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A FUZZY APROACH FOR FACIAL EMOTION RECOGNITION

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Abstract: *This article deals with an emotion recognition system based on the fuzzy sets. Human faces are detected in images with the Viola - Jones algorithm and for its tracking in video sequences we used the Camshift algorithm. The detected human faces are transferred to the decisional fuzzy system, which is based on the variable fuzzyfication measurements of the face: eyebrow, eyelid and mouth. The system can easily determine the emotional state of a person.*

Key words: face detection, face tracking emotion recognition, fuzzy system, fuzzy rules

1. Introduction

People interact through their facial emotions. Facial emotions are used in areas such as telemedicine, distance learning, robotics and automotive. Many psychologists have agreed on six main types of basic emotions: happy, anger, fear, sadness, disgust and surprised. All other emotions are variations of this basic emotions. Each emotion is characterized by psychological and behavioral qualities, including movement, posture, voice, facial expression and heart rate fluctuation. Although there are many different types of emotions, all have some common characteristics.

Firstly, emotions are largely instinctive and without a clear purpose. Secondly, psychological, emotional behaviors are closely related to the autonomic nervous system responsible for controlling certain innate behaviors, such as breathing or heartbeat. A third feature of emotions is that, in a broad sense, they appear to be innate.

Charles Darwin was the first to bring into discussion the universality of emotions, using this idea in his book [1], to support the theory of evolution, arguing that emotions are mental reaction patterns imprinted in the nervous system.

American psychologist Paul Ekman from the University of California (expert in the study of emotions, their manifestations and the study of the mechanism of lies), based on the results of a long research on all the continents, he finds that there are six facial expressions which can be recognized by any person belonging to any culture on the planet: fear, anger, sadness, surprise, disgust and joy [2]. The universality of these events may be treated as a strong indication that these emotions are six basic emotions related to human nature.

The American psychologist Robert Plutchik has one of the most popular theories about emotions , proposing a detailed breakdown of emotional responses. He introduces a set of eight basic emotions, which are divided into four pairs of opposite states: joy - sadness; acceptance - disgust; surprise - anticipation; anger-fear. All these emotions are considered to be innate. Plutchik also created a wheel of emotions used to describe the links between them - Figure 1 [3].

There is a connection between the idea of making his circle of emotion and a color wheel. Like the colors, primary emotions can be expressed at different intensities and can be mixed to form different emotions. Emotions which are at the base of the cone are considered to be the most intense, and as the intensity decreases, the emotions are indistinguishable [3].
Psychologist Daniel Goleman (known for his research on emotional intelligence), in his book [4], focuses on 8 basic emotions, which have several secondary emotions.

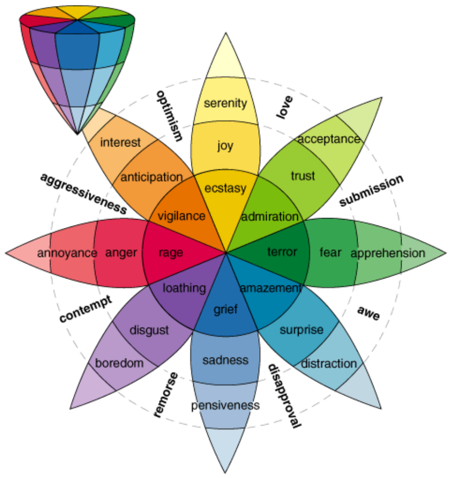

Figure 1: The Emotions wheel by Plutchik

2. Related works

Fatemeh Shahrabi Farahani et al., presents a new method based on fuzzy logic for recognizing emotion from the eyes and mouth features. Their approach shows an emotion recognition system which has 3 levels: face detection, feature extraction and classification.

The fuzzy logic used by the authors in the third stage is performed using the Mamdani type inference relations with 94 rules of the trapezoidal membership functions to encode facial attributes and their mapping of the emotion space [5]. Yuwen Wu et al. present a method for modeling the space of the facial expression based on the fuzzy integral which aims to recognize human emotions [6]. Their method consists of two steps: first using fuzzy integral values in different expression spaces to describe the uncertainty of the facial expression, in the second, the fuzzy sets are built automatically for every space of each facial expression; we can find different facial features for each facial expressions classification. Joseph W. Matiko et al. present in their paper, an algorithm designed to classify emotions into two categories: positive and negative. Their proposed algorithm is based on fuzzy sets making the fuzzyfication of signal from the EEG. Their method is advantageous compared to the literature, because the classification includes the type of emotions, but also its power [7].

