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IDENTIFYING EMOTION FROM FACIAL MICRO EXPRESSIONS

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RESUMEN
Las expresiones faciales son uno de los métodos visuales más robustos para transmitir emociones y uno de los medios más utilizados por el hombre para relacionarse. Los métodos de imagen facial pueden capturar fácilmente las emociones experimentadas por un individuo utilizando las expresiones faciales. Esto puede aplicarse para detectar el estado emocional de una persona que recibe estímulo con un método iterable. En este artículo describimos el proyecto de investigación para la identificación de las seis emociones básicas – felicidad, disgusto, tristeza, enojo, miedo y sorpresa – con el desarrollo de un modelo de imagen facial y lógica difusa, al que denominamos FMEE (Facial Micro Expressions of Emotion), que detecte y grabe las reacciones emocionales de los sujetos de prueba a un determinado estímulo. Se muestran resultados preliminares con el módulo de landmarks faciales, así como un error de 0.03cm de posicionamiento de los mismos.
Palabras Clave: Emociones, Micro Expresiones Faciales, Imagen Facial, Point Landmarks.

ABSTRACT
Facial expressions are one of the strongest visual methods to transmit emotions and the most powerful means used by humans to relate to each other. Facial Imaging can passively record human emotions from facial expression. It can be applied to detect a person's emotional response to stimuli with a repeatable method. This article describes an investigation project for identifying six basic emotions - happiness, disgust, sadness, anger, fear, and surprise – with the development of a facial imaging system using fuzzy logic, called FMEE (Facial Micro Expressions of Emotion), to detect and record emotional reactions from test subjects under a certain stimulus. Preliminary results are showed for the facial landmark detection module, with a 0.03 cm error in displacement.
Keywords: Emotion, Facial Micro Expressions, Facial Imaging, Point Landmarks.

1. INTRODUCTION
Emotions are an important part of human life, since the development of a child's psychological and social life, to the definition of a personality and behavior of a person. It allows individuals to interact with each other and understand each other emotions to determine the best approach to another individual. Basic research of emotions for the past few decades has produced several important discoveries; the universality of facial expressions of emotion and the existence of micro expressions [1] [2]. Both of these discoveries play an important role in studies that have created programs for reading facial expressions of emotion and documenting his efficiency. Recently it has been complemented with the use of electroencephalography (EEG) and electromyography (EMG), along with several other techniques.

The current paper describes a research project for identifying six basic emotions (happiness, anger, fear, disgust, sadness, surprise) according to Ekman [3] with the development of computer software using computer vision (CV) methods. Emotion identification has been used in a

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variety of studies such as behavioral analysis, communication, personality, and child development [4], where emotions play an important role. Recent advances in computer vision and pattern recognition opened up the possibility of automatic measurement of facial signals, which makes it a far more accessible research tool for facial expression recognition.

2. WHAT IS A MICRO EXPRESSION?

A micro expression is a brief involuntary expression of emotion that usually occurs when an individual experiences a strong emotion but tries to conceal the emotion being felt [5], which can last from 1/15 to 1/25 of a second [6], [7]. They may also occur because a person experiences multiple emotions in rapid succession. Unlike normal facial expressions, it is difficult to voluntary produce or neutralize micro expressions, which can display any of the seven universal facial expression of emotion: disgust, anger, fear, happiness, sadness, surprise and contempt.

To these days it has been proven that facial expression are genetically programmed reactions [4] and not defined by the person's culture as was supposed earlier [8]. There are different types of facial expressions: Macro expressions, normal expressions that usually last between ½ to 4 seconds and that often repeat fitting with what is said and the sound of the person's voice; micro expressions, a brief expression lasting between 1/15 to 1/25 of a second which they often display a conceal emotion as a result of suppression (deliberate concealment) or repression (unconscious concealment) [12] [13]; subtle expressions, are associated with the intensity of the emotion, when a person is just starting to feel an emotion or when the emotional response to a situation or environment is of low intensity.

We all can see and detect macro expressions and are relatively easy to see, if we know what to look for. However, micro expressions are an on and off expression, that if we blink we missed them [7]. Some people can be trained to detect micro expressions, since these are a way to determine what a person is really feeling or what emotions is experiencing at a given moment.

