely, Winkymote, an infrared remote control for individuals with quadriplegic disability and Kinisi, an artistic makeup that acts as an empowered second skin for triggering multiple devices.

In previous studies [1, 2, 3], Beauty Technology prototypes were developed using conductive makeup (for connecting sensors and actuators on the face) and black fake eyelashes that were chemically metalized for acting as blinking switches. In order to prove the feasibility of the Conductive Makeup Prototype as a conductive component, some applications were developed. Blinklifier uses blinking for switching LEDs on and off on an artistic head dress. Arcana uses blinking for changing music tracks and images visualizations. Superhero is another artistic application that makes use of Conductive Makeup for triggering a remote control to levitate an object.

In this work, we propose FX e-makeup, another prototype that is focused on the human agency for controlling devices by sensing voluntary movements of face's muscles. It differs from: Vision Computing that provides methods for facial expression analysis by automatically recognizing facial motions and facial feature changes from visual information [4]; Biopotential sensors such as Electroencephalogram (EEG),

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Electromyogram (EMG), and Electrooculogram (EOG) that have been used as inputs for several healthcare devices [5]; and Brain- Computer Interfaces that links the computer to the human nervous and muscular system for recognizing user's gestures in several hands free interfaces [6-8].

Section 2 identifies previous works on recognition of facial muscle movements. Section 3 describes our approach of creating a second skin a combination of FX makeup and sensors for sensing facial movements where a muscle movement is interpreted as commands to devices. Section 4 shows Winkymote a proof of concept of this technology that is geared for individuals with quadriplegic disabilities. Section 5 presents Kinisi, an artistic FX e-makeup application that tries to answer the question: "Could your skin act as an interface?" Section 6 reviews the lessons learned from prototyping and using FX e-makeup. Conclusion and future work are shown in the last section.

2 Related Work

In past decades, significant effort has been done in developing techniques for sensing facial expressions [9]. A facial expression originates from the motion of the muscles beneath the skin of the face. Involuntary movements convey the emotional state of an individual to observers in a non verbal communication.

Micro-movements involve facial muscles actions which are triggered by the nerve impulses generated by emotions. Maximally Discriminative Facial Movement Coding System (MAX) [10] and Facial Action Coding System (FACS) [11] are observational coding systems to identify micro-movements thought to be associated with emotion. All possible facial displays are coded in 44 action units that represent a set or an individual muscle movement [11]. Traditionally, FACS' measurements are done by experts' observation [12]. However, thanks to the advances of technology, there are other techniques that support the action units' recognition like Computational Vision techniques that senses movements and gestures, and reproduce them in a 3D environment [13]. Unfortunately, they present some issues like occlusion and lighting limiting their sensing opportunities [14]. Bartlett et al. [15] uses a neural network approach to detect six individual action units combining holistic spatial analysis and optical flow with local feature analysis. Cohn et al. [16] uses facial feature point tracking and discriminant function analysis. Pantic et al. [17] uses face-profile-contour tracking and rule-based reasoning to recognize 20 action units.

For the purpose of this work we are interested in sensing voluntary movements. When humans initiate a voluntary action, the brain sends an electrochemical signal that traverses our nervous system through the spinal cord and eventually reaches the motor neurons. They stimulate specific muscles causing movement or force [18]. Non-vision techniques for identifying voluntary actions include Electromyogram (EMG) that is based on electrical measurement of the potential difference between two muscles. There are some known issues about using EMG [12] such as the placement of the leads on the face inhibits the subject movement, ambiguities on the measure due to the proximity of the muscles and no specific place for putting the electrodes. Figure 1.a show a head-mounted measurement device that senses the intensity of facial activity [19]. The muscles responsible for raising the eyebrows, lowering the eyebrows, raising the mouth corners, and pulling down the mouth corners are measured simultaneously with a capacitive method and EMG. Figure 1.b shows Manabe using electric sensors to stimulate muscles in his face in synchronization with music [20]. Another example is a Tongue Computer Interface that was developed for patients with paralyzing injuries or medical conditions. Infrared optical sensors are embedded within a dental retainer in order to sense explicit tongue movements [21].

