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Efficient Edge Detection Technique Based on Hidden Markov Model using Canny Operator

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Abstract—**Robust are highly demanded due to the development of digital image processing and its wide use in many fields. In the security field, for example, speed is the essence. In this paper, Hidden Markov models alongside the canny operator which proved high accuracy recognition of the face and its boundary. The presented technique is faster than some other techniques that are investigated for comparison. In addition to that, it reveals, its ability to recognize the normal face and face boundary very efficiently**

Keywords— HMM, Canny operator, Face Recognition, Accuracy

I. Introduction

Many up to date techniques have been immerged during the recent years, due to the urgent need for security issues and in particular the pattern recognition. In digital image processing, edge detection [1] is considered the main element of recognition method. Therefore, it is a necessary for image analysis to extract its landmarks, forms, and then convert it into data that can be processed Face recognition has become necessary in commercial, law and security researches. Recently, a dedicated work targets face recognition process that aims to handle the relation between time and accuracy. However, face recognition faces too many challenges such as the difference between human faces in color, shape, and dimensions. Thus, a demand for image analysis has appeared to extract its landmarks and forms, and then convert it into data to be processed. A different number of models can be used for addressing this issue. Such as, stochastic process is the hidden Markov model.

There are two main features used for face detection. The first one is the feature based where analysis is performed on the main geometry of the face like eyes, nose, ears, and mouth. The second feature is a holistic base where the face is analyzed as a two-dimensional pattern [2]. The available researches have followed a certain techniques for data reduction and feature extraction, which is used for face detection, for example Linear discriminate analysis (LDA), the fuzzy logic technique , Discrete cosine transform (DCT) and Principal component analysis (PCA), which is used for face detection [3].Hidden Markov Model is used for developing features extraction methods and enhancing not only the operation of face detection but also the data processing time as will be shown in this paper. This paper is sorted as follows. In section 2, the proposed (presented) technique is explained. In section 2.1, the pre-processing step is presented. In section 3, the feature extraction followed by recognition system with the use of HMM is introduced in section 4. In section 5 simulation results are described. Finally, conclusions are highlighted in section 6.

II. The Proposed Technique

Our presented Technique consists of multiple steps:

- The pre-processing step which will be explained in section 2.1.
- The feature extraction to prepare data to be processed.
- Appling HMM on the recognition system.

We calculate the accuracy (recognition rate) to measure the ability of recognize the image by the system.Fig.1 shows the block diagram for our proposed technique

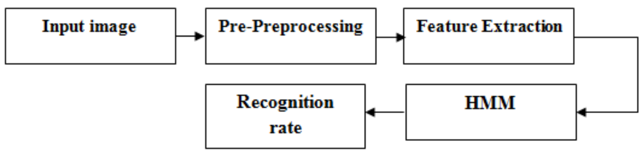

Fig. 1 The Proposed Technique

A. *Pre-processing*

The image from RGB format is change to analogous grayscale format, as a first step. A grayscale image is a monochrome image, which contain data related to brightness only without containing any information about the color. A grayscale data represents a broad range of intensities. The typical image contains 8 bit/pixel, this let the image to be represented with different level of brightness (0-255) [4]. The pre-processing is mandatory step to enhance the ease of features extraction and reduce the noise in the image, by using the median filter. The pre-processing step includes changing of the image's edges to a settled pixel's numbers ,that occasionally decrease the space between parts of pixels, if this space is larger than a calculated threshold.

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B. *Changing the input image's edge*

There are contradictions in the image's edges in the database. After several trials, it was found that a rise in the recognition rate after normalizing the input image's edges and pixels, that goes through two steps:

1) Change the input image's edges as shown in Fig.2.b; after changing, the image's edges in the original are thinner than others of the same image as shown in Fig. 2.a. After thinning, the image's edges of each will have become the same pixels (2 pixels) as shown in Fig. 2.c.

2) Spread the binary image by using 4-pixels framing the original pixel, as shown in Fig. 2.d. So, the two image's edges will become the same

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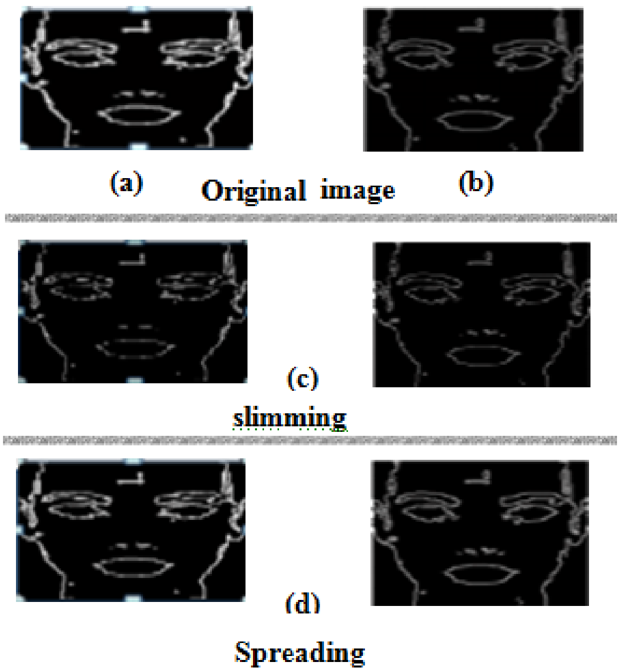

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Fig.2 The input image's edges are changing, in (a, b) The identical original image, which the edges are not the same, (c) After thinning the edges, (d) After spreading to fix the image's edges.

