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Memory Efficient Human Face Recognition Using Fiducial Points

Rajib Saha*
Department of Computer Science and Engineering
RCC Institute Of Information Technology
Kolkata, India

Debotosh Bhattacharjee
Department of Computer Science and Engineering
Jadavpur University
Kolkata, India

Abstract- **The objective of this paper is to design an automated face recognition system which can be used in application like recording of daily attendance. In this paper fully automatic recognition of frontal 2D face image of an individual has been described. Firstly, all the 2D frontal faces from FRAV3D image database are selected and by applying SUSAN (Smallest Univalue Segment Assimilating Nucleus) method all the images are converted into grayscale images for detection of the edges .After that the method which is represented here is used to extract n (n=4) feature points(which are expression, light, size invariant). But in this method only different frontal facial expressions have been considered. For face recognition of every individual only three ratios in terms of database have been stored. Experimental results show that frontal face images may be easily recognize and this technique can be used for simple face recognition.**

***Keywords* - SUSAN, Segmentation, Eye corner detection, Nostrils detection, Face recognition.**

I. INTRODUCTION

Translation of input data into some set of features is called Feature Extraction. Use of feature extraction can simplify huge amount of data in a relatively small set. For image database, the main problem is that it requires huge space to store and for face recognition it requires a comparison of large number of pixels. Recognition of face generally requires a large amount of memory and computation cost.

So feature extraction of an image can reduce the required memory for storing images. In this method only three numbers need to be stored instead of the image for every individual.

Due to variations in illumination and facial expression, the face appearance in an image possesses a complex density (manifold), so large numbers of samples are required to sufficiently and correctly extract the feature points [5]. Feature-based methods that depend on local features such as the eyes, nose and mouth, which are first extracted and their locations and local statistics are fed into a structural classifier [4].

explained an efficient approach for detecting and locating the eyes in frontal images. Possible eye candidates in an image are identified by means of the valley features and corners of the eyes.

For the extraction of the outer corners of the eyes, the mouth corners and the nostril corners, the SUSAN (Smallest Univalue Segment Assimilating Nucleus) algorithm for corner and border extraction [3] has been used as an alternative to artificial template matching.

In this method, rightmost point of right eye, leftmost point of left eye, rightmost point of right nostril, and leftmost point of left nostril have been extracted using proposed algorithm.

II. PRESENT METHOD

This method is mainly divided into three parts. Firstly (A) SUSAN method have been applied to convert the 2D images into gray scale images, after that (B) segmentation algorithm and (C) eye corner extraction and nose corner extraction algorithm have been applied.

II.A SUSAN operation

Here SUSAN is used mainly for edge detection of the images, SUSAN places a circular mask over the pixel to be tested, which is termed as the nucleus [1]. The circular mask is moved through each point of the image; the intensity of each pixel within the mask is compared with that of the nucleus. A Simple equation determined this comparison is as follows:

$$c(r,r_0)=\begin{cases}1 & if\,|I(r)-I(r_0)|\leq t\\ 0 & if\,|I(r)-I(r_0)|>t\end{cases} \quad (1)$$

A more stable and reliable form of the above equation is used in the following form:

$$c(r,r_0)=e^{-\left(\frac{I(r)-I(r_0)}{t}\right)^6} \quad (2)$$

where, $I(r_0)$ is the intensity of the nucleus, $I(r)$ is the intensity of any other pixel within the mask, t is the gray level difference threshold and $c(r,r_0)$ is the output of the comparison. This comparison is done for each pixel within the mask, and a running total of the outputs $c(r,r_0)$ are computed as follows:

$$n(r_0)=\sum_{r\in c(r_0)} c(r,r_0) \quad (3)$$

Setting area threshold as g , and comparing it with USAN's area to get the initial corner response function:

$$R(r_0)=\begin{cases}g-n(r_0) & if\; n(r_0)<g\\ 0 & otherwise\end{cases} \quad (4)$$

where, g is named the `geometric threshold' or SUSAN threshold . So from the above equation it can be stated that if the SUSAN area is small then it will get positive value for $R(r_0)$ otherwise it will be 0 as the value of g is set to be 27 generally[1]. This concept of each image point having associated with it a local area of similar brightness is the basis for the SUSAN principle.