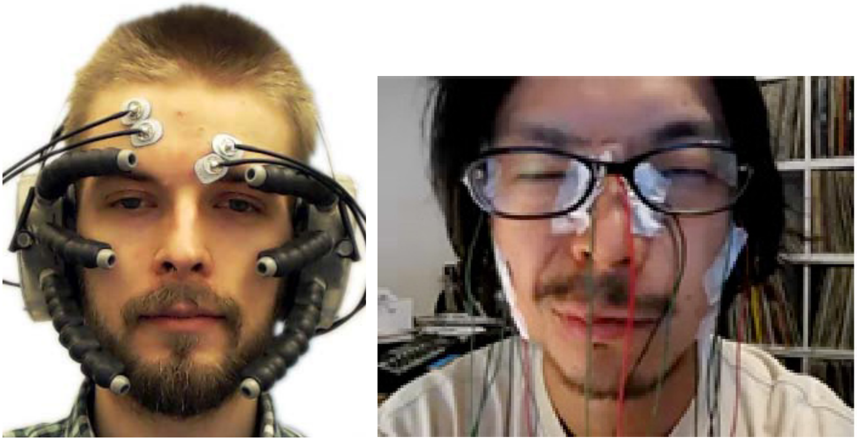

Fig. 1. a) Measuring upper face movements with a Head-Mounted Measurement Device [19]. b) Music created by face muscle movements [20].

A Beauty Technology prototype that senses blinking using a non-vision technique approach is the Conductive Makeup [22]. It is an aesthetic interface that detects voluntary blinking by embedded electronics into conductive eyeliner and eyelashes. Conductive eyeliner connects sensors and actuators by using conductive materials that stick to the skin. Conductive fake eyelashes are plastic eyelashes that are chemically metalized. FX e-makeup hides the conductive makeup inside a latex material that matches skin colour. The following session describes the design of this technology.

3 FX e-makeup

The senses of agency and of body ownership are two aspects in the bodily self which must be distinguished to identify different effects in body awareness [23]. A person has the capacity to act in the world through his sense of agency. Thus, intending and executing actions include the feeling of controlling one's own body movements, and, through them, events in the external environment [24]. Only voluntary actions produce a sense of agency and it is originated in neural processes responsible for the motor aspects of action [25]. On the other hand, the sense of body ownership refers to the understanding that the person's own body is the source of her movements or sensations, whether it was voluntary or not [24]. During a voluntary action, sensor mechanisms generate a sense of body ownership; however, only action provides a coherent sense of the whole body. Thus, the unity of bodily self-consciousness comes from action and not from sensation [26]. In this work, we propose an interface that makes use of sense of agency inherent in humans to augment their capacities through voluntary muscle movements.

The muscles of the face are divided into two groups according to the function they serve: mastication muscles (four muscles attached to the bone and ligament that are mainly used for chewing and have a minor effect on expression) and expressive or "mimitic" muscles [26]. Facial expressions are caused by the movement of the mimitic muscles that are attached to the skin and fascia in the face, unlike other skeletal muscles that are attached to the bones. This group of muscles move the skin, creating lines, folds and wrinkles, causing the movement of facial features, such as mouth and eyebrows. [26]. FX e-makeup sensors act as switches when strategically placed on these muscles.

