INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume3, Issue4)
Available online at www.ijariit.com

Multiple Face Detection for Color Images

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Abstract: ***The emergence of high-resolution digital cameras for the recording of still images and video streams has a significant impact on how communication and entertainment have developed during the recent years. At the same time, Moore's law has made tremendous computing power readily available that only some 20 years ago was reserved for high profile research establishments and intelligence services. These two tendencies have respectively called for and fostered the advent of unprecedented computationally heavy image processing algorithms. Algorithms that in turn have allowed for new processing of existing image based material.***

Parallel to this technological development the measures deployed in the protection against attacks from the enemies of modernity calls for more surveillance of the public space. As a result of this regrettable circumstance, more video cameras are installed in airports, on stations and even on open streets in major cities.

Whether or not the purpose is entertainment or dead serious surveillance, tasks like detection and recognition of faces are solved using the same methods. Due to the varying and generally adverse conditions under which images are recorded there is a call for algorithms capable of working in an unconstrained environment.

In 2004 an article by Paul Viola and Michael J. Jones titled "Robust Real-Time Face Detection" was published in the International Journal of Computer Vision. The algorithm presented in this article has been so successful that today it is very close to being the de facto standard for solving face detection tasks. This success is mainly attributed to the relative simplicity, the fast execution and the remarkable performance of the algorithm. This report documents all relevant aspects of the implementation of the Viola-Jones face detection algorithm. The intended input for the face detection algorithm is any conceivable image containing faces and the output is a list of face position.

Keywords*: *Viola-Jones Face Detection Algorithm, Template Based Approach, Adaboost Algorithm, Cascaded Classifier.

I. INTRODUCTION

Human face detection is the first step of face processing method, computer vision, and computational image analysis. The commonly used biometric characteristics for person recognition are faced. The repeatedly using approach is to face recognition, such as eyes, eye brows, nose, lips, chin and the relationships of these attributes. The detection of the present is the initial step in face processing system and subsequently the position of human faces in an image or video. The face detection has a challenge of cope with a wide variety of variations in the human face such as face pose and skin color, scale, facial expression, face orientation and ethnicity.

The extracted feature locations and topological relationships are used for faces detection. Both types have some limitations that are amplified by specifics of dissimilar application areas. It is a large search space, losing color information, inadequate face geometry features etc. Color is an efficient basic prompt that can be utilized as the initial step in the face detection performance. An RGB color space is an additive color space related to the RGB color model.

II. LITERATURE SURVEY

Automatic human face detection is a challenging problem which has received much attention during recent years. Propose a method that includes a denoising preprocessing step and a new face detection approach based on skin color fusion model and eye region detection. However, there is not a common opinion about which color space is the best choice to do this task is done by. Human face detection plays an important role in applications such as video surveillance, human computer interface, face recognition, and face image database management. Then a face detection algorithm for color images in the presence of varying lighting conditions as well as complex backgrounds was proposed.

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Hence, some automatic initialization techniques more specific for face detection have been developed, and mainly rely on skin color information

Face detection is a necessary first step in face recognition systems with the purpose of localizing and extracting the face region from the background. Face detection techniques can be roughly classified into four categories, namely, skin color model-based approaches, template matching-based approaches, feature-based approaches, and statistical model based approaches. Usually, face detection techniques integrate some or all of the four approaches to achieve high face detection accuracy and a low false detection rate. Detection rate and the number of false positives are important factors in evaluating face detection systems. Detection rate is the ratio between the number of faces correctly detected by the system and the actual number of faces in the image.

Skin color model-based approaches build a skin color model using Gaussian normal distribution since the color is one of the most widely used visual features in face detection.

Feature-based approaches first process the input image to identify and extract (and measure) distinctive facial features such as the eyes, mouth, nose, etc., as well as other fiducial marks, and then compute the geometric relationships among those facial points, thus reducing the input facial image to a vector of geometric features.

