Viola-Jones Algorithm Based Approach for Face Detection of African Origin People and Newborn Infants

Laxmi Narayan Soni[#1], Dr. Ashutosh Datar[*2], Prof. Shilpa Datar[*3]

[#]*Department of Electronics and Communication Engineering, Samrat Ashok Technological Institute, Vidisha M.P. India*
[*]*Department of Electronics and Instrumentation Engineering, Samrat Ashok Technological Institute, Vidisha M.P. India*

Abstract *— This work dispenses to design a face detection system, especially for African origin people and newborn infants. Since many years, detection of African origin people faces is the huge problem. Using Viola-Jones algorithm with some specific threshold value, the face was detected from the image with high accuracy rate. In this approach, the distance between human face and camera does not affect the detection rate. Black skin faces are hard to detect in comparison to fair skin faces because the difference in intensity of contrast between the eyes, upper cheek and nose are hard to separate by the algorithm in the black faces. Complicated background or dark/shaded background creates more complication in the detection of the black skin faces.*

Keywords *— Face Detection, PCA, ANN and Viola-Jones Algorithm.*

I. INTRODUCTION

Detecting black face has been a difficult task since long ago. The cameras are used routinely by police across the US to identify citizens, their faces cross-matched against databases of suspects and past criminals. On April 2016 the Guardian British daily newspaper published a blog by Nellie Bowles who is the technology reporter for Guardian US in San Francisco.

He published a blog [1] in favour of African American peoples that, 'I think my blackness is interfering': does facial recognition show racial bias?

Further, HP's Media Smart webcam included facial recognition software so that the camera could move to follow the position of the user. It is shows that, in 2009, two co-workers in a retail store highlighted how the camera would pan to follow a white face, but stop as soon as her black co-worker entered the picture [2].

The databases they use are disproportionately African American, and the software is especially bad at recognizing black faces, according to several studies. Bias in facial recognition software has been highlighted before. So the detection of black faces is the complicated task for so many years till now.

In case of newborn infants/babies, we find that the features of the new infant's face are rarely seen because the newborn infant has small eyes, nose, eyebrows and a small mouth which is hard to separate from each other by machine vision system as well as the facial features (like eyes and nose) are not that much sharp like a young age or grown up person.

If we talk about the Asian origin people they tend to have less body hair, less facial hair, flatter faces, smaller noses, wider cheekbones, and "shovel-shaped" incisor teeth [3]. Further, Asian origin people face has lot of feature similarity with baby faces. Due to flatter face and small nose, detection of face is going to be tough for any machine and hard to recognise with the database.

In this work, we used a specific threshold value with Viola-Jones algorithm which gives the most accurate results especially for Asian origin people, African American people and newborn infant faces.

II. RELATED WORK

The approach suggested by Paul Viola et al. [4] is usually called Viola-Jones algorithm. Its original motivation was face detection, but it can also be trained to detect different object classes. It combines four key concepts. Qiao Qiang et al. [5] elaborated a face detection method in colour images using multi-resolution sub-images fusion combined with support vector machine (SVM). The long distance of the faces in a group photo is not detected properly and that was a drawback of this method. Zhao Fei et al. [6] approach is based on the external face of the rectangular knowledge rules, can be used to determine whether the human face is in skin colour area [7], then use the positive human face structural characteristics to remove the non-human face to further determine human face. Very less number of research papers are available on black skin faces detection or recognition system.

There are so many methods and algorithms available to locate human face from the image with the complex background. Viola-Jones algorithm, PCA, and ANN are major three of them which are comparably better than others. Following is the comparison of the three methods.

A. Viola-Jones Approach

It is the widely used algorithm for face detection in real time. The Viola-Jones object detection framework was proposed by Paul Viola and Michael Jones in 2001 which was the first framework to give competitive object detection rates. It is a framework which is used for detecting objects in real time but mainly applied to face detection application because its training rate is very high and the result is more accurate in comparison to others. Due to its high detection rate (true-positive rate) and fast processing at least two frames per second must be processed that is to distinguish a face from non-faces.