In their paper, Yong-Hwan Lee et al. proposed a method of extraction and recognition of facial expression and emotions on mobile cameras. They formulated a classification model using 65 landmarks in order to estimate facial expressions [8]. With their method we can recognize three types of emotions: neutral, happy and angry.

Hadi Seyedarabi et al. have developed an emotion recognition system based on the tracking of twenty-one facial feature points using optical flow. The classification of emotions is performed with a neural network which has the following properties: seven inputs, one hidden layer and six outputs or using a fuzzy inference system [9].

Xinqi Lin et al. have proposed a new algorithm based on fuzzy logic, containing three stages [10]. The first stage is to extract two feature extraction models from the grammatical analysis of the film. The second stage performs the conversion of feature vectors into fuzzy vectors.

The third stage describes the fuzzy logic inference rules through which the system can classify the emotional state from a given scene, based on the fuzzy theory.

3. System overview

We have proposed an emotions recognition system with a simple structure as in Figure 2. The system consists of three subsystems: the first is to detect the human face in images, the second is to track the human face, and the third is to decide what emotion is shown on the human face.

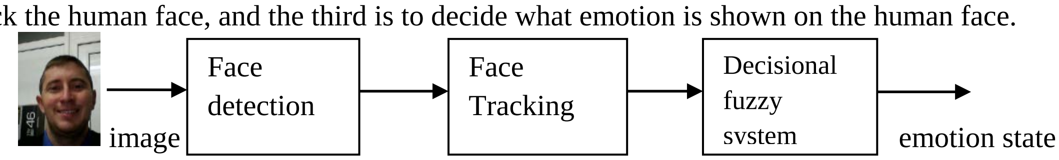

Figure 2: Structure of proposed system

3.1. Detection of faces using the Viola-Jones algorithm

Figure 3 [11] illustrates the Viola and Jones object detection algorithm in two steps: detecting of the face in an image region and then applying on it a cascade of boosted classifiers. The first step detection window is realized by scanning the same image many times, each time with a new size. During the second stage each window is passed through a cascade of classifiers which in its turn is divided in various steps, each step uses a set of weak learners.

Each stage is trained to select only the wanted images using a technique called boosting. Boosting has the advantage of training a very accurate classifier to choose a weighted average of the decisions taken by the weak learners. Each level of the labeled region belonging to the classifier is defined as being the current location of the sliding window, being positive or negative.

The detector reports a found face in the current location when the final level classifies the region as being positive. If we have the k classifiers in a cascade, the result of detection rate, D, and false positive rate, F, is given by the product rates on each stage classifier [12]:

$$D = \prod_{i=1}^{K} d_i \qquad F = \prod_{i=1}^{K} f_i \qquad (1)$$

,where d_i is the detection rate of the *i* the classifier in the examples that get through to it and f_i is the false detection rate of the *i* the classifier in the examples that get through to it.

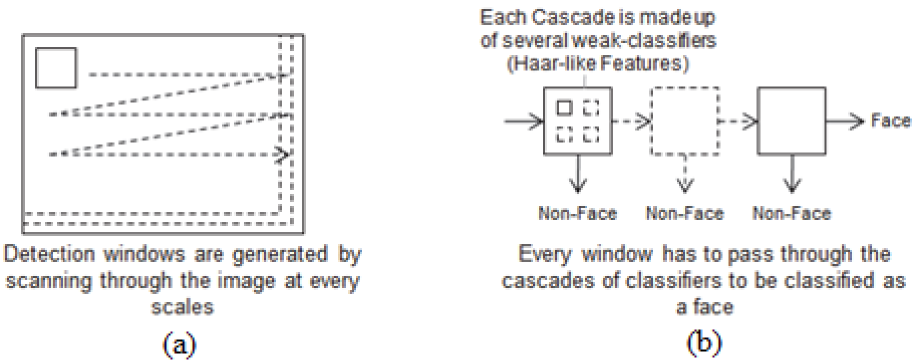

Figure 3: The Viola-Jones Object Detection Algorithm: a) Detection windows ; b) Classified windows

3.2. Face tracking using the Camshift algorithm

For face tracking in a video sequence, we used the camshift algorithm proposed by the authors in their paper [13]:

a) Set the calculation region of the probability distribution for images.
b) Choose an initial location of the Mean Shift search window; it will be the tracked target.
c) Calculate a color probability distribution of the region centered on the Mean Shift search window, where the target is slightly larger than Mean Shift window size.
d) Run Mean Shift algorithm to find the centroid of the probability image. Store the zero moment (the area) and the centroid location.
e) For the next frame, put the search window at the mean location found in Step d) and set the window size to a function of the zeroth moment. Go to Step c).