For corner detection, two further steps have been used. Firstly, the centroid of the nucleus has been identified. A proper corner will have the centroid far from the nucleus. The second step insists that all points on the line from the nucleus through the centroid out to the edge of the mask are in the SUSAN.

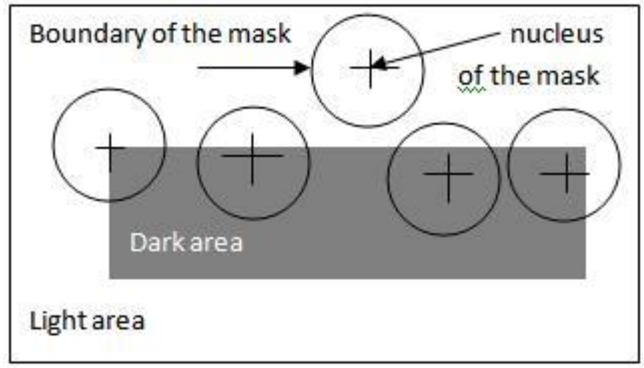


Figure 1: Four circular masks at different places on a simple image.

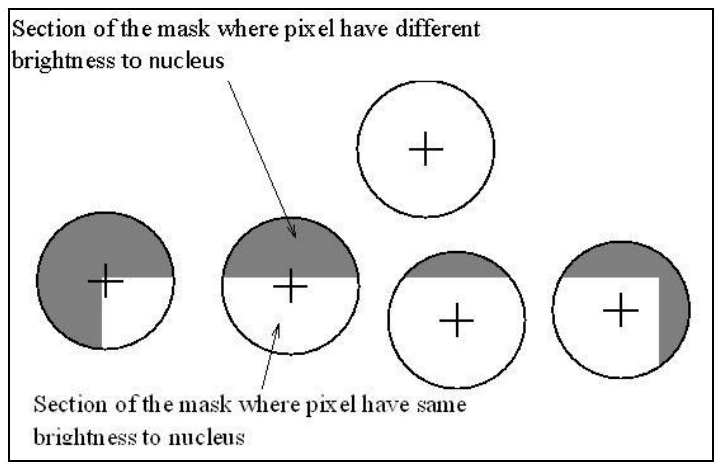
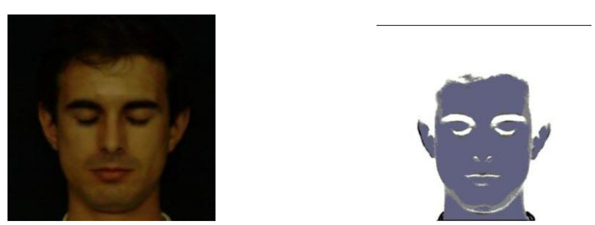


Figure 2: Four circular masks with similarity colouring; USANs are shown as the white parts of the masks.

After converting the image into gray scale, this method is applied to extract the feature points. And then various image of a person with various expressions are experimented.

