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Face Recognition Using Viola-Jones Detector

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Abstract- **In this paper we propose a framework for recognition of faces in controlled conditions. The framework consists of two parts: face detection and face recognition. For face detection we are using the Viola-Jones face detector. The proposal for face recognition part is based on the calculation of certain ratios on the face, where the features on the face are located by the use of Hough transform for circles. Experiments show that this framework presents a possible solution for the problem of face recognition.**

Keywords-face detection, face recognition, Viola-Jones, Hough transform

I. INTRODUCTION

Although the field of face recognition was extensively researched in the past decade, it remains a vibrant area of research. Computer-based face recognition algorithms are constantly improving. There are differing requirements on the face recognition software, depending on the desired application. On one end of the spectrum, there are face recognition systems that do not have very high requirements on the accuracy of the results, but have a requirement towards the overall speed of the system (e.g. photo album organizer services), while on the other end of the spectrum there are systems where the fundamental requirement on the system is the recognition accuracy (e.g. terrorist watch lists). Both of these applications face a fundamental obstacle in the fact that subjects being recognized are not cooperating with the recognition system. Images are not acquired in controlled environments, while illumination and overall appearance of subjects can drastically change between images (e.g. image taken inside versus image taken outside, with or without

glasses, different hair, etc.). All the while properly controlled training data for the algorithms is either sparse or virtually nonexistent. Researchers have shown that some face recognition algorithms have already surpassed humans in face-matching tasks of unfamiliar faces, like the ones described above, where images were taken under differing

illumination conditions. However, there is a lot of applications where the subjects being recognized by the system are still allies of the system(e.g. in computers, automobiles, or mobile phones), so it is reasonable to expect availability of adequate training data Our proposed framework belongs in this segment of the spectrum. Since we

can expect, for our application, a certain level of pose invariance in our input data, method we are proposing is based entirely in 2D. Also, we have a reasonable expectation for well lit, high quality input images.

II. PROPOSED SYSTEM

2.1 FACE DETECTION

The role of face recognition software is to detect a face (or faces) in the image, and subsequently classify those faces.There has been a multitude of methods for face detection, but one of the most popular methods is the seminal work of Viola and JonesReview Stage.

1.Viola-lones face detector-Viola-Jones detector was chosen as a detection algorithm in our framework because of its high detection rate, and its ability to run in real time. This detector is comprised of three main concepts which allow it to run in real time: the integral image, Ada Boost, and the attentional cascade structure. The Integral Image: Integral image is an algorithm for cost-effective generation of the sum of pixel intensities in a specified rectangle in an image . In Viola-Jones method Integral image is used for rapid computation of Haar-like features, according to the following equation:

$$ii(x,y) = \sum_{x' \leq x, y' \leq y} i(x',y')$$

where ii(x, y) is the integral image at pixel location (x, y), and i(x', y') is the original image. Calculation of the sum of a rectangular area inside the original image is extremely efficient, requiring only four additions for any arbitrary rectangle size.

2. AdaBoost- AdaBoost was first introduced by Freund and Schapire in . It is used for construction of strong classifiers as linear combination of weak classifiers, as shown in the following equation:

$$H(x) = sign\left(\sum_{T=1}^{T} \alpha_t h_t(x)\right)$$

where ht (x) is a weak classifier, Cit is the weight and H (x) is the final strong classifier. In the training process, every weak classifier is configured to detect those features that were misclassified in previous classifiers.

3. Attentional cascade structure- It is a critical component in the Viola-Jones detector, where the main idea behind it is in building smaller boosted classifiers . Each node is acollection of weak classifiers. Nodes are forming a degenerate decision tree, called a cascade. Number of classifiers in a node usually increases with level, where later stages have more classifiers, because each node tries to pass all the positive sub-windows to further stages, while still rejecting some of the negative ones. Input sub-window passes a series of nodes, where each node makes a binary decision whether to reject it,

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or pass it on to the next stage. That way, only small amount of sub-windows will pass through to the latter stages, with most of the negatives being rejected early on, thus vastly improving efficiency.

