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Performance Comparison of Viola-Jones Method and Skin Color Segmentation based Hybrid Approach for Eyes Localization in Facial Images

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Abstract - *This paper deals with the comparative study of two techniques to detect and localize eyes in facial images. The two techniques are namely Viola-Jones method and Hybrid method (based on YCbCr and HSV Color Models). The objective was to deduce a conclusion based on the results on the images from three datasets: PICS, Specs on Face and Indian Faces both male and female. The images were categorized into frontal facial images, looking up & down, with and without glasses. The comparison reveals that Viola-Jones Method shows comparable detection accuracy and success rate to the Hybrid Model. Hybrid Approach has reported significantly higher FAR as compared to Viola-Jones method*

Key Words: Eyes Localization, Viola-Jones Algorithm, Skin Segmentation and Facial Images

1. INTRODUCTION

Since the Internet has become ubiquitous the masses have unprecedented dependence on the services provided by it. This has led to concerns regarding credibility and security issues. Thus, it has become inevitable to recognize this need for security and work on it. Eye-Localization refers to, the extraction of certain features of the face, in this case, eyes and separating it from the other features. For carrying out this operation there are a plethora of techniques available. Two such techniques are being put into implementation, using several mathematical operations performed on images through MATLAB and analyzing their performance to bring forth desired results.

Eye Localization is used on a very wide scale in applications like iris detection, face validation, blink detection, eye gaze tracking, video conferencing, criminal recognition, recognition of autism and entertainment to name a few.

Since Eye Localization has been implemented, studied and applied on s a huge scale. Along with the research and development, there is a fair share of challenges that need to be addressed namely, occlusions [1]like glasses[1], spectacles, beard, poor lighting conditions, pose orientation, blinking of eyes, to name a few.

2. RELATED WORK

This Research paper is based on two methodologies of Eye-Localization, they are:

Viola-Jones [1 - 5]: This utilizes all the basic features of the methodology for localization of the eyes.

Hybrid method [6 -10]: There are two color space models namely, YCbCr and HSV. These are combined and certain Image Morphological operations are implemented to acquire results.

Calculation and Results [11-15]:The calculation is done using formulae . The comparison is based on statistical tool of Data Analysis ANOVA (Analysis of Variance.). This helps in forming a plausible conclusion.

3. VIOLA-JONES METHOD

3.1 Viola-Jones Approach

This approach is widely used when it comes to object-detection. This approach was developed in 2001 by Viola-Jones [2][5]. The basic approach is to detect the object of desire with the help of variation in the intensity of the pixels. In order to do so, the feature extraction is done by applying a convolutional approach. There are basically four methods to extract features in this Algorithm namely, Haar Feature, Integral Image, Adaboost and Cascading.

3.2 Haar Feature Selection

A simple notion is that pixels in a sample picture vary in intensities. Thus the features that vary or have a huge difference can be represented by rectangles of either black or white. The black or dark region is represented by 1 and the white one by zero. Thus the intensities vary accordingly from 0 to 1. There are four rectangles that are used to extract the features.

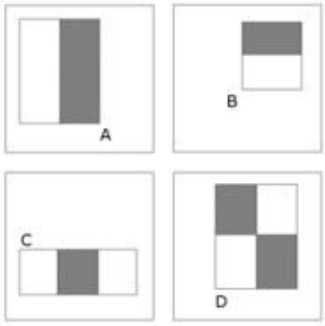

Figure-1: Haar Feature rectangles [3]

3.3 Integral Image

Since there is a fixed pixel value in a single set and there are many sets in a picture the computation becomes tedious. Thus Integral Image that is represented by the sum of the adjacent cells is computed using a formula.

This makes it easier to calculate and a robust process. The values are manipulated and a single pixel value represents a number of other pixel values.

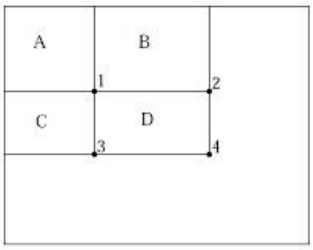

Figure-2: Integral Image in Viola-Jones Methodology [4]

3.4 Adaboost Training

There are a number of features detected that can or cannot be the desired result. These outputs if they have more than half accuracy are classified as the weak classifiers by selecting the weak classifiers it is then assigned a weight and it is combined in a linear manner in order to detect the feature with more probability and accuracy.

