A Prototype Hybrid Algorithm to Detect Face Oval Based on Facial Expression Recognition
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Pages 253 – 258
**DOI: http://dx.doi.org/10.21700/ijcis.2016.130**

# A prototype hybrid algorithm to detect face oval based on facial expression recognition

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**Abstract:** *The facial expression recognition system (FERS) is a complex computer vision problem because it effects on occlusion, illumination, and imaging condition on the capture images. FERS consists of three stages in the basic structure. In this paper, we focus on the first stage because it is the complex one and need more calculations in comparing with other stages. The first stage in facial expression recognition called pre-processing step that includes acquiring image, face detection, and noise reduction. The core of this stage is to find the region of interest which represents the face region. A prototype algorithm of this step is based on combining two techniques which are the Viola Jones algorithm to detect face region, and integral projection to extract face oval. The proposed algorithm gives excellent results by examining it on two data base: Japanese Female Facial Expression (JAFFE) and* Multimedia Understanding Group *(MUG) facial expression database.*

**Keywords:** *facial expression algorithm, preprocessing, face oval , ROI, detect face region.*

**Received**: May 10, 2016 | **Revised**: July 23, 2016 | **Accepted**: August 10, 2016

## 1. Introduction

The automatic facial expression involves the application of an artificial intelligent system to recognize the expression of the face under any circumstance. Now, the studies of facial expression have more interest in computer vision, pattern recognition and many related fields, in modern society of technological age, therefore the technology is applied in a wide variety, such as, robotics, mobile application and medicine. In fact and it is reported "some robots can operate by first recognizing expression of humans" [1]. In example the [1]AIBO robot is a biologically inspired robot that can show it's emotion via an array of LEDS which is put in the frontal part of the head [2]. In behavioral sciences and medicine for instance, expression recognition is effectively applied for intensive care monitoring [3].
Today, there are developing systems that are capable of making routine examinations of facial behavior during pain in clinical settings. The technology is being used in more advanced settings to reduce accidents through the implementation of automated detection of driver drowsiness in public transports. Human face varies from cone person to another due to gender, age, and other physical characteristics.

[1] AIBO (**A**rtificial **I**ntelligence ro**BO**t) is an entertainment robot designed by Sony which owns ability to emotions. More details can be found at http://www.sony-aibo.com.

Therefore, the detection of the face is more challenging task in computer vision, thus, this stage includes the input of the picture which has the part of the face .The suggested algorithm works throughout the developer system on discovering that part of the face and separating it out of the background. Our goal is to create a system that can detect the face area which is used for feature extract in the second stage of FERS.

The steps include determining that containing the facial area fully using the viola and jones algorithm and then extract face oval based on integral projection method. In addition, the use of ways to image processing by reduce the noise, and limit illumination variation. Any model uses for object recognition involves cropping and isolated the area that contains the interested information which called region of interest (ROI).

## 2. Related works

Many researchers have used developing methodology, for this purpose. Some few examples; Sobottka et al. and Baskan et al. They proposed methods that use shape and color information as the cues to locate the face and extract facial features [4, 5]. The method includes detected skin-like regions by describing color skin in hue and saturation components of the HSV (Hue, Saturation, and Value) color model, then they use ellipse fitting to find all face candidates.

Gizatdinova and Surakka [6], introduced edge-based technique of locating ROIs of prominent facial features from up-right facial images. They proposed a new accuracy evaluation method for feature ROI localization.

R. FeÂraud, O.Bernier, E.Viallet, and M.Collobert [7]. They proposed the neural network model used to extract face region. Performs an accurate method of the face set, using a small set of adverse. The strength of this algorithm detects side view face besides front view face but the disadvantage to this algorithm is the size of the model.

In 2015, Priya Saha, Debotosh Bhattacharjee, Barin Kumar De, and Mita Nasipuri, proposed in paper [8], the eye region has been considered as a combination of both eye and eye-brow area. In case of extracting the mouth region, local edge map is also needed to be constructed. The main aim of this paper is to evaluate the efficiency of proposed method on a benchmark facial expression database.