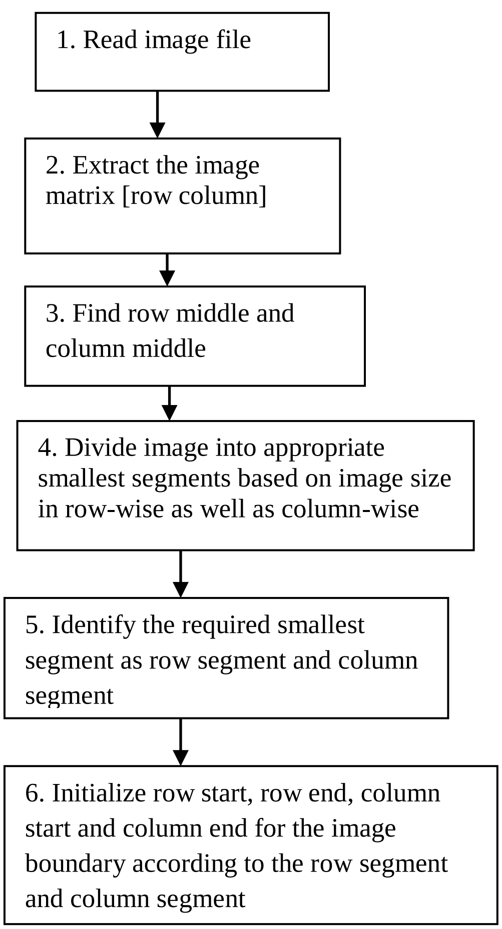


3.a	3.b

Figure 3.a Sample Input 3.b Output image after applying SUSAN algorithm

II.B Segmentation Algorithm

The objective of this part of the algorithm is to determine the region of work to extract the feature points. For these purpose first the image matrix has been extracted and then find the middle point of it. Then divide the image into appropriate smallest segments based on image size in row wise as well as column wise, then identify the required smallest segment as row segment and column segment and then calculate the translation value for the image if the face not in middle of the image. After that, it will define a frame of operation to extract the features point.



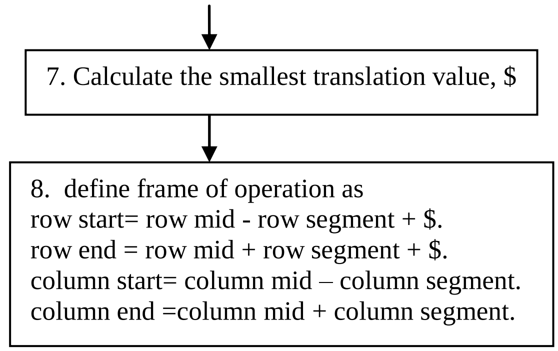
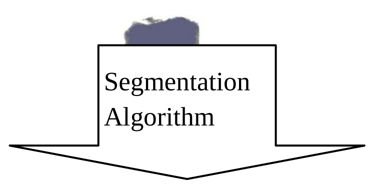
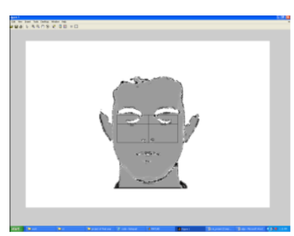
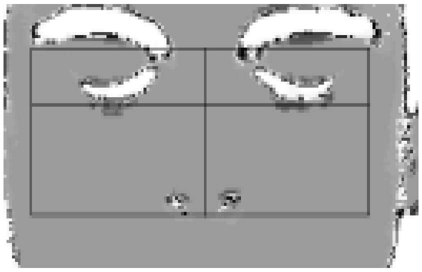


Figure 4: Flow chart of the above method

Here, the smallest translation value is used to translate the operational frame, as shown in Figure 5.c. This is required if the face is not at the middle of the image.







5.a

5.b

5.c

Figure 5.a Input Image for Module Extraction and Segmentation
5.b Output Image after Module Extraction and Segmentation
5.c Magnifying the working area

II.C Eye corner extraction and nose corner extraction algorithm

The objective of this part of the algorithm is to extract the feature points from eye and nose namely rightmost point of right eye , leftmost point of left eye , rightmost point of right nostril and leftmost point of left nostril). First the frame of operation has been divided into 2 symmetric halves about column middle. Then, at first, the left half of the frame has been considered and scanned the entire half to check whether the test value is within the range 245 to 255, which denotes the brighter points. If it satisfies, then again it checks whether the corresponding column value is greater than the column of iteration or not. If so then it will assign the column of iteration to the corresponding column value. If the test value is not within the range 245 to 255, then it goes for the next pixel and stores the feature point in the database. After that, the same procedure has been applied for the right half of the frame. The entire procedure is explained below with the flowchart.