3.3. The decisional fuzzy system

After the operations of detection and tracking of the human face, it goes through a fuzzy system modeled using the Fuzzy Logic Toolbox of Matlab. The system takes into account in making the decision three face variables that change for each emotional state. Our system is modeled to recognize six states: happiness, anger, fear, sadness, disgust and surprise. More details of this system are given in the next section.

4. The design of the fuzzy logic system in determining emotion recognition

The fuzzy model projected by us looks like Figure 4:

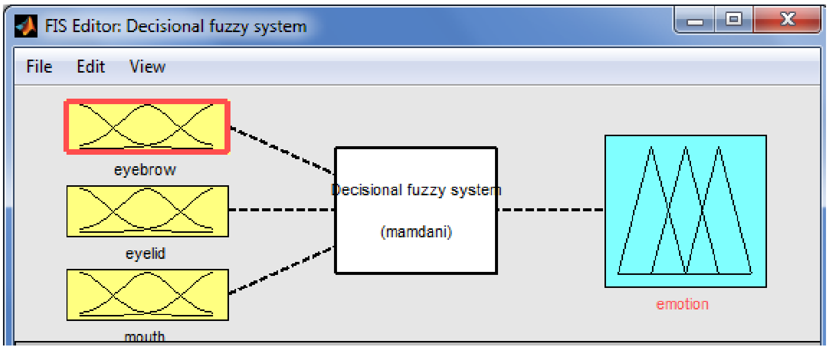

Figure 4: The fuzzy system model

The three yellow rectangles represent the three inputs of the fuzzy logic system: eyelid, eyebrow and mouth. In these three blocks the fuzzyfication takes place. The light gray rectangle represents the process of inference and the turquoise rectangle represents the output fuzzyfication block (in these rectangle the defuzzyfication takes place).

4.1. Inputs

In this subsection we define universes of discussion for the 3 inputs variables thus:

- Eyelid: [40; -100];
- Eyebrow: [100;-100]:
- Mouth: [10;-100].

These are detailed in Figures 5, 6, 7:

Figure 5: The universe of discussion of eyelid

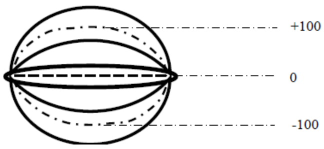

Figure 6: The universe of discussion of eyebrow

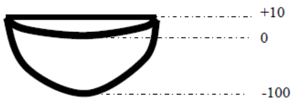

Figure 7: The universe of discussion of mouth

The associated fuzzy set of input variables are: small, moderate and large.

4.2. Outputs

For the output variable emotion, the universe of discussion is [0;1] and the associated fuzzy sets are: happy, sad, surprise, fear, anger, and disgust, each with the following universes of discussion, in order: [0;0.2], [0.2;0.4], [0.4;0.6], [0.6;0.8], [0.8;1], [1;1.2].

4.3. The defining of a set of rules for the decisional fuzzy system

The system works with fuzzy rules type if ..., then ..., that condition of if must be complied with in order to deduce the desired output, which makes system to be decisional. We have created a knowledge base for the system with the six following rules:

- If (the mouth is moderate) and (Eyelid is small) and (Eyebrow is moderate) then (Emotion is happy);

- If (mouth is small) and (Eyelid is large) and (Eyebrow is moderate) then (Emotion is sad);
- If (Mouth is moderate) and (Eyelid is large) and (Eyebrow is small) then (Emotion is anger);
- If (Mouth is large) and (Eyelid is large) and (Eyebrow is large) then (Emotion is surprised);
- If (Mouth is moderate) and (Eyelid is large) and (Eyebrow is large) then (Emotion is fear);
- If (Mouth is small) and (Eyelid is moderate) and (Eyebrow is small) then (Emotion is disgust);

E.g. if we have the following values of the input variables: Mouth is -20, Eyelid is 20 , and Eyebrow is 0 then the output will be happy.