C. *Decreasing the space between pixel's part*

To find the places where no pixels exist the vertical projection is used, after that calculates the width (d) of each place, as shown in fig.3a. If the width is larger than a threshold (8 pixels, by trial and error), then removing (d-threshold) to get a stable separation between of pixel's parts as shown in Fig. 3.b.

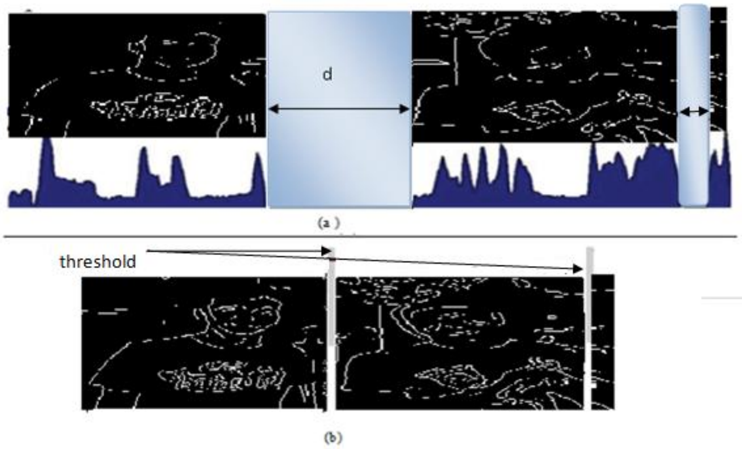

Fig. 3 (a) Original image with large space between pixel's parts, (b) Decreasing the space between pixel's parts.

III. Feature Extraction

After the pre-processing stage, the binary format of the input image as represented in the GTFD database, which is used to get a feature vector. Identified the pixel's background "zero" and the foreground "one". The image is split into n horizontal segments, which have an identical number of the pixel located in the foreground in each segment. The total pixels of the image are counted and divided by n, to get the exact number of pixels per segment. The image is split into vertical frames (overlapping), each frame is split into fixed-width small cells, that the cell's height reliant on the distribution and the pixels of the foreground in the images. In the image, the sliding window is moved from right to left and determines the features for each frame, as shown in Fig. 4

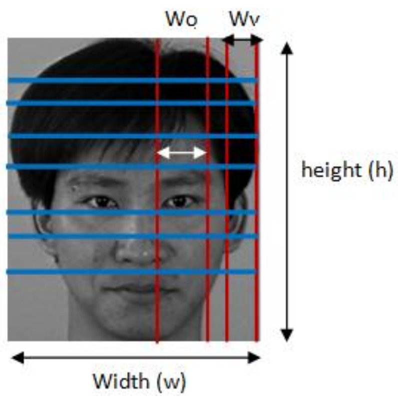

Fig.4 Using the sliding window

The image's height represents (h), the image's width represents (W), (Wo) represents the width of overlapping of the vertical frames, and (Wv) represents the width of the vertical frame. The best scenario in our technique when 'Wv'= 7 pixels with 'Wo'= 4 pixels, this sliding accomplished the 100% accuracy (recognition rate) as it extracted the maximum necessary features for recognition.

A. Canny Edge Detection

Canny edge detection can be applied using the following five steps [5]:

1. Removing the noise and smooth the images by applying Gaussian filter.
2. Finding the intensity gradients of the image.
3. Getting rid of spurious response to edge detection by applying non-maximum suppression.
4. Determine potential edges by applying double threshold.
5. Track edge by hysteresis: Remove all weak edges that are not connected to strong edges to finalize the process of detection.

Detector eliminates noise by smoothing the image, and then it finds the gradient to show high spatial derivatives regions [6]. In these areas the canny edge detector performs tracking and eliminates any pixel that is not at the maximum. [7]

IV. Hidden Markov Model

HMM process is a complex stochastic process. This process is repeated twice to form a well- defined model for the sequential data. HMM is a defined set of states, and transition probabilities control the transitions among those states. HMM consists of a different number of states and transition between those states. These transitions are controlled by transitions probability distribution. HMM process considers the feature observations in every state, those to produce the confidence of the modeled object according to its probability density function. From the unknown pattern, the classification can be obtained according to the extracted feature by searching a model that produces a maximum probability [8].In this paper, HMM is discrete. In HMM Viterbi algorithm is searching for the best sequence of a hidden state given the input feature vector. Three states HMM are represented in fig.5, which shows that we let a move to the current and the following states only. Two of these are emitting states and have their output probability distributions [9]. The transition matrix for this model is [3 x 3], which represent the transitions between these states such that in the case of transition, we will set the matrix element to one and matrix element will be set to zero in the case of no transition.

