AffectiveWear: Towards Recognizing Affect in Real Life

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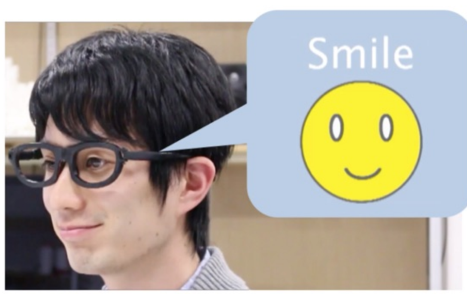

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Abstract
We present a novel wearable facial recognition system "AffectiveWear". This device can recognize 7 facial expressions (neutral, disgust, angry, smile, laugh, sad, and surprise). It looks like a normal eyewear; you can wear anytime, anywhere. We made 2 prototypes with 8 sensors and 16 sensors. Its accuracy of categorization is up to 98.7%. With this, you can enrich your communication with others or computers in various ways.

Author Keywords
Emotion Detection; Smart Eye Glasses; Eye Wear Computing

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

Introduction
Facial expression can give us insights about our emotional life. They are also important non-verbal cues during communication. Therefore, there are a couple of researchers focusing on facial expression recognition. Most of the approaches are camera-based . This limits recognition applications to specific locations and environments.

In this paper, we present the eyewear that can recognize 7 facial expressions in daily life. Our eyewear can categorize

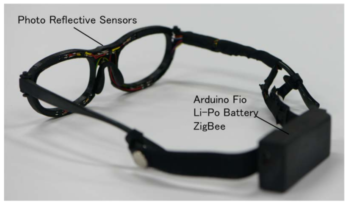

Figure 1: The Affective Wear Prototype

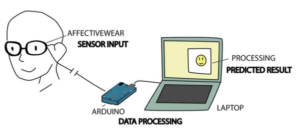

Figure 2: System Overview

facial expressions by measuring the distance between the eyewear frame and the surface of a persons face with photo reflective sensors. Recognizable states are as follows: neutral, disgust, angry, smile, laugh, sad, and surprise. This demonstration paper is an extension of our work for Siggraph Emerging Technologies [4].

Our eyewear can recognize 7 facial expressions automatically in daily life and user can control how that information is used. Though these are the big advantage over camera-based systems, there are two other advantages: (1) Low Cost Sensing: we only use photo reflective sensors, the cost can be less than $5 for all 15 sensors.(2) Simplicity: The recognition system is simpler than the usual process of the related camera-based system. It does not require much processing.

Approach

In the following, we explain our approach. First, why we focus on eye wear computing as platform, then about the principle behind our facial expression recognition method.

Eyewear Computing

Although sensing/computing in eye wear was so far not socially acceptable (usually due to bulkiness or looks), computing devices, PCBs, sensors etc. have now reached a level of integration to make it possible [1, 3]. The head is also a natural position to target for sensing due to the human physiology. We focus on smart eye glasses for our prototype as glasses are socially acceptable and their position is suitable for facial expression detection.

Skin Deformation

We leverage the skin deformation caused by the movement of facial muscles. When users move their facial muscles, 3 dimensional movement of skin occurs. Various facial muscles move when users change their facial expressions. Therefore, the distances between the various spots of the eyewear and skin surface on face change depending on different facial expression. (Figure 4) These distances are measured with photo reflective sensors. The data collected from sensors is applied to machine learning algorithm to categorize facial expressions.

Facial Action Encoding

We referred the action unit from facial action coding system. [3,14] Action units include the movement of head, eyelid, eyebrow, nose, cheek and lip. Among those of the action units, the sensors integrated into the eyewear can detect the movements of eyelid, eyebrow, nose and cheek because those movements cause the 3 dimensional skin deformation around the eyes. The movement of the lip is partly detectable because the lip movement influences the cheek movement. The point here is that the sensors integrated in the eyewear can detect most of the movements that are crucial for facial changes related to the facial expressions we want to recognize. Simulation We simulated to find the best position to place sensors and sufficient amount of sensors for detecting 7 facial expressions For this experiment, we created special version of the eyewear which has 16 sensors on it. (Figure5)

Affective Wear Implementation

AffectiveWear (see Figure **??**) can detect 7 facial expressions (neutral, disgust, angry, smile, laugh, sad, surprised). The 7 facial expressions are chosen considering the six universal emotions (happy, anger, disgust, sad, surprise and fear).