4. **Hough transform**-The Hough transform is a technique used primarily for detection of features in an image . It is mostly used for detection of simple regular curves, like lines or circles, although it can also be used for detection of more complex shapes. Only requirement is that the shape being detected can be represented in the parametric form. We used Hough transform for circle detection, where the parametric equation of the circle is:

$$(x-a)^2+(y-b)^2=r^2$$

Parameters a and b are the coordinates of the circle center and T is the radius. Algorithm creates an accumulator whose dimension equals three, since there are three unknowns of the every contour pixel in the threshold image (f(x, y) the algorithm calculates parameters a, band T for all possible circles and increments the values in the accumulator at positions (a, b, T). Resulting peaks in the accumulator represent parameters of the circles in the image. In cases where a simple parametric representation of a feature is not possible, a generalized Hough transform can be employed .

2.2 FACE DETECTION AND RECOGNITION FRAMEWORK

The main idea of this article is to propose a face recognition framework which could be employed in controlled conditions, on frontal face images with a head rotation of less than 5 degrees. All coding is done in MATLAB using computer Vision System Toolbox for Viola-Jones face, eye and nose detection whereas Hough transform is being used for precision iris detection. The ratio between mentioned distances will be used as a face recognition tool. In this research we used our own set of images, i.e. images of human torso as presented. All images have the resolution of 3888 x 2592 pixels.

Fig 2.2(a) Starting figure

Fig. 2.2(b). Face detected by Viola-Jones algorithm

1. Step by step procedure of iris detection-First we start by using Viola-Jones face detector only with Merge Threshold parameter changed to 20 to achieve better face detection due to various types and shapes of head and hair. This process will be monitored on subject. The result of face detection can be seen where only the detected face is presented. Next step is to find the eyes and the nose. Eyes and nose are enclosed in a rectangle in order to find the center of the eyes and the nose. The center is the intersection of diagonals of the before mentioned rectangle. As can be seen by careful examination of the centers found by this method are off by a couple of pixels. Center of eye is defined as the iris center and the center of the nose is defined as the highest point of the nose. Usually it is a region with the highest brightness due to the usage of flash. Next step is to find more accurate coordinates of the center of the eye. This is achieved by using Hough transform. First a Sobel edge detection algorithm, with modified threshold to achieve better results, is applied to starting face image.

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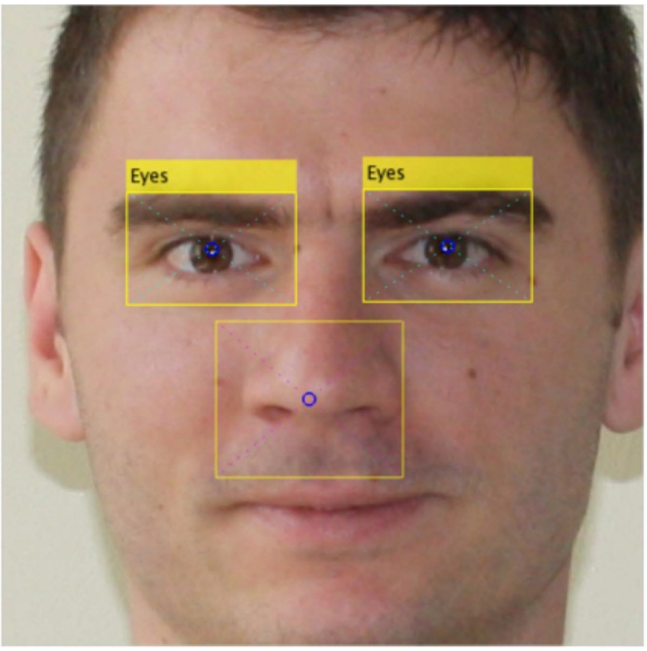