1. Divide frame of operation into 2 symmetric halves about column_mid

2. Consider left half of frame of operation

3. Start loop to scan the entire half and check test value whether test>=245 and test<=255

If false

If true

4.Check whether test_col>column of iteration If true, assign test_col=column of iteration; test_row=row of iteration

5. If scan of the this half is complete then goto step 6 else go to step 3

6. Store feature point in the database

7. Consider right half of frame of operation

8. Start loop to scan the entire half and check test value whether test>=245 and test<=255

If false

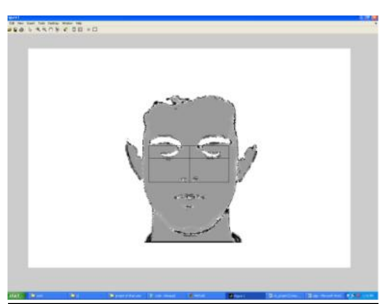
If true

9.Check whether test_col<column of iteration If true, assign test_col=column of iteration; test_row=row of iteration

10. If scan of the this half is complete then go to step 11 else go to step 8

11. Store feature point in the database

Figure 6: Flow chart of Eye corner extraction and nose corner extraction algorithm



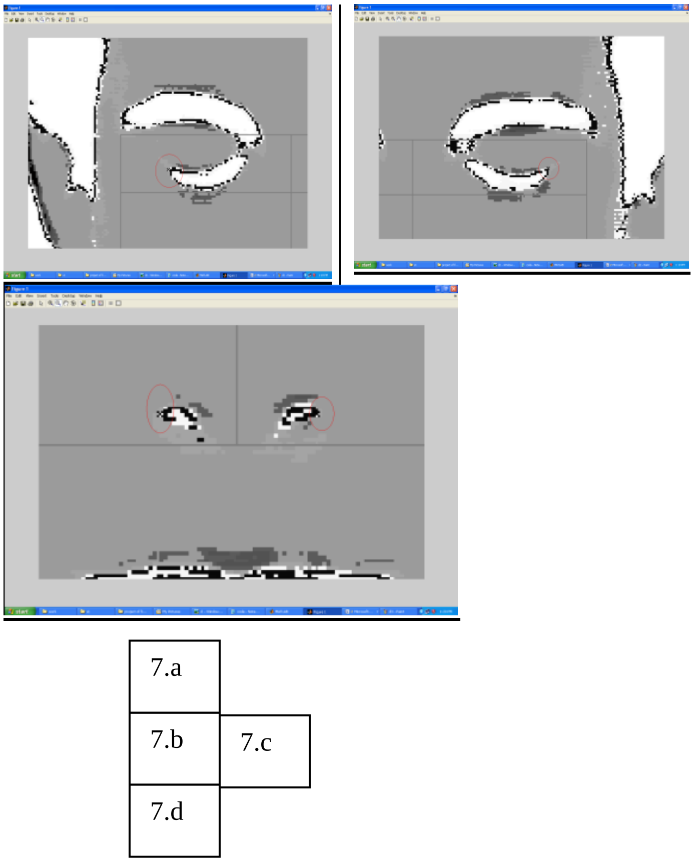


Figure 7.a Sample input for feature extraction
7.b Left corner of left eye
7.c Right corner of right eye
7.d Both nostrils corners

II.D The Triangle-Ratio Hypothesis for image comparison

The GOLDEN RATIO concept governs all the laws and physical identities of nature. This concept has been a major source of inspiration to this logic for comparing various images of the same person as well as images of different persons. Applying standard laws of triangle and ratio and proportion, it can be concluded that every face exhibits unique geometrical properties. Irrespective of facial expressions, these properties hold and satisfy a specific range of values. The diagram below gives a detailed outline of the geometrical analysis of the hypothesis and the ratios that have considered for the present work.