The outline of this paper is the following: Section 2 is the methodology that used to develop the models. The database used is reported in section 3. The graphical user interface (GUI) and results are shown in section 4. Finally, section 5 presents the conclusion and proposes future works.

## 3. Methodology

In this part, we will discuss an approach that is being followed to detect face region. In many problems we need combining more than one methods to achievement task in order to get performance improvement rate. The proposed method consists of two stages use viola and jones algorithm (V&J), and integral projection to get the final result. In addition, we use operation on the matrix to get the region of interest (ROI) such as (Right eye, left eye, and mouth), and the steps for a prototype algorithm proposed are:

### 3.1 Detect whole face region (Viola & Jones)

Viola & Jones algorithm is an object detection method to provide competitive advantage for object detection. This algorithm passes great popularity in the field of face detection problem, it consists of three stages cascading classifiers and haar feature selection, creating an integral image, and adaboost training [8].

### 3.1. A cascading classifier and haar feature selection

haar feature classifier is a machine learning algorithmic method to detect visual object [9,10]. Of the most important features for this classifier is speed to reject regions that are unlikely to be contained in the object. The essence for haar cascade classifier is the haar-like-feature. These features, use change in contrast values rather than using the intensity values of pixels [11].

The pixel groups that variance of contrast are used to locate relative light and dark area. Figure 1 shows the basic haar-like-feature.

The final result for cascade classifier is the difference between sum of pixel value (gray level) within the white and black rectangular area [9], i.e.

$$f(x) = \text{sum}_{\text{black rectangle}}(\text{pixel gray level}) - \text{sum}_{\text{white rectangle}}(\text{pixel gray level}) \quad \dots (1)$$

As shown in figure 2.

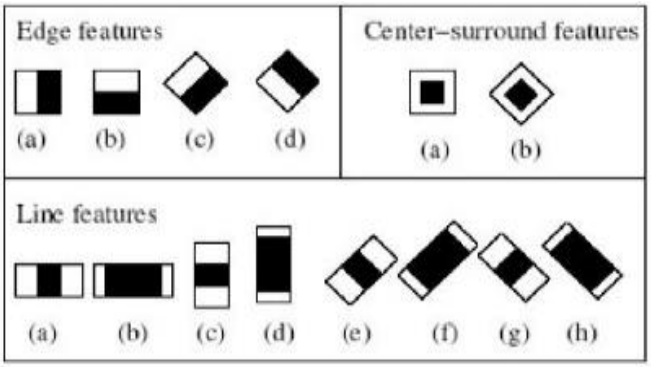


**Figure 1.** Basic Haar-Like feature.

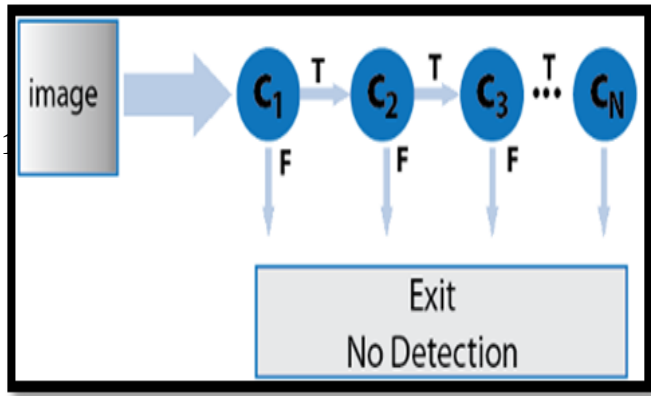


**Figure 2.** Cascade classifier structure.

### 3.1. B Creating an Integral Image (II)

The Haar-Like feature can be calculated rapidly based on "Integral Image". II is used for calculating the average intensity within a given image [13, 14]. To clarified we suppose the sum of group pixel values at location of x, y then integral image for it is

$$ii(x,y) = \sum_{p \le x, q \le y} i(p,q) \quad \dots (2)$$

Where ii(x, y) integral image at the pixel (x, y), *i* is a given image, and x, y represent the pixel values. For more details see figure 3.