3. WHAT IS AN EMOTION?

Emotions are an important aspect of human life, every day we use them to communicate with each other. Although, we daily made use of them, it still is a very difficult topic to define. Emotions are present on every path of our life [4], it defines the way in which we develop as children and they play an important role in how a child's social life and personality is formed. When we are adults, emotions are easily influenced by other people's emotions and the environment that surround us. A human being can use emotions as a way to relate and interact with each other by recognizing these emotions through words, voice intonation, facial expressions, and body language [8], this helps us find the best way of approach or improve the communication in a certain situation.

In the figure 1, we can clearly distinguish each emotion expressed by every individual. For every emotion there is a respective facial expression; the proper identification for expressions helps us understand what emotion is being experienced by that person, and that way we can choose the best approach mechanism to interact during the situation.

Figure 1. Seven Universal Emotions with their respective facial expression.

The emotional state of an individual defines the interaction that it will have with others. It's highly important to differentiate between an emotional reaction (a psychological response to stimuli) and the feeling of an emotion (supposed as the center responsible for the emotional reaction). Therefore, the recognition of emotion has become an important concern in studies to be able to develop real-life applications that require human-machine interaction, this way our computer will be far more enjoyable and easy to use.

4. IDENTIFYING EMOTION USING FACIAL MICRO EXPRESSIONS

Facial expressions come naturally for all human beings. Throughout several years of research it has been proven that facial expressions are an important way for expressing our emotions and communicate with others.

FMEE.

FMEE (Facial Micro Expressions of Emotion) is the proposed model being developed for identifying human basic emotions based on micro expressions, with the use of a 3D

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camera. This type of development comes with many challenges, such as performing detection, landmark location and pose estimation, all at the same time, to be able to track the expressions video sequence. These three tasks have been approached by the community as separate problems, but rarely simultaneously.

Here, we proposed a model capable of identifying basic human emotions from a video sequence. In the figure 2, we present the block diagram for the proposed model. The video is recorded using a 3D camera; we implement a conditioning phase for the video acquisition and restrict the video image to 640 x 480, to be able to capture clearly each movement of the subject being tested.

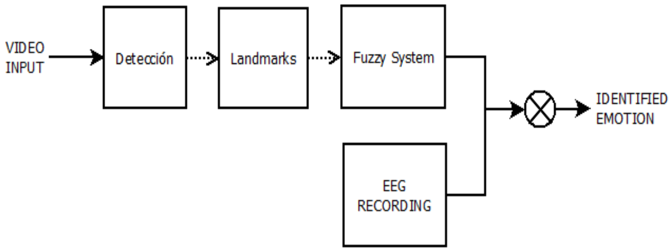

Figure 2. FMEE Block Diagram.

As seen in block diagram from figure 2, the model consists of four blocks to be able to detect an emotion. First, we configure the camera parameters accordingly to the work ambient, mostly illumination. The camera starts recording and sending feed to the system. Face detection is performed using a real-time face detection scheme proposed in [17], which represents an adapted version of the original Viola-Jones (VJ) face detector [18]. The VJ face detector consists of a cascade of classifiers trained by AdaBoost; the adapted version of the detector that we employed uses GentleBoost instead of AdaBoost.

Secondly, the facial landmark detection is done by histogram based features, such as local binary patterns (LBPs) [19] and histograms of oriented gradients (HOGs) [20], [21]; this type of methods have become very popular because of their successful performance and efficiency. These landmark points need to be tracked along the video sequence and the head pose movement for changes in facial expression to discriminate between macro and micro expressions. The process is explained in section 4.2.

The data gathered with the landmark points is then analyzed with the use of a fuzzy system. For the analysis of the data, we propose a grouping of the points by facial regions, such as: right brow (RB), left brow (LB), right upper eyelid (RUE), right lower eyelid (RLE), left upper eyelid (LUE), left lower eyelid (LLE), nose (N), upper lip (UL), lower lip (LL), and jaw (J). In addition, to assure correct identification of emotion, we selected seven distances (see figure 3): between eyebrows (D1), right brow to upper lid (D2), left brow to lower lid (D3), opening of right eye (D4), opening of left eye (D5), vertical opening of mouth (D6), and horizontal opening of mouth (D7).