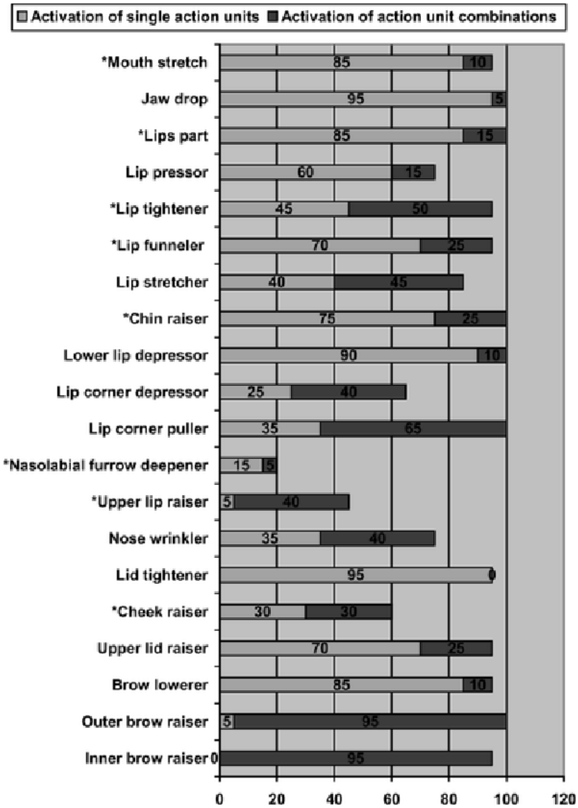

Fig. 2. Percentage of participants who succeeded in activating the target action units [29]

Duchenne de Boulogne [27] found that some muscles that are activated by emotions are difficult to activate voluntarily. Ekman et. al. [28] also addresses the same difficulty in voluntary movements but got different results when children were asked to voluntarily activate muscular actions by imitating a model presented on a video monitor. Gosselin et. al. [29] report is based on FACS to determine the extent to which adults are able to voluntarily produce facial muscular actions and also to discover the muscles that could be activated without the co-activation of other unwanted muscles. Twenty participants were asked to produce 20 facial action units, reproducing five times each action. Figure 2 indicates the percentage of participants who were able to activate the target action units at least once [29].

Based on this report, we identified the action units that will be used in our study. FACS' action units plus combinations that achieved more than 95% of success (except for the lip pressor that achieved roughly 75% of success) and have fewer associations with other movements were the ones that were considered in this work: jaw drop, lips part, lip corner puller, lid tightener, outer low brow raiser and lip pressor. Jaw drop and lips part action units had no associated movements. The lip corner puller action unit is associated with the check raiser action unit and the outer brow raiser is associated with the inner brow raiser one: in both cases, the associated movement is not constantly repeated. The chin raiser was the action unit most associated with other movements (5 times). The lower lip depressor has the chin raiser action unit as an associated movement. Both action units were discarded. The lid tightener action unit achieved 95% of success and got the lowest percent of associated movements. Figure 3.a shows the sensors on these muscles.