4.4. The results design of the fuzzy system decisional system

Figure 8 shows the operation of the fuzzy system designed by us for the example above. The results are found by the system as being valid only for the first rule, where the values of the three variables belong to the fuzzy sets in the fuzzification process. The system output is that the variable has the value equal with 0.1, so it was classified as happy.

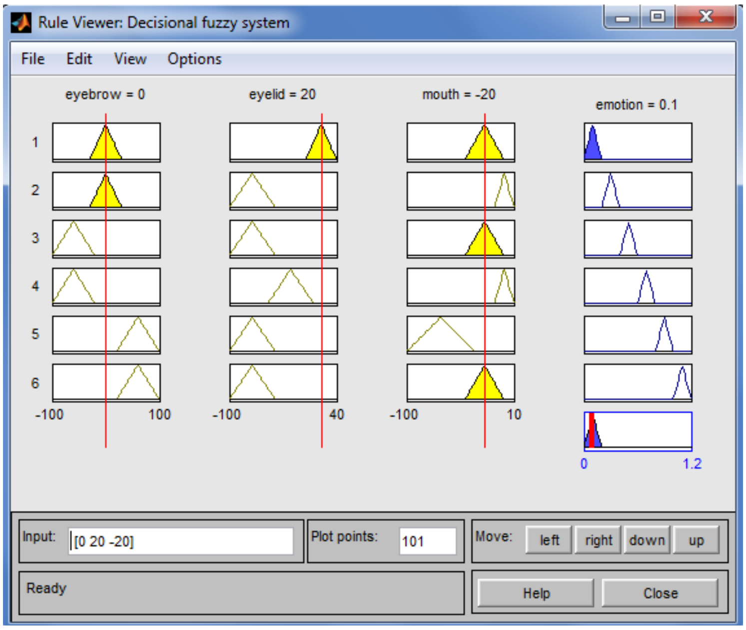

Figure 8: Happy emotional state classification by the fuzzy system decisional

Figure 9 shows the results after designing the decisional fuzzy system through a three-dimensional graphics that indicates the emotion status, taking into account two input variables: eyebrow and eyelid.

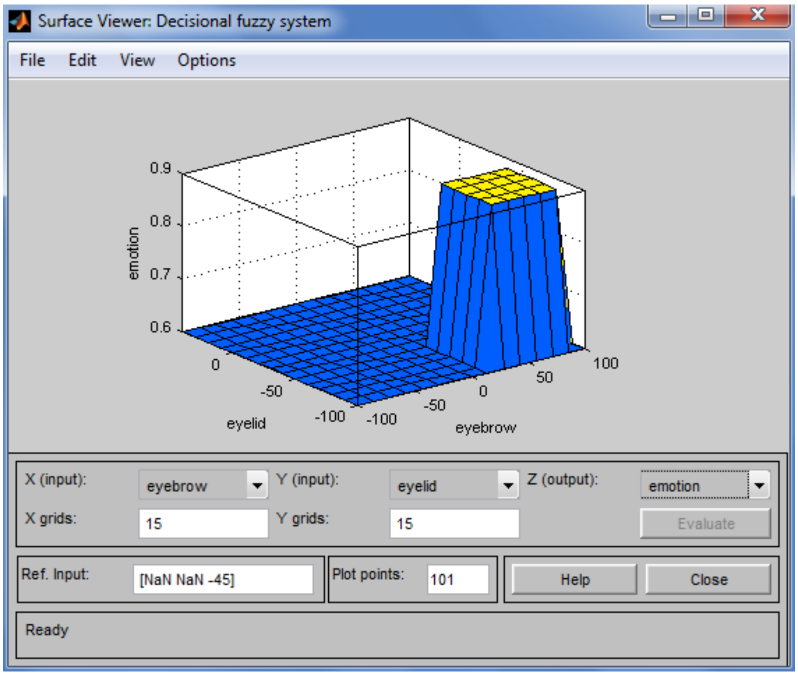

Figure 9: The output emotion state depending eyebrow and eyelid

5. Conclusions

The proposed system can recognize emotions quickly and easily, because it has strict rules in its knowledge base and the membership functions of the output variable are not overlapped. As future work the proposed system will be extended to recognize human emotion in a real-time which will be implemented on a mobile robot and on a car.

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