The four main steps of this algorithm are as follows:

1. Haar features: Simple rectangular features, called Haar features. The various Haar features used in the Viola-Jones algorithms are shown in Fig 1. The Haar feature varies in width and height. This Digital image feature used to locate human faces, pedestrians, objects and facial expressions in an image [8]. All human face has similar properties like eyes, mouth, and bridge of a nose. These properties are compared using Haar feature and mainly used for face detection.

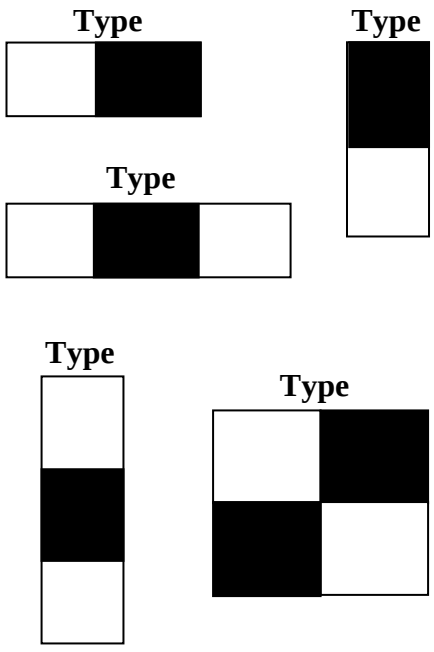

Fig 1: Haar features in Viola-Jones

2. Integral Image: Integral Image concept is for rapid feature detection. Rectangle features can be computed very fast using an intermediate representation of the image which is called the integral image. The integral image computes a pixel value, quick and effective way at each pixel (x,y) as shown in Fig 2.

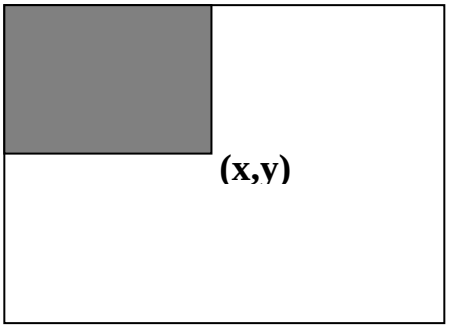

Fig 2: Demonstrating the concept of integral image

Integral image value at a pixel (x, y) is the sum of the pixel values of the original image above and to the left of (x, y), inclusive.

3. AdaBoost: The AdaBoost algorithm was introduced in 1995 by Yoav Freund and Robert Schapire [9]. It is machine learning algorithms used to improve their performance and detect weak feature selector [10]. The AdaBoost reduce the unwanted features. Based on these features the face is detected in the image and is resized to a desired standard resolution.

Some steps are involved in this algorithm:

3.1. Initially, weight each training example equally, as shown in Fig 3.

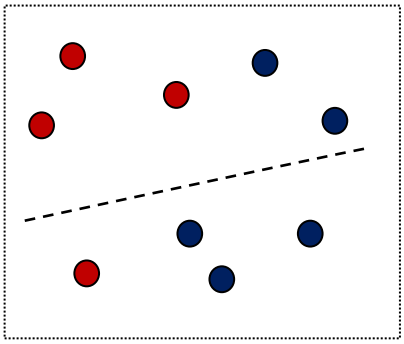

Fig 3: Weak Classifier initially

3.2. In each boosting round:

- Find the weak learner that achieves the lowest weighted training error
- Raise the weights of training examples misclassified by current weak learner

3.3. Compute final classifier as linear combination of all weak learners (weight of each learner is directly proportional to its accuracy)

3.4. Exact formulas for re-weighting and combining weak learners depend on the particular boosting scheme as shown in Fig 4.