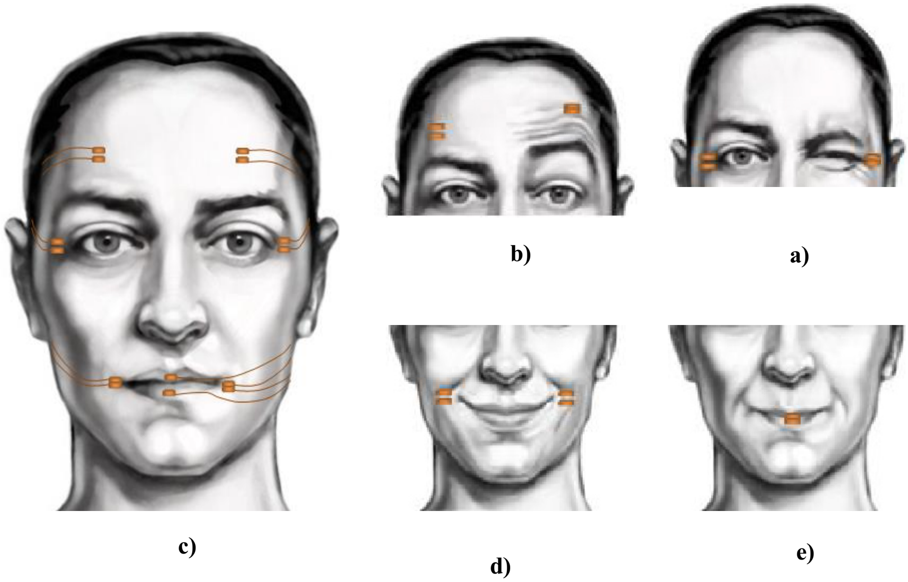

Fig. 3. FX e-makeup interface

Figure 3.b shows the sensor located on the brow, associated with the outer low brow raiser action unit, and it is activated when the user raises his eyebrow and both contacts of the sensors are touched. Figure 3.c shows the eyelid sensor (associate with the lid tightener action unit) that senses blinking when the lid is tightener and both contacts are touched. Figure 3.d shows the sensor associated with the Jaw drop, lips part, lip corner puller action units. It senses a smile when there is no contact, in an opposite way of the other sensors. Finally, the sensor on Figure 3.e is associated with the lip pressor action unit and it activates when both lips are pressed together. Wires are hidden with FX makeup materials like ink and latex.

4 Kinisi

Figure 4 presents Kinisi, a FX e-makeup application. It tries to answer the question: "Could your skin act as an interface?" with an artistic video [30] that exposes the use of FX e-makeup for activating different light patterns with smiles, winks, raised eyebrows and lips [30]. The voluntary movements approximate the points closing circuits. According to one's face, action units are identified and marked as it is show in Figures 4.a and 4.b. A first layer of latex is applied to isolate the skin from the electronics. Sensors are precisely glued to the latex mask on the chosen points. LEDs are placed on the mask and between braids. Finally, face paint was used for colouring the user's face black.

a) Eyebrow in a neutral position.

b) Eyebrow up closing the circuit.

c) Kinisi wearing FX e-makeup.

Fig. 4. Kinisi

5 Winkymote

Numerous approaches have been tried to develop technological solutions to facilitate independent communication and mobility for individuals with disabilities, among these the mouth stick, sensors activated by blinking, respiration and head movement [31, 32]. A communication interface controlled by voluntary blinking that activates infrared controlled devices simulating a remote control is being developed for individuals with quadriplegic disability.

Winkymote is inspired by Felipe, a 33-year-old master student in Administration. He hurt himself playing jujitsu and now has quadriplegic disability for 13 years. Felipe uses a speech recognition system keyboard replacement for controlling his computer but, unfortunately, depends on others to do common activities such as changing TV channels.

Fig. 5. Winkymote, an infrared-controlled interface for individuals with quadriplegic disability

Winkymote (Figure 5) is an infrared-controlled interface that uses FX e-makeup sensors connected to an infrared-transmitting module mounted on the user's necklace. These sensors are placed close to the outer end of each eye, i.e., close to the lid tightener action unit. They are connected through wires to the infrared-transmitting module mounted placed on his chest. Whenever he winks tightly, the switch closes sending a digital signal to the microcontroller that activates a sound feedback informing that an infrared LED is sending the appropriate sequences for triggering the TV. Blinking with his left or right or both eyes turns the TV on, off or change the channels up and down.

6 Discussion

The first FX e-makeup prototype comprised gelatine powder without flavour, distilled water and glycerine. This kind of FX makeup is often used for creating prosthetics such as wounds, scars, burns and blisters. Finding the proper makeup consistence of the makeup depends on its preparation given that it requires heating the ingredients. Our initial results were too thick and had the tendency to fell off depending on the skin properties and the user's movements. Three participants worn the makeup for 6 hours but it didn't work on Felipe, whose makeup fell off after 1 hour, because of his oily skin. After deciding to use hydrogel, which help to fix the electronics, we had to give up for the same reason: his oily skin. Finally, we decided for using liquid latex. It was applied to the skin using a disposable sponge taking about five minutes to dry. As it dries it turns to a rubbery consistency getting moulded to the user's skin. Then, more layers were applied to the skin for embedding and isolating the electronic components.

The face has over 40 anatomically independent muscles referred as specific action units that could be coactivated. The corrugator muscle group, for instance, which brings the brows down and together, is comprised of three muscles that are normally activated together. Although, the sensors on the FX e-makeup action units could operate independently, not combinations are possible like concurrently raising the left eyebrow and tighten the left eyelid, and raising each eyebrow independently.