3.5 Cascading Classifiers

It refers to simply passing on the result to a number of filters that detect, if the feature selected is the desired one or not. Thus there is more accuracy and efficiency in the system implemented. The group of filters working together is referred to as the cascade

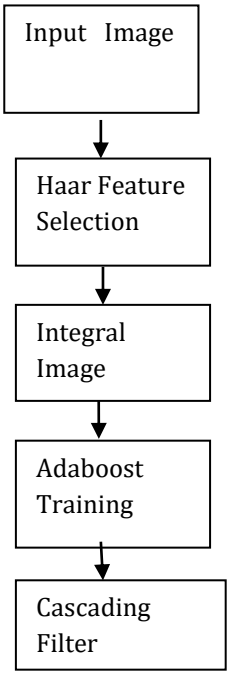

Figure-3: Block Diagram of Viola-Jones Approach [5]

4. HYBRID METHOD.

4.1 Color Segmentation and Eye Geometrical Shape based Approach

The research methodology can be classified into two parts the first one is, in which the color models namely YCbCr and HSV Models are implemented and the features of our choice are extracted using Morphological operations. The Morphological operations are however applied on the images combined after OR operation it. The results after implementing all three operations are to be compared to reach a conclusion.

4.2 Color Models Used in Eyes Localization

There are two models being implemented on the images to extract the features from both the models by using OR operation. The models are namely the YCbCr Model and HSV Model for skin Recognition.

4.3 YCbCr Model

This model belongs to the family of color spaces comprising other models such as YPb/Cb also written as Pr/Cb or YCbCr or Y'CbCr. This model is primarily used in video and digital photography. This model is encoded non-linear RGB Model.

Y=0.299R+0.587G+0.114B

Cr=R-Y and Cb=B-Y [6]

Where, Y is the luma component and Cb and Cr are the blue difference and red difference in chroma component.

Significance of this color model in the eyes localization: for recognizing and separating the skin color from the background this model is very efficient. As the threshold values for the skin falls in a certain range they can be used to extract certain features from the image. [7]

In the proposed hybrid model the following threshold values were used is Cr1=137 and Cr2=177 and Cb1=90 and Cb2=130

These values fall under the range that covers the skin tones of people from majority of the races. Thus more number of people can be included in the task undertaken.

4.4 HSV Model

HSV (Hue Saturation Value/Intensity/Lightness) is represented by angle (Θ) varying from 0 to 360, the radius corresponds to Saturation value varying from 0 to 1 and Intensity varies along z-axis with 0 as black and 1 as white. This model recognizes the skin color after defining the threshold value for the skin. The values fall in the range h (0, 50) and s (23 to 68) [7].

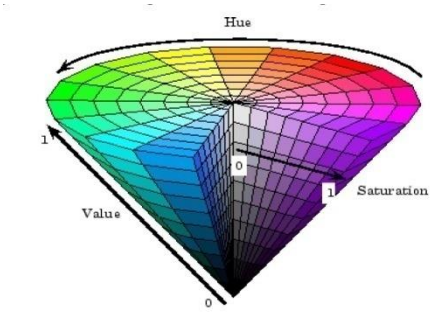

Figure-4: HSV Color Model [7]

4.5 Morphological Operations [8][9]

Aftermath the implementation of the models the following functions are carried on the Images:

1. Binary Image is obtained by performing the OR function on the images.
2. Erosion and Dilation that define the area of concern by defining the boundary and enlarging them.
3. Blob (Binary Large Objects) Removal and Solidity for recognizing the similar areas and removing them. Further recognizing the shape by solidity.
4. Setting the Aspect Ratio along the axis.
5. Orientation of the images for corner detection.
6. Defining the pixels and drawing

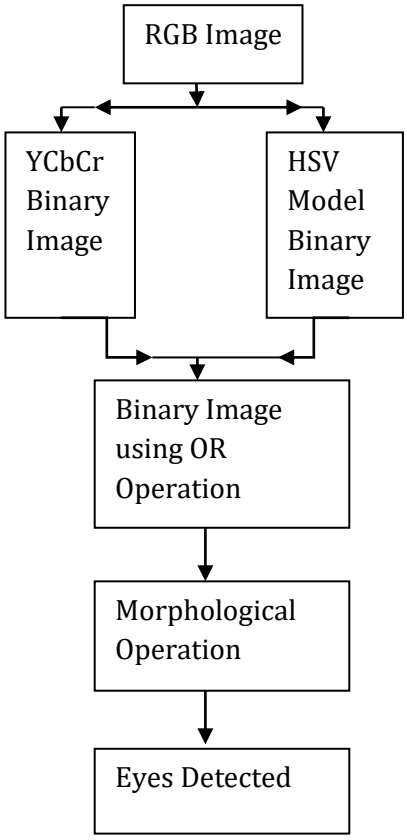

Figure-5: Block Diagram of Skin Color Segmentation based Hybrid Approach [10]

5. SPECIFICATION OF HARDWARE AND SOFTWARE USED

Computer: DESKTOP-L7HGAOSIntel(R) Core(TM) i5-2320 CPU @ 3.00GHz 3.00 GHz, 64 bit Operating System Windows 10 Home

MATLAB: R2015a (8.5.0.1976) 64-bit Win 64With Image Processing and Computer Vision Toolbox.