In Image based approach, there is a face pattern standard predefined is used to match the segment in the image to determine whether they are faces or not. It uses training algorithms to classify regions face or non-face classes. Image based techniques depend window multi-resolution scanning detect faces so that these techniques have high detection rates but slower than the techniques of feature-based. This approach has the advantage of being simple to implement, but it cannot deal effectively with the variation in scale, pose and shape.

Edge detection approach is a very important area in the field of Computer Vision. Edges define the boundaries between regions in an image, which helps with segmentation and object recognition. They can show where shadows fall in an image or any other distinct change in the intensity of an image.

III. EXISTING SYSTEM

Template based approach used several templates to find out the face class and extract facial features. The template matching compares the face candidate image with the face template, measures the level of similarity and concludes whether it is a human face or a non-face. The color space chosen for the template matching is gray because the best results have been experimentally obtained. The face template is an image made by averaging all faces on the training images. A few human faces are not detected if only one face template is used.

This project presents an improved color based segmentation technique to segment the skin regions in a group picture and use of skin based segmentation in face detection. Skin based segmentation has several advantages over other face detection techniques like this method is almost invariant against the changes of size of the face, the orientation of the face. The primary aim of skin based segmentation is to detect the pixels representing the skin regions and non-skin regions.

A. Segmentation based on Edge Detection Sobel Operator

The computation of the partial derivation in gradient may be approximated in digital images by using the Sobel operators which are shown in the masks below:

1	2	1
0	0	0
-1	-2	1

Figure 1: Sobel Mask Operators

This method attempts to resolve image segmentation by detecting the edges or pixels between different regions that have a rapid transition in intensity are extracted and linked to form closed object boundaries. Face detection is difficult mainly due to a large component of non-rigidity and textural differences among faces. The long list of these factors includes the pose, orientation, and facial expression, facial sizes found in the image, luminance conditions, occlusion, structural components, gender, and ethnicity of the subject, the scene and complexity of image's background.

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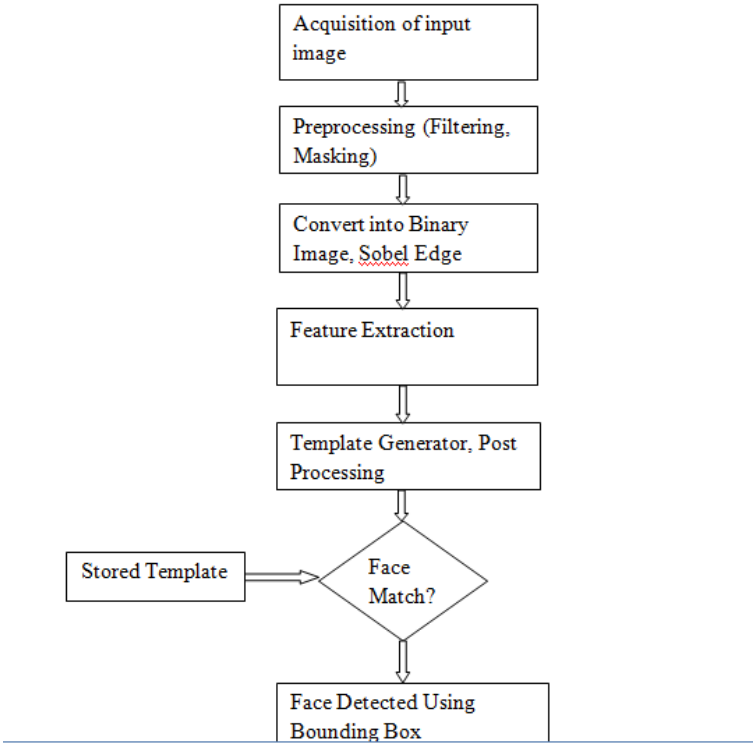
B. FLOWCHART



C. EXPLANATION OF FLOW DIAGRAM

- Acquisition Of Input Image - Capturing the input image from the digital camera.
- Preprocessing - Resize the input image and remove the noise using filtering and masking.
- Binary Image - Convert the color image into a binary image using sobel edge detection function.
- Feature Extraction - Separate the same type of pixels and extract the features.
- Post Processing - Resize the changed image size into the required original size and generate a template for each face.
- Face Match? - If generated template matches with the stored template then Face will be detected otherwise it cannot detect the face.