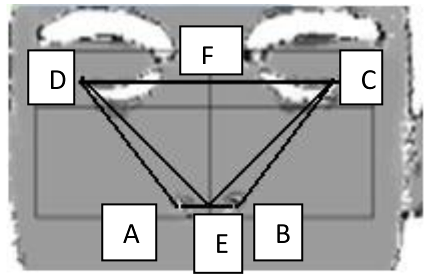


Figure 8 . Calculation of the ratios

A human face is known for its symmetry. Hence, it has been presumed in this approach the above triangle is an isosceles one. The basic notion conceived at this very first stage of the hypothesis is to compare all the different lengths of the triangle viz. ALTITUDE/BASE(DE/DC), ALTITUDE/SIDE(DE/EF) and SIDE/BASE(EF/DC) as specified by the different ratios in the above diagram. Now, it compares between the ranges of these various ratios of different expressions of the same person and obtain a range for these values. For different expressions of the same man the range is specified by the FOUR expressions that display the maximum deviation on either side of the axis and for any further image of that man these ratios should hold a value within that range. In above results it has seen that 4 different expression of person but all the ratios lies within a specific range.

Hence, for every person there stands a specific range of ratios between different expressions. As somewhat evident from the above calculations that at least one, if not more range of a sample does not coincide with that specific range of the other person, even if every other range of the ratios overlap. There are many more sets of data are considered and experimented on and then a concrete result of its hypothesis are obtained.

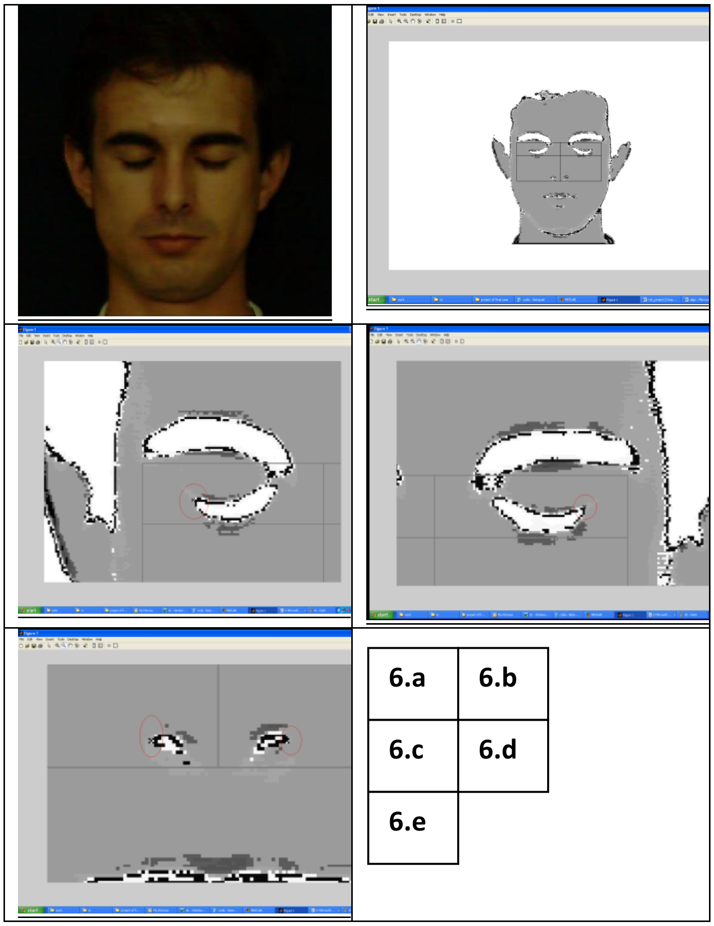
III. RESULTS

Here all the 2D frontal faces from FRAV3D image database are taken. As this algorithm may be applied for 3D faces in future, so 3D database is taken. Total 935 frontal face images of 116 different individual are selected to test the experimental results. Experimental results have shown that frontal face images can be successfully recognize with the rate of **92%** and this technique can be used for simple face recognition.