Table-1: Dataset showing number of Images

Datasets	Number of Images	Reference
PICS	457	[14]
Specs On Face	150	[15]
Indian Face	461	[16]

The comparison of the two methodologies has been carried out using the database of PICS data, Specs on faces and Indian faces. The PICS data comprises of 457 pictures, the specs on faces comprise 150 pictures and Indian faces have 461 images. The Indian database has been further

classified into front facing images, tilted, up and down images. There are all in all 1061 images.

6. EVALUATION PARAMETERS [11][12]

True Positive (TP): Correctly Detected Eyes

False Positive (FP): False Detection of Eyes

False Negative (FN): Missed Detection

Detection Accuracy (DA) = $\frac{TP}{TP+FN}$ (1)

False Alarm Rate (FAR) = $\frac{FP}{FP+TP}$ (2)

Success Rate (SR) = $\frac{DA}{DA+FAR}$ (3)

7. RESULTS AND DISCUSSION

The objective of implementing two algorithms namely Viola-Jones Algorithm and Hybrid Algorithm on datasets resulted in varying result that is discussed in a comprehensive manner in this section.

Both the techniques vary in their approach. There is a different set of coding that has been put into implementation.

The data has been collected after implementing the commands using MATALAB on each image, one by one. After this, the result of each image is collected. The outcomes are segregated as, True Positive, False Positive or False Negative. In this manner, the results for both methodologies have been collected. The data is used for concluding the objective of comparison between the two methodologies.

7.1 Viola-Jones Results in Images

Figure-6: Viola-Jones showing True Positive in frontal image [PICS Dataset]

Figure-7: Viola-Jones showing False Positive in frontal image [Specs on Faces Dataset]

In case of true positive result, a box is drawn around the eyes. This is shown in Figure 6. In case of false positive, the algorithm considers non-eye area as the eye, as shown in Figure 7.

7.2 Hybrid Approach Results in Images

Figure-8: Hybrid Approach showing true positive result in frontal image [PICS Dataset]

Figure-9: Hybrid Approach showing false positive result in frontal image [PICS Dataset]

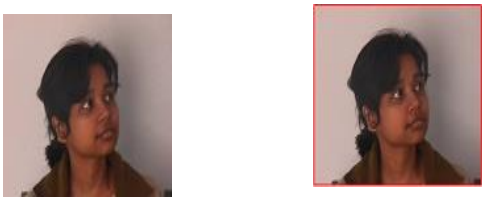

Figure-10: Tilted Image showing false positive using Hybrid Approach [Indian Face Dataset]

False Positive results are shown in Figure 9 and Figure 10.The eyes-localized successfully is shown in Figure 8 (frontal), Figure 11 (looking down) and Figure 12 (looking up).

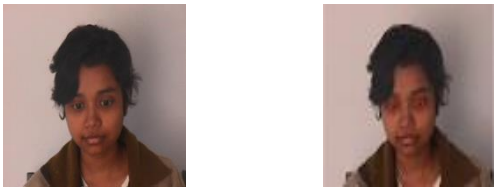

Figure-11: Image looking down giving True Positive Hybrid Approach [Indian Face Dataset]

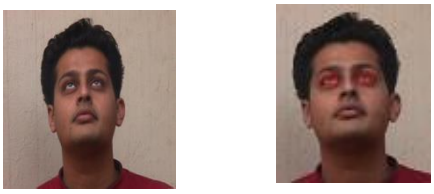

Figure-12: True Positive in UP using Hybrid Approach [Indian Face Dataset]

The result calculated for all the images is given in the Table 2 and Table 3. The Detection Accuracy, False Alarm Rate and Success Rate are calculated separately for Viola-Jones method and Hybrid Method.

It can be deduced from Table 2 that the Detection Accuracy for Viola-Jones Method varies according to the dataset considered and used. The Average Detection Accuracy is 79.893%.

The False Alarm Rate is only in the case of the Specs on Faces Dataset. Otherwise, the False Alarm Rate is not there at all. The average FAR is 10.88%.