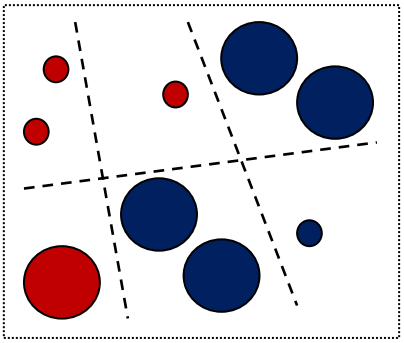

Fig 4: Final classifier is a combination of all weak classifiers

4. Cascading Classifiers: The process of combining the classifiers which quickly discards the background windows so that more computation can be performed on face-like regions [11]. It can keep high detection rate and low false positive rate [12].

B. PCA Approach

Principal component analysis (PCA) is a statistical procedure. The main purpose of a principal component analysis is the analysis of data to identify patterns and finding patterns to reduce the data set with minimal loss of information.

This approach transforms faces into a small set of essential characteristics, eigenface, which are the main components of the initial set of learning images (training set) [13].

Recognition is done by projecting a new image in the eigenface subspace, after which the person is classified by comparing its position in eigenface space with the position of known individuals.

C. ANN Approach

Neural Network inspired by human brain composed of simple artificial neurons also known perceptions are connected to each other in multiple layers [14]. There is a long history of using a neural network for the task of face detection [15].

In the case of face detection, neural network system examines each and every window to determine whether it consists of face or not. It reduces the computational task as it doesn't require to train with non-face images [16].

III. METHODOLOGY

This paper presents an efficient algorithm for detecting the face in the given image by applying Viola-Jones algorithm with specific threshold value.

The block diagram for proposed methodology is as shown in Fig 5. As can be seen, there are five blocks which defined the whole system from face detection to making of the face database. All five blocks are sequentially described below with their functionality.

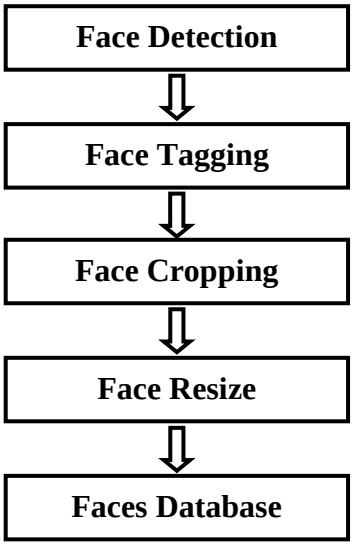

Fig 4: The Block Diagram of the System

A. Face Detection Block

The first block converts an image from colour to the gray scale for image normalization process, after that it detects the face by using Haar feature-based cascade classifiers which is an effective object detection method. This approach is based on machine learning where a cascade function is trained from a lot of images [17]. The Viola-Jones Algorithm is based on Haar features that are basically black and white rectangles. The algorithm generates the sum of pixel intensities in rectangles in an image depending upon the threshold values [18].

B. Face Tagging Block

After detection of the human face that can be of a newborn infant face or the black face, detected face is shown inside a rectangular box that is called a boundary box [19]. There outside of boundary box, it shows a 'Face' in the text format and tags the human face.

C. Face Cropping Block

In this block, when the human face is detected by the Viola-Jones algorithm, the image is cropped to the region of the face [20].

D. Face Resize Block

Every image can be of different dimension, size, and pixels. The face position can also be not in a particular manner and the face size also can be different. So resize the cropped faces before making a database. It gives the normalized face results that use in the face database.

E. Face Database Block

The last block of the system is a database making block. The face that already has been cropped and resized in the last block is saved in an appropriate place for the security purpose or some future

reference. The database can be helpful for the security reasons, some kind of attendance, or may be for checking the presence of any particular person in an area.

IV. SYSTEM FLOWCHART

The step followed by the system in implementing the process blocks discussed in Fig 5, are presented in details by the flowchart shown in Fig 6. The system begins the face detection process by reading an image. First, an image converts from RGB to gray scale image under normalization process. Face is detected by the use of the Viola-Jones algorithm which takes some time for the process.