TABLE I
EXPERIMENTAL RESULTS

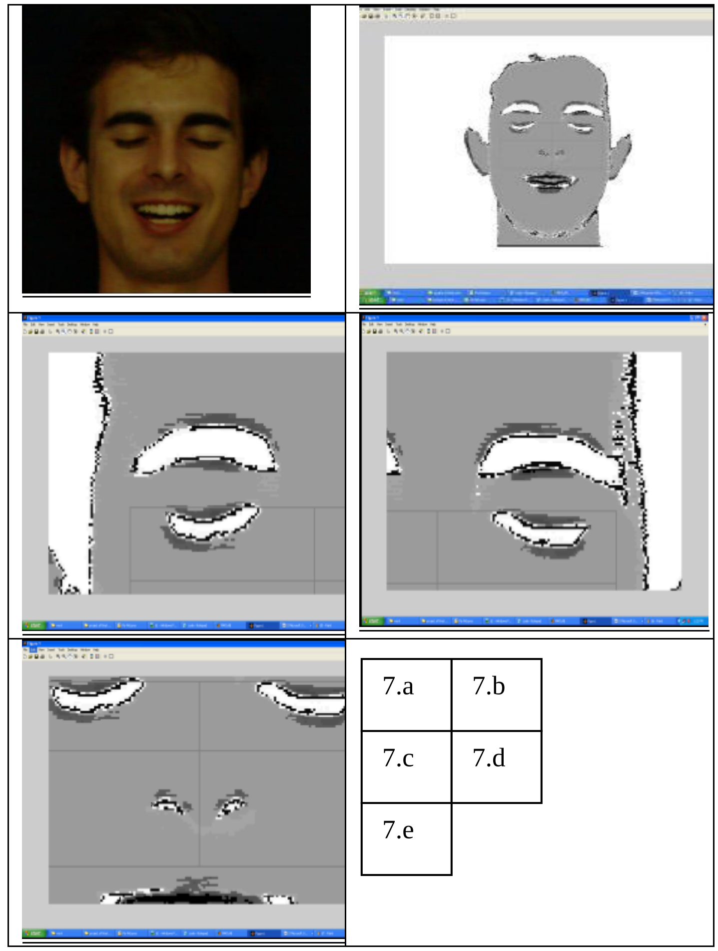
Total Sample images	**Successful sample images**	**Success rate**
935	**862**	**92%**

III.A Sample outputs



6.a	**6.b**
6.c	**6.d**
6.e	

Figure 6.a Sample input
6.b Output Image after Module Extraction and Segmentation
6.c Right corner of right eye
6.d Left corner of left eye
6.e Both nostrils corners



7.a	7.b
7.c	7.d
7.e	

Figure 7.a Sample input
7.b Output Image after Module Extraction and Segmentation
7.c Right corner of right eye
7.d Left corner of left eye
7.e Both nostrils corners