D. DRAWBACKS

- The existing systems do not have efficiency, stability.
- High complexity.
- cannot detect a face in the image exactly
- The computational speed is comparatively slower.
- More noise.

IV. IMPLEMENTING SYSTEM

This section describes the work carried out concerning the implementation of the Viola-Jones face detection algorithm. The first part elaborates on the methods and theory behind the algorithm. In order to avoid copying the original Viola-Jones paper this section is kept relatively short, but still, the most important points are explained. Secondly, interesting aspects of the actual implementation are emphasized and presented together with results and comments on performance. This structure is preferred since many intermediate results have affected implementation decisions and vice versa.

Methods: The basic principle of the Viola-Jones algorithm is to scan a sub-window capable of detecting faces in a given input image. The standard image processing approach would be to rescale the input image to different sizes and then run the fixed size detector through these images. This approach turns out to be rather time-consuming due to the calculation of the different size images. Contrary to the standard approach Viola-Jones rescale the detector instead of the input image and run the detector many times through the image – each time with a different size. At first one might suspect both approaches to be equally time-consuming, but Viola-Jones have devised a scale invariant detector that requires the same number of calculations whatever the size. This detector is constructed using a so-called integral image and some simple rectangular features reminiscent of Haar wavelets. The next section elaborates on this detector.

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The scale invariant detector: The first step of the Viola-Jones face detection algorithm is to turn the input image into an integral image. This is done by making each pixel equal to the entire sum of all pixels above and to the left of the concerned pixel. This is demonstrated in Figure 2

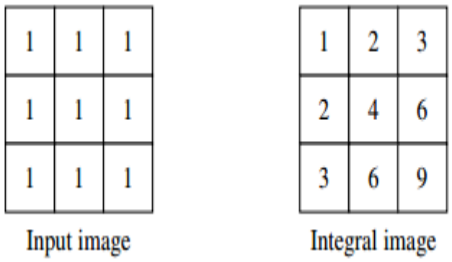
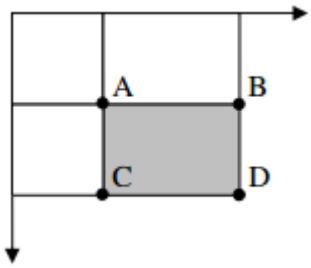


Figure 2: Integral image.

This allows for the calculation of the sum of all pixels inside any given rectangle using only four values. These values are the pixels in the integral image that coincide with the corners of the rectangle in the input image. This is demonstrated in Figure 2.



Sum of grey rectangle = D - (B + C) + A

Figure 3 - Sum calculation.

Since both rectangle B and C include rectangle A the sum of A has to be added to the calculation. It has now been demonstrated how the sum of pixels within rectangles of arbitrary size can be calculated in constant time. The Viola-Jones face detector analyzes a given sub-window using features consisting of two or more rectangles. The different types of features are shown in Figure 3.

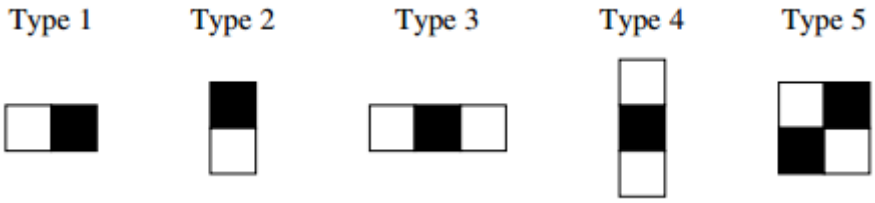


Figure 4 - The different types of features.

Each feature results in a single value which is calculated by subtracting the sum of the white rectangle(s) from the sum of the black rectangle(s).