$$P_1 = A, P_2 = A + B, P_3 = A + C, P_4 = A + B + C + D$$
$$P_1 + P_4 - P_2 - P_3 = A + A + B + C + D - A - B - A - C = D$$

The sum of pixel values within "D"

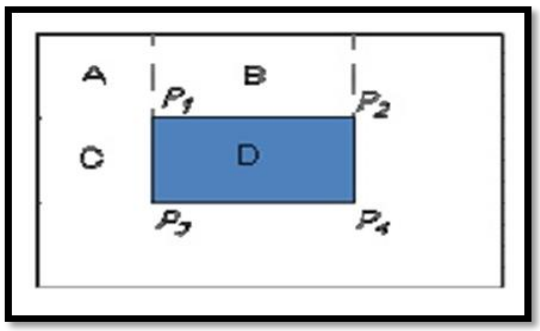


**Figure 3**. Haar-Like feature points.

### 3.1. C AdaBoost classifier

Boosting is one of the machine learning approaches based on the idea of creating a highly accurate prediction rule by combining many relatively weak and inaccurate rules. The algorithm to Adboost can be shown in the following scheme [18].

- Samples x … $x_n$
- Desired outputs $y_1$ … $y_n$ , y Є {-1, 1}
- Initial weights $w_1$,1 … $w_n$ ,1 set to 1/n

- Error function E(f(x),y, i) = e-$y_i$ f(xi)
- Weak learners h:x → [-1,1]

*For t in 1 ... T*

*Choose* $h_t(x)$

Where $h_t$ is weak learner that minimizes ℜt, the weighted sum error for misclassified points

$$\epsilon_t = \sum_i w_{i,t} E(h_t(x), y, i) \quad \dots (3)$$

- *Choose*

$$\alpha_t = \frac{1}{2} \ln\left(\frac{1-\epsilon_t}{\epsilon_t}\right) \quad \dots (4)$$

- *Add to ensemble:*

$$F_t(x) = F_{t-1}(x) + \alpha_t h_t(x) \quad \dots (5)$$

- *Update weights:*

For all *i*

$W_{i,\,t+1} = W_i \, , \, t^{e^{-yi\ at\ ht\ (xi)}}$ … (6)

*Renormalize* $W_{i,\,t+1}$ *such that*

$$\sum_i w_{i,t+1} = 1 \quad \dots (7)$$

- *(Note: It can be shown that*

$$\frac{\sum_{h_{t+1}(x_i)=y_i} w_{i,t+1}}{\sum_{h_{t+1}(x_i)\neq y_i} w_{i,t+1}} = \frac{\sum_{h_t(x_i)=y_i} w_{i,t}}{\sum_{h_t(x_i)\neq y_i} w_{i,t}} \quad \dots (8)$$

At every step, which can simplify the calculation of the new weights.)

In the end, the result to this stage detects face region and an example for this, is shown in figure (4).

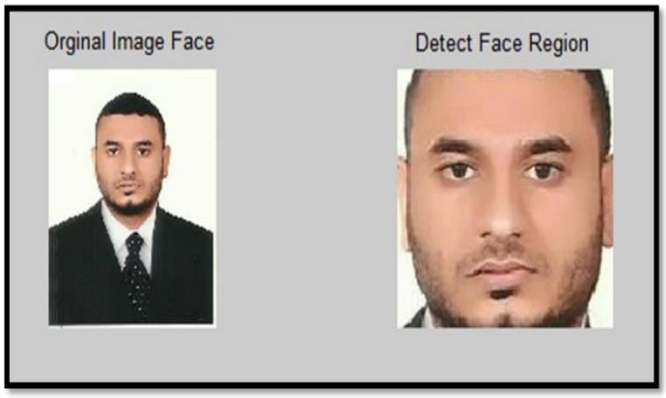


**Figure 4**. Detect face region.

### 3.2 Detect Face Oval

In this stage, the proposed method is used to detect face oval based on Integral Projection (IP) method.

Integral Projection Function (IPF) is a one-dimensional pattern, or signal calculate through the sum of a given set of pixels a long a given direction. Vertical and horizontal integral projection are most commonly used, although they can be applied on any direction [12, 15].