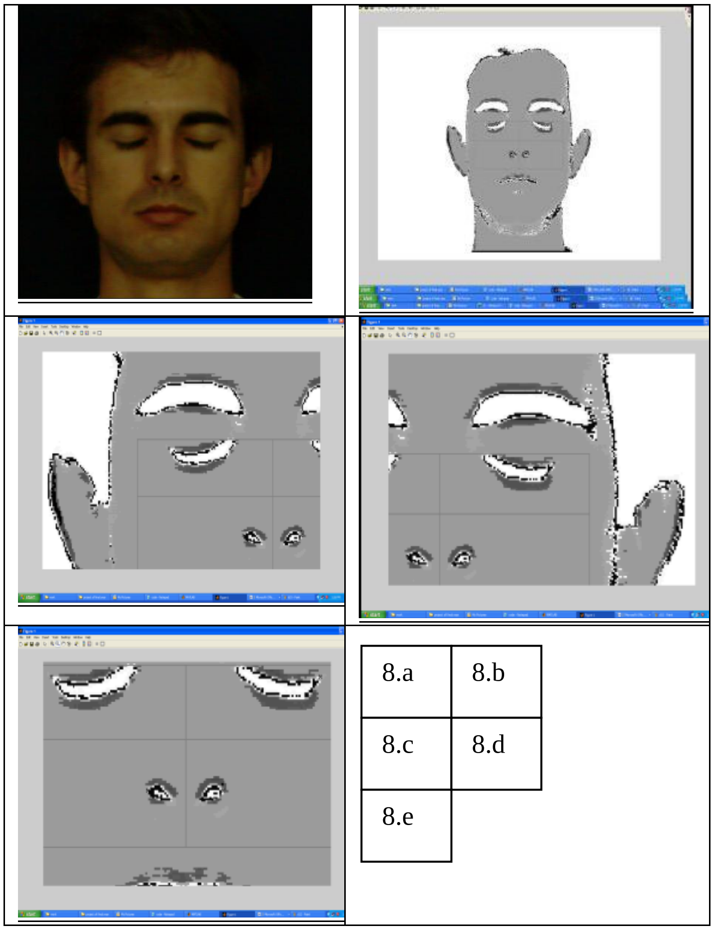


Figure 8.a Sample input
8.b Output Image after Module Extraction and Segmentation
8.c Right corner of right eye
8.d Left corner of left eye
8.e Both nostrils corners

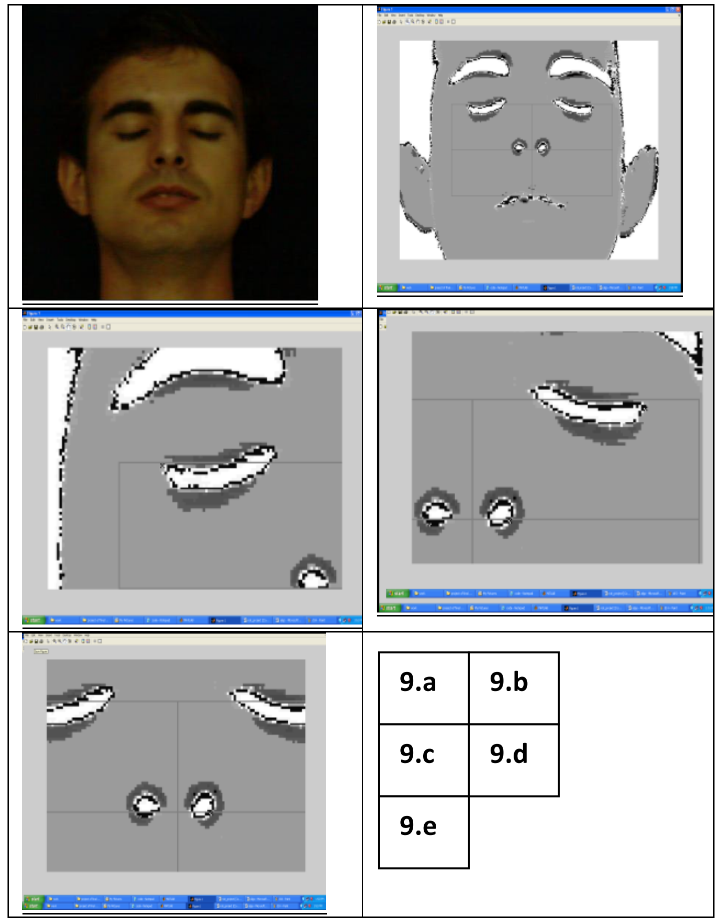


Figure 9.a Sample input
9.b Output Image after Module Extraction and Segmentation
9.c Right corner of right eye
9.d Left corner of left eye
9.e Both nostrils corners

IV. DISCUSSION

As only three ratios have been considered, so in some of the cases fault result have occurred. For this reason the success rate of this algorithm is 92%. The best way to improve the success rate is to include more feature points , which may be lead to better result.

V. CONCLUSION

The present method is developed to extract various feature points from 2D facial image in an efficient way. The next approach will be to study the various feature points from the same image database to determine a comparatively efficient study. And we can further apply this work in multimodal

domain. But this work have the following constraints:

1. One normal expression reference picture
2. Only frontal face should considered

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