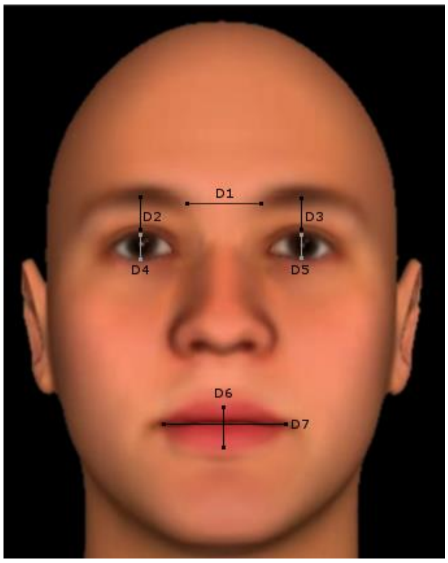

Figure 3. Seven distances for emotion identification accuracy.

In the figure 4, we present a diagram for the proposed fuzzy system. We can see how the distances provide us with extra information for the rules decision making.

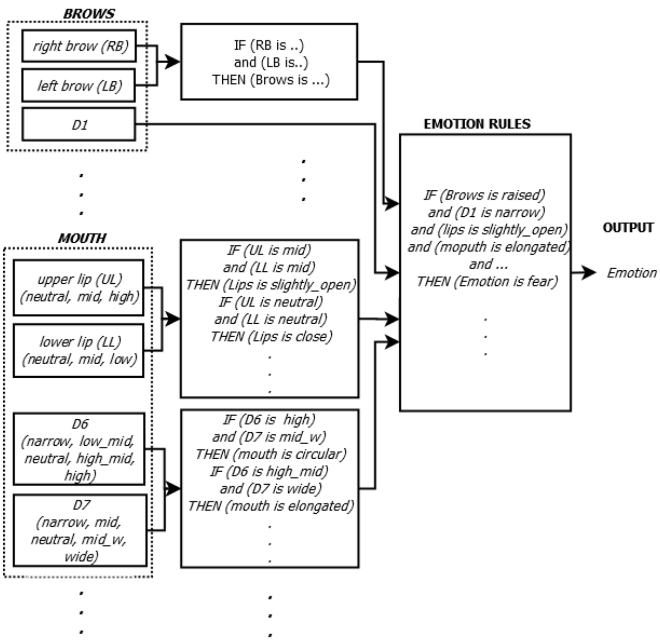

Figure 4. Fuzzy System Diagram for Emotion Identification based on micro expressions.

All subjects will receive visual stimulation for evoking an emotion reaction, for both the CV analysis and the EEG recording. While the subject is receiving audiovisual stimulation, the CV system will be analyzing the facial data for emotion identification and, with the aid of an EEG headset, we will record the brain signals of the subject. The CV method provides us with a time lapse where the micro expression was identified, and the system keeps a record with the initial and final time of the micro expression, along with the emotion identified by the fuzzy system. We only keep record of micro expression and not macro expressions (fully expressed emotions visible to every person). After the subject's testing session is finalized, we do feature extraction to the EEG signals segments (± 1 sec) where the fuzzy system identified the micro expression, and for these we use Hjorth parameters as seen in [22].

The Hjorth parameter is one of the ways of indicating statistical property of a signal in time domain and it has three kinds of parameters: Activity, Mobility, and Complexity. Activity parameter, the variance of the time function, can indicate the surface of power spectrum in frequency domain. Mobility parameter is defined as the square root of the ratio of the variance of the first derivative of the signal and that of the signal. This parameter has a proportion of standard deviation of power spectrum. Complexity parameter indicates how the shape of a signal is similar to a pure sine wave. The value of Complexity converges to 1 as the shape of signal gets more similar to a pure sine wave. In addition to the information about the signal, a lower computational complexity can be achieved with the use of them.

At the time, these information is gathered with the goal of detecting a pattern or distinctive characteristics for each micro expression of emotion with the use of EEG, and later be able to detect them with the sole use of EEG recordings.

4.2 FACIAL IMAGING TECHNIQUE.

Facial Imaging technique consists in detecting the movement of the facial muscles when a person shows an emotion. Facial expressions of emotions can be detected and measured with the use of the facial imaging technology that uses sophisticated algorithms for real-time capture and analysis of facial muscle reaction to identify the emotion being felt by an individual. This technology is used by the machine learning systems that decode facial movement into basic human emotions.