Figure 7 shows the original image. As discussed above, the system determines through a set of processes whether a person's face is present in the image and shows the face inside a boundary box as shown in Fig 8. It also provides the number of faces present in the image. In the case that no faces are found from the image, the system will give a pop-up message in order to upload another image.

Faces are cropped when it detects all the faces that are present in the image. The cropped face will be resized as per given size (height and width). The Figure 9 shows the output of the face tagging block of the system which is the cropped faces that were present in the image with its modified size (same height and width).

All resized faces are saved in a particular user defined place or folder. Finally, it makes a database of all human faces. The face detection is the first step before face recognition process.

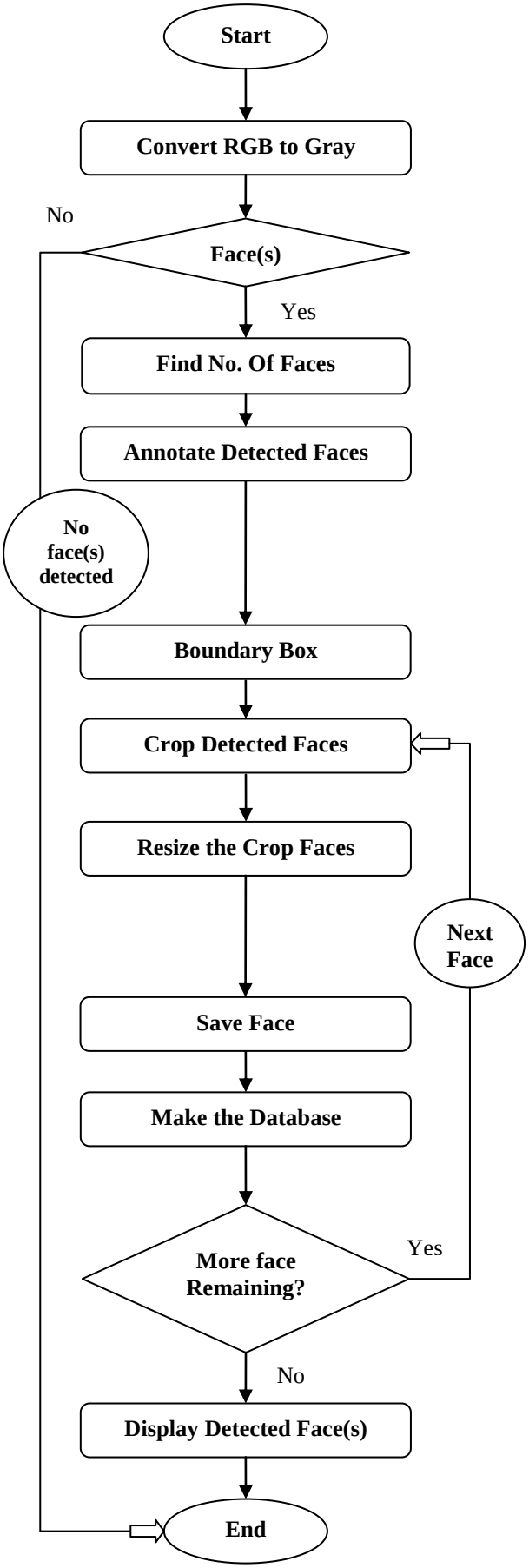

Fig 6: The Block Diagram of the System

V. RESULT AND DISCUSSION

Generally, the black skin faces and a newborn infant faces are very hard to detect. The Viola-Jones approach gives the appropriate results but in case of black faces it does not give the result as per our expectations. The method of Viola-Jones with specific threshold value gives the best results in detection of the African American peoples face, Asian origin people as well as the newborn infant. Figure 7 shows the images read by the program which is not stored in the database.

