A Genetic Algorithm based Method for Face Localization and pose Estimation

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Abstract: This paper introduces a new method using genetic algorithms (GA's) for face localization. Face images often have a background that can affect on the face localization algorithm. So, finding the exact location of face after localization algorithm is crucial. In our algorithm, input image is first enhanced by means of histogram equalization. Then connected components are determined by applying a region growing algorithm (coarse segmentation), followed by computing the fit ellipse for face area and at least exact location of face is found by genetic algorithms method. To check the utility of our proposed algorithm, we have defined tilt error and translation error that are the difference between obtained and real tilts and centers of localized face respectively. Simulation results on the ORL database show the effectiveness of this method. As, mentioned errors are obtained 4.2 degree and 5.4, respectively.
Key words: Face Localization, Pose Estimation, Genetic Algorithms, Shape Information.

1 Introduction

Automatic Face recognition has been an active research topic due to their extensive range of applications, such as film processing, access control systems, content-based video browsing, criminal identification and authentication in secure systems like computers or bank teller machines (Chellappa R& al., 1995).

Face localization is a fundamental step in the process of face recognition (Hddadnia J& al., 2003). The accuracy of the localized face center coordinates and orientation has a heavy influence on the recognition performance. To ensure a robust and accurate feature extraction that distinguishes between face and nonface regions in an image, we require the exact location of the face in two-dimensional images (Hddadnia J& al., 2003).

Many algorithms have been proposed for face localization and detection, which are based on using shape (J. Wang& al., 2000), (Klaus J. & al., 2002), color information (K. Sobotta & al., 1996), motion (R. Herpers& al., 1999) etc. See (J. Daugman, 2001) and the references cited therein.

Genetic algorithms (GA's) are optimization technique based on the mechanics of natural selection. They used operations found in natural genetics to guide itself through the paths in the search space (A. Homaifar& al., 1995). Because of their advantages, recently, GA's have been widely used as a tool in pattern recognition applications.

In this paper, we have proposed a new method for face localization that is utilizes shape information and genetic algorithms approach. Architecture of this method is shown in Fig. 1. After preprocessing, connected components are determined by applying a region growing algorithm (coarse segmentation). Then the best-fit ellipse for face area is computed. We have used genetic algorithms to find the best location (includes the best orientation and the best position) of face in image.

This paper is organized as follows: In section 2, a description of the face localization based on shape information is given. Section 3 presents the overview of genetic algorithms. In section 4, we discuss the experimental results. Conclusion remarks are given in section 5.
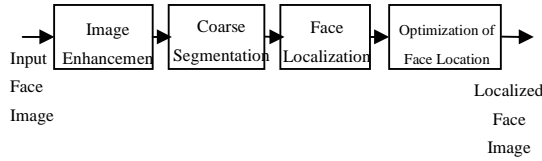
Figure 1. *Basic Flowchart of the algorithm*

2 Face Localization

2.1 Face Localization based on Shape Information

The oval shape of face can be approximated by an ellipse. Therefore looking for faces in an image means to detect objects with nearly elliptical shape. The localization algorithm utilizes the information about the edges of the facial image or the region over which the face is located (J. Wang& al., 2000).

The advantage of the region-based method is its robustness in the presence of the noise and changes in illumination. In the region-based method, the connected components are determined by applying a region growing algorithm, then for each connected component with a given minimum size, the best-fit ellipse is computed using the properties of the geometric moments. To find a face region, an ellipse model with five parameters is used: X_0, Y_0 are the centers of the ellipse, θ is the orientation, α and β are the minor and major axes of the ellipse respectively, as shown in Fig. 2.
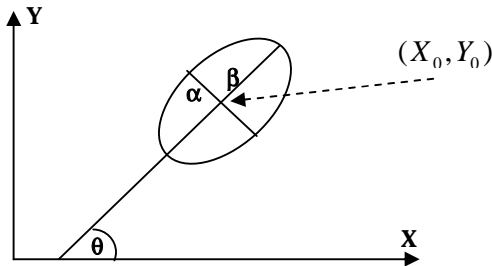

Figure 2. *Face model based on ellipse model*

To calculate these parameters, first we review the geometric moments. The geometric moments of order p + q of a digital image are defined as:

$$M_{pq} = \sum_x \sum_y f(x, y) x^p y^q \tag{1}$$

Where p, q = 0, 1, 2,…and f(x, y) is the gray scale value of the digital image at x and y locations. The translation invariant central moments are obtained by placing the origin at the center of the image.

$$\mu_{pq} = \sum_x \sum_y f(x - x_0, y - y_0)(x - x_0)^p (y - y_0)^q \tag{2}$$

Where $x_0 = M_{10}/M_{00}$ and $y_0 = M_{01}/M_{00}$ are

the centers of the connected components. Therefore, the center of the ellipse is given by the center of gravity of the connected components. The orientation θ of the ellipse can be calculated by determining the least moment of inertia:

$$\theta = 0.5 \times Arc\tan(2\mu_{11}/(\mu_{20} - \mu_{02})) \tag{3}$$

Where μ_{pq} denotes the central moment of the connected components as described in equation (2). The length of the major and the minor axes of the best-fit ellipse can also be computed by evaluating the moment of inertia. With the least and the greatest moment of inertia of an ellipse defined as:

$$I_{Min} = \sum_x \sum_y [(x - x_0)\cos\theta - (y - y_0)\sin\theta]^2 \tag{4}$$

$$I_{Max} = \sum_x \sum_y [(x - x_0)\sin\theta - (y - y_0)\cos\theta]^2 \tag{5}$$