A well-known coding system developed for emotion identification is called Facial Action Coding System (FACS) developed by Ekman and Friesen in [9] [11], the system separates the facial muscles in 23 sections called Single Action Units (AU) for focalized analysis of muscle reactions, and units can be combined to detect an expressed emotion.

This technique is widely used by experts to detect when an individual is lying or deceiving during interrogations and in conference rooms full of people to detect treats [9-12]. The analysis can be performed by an expert in real-time, if the situation requires taking immediate action based on the findings, or via recordings, at a later time; also, it can be done using machine-learning techniques with an integrated coding system using CV to capture real-time facial micro expressions and measure the emotional reaction.

It has been explained that certain patterns of muscle activity can be evoked by several categories of basic facial expressions. These can be measured by EMG in two distinct muscles, the corrugator supercilii (CS) which knits the eyebrow when frowning, and the Zygomaticus major (ZM) which elevates the lips when smiling. In other words, an increase of CS activity happens when the subject makes an anger expression, while happy faces result in high ZM activity [6] [9]. This indicates a tendency of the subject to mimic the emotional expression of another face. These reactions happen relatively fast, within 500ms after the stimulus happened [14]. It may also happen unconsciously, even when the subject immediately masks the emotion after receiving stimuli. These expressions are also independent of voluntary control, as they can be appreciated even when the subject is asked to not do facial movements or to show illogical reactions, such as a smile in response to an angry face [14].

The face muscles, seen in the figure 5, to be analyzed with the use of the CV technique are the ZM (Figure2 -1), the Zygomaticus Minor (ZMi) (Figure 2- 4), the CS (Figure 2 - 3), and the orbicularis oculi (OO) (Figure 2-2). These facial muscles are the main participants in creating the facial expression for each of the basic emotions. The ZM and ZMi are the muscles responsible for the movement of the mouth, nose and cheeks; OO muscle is the responsible for the expressions showed around the eyes; along with the CS muscle responsible for the frowning of the eyebrows.

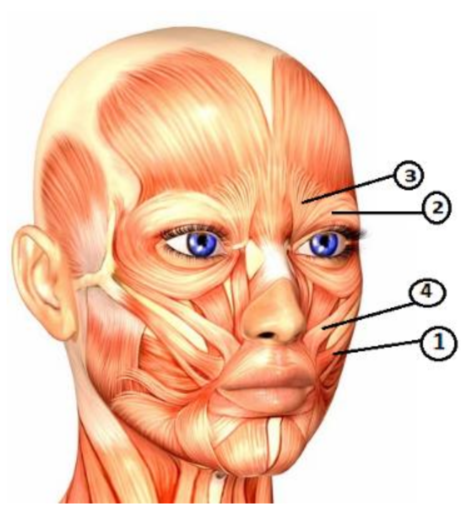

Figure 5. Facial Muscles used for reflecting an Emotional Expression: 1) Zygomaticus Major, 2) Orbicularis Oculi, 3) Corrugator supercilii, 4) Zygomaticus Minor.

The technique used for capturing subtle changes in expression for this investigation is facial landmarks, points. They can help us locate a specific area on the face and check for changes. There are several important tasks to take into account, such as detection, head pose and reliability on landmark location. The identified muscles will help us determined the best placement for the landmarks on the face.

We made us of LBP+HOG feature extraction for placement of the facial landmarks. Both LBP and HOG features are extracted using a grid of 6x6 pixel cells. For LBP, features are created by using circular (8, 1) neighborhoods, and the resulting histograms where normalized to sum 1. For HOG, we used 9 bins of unsigned gradient orientation over color images as in [23]. In the figure 6, we show the 78 point landmarks selected for micro

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expression recognition. These are placed in specific regions of the face, where the system must focus for capturing muscle reactions of emotion.

Figure 6. 78 Facial Landmarks used in FMEE for micro expression detection.

5. TESTING

For testing the landmark location, we use the CASME [15] [16] databases. CASME I [15] was recorded at 60fps, 195 micro expressions are tagged from a total of 19 subjects. For CASME II [16], the recordings are made at 200fps, and 247 micro expressions where tagged. 6 subjects where used. The tagging was made using Ekman's AUs.

Both of these databases contain video recordings of each subject's session, and the respective frame images to each video.

FACIAL LANDMARK LOCATION.

