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Face Objects Detection in still images using Viola-Jones Algorithm through MATLAB TOOLS

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ABSTRACT:A human face is used in many applications such as gender classification, biometric, information cryptography, forensic identification, access control, border surveillance and human interactions etc. In this paper, MATLAB Computer vision system tool is used to identify various parts of human face like nose, face, eyes etc. This MATLAB tool is based on Viola-Jones face detection algorithm. After applying different threshold values various parts of face is identified successfully for different images containing one to multiple faces in it.

KEYWORDS: image processing, face detection, learning, Boosting

I. INTRODUCTION

Face Recognition is the most popular research area now days. Face and various parts of face can be detected in images and videos also for various purposes. Face recognition system has two main tasks: verification and identification.

A. FACE DETECTION TECHNIQUES

Some of the face detection techniques are as follows:

(i) Traditional
Traditional algorithms identify facial features by extracting most important features as landmarks from an image of the subject's face. Some of the popular face recognition are principal component analysis , the hidden Markov model, the multilinear subspace learning using tensor representation ,linear discriminant analysis etc.

(ii) Three-Dimensional Recognition
It uses 3D sensors to capture information about the shape of a face. This information is then used to identify distinctive features on the surface of a face, such as the contour of the eye sockets, nose, and chin.

(iii) Skin texture analysis
This technique uses skin spots and particular patterns apparent on a person's skin known as called skin texture analysis.

(iv) Thermal cameras
These are special cameras which will only detect the shape of the head and it will ignore the subject accessories such as sun-glasses, hats, or make up.

II. LITERATURE REVIEW

Many developments in the face detection algorithms has been done in past years. Multi resolution rule method was implemented by G. Yang[1]. This method used the structural nature of face for detection. Feature based method uses

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the facial features [2][3], skin color [4][5]and combined multiple features [6]of the face for better accuracy and detection speed. A steady and uniformly scaled images using template matching method was employed. Predefined face templates [7] and deformable templates [8] were incorporated which was completely based on the template (a predefined structure) without using learning. Appearance based methods gives faster detection speeds, more accurate results and adaptive nature that could distinguish a face from a non-face in any environmental conditions.

III. INTRODUCTION TO VIOLA–JONES OBJECT DETECTION FRAMEWORK

The **Viola–Jones object detection framework** is the first object detection framework to provide competitive object detection rates in real-time proposed in 2001 by Paul Viola and Michael Jones[9][10] . Although it can be trained to detect a variety of object classes, it was motivated primarily by the problem of face detection.

VIOLA JONES APPROACH

A very fast and accurate approach to detect an object was devised by viola and Jones [11] in the year 2001.

This method is very commonly used in cell phone cameras, security perimeters and list goes on. Computational speed is increased due to the use of Haar features and adaboost machine learning and a face can be detected in a frame within a millisecond. Initially the value of all pixels in greyscale images which are in black accumulated. Thereafter, these values are subtracted from the total of white boxes. Finally, the result will be compared to the defined threshold and if the required criterion is met, the feature considers is identified [12, 13].

In this approach objects are detected through these four key concepts.

1. Simple rectangular features, called Haar-like features.
2. Integral image for rapid features detection
3. AdaBoost machine-learning method
4. Cascade classifier to combine many features efficiently

1. Haar like features

Haar like features are used to detect variation in the black and light portion of the image. This computation forms a single rectangle around the detected face. Based on the color shade near nose or forehead a contour is formed [14]. Some commonly used Haar features are:

Two, Three and Four rectangle features

2.Integral Images

They are also known as summed area tables. Integral image is used to felicitate quick feature detection [14]. The meaning of integral image is the outline of the pixel values in the original images.

3. Adaboost machine learning method

It uses an important concept of Bagging that is procedure for combining different classifiers constructed using the same data set. It is an acronym for bootstrap aggregating, a motivation of combining classifiers is to improve an unstable classifier and an unstable classifier is one where a small change in the learning set/classification parameters produces a large change in the classifier.

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AdaBoost algorithm helps to select small features from the face that facilitates fast and easy computation [9,10].Unlike other methods, AdaBoost algorithm gives desired region of the object discarding unnecessary background. The working model can in interpreted by using neural networks [15,16].