Let I(x, y) is the intensity of a pixel at location (x, y), and the intervals [$y_1$, y2] and [$x_1$, x2].

The vertical integral projection of x ($IPF_v(x)$) can be defined as shown in equation (9).

$$\mathrm{IPF}_{\mathbf{v}}(x) = \int_{y1}^{y2} I(x,y)\,dy \quad \dots (9)$$

And the horizontal integral projection ($IPF_h(y)$), Appears by equation (10).

$$\mathrm{IPF}_{\mathbf{h}}(x) = \int_{x1}^{x2} I(x,y)\,dx \quad \dots (10)$$

Usually use the mean horizontal and vertical projection which can be defined and as shown in equation (11), and (12) respectively.

$$\mathrm{IPF'}_{h}(y) = \frac{1}{x_2 - x_1} \int_{x1}^{x2} \mathrm{I}(x,y)\,dx \quad \dots (11)$$

$$\mathrm{IPF'}_{v}(x) = \frac{1}{y_2 - y_1} \int_{y1}^{y2} \mathrm{I}(x,y)\,dy \quad \dots (12)$$

Figure (5), shows the vertical ($IPF_V(x)$), and horizontal ($IPF_H(y)$) integral projection in the image of the face.

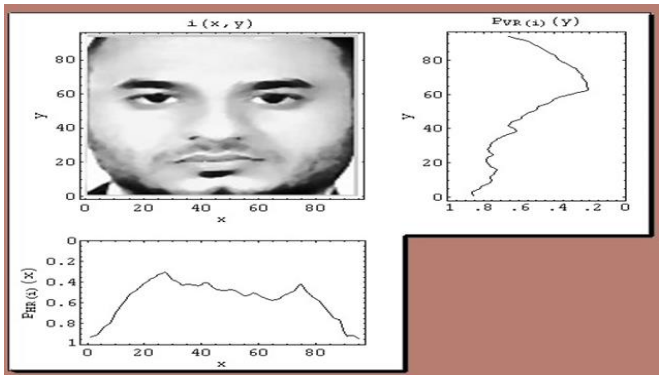

**Figure 5**. Vertical & horizontal Integral projection.

The method which is suggested includes the combination of two different algorithms .Firstly, the whole facial area is detected by using Viola&Jones algorithm and then the Integral Projection method is used to determine the face oval area. Databases used for the purpose of examination of the proposed system are the JAEFF and MUG facial expression databases.

The proposed method is shown in the following flowchart, figure (6). It explains the step to a prototype algorithm to face extract. Firstly, test image is input to the system and test for Scan to make sure if it is gray scale or no, and it is converted to gray level if no.

In the second preprocessing, we applied normalization to image and improve the illumination variance and noise reduce. Then we applied the proposed algorithm to detect the whole face region and then face oval. Finally, For the purpose of extract the subspace face region such as right eye, left eye, and mouth region scale the face oval extracted to (124*124) and extract face region .