Viola-Jones has empirically found that a detector with a base resolution of 24*24 pixels gives satisfactory results. When allowing for all possible sizes and positions of the features in Figure 4 a total of approximately 160.000 different features can then be constructed. Thus, a number of possible features vastly outnumbers the 576 pixels contained in the detector at base resolution. These features may seem overly simple to perform such an advanced task as face detection, but what the features lack in complexity they most certainly have in computational efficiency.

One could understand the features as the computer's way of perceiving an input image. The hope is that some features will yield large values when on top of a face. Of course, operations could also be carried out directly on the raw pixels, but the variation due to different pose and individual characteristics would be expected to hamper this approach. The goal is now to smartly construct a mesh of features capable of detecting faces and this is the topic of the next section.

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A. BLOCK DIAGRAM

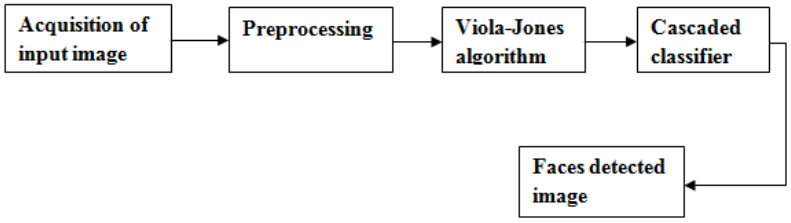

Figure 5: Block diagram

- **Acquisition Of Input Image -** Capture the input image using the camera.
- **Preprocessing -** Resize the input image and convert that into gray scale image.
- **Viola-Jones algorithm -** The basic principle of Viola-Jones is to scan a sub-window capable of detecting faces in a given input image.
- **Cascaded classifier -** It composed of stages each containing a strong classifier. The job of each stage is to determine whether a given sub-window is definitely not a face or maybe a face.
- **Faces Detected Image -** It shows the detected faces that are represented in graphical user inter face.

B. EXPLANATION OF PROCESS

- Take the original color image by using the digital camera.
- Convert that image into gray scale image during the preprocessing phase.
- Apply Viola-Jones Algorithm to the image.
- The cascaded classifier will find out the faces and non-faces in the given input image.
- Implement in Graphical User Interface representation.

C. THE CASCADED CLASSIFIER

The basic principle of the Viola-Jones face detection algorithm is to scan the detector many times through the same image – each time with a new size. Even if an image should contain one or more faces it is obvious that an excessively large amount of the evaluated sub-windows would still be negatives (non-faces). This realization leads to a different formulation of the problem instead of finding faces, the algorithm should discard non-faces.

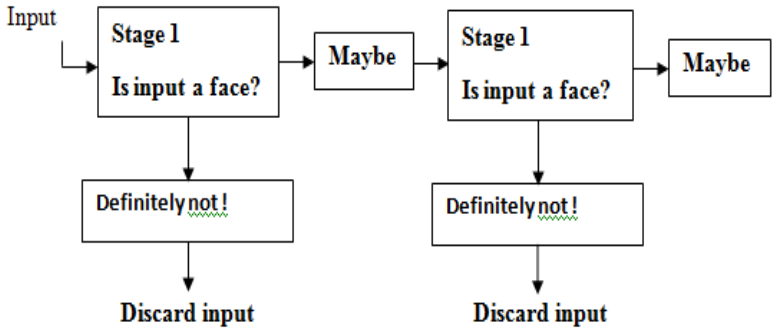

Figure 6: The Cascaded Classifier

V. THE MODIFIED ADABOOST ALGORITHM

As stated above there can be calculated approximately 160.000 feature values within a detector at base resolution. Among all these features some few are expected to give almost consistently high values when on top of a face. In order to find these features, Viola-Jones use a modified version of the AdaBoost algorithm developed by Freund and Schapire in 1996.