- Given example images $(x_1, y_1), \ldots, (x_n, y_n)$ where $y_i = 0, 1$ for negative and positive examples respectively.
- Initialize weights $w_{1,i} = \frac{1}{2m}, \frac{1}{2l}$ for $y_i = 0, 1$ respectively, where m and l are the number of negatives and positives respectively.
- For $t = 1, \ldots, T$:
  1. Normalize the weights,
  $$w_{t,i} \leftarrow \frac{w_{t,i}}{\sum_{j=1}^{n} w_{t,j}}$$
  so that w_t is a probability distribution.
  2. For each feature, j, train a classifier h_j which is restricted to using a single feature. The error is evaluated with respect to w_t, $\epsilon_j = \sum_i w_i |h_j(x_i) - y_i|$.
  3. Choose the classifier, h_t, with the lowest error ϵ_t.
  4. Update the weights:
  $$w_{t+1,i} = w_{t,i}\beta_t^{1-e_i}$$
  where $e_i = 0$ if example x_i is classified correctly, $e_i = 1$ otherwise, and $\beta_t = \frac{\epsilon_t}{1-\epsilon_t}$.
- The final strong classifier is:
$$h(x) = \begin{cases} 1 & \sum_{t=1}^{T} \alpha_t h_t(x) \geq \frac{1}{2} \sum_{t=1}^{T} \alpha_t \\ 0 & \text{otherwise} \end{cases}$$
where $\alpha_t = \log \frac{1}{\beta_t}$

Fig 1: AdaBoost Learning algorithm

AdaBoost learning process is fast and gives more number of desired data. This data can be classified into classifier. A classifier contains small features the face. It is commonly employed for pattern detection.This method has high accuracy and detection speed with about 1% false detection but requires more time to train.

4. Cascade classifier

This algorithm eliminates face candidates quickly using a cascade of stages. The cascade eliminates candidates by making stricter requirements in each stage with later stages being much more difficult for a candidate to pass. Candidates exit the cascade if they pass all stages or fail any stage[17]. If the candidate passes all the stages then only the face is detected. This process is shown in Fig. 2.

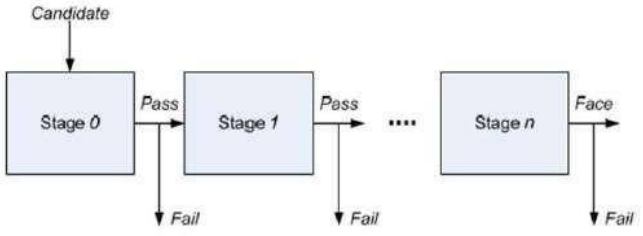

Fig 2 : Cascade of stages. Candidate must pass all stages in the cascade to be concluded as a face.

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IV. METHODOLOGY AND RESULTS

In this work, MATLAB in-built APIs are used to detect face, upper body, nose, mouth and eyes etc. Viola-Jones face detection algorithm, the computer vision system toolbox contains **vision. Cascade Object Detector System** object which detects objects based on above mentioned algorithm. MATLAB 2014 is used in this work, which has **Computer vision system toolbox** in the default tool box list.This complete work is divided into six segments in which various parts of the face is detected.

A. Face Detection
B. Upper Body Detection
C. Single Eye Detection
D. Mouth Detection
E. Eye Pair Detection
F. Nose Detection

The details of these segments are as follows:

A. FACE DETECTION

The face object can be detected using vision.CascadeDetector function which has face as default object. In this work face detection is performed on various types of images which include images with one, two, three and ten different faces as objects.Figures 3, 4, 5 and 6 shows images with one, two, three and ten faces respectively as an image object.

Fig 3: Face detection with one object

Fig 4: Face detection with two objects

A rectangle is shown in this entire figure to identify face related area of that object.

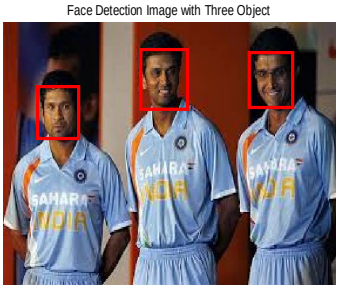

Fig 5: Face detection with three objects

Fig 6 : Face detection with Ten objects

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It can be seen from these figure face portion of each images is successfully identified for all types of images. Figure 6 shows the ten faces in one images and that has been identified successfully.