The first step to assure correct micro expressions detection in the proposed system is by testing the accuracy of the landmark location. For this, we used the video sequences from the CASME I and II databases. We needed to test is the landmark points managed to stay correctly positioned thought the video sequence.

First, we detected the faces in the video and cropped them to have them all scaled at the same size, this way we could measure the distance from where the landmark needed to be to the actual location obtained. The faces where scaled at 640x480p, and then measure the distance from the point.

From database CASME I, we used 20 randomly selected video sequences from all 19 subjects. And, from database CASME II we used 30 randomly selected video sequences.

In the figure 7 and 8, we can see the faces cropped with the 78 facial landmarks positioned that showed some signs error in displacement. The faces correspond to subject 1 from CASME I. For better understanding of the landmarks mentioned in the figures, we marked them with a red color. In figure 7, three landmarks missed correct positioning; two around the subject's right upper eyelid and one at the bottom of the nose. While in figure 8, three landmarks from the subject's right eyebrow are clearly lower than the position of the eyebrow.

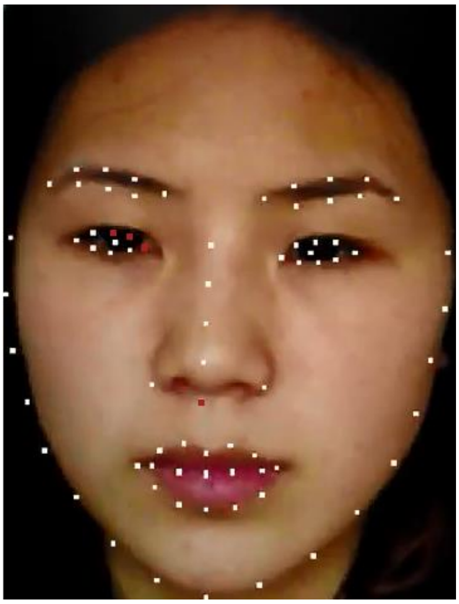

Figure 7. Landmarks at the subject's right eye upper eyelid missed position and the one at bottom of the nose.

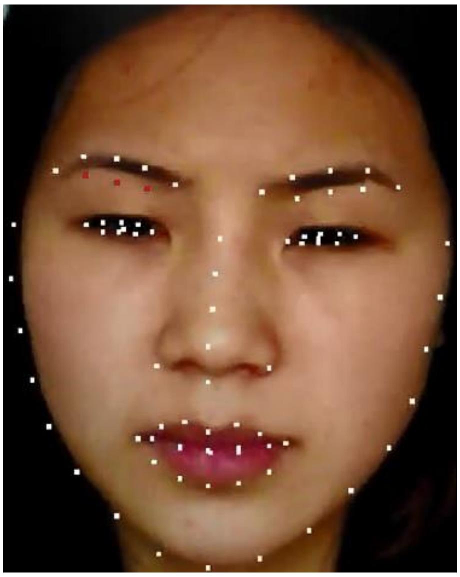

Figure 8. Three of the landmarks at the bottom of the subject's right eyebrow are not well positioned.

6. CONCLUSION

The research of emotions has a long trajectory on psychology studies for several years, but the fast advance in technology has provided us with more techniques to try and identify with better efficiency all human emotions. CV plays a major role in today's science studies, it help us to obtain better algorithms for machines to be able to perform human tasks in a much more efficient way and time. Psychology and CV have come to work together to try to better understand and identify human emotion.

With this study we are aiming to create a model to help identify basic emotions on a subject receiving audiovisual stimulation, and compliment it with the use of EEG reading for achieving better emotion identification. The model will be based on a set of landmark points focused on the facial muscles responsible for the facial micro expressions of basic emotions and processed with the use of a fuzzy system to obtain the most accurate emotional response displayed by the subject being tested.

This type of emotion detection systems have been growing in demand because of the many uses, it can help us detect lies and treats under different circumstances, which for today's world are much needed.

The results obtained for the landmark location tests performed, showed a 0.3 cm average error of displacement through the video sequences. Currently our range of movement allowed for landmark location is 75 degrees. For head pose, the current system is capable of following the subject's head movements with ease.

With the tests performed, we can clearly see that the landmark location is working properly and can be used for micro expressions detection. With these results, the data collected from the landmarks can be sent to the fuzzy system for emotion identification based in micro expressions.

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