Action units' activation differs in duration and intensity. Differently from previous works [1, 2, 3] where a preset time interval for sensing voluntary movements was defined, given that FX e-makeup sensors are precisely located, they are only activated when the intensity of the movement reaches a high level.

FX e-makeup may be used to control multiple devices. Sensors could be connected to a variety of devices providing user feedback and communication with other devices. For example, a device for changing slides (closing the right eye the presentation moves forward to the next slide) was prototyped for working with Winkymote.

7 Conclusion and Future Works

This work proposes FX e-makeup as a Beauty Technology prototype for sensing voluntary face's movements for triggering multiple devices. FX e-makeup is moulded as a second skin on the user's face for embedding electronics.

Action Units were selected based on a previous study that identifies the success rate to activate an action unit and the other muscle's movements associated with it. Jaw drop, lips part, lip corner puller, lid tightener, outer low brow raiser and lip pressor were the action units chosen as inputs for FX e-makeup. The FX e-makeup sensors acts as switches that are activated with the folding of the skin.

Two applications showed the feasibility of this technology. Kinisi is an artistic application that uses muscle movements for activating light patterns on the face and hairdo. Winkymote is an application for individuals with quadriplegic disability that controls infrared devices like TV sets.

Future work will include new Beauty Technology prototypes for sensing other facial action units via FX e-makeup. Sensors and their duration/intensity level combinations connected to other action units will be incorporated to FX e-makeup applications. We also intend to expand FX e-makeup sensors to explore neck movements for controlling different devices like air conditioning and hospital beds. Other future potential uses of this technology will explore novel hands free interfaces like dealing with amplifying or unnoticed gestures, keeping people awake, and decoding blinking gestures for physical and physiological analysis.

As seen above, there are several possibilities to turn FX e-makeup prototypes into products. Firstly, there are market challenges that should be overcome in order to deliver value to their potential customers. How to segment the market? Who are the potential targets? How to position the new products? These are decisions to be taken by the holders of this promising Muscle Based Interface technology in the future.

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References

1. Vega, K.F.C., Fuks, H.: Empowering electronic divas through beauty technology. In: Marcus, A. (ed.) DUXU/HCII 2013, Part III. LNCS, vol. 8014, pp. 237–245. Springer, Heidelberg (2013)
2. Vega, K.: Exploring the power of feedback loops in wearables computers. In: Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction, TEI 2013, pp. 371–372. ACM, New York (2013)
3. Vega, K., Fuks, H.: Beauty technology as an interactive computing platform. In: Proceedings of the 2013 ACM International Conference on Interactive Tabletops and Surfaces, ITS 2013, pp. 357–360. ACM, New York (2013)
4. Jain, A.K., Li, S.Z.: Handbook of Face Recognition. Springer-Verlag New York, Inc., Secaucus (2005)
5. Lin, M., Li, B.: A wireless EOG-based human computer interface. Biomedical Engineering and Informatics (BMEI) 5, 1794–1796 (2010)
6. Curran, E., Sykacek, P., Stokes, M., Roberts, S., Penny, W., Johnsrude, I., Owen, A.: Cognitive tasks for driving a brain-computer interfacing system: a pilot study. IEEE Transactions on Neural Systems and Rehabilitation Engineering 12(1), 48–54 (2004)
7. Tanaka, K., Matsunaga, K., Kanamori, N., Hori, S., Wang, H.: Electroencephalogram-based control of a mobile robot. In: IEEE International Symposium on Computational Intelligence in Robotics and Automation, vol. 2, pp. 688–693 (2003)
8. Fabiani, G., McFarland, D., Wolpaw, J., Pfurtscheller, G.: Conversion of eeg activity into cursor movement by a brain-computer interface (bci). IEEE Transactions on Neural Systems and Rehabilitation Engineering 12(3), 331–338 (2004)
9. Kanade, T., Cohn, J., Tian, Y.: Comprehensive database for facial expression analysis. In: Proceedings of the Fourth IEEE International Conference on Automatic Face and Gesture Recognition, pp. 46–53 (2000)
10. Izard, C.E.: The maximally discriminative facial movement coding system. University of Delaware (1979)
11. Ekman, P., Friesen, W.: Facial Action Coding System: A Technique for the Measurement of Facial Movement. Consulting Psychologists Press, Palo Alto (1978)