B. UPPER BODY DETECTION

Figure 7, 8, 9 and 10 shows the upper body of the objects in the one, two , three and four respectively.

Fig 7: Upper body detection with one object

Fig 8: Upper body detection with two object

It can be seen from these figures that the upper body portion is clearly visible for single and two objects. The size of rectangle clearly shows the difference between face and upper body.

Fig 9: Upper body detection with three objects

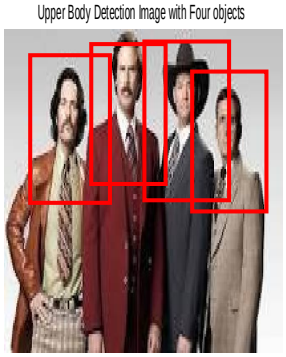

Fig 10: Upper body detection with four objects

Figure 9 and 10 shows the upper body for three and four different objects respectively. It can be observe that this method identified three and four upper body portions of different objects successfully.

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A. SINGLE EYE DETECTION

In this method single eye of one and two objects is detected which is shown in figure 11 and 12. Both the eyes are separately differentiated through two rectangles. Right and left eye is shown with different rectangles.

Fig 11: Single eye detection with one object Fig 12: Single eye detection with two objects

B. MOUTH DETECTION

In this mouth of different objects can be detected which is shown in figure 13, 14 and 15.

Fig 13: Mouth detection with one objects Fig 14: Mouth detection with two objects

Figure 13 and 14 shows the mouth detection in image with one and two objects respectively which is properly identified.

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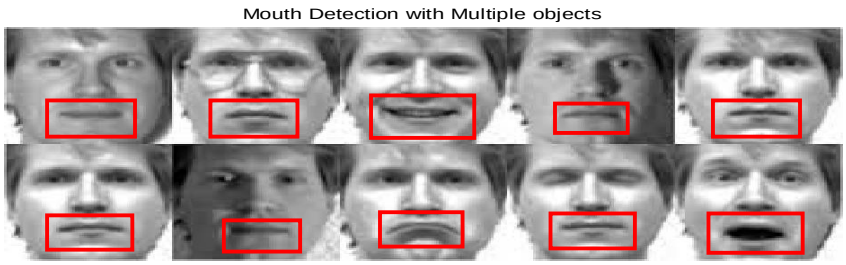

Fig 15 : Mouth detection with ten objects

It is shown is these figures that the mouth is properly detected for images with one, two and ten objects as well. In figure 15 there are ten different faces, but this method is successfully identifying different mouth structures in different faces.

C. EYE-PAIR DETECTION

Figure 16 shows the eye pairs detected using this method. A zoomed image of eye pair is shown in figure 17.

Fig 16: Eye pair detection

Figure 17: Zoomed version of figure 16

D. NOSE DETECTION

To identify nose section in different types of pictures, a threshold is also applied with this method.The default threshold is 4 which can be varied from 3 to 18 for different types of face gestures. Figures 18, 19 and 20 shows Nose detection with one, two and ten objects respectively.

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Fig 18: Nose detection image with one object

Fig 19: Nose detection image with two objects

In figure 19 two objects in one image are having different postures but they are also very clearly identified.

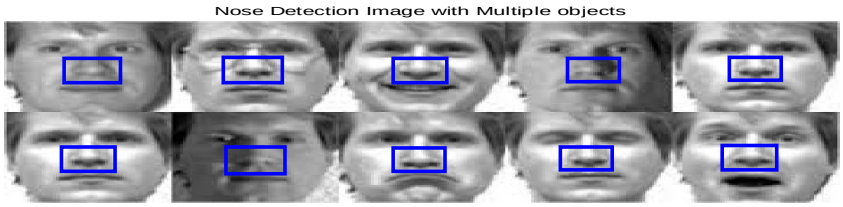

Fig 20: Nose detection image with ten objects

It can be seen from these figures that the nose object is clearly identified in all types of images.

IV. CONCLUSION

In this work image processing capability of MATLAB is used to identify various parts of human face. In this work viola jones algorithm for face detection is used. MATLAB provides this algorithm in the form of in-built function in the vision.CascadeDetector package. Eye, mouth , nose and upper body portion of human are detected for images having one , two up to ten different objects of different postures and faces. This is concluded that this method successfully finds all the above mentioned features of human face and body for almost all types of pictures.

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