AdaBoost is a machine learning boosting algorithm capable of constructing a strong classifier through a weighted combination of weak classifiers. (A weak classifier classifies correctly in only a little bit more than half the cases.) To match this terminology to the presented theory each feature is considered to be a potential weak classifier. A weak classifier is mathematically described as:

$$h(x,f,p,\theta) = 1 \text{ if } pf(x) > p\theta$$

0 otherwise

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Where x is a 24*24 pixel sub-window, f is the applied feature, p the polarity and ø the threshold that decides whether x should be classified as a positive (a face) or a negative (a non-face). Since only a small amount of the possible 160.000 feature values are expected to be potential weak classifiers the AdaBoost algorithm is modified to select only the best features.

An important part of the modified AdaBoost algorithm is the determination of the best feature, polarity, and threshold. There seems to be no smart solution to this problem and Viola-Jones suggest a simple brute force method. This means that the determination of each new weak classifier involves evaluating each feature on all the training examples in order to find the best performing feature. This is expected to be the most time-consuming part of the training procedure.

VI.SIMULATION RESULTS

A. VIOLA-JONES USING GUI

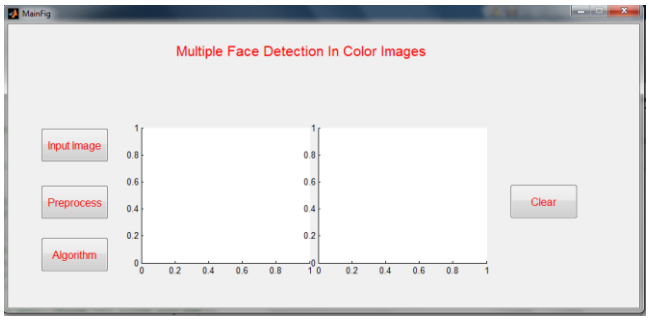

Figure 7: Initial GUI Image

Figure 8: Input Image

Figure 9: Preprocessed Image1

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Figure 10 : Faces Detected Image1

B. COMPARISON TABLE

TABLE 1: COMPARISON

Name Of The Image	Method Used	Total Number Of Faces In Image	Total Number Of Faces Detected	Total Number Of Faces Not Detected	Accuracy (%)
Input Image1	Viola-Jones	23	23	0	98
	Template Matching		10	13	45

- In template matching method, every time faces in the given input image stored in the data base and it can detect those faces only. So this method uses large storage when compared with the viola-Jones algorithm.
- So Viola-Jones method is faster than template matching method.

VII ADVANTAGES

- Reduces complexity - There is no matching of faces that reduces the work of the face detector.
- Efficient feature selection – Features of the faces can be extracted from the known- faces in the image.
- Useful in real time applications - It is useful for real time applications such as Face recognition, Surveillance etc.,
- Fast - Due to avoiding of the data base, every time, faces in the image is not stored in the data base so the code can run fastly.

APPLICATIONS

- Face- based screen lock - Used for security purpose in computers, mobiles.
- Identification Systems - face recognition is the secondary biometric added to an existing fingerprint identification system for ensuring that people do not obtain multiple driving licenses.
- Surveillance - Automated face detection in face recognition can be applied to search for a watch-list of 'interesting' people, or after the fact using surveillance footage of a crime.
- Marketing - Face detection is gaining the interest of marketers. A webcam can be integrated into a television and detect any face that walks by. The system then calculates the race, gender, and age range of the face.

CONCLUSION

Face detection is an important field which can have a great impact in generating security systems more reliable and making color applications. An efficient face detection method using the fusion of skin color modeling and the half face template matching method. This work offers various methods of face detection techniques. The proposed Viola-Jones Algorithm is implemented in 16 stage cascade classifier in Graphical User Interface representation. A total of four different implementations of the modified AdaBoost algorithm was also developed and then this cascade classifier was implemented and finally, the face detection algorithm itself was implemented as an easy-to-use MATLAB function.

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Radhika Anchanala received the B.Tech Degree from Audisankara college of Engineering and Technology in 2014 and currently pursuing her post-graduation (M.Tech.) from Gokula Krishna College of Engineering, Sullurpet, SPSR Nellore (Dist), A.P, India.

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