The lengths of the major and minor axes are calculated as follow:

$$\alpha = (1/\pi) \times [I^3_{Max}/I_{Min}]^{1/8} \tag{6}$$

$$\beta = (1/\pi) \times [I^3_{Min}/I_{Max}]^{1/8} \tag{7}$$

3. Overview of Genetic Algorithms (GA's)

The GA's is a stochastic global search method that mimics the metaphor of natural biological evolution. These algorithms are general purpose optimization algorithms with a probabilistic component that provide a means to search poorly understood, irregular spaces (M. Srinivas& al., 1994)

GA's work with a population of points rather than a single point. Each ''point'' is a vector in hyperspace representing one potential (or candidate) solution to the optimization problem. A population is, thus, just an ensemble or set of hyperspace vectors. Each vector is called a chromosome in the population. The number of elements in each vector (chromosome) depends on the number of parameters in the optimization problem and the way to represent the problem.

A typical series of operations carried out when implementing a GA paradigm is:
1) Initialize the population;
2) Calculate fitness for each chromosome in population;
3) Reproduce selected chromosomes to form a new population;
4) perform crossover and mutation on the population;
5) Loop to step (2) until some condition is met.

Initialization of the population is commonly done by seeding the population with random values. The fitness value is proportional to the performance

measurement of the function being optimized. After fitness calculation, the next step is reproduction. Reproduction comprises forming a new population, usually with the same total number of chromosomes, by selecting from members of the current population using a stochastic process that is weighted by each of their fitness values.

The next operation is called crossover. Crossover is the process of exchanging portions of the strings of two ''parent'' chromosomes. The final operation in the typical GA procedure is mutation. Mutation consists of changing an element's value at random, often with a constant probability for each element in the population.

4. Experimental Results

To check the utility of our proposed algorithm, experimental studies are carried out on the ORL database images of Cambridge University. This database contains 400 facial images from 40 individuals in different states. The total number of images for each person is 10. None of the 10 images is identical to any other. Fig. 3 shows some images of this database.

Figure 3. *Some images of ORL database*

After preprocessing (histogram equalization) the facial images, we extract connected components by applying a region growing algorithm. Then the ellipse that is good approximation of connected components is selected by the shape information method that is mentioned in section 2.1. In the case of example, we obtain the results shown in fig. 4.

(a)   (b)

(c)   (d)

Figure 4. *Primary Face Localization: (a) Original Image, (b) Segmented image (c) Connected Components, (d) ellipse*

We calculate the major and minor axes of best-fit ellipse by the 6 and 7 formulas and the exact orientation and center coordinates using genetic algorithm that is described in following.

Because of the background effect, the ellipse that is obtained in previous part is not the best-fit ellipse. So, we must optimize the orientation and the center coordinates of this. In the optimization section, the population was initialized with random points. In order to select the individuals for the next generation GA's roulette wheel selection method was used. Further genetic parameters were:

- ❖ Probability of crossover: 0.8
- ❖ Probability of mutation: 0.003
- ❖ Population size: 30

We use binary coding for genotype coding and the symmetric of localized image respect to major axis of obtained ellipse for fitness function. I.e. the fitness of each generated ellipse is calculated by comparing the mean of gray scale of ellipse right side pixels and left side pixels respect to major axis.

As crossover operator we use the natural extension of the one-point crossover and mutation is represented by random bit flip with a probability of 0.003 for each bit.

Fig. 5 and 6 show the localized faces before and after of genetic algorithm optimization.
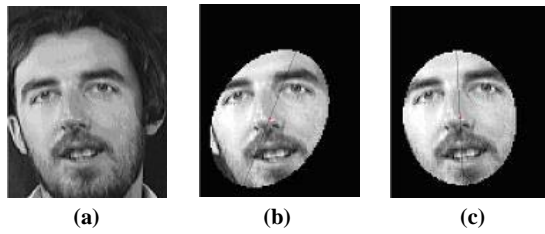

(a)   (b)   (c)

Figure 5. *Localized Face: (a) before optimization (b) after optimization*

(a)   **(b)**   **(c)**

Figure 6. *Localized Face: (a) before optimization (b) after optimization*

We have defined two criteria to evaluate the performance of our algorithm. One of them is tilt error that is difference between real tilt and obtained tilt of localized image and another is translation error that is difference between real and obtained centers of localized image:

$$Error_{tilt} = \left| tilt_r - tilt_o \right| \tag{8}$$

$$Error_{trans.} = \sqrt{(x_r - x_o)^2 + (y_r - y_o)^2} \tag{9}$$

Where indices of "r" and "o" refer to "real" and "obtained" words.

Also (x_r, y_r) and (x_o, y_o) refer to real and obtained center's coordinates of localized face respectively.

We calculate the average of tilt error and translation error over all images of ORL database with shape information based method and our algorithm that are summarized in the following table:

Table 1. *Comparison of tilt error and translation error before and after of our algorithm*

Method	Tilt Error (degree) ($Error_{tilt}$)	Translation Error ($Error_{trans.}$)
Shape Information Based Method (before optimization)	17.5	26.7
Our Algorithm	4.2	5.4

Simulation results on ORL database show that the position of localized face (pose) with our algorithm is better compared with general method that is based on shape information.

Conclusion

We have presented a new way to face localization and pose estimation. At first, we find the fit-ellipse that is good approximation of connected components in face and to cancel the background effect, genetic algorithm is used for optimization and to find the best-fit ellipse and exact location of face. To check the utility of our proposed algorithm, experimental studies

are carried out on the ORL database images. Simulation results show that the tilt error and translation error of localized face (pose) with our algorithm is lower compared with general methods that are mentioned in part 1.

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