12. Scherer, K., Ekman, P.: Handbook of methods in nonverbal behavior research, pp. 45–135. Cambridge University Press, New York (1982)
13. Chambayil, B., Singla, R., Jha, R.: Virtual keyboard BCI using eye blinks in EEG. In: 2010 IEEE 6th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob), pp. 466–470 (2010)
14. Królak, A., Strumiłło, P.: Eye-blink detection system for human-computer interaction. Universal Access in the Information Society 11(4), 409–419 (2012)
15. Bartlett, M.S., Hager, J.C., Ekman, P., Sejnowski, T.J.: Measuring facial expressions by computer image analysis. Psychophysiology 36, 253–263 (1999)
16. Cohn, J.F., Zlochower, A.J., Lien, J., Kanade, T.: Automated face analysis by feature point tracking has high concurrent validity with manual facs coding. Psychophysiology 36, 35–43 (1999)
17. Pantic, M., Patras, I., Rothkruntz, L.: Facial action recognition in face profile image sequences. In: IEEE International Conference on Multimedia and Expo, vol. 1, pp. 37–40 (2002)
18. Singla, R., Chambayil, B., Khosla, A., Santosh, J.: Comparison of SVM and ANN for classification of eye events in EEG. Journal of Biomedical Science and Engineering 4, 62–69 (2011)
19. Rantanen, V., Venesvirta, H., Spakov, O., Verho, J., Vetek, A., Surakka, V., Lekkala, J.: Capacitive measurement of facial activity intensity. IEEE Sensors Journal 13(11), 4329–4338 (2013)
20. Manabe, D.: Daito manabe, `http://www.daito.ws/` (accessed April 4, 2010)
21. Saponas, T.S., Kelly, D., Parviz, B.A., Tan, D.S.: Optically sensing tongue gestures for computer input. In: Proceedings of the 22nd Annual ACM Symposium on User Interface Software and Technology, UIST 2009, pp. 177–180. ACM, New York (2009)
22. Vega, K.: Conductive makeup, `http://katiavega.com` (accessed April 4, 2010)
23. Gallagher, S.: Self-reference and schizophrenia: A cognitive model of immunity to error through misidentification. In: Exploring the Self: Philosophical and Psychopathological Perspectives on Self-Experience, pp. 203–239. John Benjamins (2000)
24. Tsakiris, M., Prabhu, G., Haggard, P.: Having a body versus moving your body: How agency structures body-ownership. Consciousness and Cognition 15(2), 423–432 (2006)
25. Tsakiris, M., Schutz-Bosbach, S., Gallagher, S.: On agency and body-ownership: Phenomenological and neurocognitive reflections. Consciousness and Cognition 16(3), 645–660 (2007)
26. William, E.R.: The neuropsychology of facial expression: A review of the neurological and psychological mechanisms for producing facial expressions. Psychological Bulletin 95, 52–77 (1984)
27. Duchenne de Boulogne, G.B.: The Mechanism of Human Facial Expression. Cambridge University Press (1990)
28. Paul Ekman, G.R., Hager, J.C.: Deliberate facial movement. Child Development 51, 886–891 (1980)
29. Gosselin, P., Perron, M., Beaupr, M.: The voluntary control of facial action units in adults. Emotion 10, 266–271 (2010)
30. Vega, K.: Kinisi, `http://katiavega.com` (accessed January 20, 2014)
31. Lathem, P.A., Gregorio, T.L., Garber, S.L.: High-level quadriplegia: an occupational therapy challenge. The American Journal of Occupational Therapy 39, 705–714 (2008)
32. Sipski, M.L., Richards, J.S.: Spinal cord injury rehabilitation, state of the science. American Journal of Physical Medicine & Rehabilitation 95, 310–342 (2006)