Fig 7: Original image

Original image is converted to the gray scale image and detects the multiple faces which are present in the image. The successfully detected faces are bounded in a rectangle. The output of image after detection of faces is shown in Fig 8.

Fig 8: Image after face detection

After detection of faces, the faces are cropped and then stored in the database. Fig 9 shows the result obtained after cropping of faces. All faces are of same size (width and height). Faces of same size are helpful in recognition of faces rapidly and efficiently.

Fig 9: Cropped faces

Sometimes it is hard to detect faces which are not clearly/partially visible in the image. Some of such faces are also detected with the help of proposed algorithm.

Fig 10: Not detected face

As shown in Fig 10, the face is not detected due to some reasons that are shown below. To detect black faces or newborn infant, there are some issues in face detection process, like:

1. Contrast ratio of image and faces
2. Hard to separate facial feature like eyes, bridge of nose and mouth.
3. Face colour and hair colour are same.
4. Generally, hairs are not present in the African origin people as well as the newborn infant.
5. Face distance, face size and large number of faces present in the image do not affect the detection rate and its process time.

The newborn infant image that shown in Fig 11. It is an original image of newborn infants. In this image we did try to detect the faces of all new born babies.

Fig 11: Original image of newborn infants

After applying face detection process for this image, we succeeded in detecting most of the faces that are present in this image. It also gives the total number of faces as an output that presents in this image.

Fig 12: Output image after face detection

In Fig 12, we can see that every newborn infant has different facial expression and pose. It is difficult to detect the faces because of different facial expression and poses but the proposed methodology is capable of detecting the faces inspite of different facial expressions and poses.

Hance this technique is useful to make the database of newborn infants that are born in the hospital for future record and information.

VI. TABLE I
RESULTS OF MULTIPLE FACES

Image / Type	Total no. of image	Total no. of faces	Detected faces	Detection rate
Asian origin	73	1463	1344	91.86%
Newborn infant	58	112	98	87.50%
Asian Origin	43	325	315	96.92%
Total	229	1900	1757	92.47%

To check its robustness, the work was tested on monkey faces and image with no faces. The monkey looks like human but cannot be counted as human face.

It is evident that software does not detect monkey faces as human faces in provided non-human face images, as shown in Table II.

VII. TABLE III
RESULTS OF NO FACE IMAGES

Image / Type	Total no. of image	Total no. of faces	Total detected faces	True detection rate
Monkey	150	0	4	97.33%
No Face Images	150	0	5	96.66%
Total	300	0	9	97%

Few faces are detected in the monkey images because sometimes monkey looks like a human. Its detection rate is 97.33%. Also in case of no face image, few faces are detected with the accuracy of 96.66% true detection rate. Finally, the overall true detection rate is 97% that we found in case of no face images, as shown in Table II.

We used more than 200 images for experiment and we get 91.86% accuracy for African origin people's face, 87.50% accuracy for newborn infant faces and 96.92% accuracy for Asian origin people's face. There is very less false result found in the image of monkeys and 'no face' images with the accuracy of 97.33% and 96.66% true detection rate respectively.

Finally, the overall detection rate is 92.47% that we found as shown in Table I.

Its computation time depends on the device processor, image size, and image resolution. The high-resolution image gives high detection rate but takes large computational time. The average computational time is 2.89456 seconds approximately on Intel i3 processor @ 2.10 GHz with 3GB RAM and Windows 7 Ultimate operating system. It is varied by the image feature and specification.

VIII. CONCLUSION

In this paper, we conclude that the Viola-Jones algorithm with some specific threshold value gives the result with fast detection rate and high accuracy to detect African origin people faces, Asian origin people faces as well as the newborn infant faces. In this approach computational time is increased when the image size is large and resolution is high. The average detection rate is 92.47% that as found in this work. A large number of faces which are present in the image do not affect the computational time as well as detection rate.

In the majority of cases, the system also rejected the monkey faces as human. Further, it did not falsely detect the human faces in 'no human face' images.

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