We designed our prototype with 8 photo reflective sensors to make it really look like normal eyewear in terms of size and design(see Figure 1 and 3). The prototype weight is around 60g. The front frame is 3D printed and the tem-

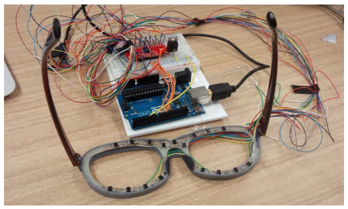

Figure 3: Second Prototype to evaluate photo refelctor placement.

ple is reused from commercial eyewear frame. We used the elastic nose pad of anti-pollen glasses from J!NS because this is made of silicon and adjustable to any shape of nose. We applied eyewear band to make the position of the eyewear stable. 8 IR reflective sensors are integrated into the eyewear. Those sensors are small enough (3.2 x 2.7 x 1.4 mm) to be suitable to integrate into the eyewear frame. We made it wireless for its mobility. The sensors are connected to Arduino Fio with ion polymer battery,laptop communication over via Xbee.

Sensors
We used photo reflective sensors (SG-105 [Kodenshi Corp]) as IR reflective sensors. The sensor composes of an IR LED and IR transistor. We chose a 180 Ohm resistor for the LED and a 62 K Ohm resistor for the transistor to transmit the sensor output to an A/D converter. This sensor can measure the subtle change of the distance, but the maximum range that the sensor can detect is short (Less than 10 mm).

Ambient Light
The photo reflective sensors are suitable to measure close distance. However, these are easy to get influenced by the ambient light such as sun or fluorescent light. In order to reduce the effect of ambient light, we applied the digital switching circuit in the middle of LED side GND with 500 ohm resistor and the transistor (TIP 31C). We measure the difference between the value with LED on and the value LED offby switching on and off frequently at high speed.

Software
We implemented a Support Vector Machine (SVM) model for the categorization in Java/Processing. SVM is a machine learning technique that is used in broad field. We used normalized data from sensors. Calibration process is implemented as follows.

1. The standard of sensor data is set when user wear our device and make natural expression.
2. User normalizes the range of the movement of facial muscles by dynamically moving facial muscles. natural expression.
3. The dataset for each facial expression is created while user makes the same facial expression as the one our user interface displays. The dataset is used as training data of SVM model.
4. User checks if facial expression is categorized correctly. If not, more training is employed.

Initial Experiments and Findings
We asked over 3 users (3 male, the average age 26) to participate in this experiment. They were asked to wear the AffectiveWear and did the procedure described in software caption. We asked them to perform the facial expressions deliberately. In this process, around 300 data points were created for each user. In total, 1095 data were collected.

We analyzed those data in iPython Notebook and used scikit-learn library. First, Those data are processed into training dataset (70%) and test dataset (30%). Training dataset was applied to the same machine learning algorithm as the one used in software. We used the feature selection algorithm SelectKBest to see how the number of sensors influences the accuracy between the predicted states from test set and the true dataset. The number of sensors improves the accuracy dramatically until we use 8 sensors. With 8 sensors, the accuracy of categorizing 7 facial expressions becomes over 90% (94.9%). If more than 8 sensors used, the result improve slowly according to the number of sensors. With all 16 sensors, the accuracy is 97.4%.

Figure 4: Oculus Rift Integration.

Application Cases

Remote Communication

Text messages do not always convey enough information. In order to convey the nuance or the context behind the messages, we use emoticons and symbols such as question mark and exclamation mark. Or in Manga, typography of characters messages changes according to their emotional state. Typography has the power to change the impression of messages. With our device, user can put emoticon or change their typography of text message according to facial expression while they are texting. It can enrich the communication with texts.

Tagging Facial Expressions

Tagging the facial expressions to images or movies captured using a life-logging system, e.g. the Narrative Clip or a GoPro. By knowing users facial expression, user can remember well about the scene user record.

Virtual Reality Headset

We embedded our facial expression recognition into an Oculus Rift DK2 Headset 4. We implemented a demo in which the user can reflect their facial expression on their avatar in virtual world. With Kinect, user also can reflect their movement. People can enjoy more natural and rich ways of communication in virtual world.

Related Work

There are a number of works related to automatic facial expression detection in computer vision [5]. The general approach to analyze facial expressions consists of three steps: face acquisition, facial data extraction and representation, and facial expression recognition. This approach proved the high accuracy of Facial Expression recognition.

Several works show wearable systems that can recognize facial expressions in daily life [2]. Yet, these works focus on detecting only specific facial expressions. Our contribution is detecting various facial expression states and the usability in daily life. With our device, computing systems that will be everywhere in the age of IoT can tap into the rich set of information provided by nonverbal communication.

Conclusion

We presented the novel device to detect 7 facial expressions anywhere and anytime. The accuracy of the recognition rate is up to 97% with 8 sensors. The optical placement of sensors is tested. Though it is still difficult to explore the emotion behind facial expression, this device can give us the rich set of information provided by nonverbal communication.

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