The average Success Rate is 83.15%. Thus, it can be seen from results that only specs on faces have False Alarm Rate. The Viola-Jones method has low FAR with the only exception being the category of Specs on faces.

Table-2: Detection Accuracy (DA), False Alarm Rate (FAR) and Success Rate(SR) for Viola-Jones Method

Methodology Viola-Jones	DA	FAR	SR
PICS DATA	91	0	90.68
SPECS ON FACES	48.9	10.88	81.79
INDIAN MALE(FRONT)	100	0	100
INDIAN MALE(UP)	91.66	0	91.66
INDIAN MALE(DOWN)	100	0	100
INDIAN MALE(TILTED)	15.71	0	15.71
INDIAN FEMALE (FRONT)	95.31	0	95.31
INDIAN FEMALE (UP)	85	0	85
INDIAN FEMALE (DOWN)	96.96	0	96.96
INDIAN FEMALE (TILTED)	74.39	0	74.39

It can be deduced from Table 3 that the Detection Accuracy for Hybrid Method varies according to the dataset. The Average Detection Accuracy is 76.106%.

The Average False Alarm Rate is 53.326%. The False Alarm Rate is there in each category unlike Viola-Jones method.

The Average Success Rate is 59.282%. There is False Detection of eyes in each category. Thus, it reduces the overall success rate in the Hybrid Method.

Table-3: Detection Accuracy (DA), False Alarm Rate (FAR) and Success Rate (SR) for Hybrid Method

Methodology Hybrid Approach	DA	FAR	SR
PICS DATA	69	45.45	80.3
SPECS ON FACES	23.14	79.6	22.52
INDIAN MALE(FRONT)	85.00	67.92	55.58
INDIAN MALE(UP)	88.88	42.85	67.47
INDIAN MALE(DOWN)	87.5	65	57.37
INDIAN MALE(TILTED)	17.80	93.33	16.01
INDIAN FEMALE (FRONT)	100	31.25	76.19
INDIAN FEMALE (UP)	100	35.50	72.72
INDIAN FEMALE (DOWN)	100	36	73.5

INDIAN FEMALE (TILTED)	89.74	36.36	71.16

The statistical findings are used to come at a plausible conclusion. This has been done by using One-way ANOVA (Analysis of Variance) Test. This is a statistical tool used to compare different groups of data.

There are two kinds of variables used. The first one is the independent variable that is, the methods used. The other one is the dependent variable that is Detection Accuracy, False Alarm Rate and Success Rate.

The p- value (significant level) is the probalistic value. In this case the value is 0.01 for the hypothesis. The hypothesis is that if the p-value is greater than 0.01 then the difference is insignificance. Otherwise, it is significant.

Table-4: Statistical Comparison of the results.

Dependent Variable	p	F	Findings
DA	p=0.77452	F=0.084571 <$F_{critical}$	Not Significant
FAR	p=9.6x10^{-7}	F=52.61745 >$F_{critical}$	Significant
SR	p=0.038009	F=5.014075 <$F_{critical}$	Not Significant

The F helps in reaching the conclusion that if the variance is significant or not. This is the compared with $F_{critical}$ that is a reference value. This decides if the difference is critical or not. The statistical findings on application of ANOVA test are presented in Table 4.

The Average Detection Accuracy (DA) of the Hybrid Approach is less than the Viola-Jones approach. Statistically, the difference is Insignificant (p>0.01).

The Average Success Rate (SR) of the Hybrid Approach is less than the Viola-Jones approach. Statistically, the difference is insignificant (p>0.01).

The Hybrid Approach has given significantly high (p<0.01,F=52.61745) False Alarm Rate (FAR) as compared to the Viola-Jones method.

7. CONCLUSION

This paper has presented a detailed comparison of Viola-Jones method and skin color segmentation-based hybrid approach for eyes localization in facial images. The datasets used comprise of 1061 images and for each image individually the results were obtained. Each image has been subjected to algorithm of eyes localization using Viola-Jones method and Hybrid Method. The average detection accuracy obtained was 79.83% and 76.10% for Viola-Jones method and hybrid method, respectively. The average success rate of Viola Jones method is 83.79% and that of Hybrid Method is 59.28%. The difference in detection accuracy and success rate is statistically insignificant. There is a significant difference in the False Alarm Rate (FAR) obtained in both the cases. The hybrid approach has given significantly higher FAR as compared to the Viola-Jones approach. The future work can be done to minimize the FAR by using appropriate filtering techniques.

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