Fig. 2.2(c). Location of centers of the eye and nose by Viola-Jones algorithm

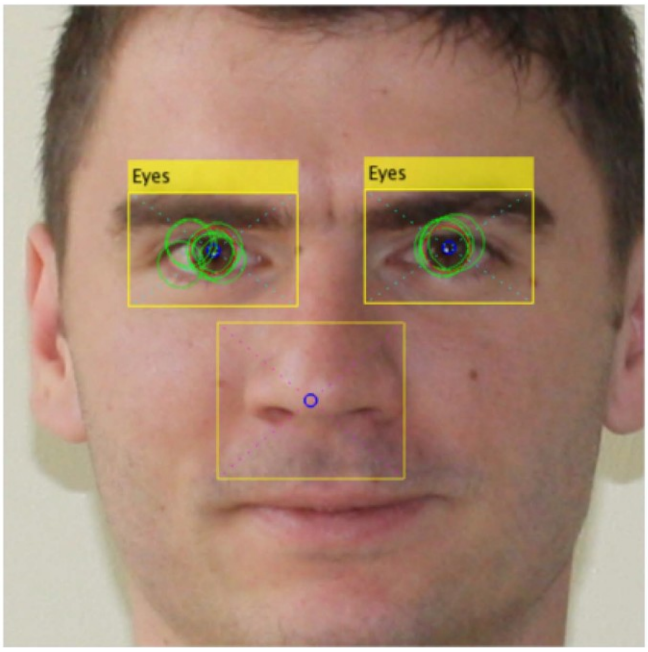

Fig. 2.2(e).

Fig. 2.2(d). Circles candidates

Fig. 2.2(f). Distances used for face recognition

In order to find circles on the image that has extrapolated border, minimum and maximum radii of the circles must be defined. For our experiments the radii are from 15 to 30 pixels. Using the Hough transform the 15 most prominent circles are drawn based on their peaks found by the algorithm. The circles that are candidates for the iris center are shown on Fig. 2.2(d) Since the peaks are stored in a single vector, by choosing the closest peak to the center found by diagonals' intersection is a pretty accurate method of calculating a center of the iris which can be seen on Fig. 2.2(e)

Fig. 2.2(g) Randomly selected subjects

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For closer inspection, unnecessary information on the image is removed which is shown on Fig.2.2(f). As can be seen by detailed examination centers of the eyes are off of the real center by a pixel or two whereas nose centers differentiate more. In the next section, detailed experimental results conducted on several test subjects will be depicted

III. RESULT

This research was conducted on 25 subjects and 2 images per subject. The subjects were photographed in front of the same wall on the same day with 5 minutes between shoots but discrepancies in brightness and contrast occurred ,in order to perceive the difference. When photographed, subject were told to look into the camera without special facial gestures. That caused the eyes to be relaxed, so for all cases eyes were never fully open so this research is interesting in context that the full iris is never shown. That made it difficult for our iris and eye detection algorithms. Only on 15 out of 25 subjects it was possible to make face and iris detection without changing the threshold levels and circle radii. By making dynamic changes to threshold levels and circle radii it is possible to detect features on all subjects. Difference between measured and estimated centers of the eye and nose are shown in Table I. Units in Table I are pixels, D represents distance between iris' centers, D 1 stands for distance between the left eye and center of the nose,D2 represents distance between the right eye and center of the nose. Values RJ and R2 are ratios of distance D and distances DJ and D2 respectively. The is a cumulative error of measured and estimated coordinates of eyes and nose.

IV. CONCLUSION

Results and research show that the face recognition can be done by observing two variables. Ratios RJ and R2 are unique to one subject. Two ratios are used because there is a possibility that one of the two ratios are similar for two different subjects (Rl or R2). Results prove that two subjects don't have both ratios similar, so the framework presented in this article provides an applicable face recognition algorithm, which will be implemented in the following research. Future work consists of upgrading and enhancing the face/eye detection algorithms to achieve better results. After enhancing and possibly making a real-time face recognition algorithm, this algorithm will be tested on one of the standardized face databases. If that proves successful then this face recognition based on images will be ported to real-time video face recognition.

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