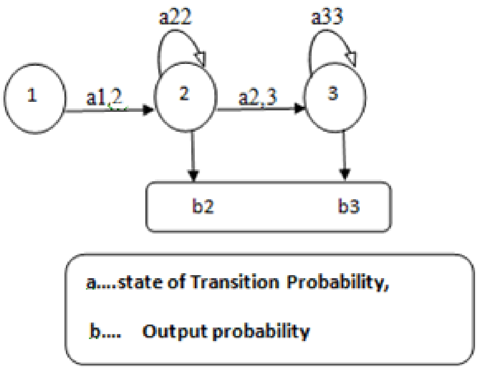

Fig.5 Three states of transition from left to right

V. Simulation Results

To estimate the behavior of the proposed technique, recognition trials have been carried out on available subsets of the benchmark Georgia Tech Face (GTFD) database. In our technique validation, we used 80 images for training purpose (8 persons × 10 images), and 40 images for testing purpose (8 persons × 5 images). The face recognition technique presented in this paper was developed, trained, and tested using Matlab 7.10 (R 2015).The computer was a Windows 7 machine with a 2.1 GHz Intel core 2 processor and 2.87 GB of RAM. The following table 1 shows the effect of changing time versus accuracy. The following Fig. 6 shows the effect of the given data in Table1.

Table 1: shows the effect of timing and stats on the recognition rate (accuracy) results.

#states	Average Time/Image(sec)	Recognition rate (Accuracy %)
3	0.00221	98.2
3	0.00210	98.5
3	0.00206	99.2
3	0.00312	100
3	0.00303	100
3	0.00300	100

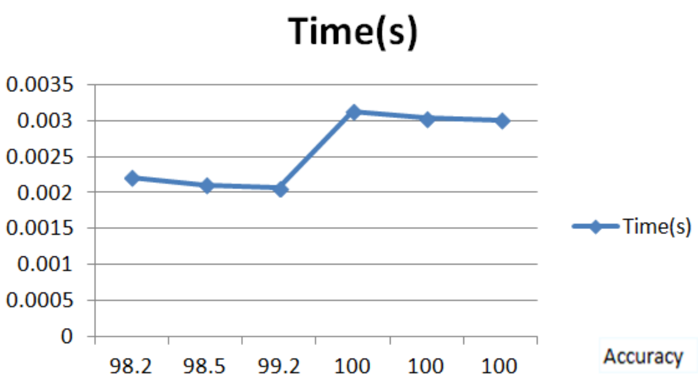

Fig. 6 Times (ms) versus the Accuracy

The recognition rate of the proposed methodology in this paper is higher than that of the traditional algorithms based on HMM. Also, we compare our proposed methodology with different face recognition methods such as EigenFace, FisherFace, Laplacianfaces, ML-HMM, MCE-HMM, and MC-HMM [10], our proposed method gives the highest recognition accuracy for all the sample sets. Comparison result is summarized in the following Table2 and
Fig. 7.

Table 2 Comparison Results of Different Face recognition algorithms

Models	Recognition rate (%)
Proposed Technique	**100**
E-HMM	99.16
Eigenfaces	85.9
Fisherfaces	92.3
Laplacianfaces	93.2
ML-HMM	88.2
MCE-HMM	93.3
MC-HMM	97.5

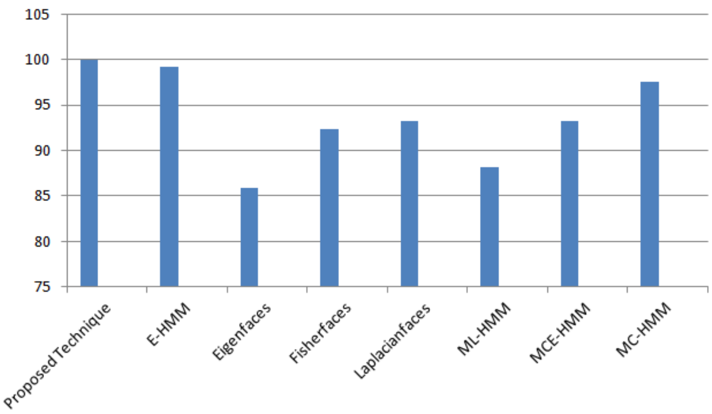

Fig. 7 Comparison Results of Different Face recognition algorithms and proposed technique

It is worth mentioning the technique has been implemented without performing the pre-processing step mentioned in section 2.1. The results for four different sets of databases showed that the recognition rate is about 96.1%. This implies clearly the importance of the pre-processing on the accuracy (recognition rate).

VI. Conclusion

In this paper, we introduced a new technique for image recognition. We proposed our technique based on intelligent features using efficient operator (Canny).The major contribution of the presented technique is the pre-processing stage. In the pre-processing, the input image's edge is fixed to four pixels and spacing between various parts of the pixels is fixed to a trial threshold. The pre-processing steps have enhanced the performance of the system by about 4 % as explained previously. Although pre-processing has simple and important steps but it simplifies the features and enhances the recognition rate. Our proposed technique showed the best performance compared with the other tested techniques in the sense of speed and recognition rate.

Acknowledgment

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