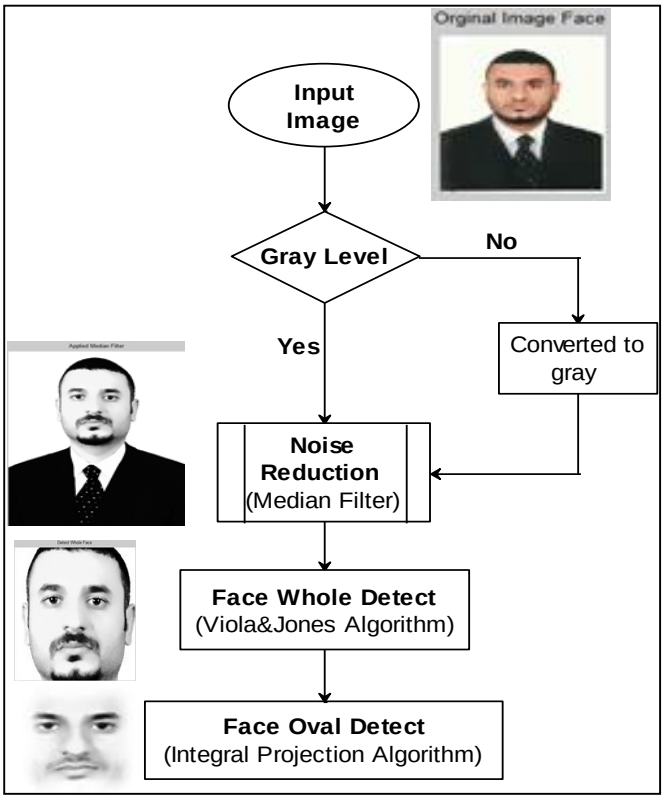


**Figure 6**. The proposed algorithm prototype.

## 4. Database used

To examine any system we need to apply it on a sample for testing the accuracy and efficiency of the system. The proposed system used two database. The first is the Japanese female facial expression (JAFFE) database. JAFFE contains 213 images of 7 facial expression (six basic facial expression plus one natural) posed by 10 Japanese female models [16] see the example for JAFFE in figure (7).

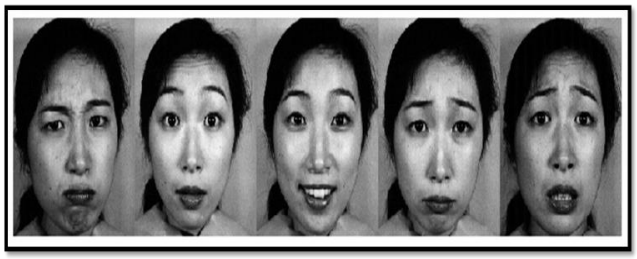

**Figure 7**. JAFFE database.

The second database is Multimedia Understanding Group (MUG). It was created to overcome some of the other similar database which appeared for the same purpose. MUG consist of image sequences of 86 subjects performing facial expression [17]. Example on subject MUG database shown in figure (8).


**Figure 8**. MUG database.

## 5. Tools

The proposed system which appears in the system interface (GUI) as shown in figure 9, was designed for that purpose. The GUI for proposed system is very simple, clear, and systematic, and makes it easier for the user to execute each task separately. The software that is used to design and implementation of our proposed a prototype algorithm is Matlab R2013a 32-bit (win32).


**Figure 9**. GUI to the proposed system.

## 6. Results

The proposed system was tested by taking 85 samples from Jaffe database, with the same number from MUG database randomly.
The result to this test appears in table 1.

**Table 1**. The proposed system test results.

| Database | Number of test image | Oval face |
|---|---|---|
| JAFFE | 85 sample | 93% |
| MUG | 85 sample | 98% |
| **Total** | 170 sample | 95.5% |

The result that is got from this test 100% for detect whole face region by V&J algorithm, but for oval face based on IPF is 95.5 and the result can be improved by reducing the noise and illumination variation because the IPF method is very sensitive to this problem.

After testing the proposed system, our system should be compared with some of the previous systems. As it is shown in table 2, which illustrates that comparison. Also the proposed system shows high detection rate.

**Table 2**. % face detect rate

| Authors | Method | %Detect rate |
|---|---|---|
| Rowley et al [19]. | Multiple neural networks | 84.5% |
| Schneiderman & Kanade [20]. | Naive Bayes | 91.1% |
| p. Saha & D. Bhattacharjee [8]. | Facial geometric based hybrid approach. | 94% |
| **Our system** | Depending on merging two methods. | **95.5%** |

## 7. Conclusion and future work

In this paper we proposed a new prototype algorithm to detect oval face. This region is very important for researchers who work in the field of face and facial expression recognition, which represents the region of interest (ROI) for design and implementation those systems. The idea for this method based on combination between two techniques. Firstly, detecting the whole face region based on the use of Viola & Jones algorithm. Secondly, we used Integral Projection function to detect face oval by $IPF_v$ and $IPF_h$ to locate eye region. The results for those methods by testing on two database is 93% for JAFFE, and 98% for MUG database. The method showed high effectively to extract face region.

In the future, will be trying to test the prototype system that proposed on the various databases for facial expression recognition. As well as, applying the proposed method for real time system to detect face oval.

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