A Novel Approach to Enhance Face feature Extraction using Pencil Sketches

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Abstract*: Feature extraction is the primary step in all the recognition problems. For recognizing a face, the facial features should be extracted. The recognition rate depends on the accuracy in feature extraction. In this paper a method for enhancing face feature extraction has been proposed. The method proposed has implemented a Double Sized Scaled Horizontal Vertical Oblique (DSHVO) filter before extracting the feature points from the face. The application of DSHVO filter converts the input image to an image resembling a pencil sketch. In this paper different feature extraction methods like SURF, Harris and FAST are carried out in gray scale images and the results obtained are compared. The feature extraction is also carried out after the application of the DSHVO filter by using these feature extraction methods. Experimental results show that the conversion of gray scale images to pencil sketch images have considerably improved the feature extraction accuracy. The performance of these feature extraction methods in gray scale and pencil sketch images is done and the results are compared. Based on the results obtained the feature extraction methods are evaluated.

***Index Terms*: FAST, Feature Extraction, Gray scale, Harris, Pencil Sketch, SURF.**

I. INTRODUCTION

In this era of Artificial Intelligence machines are trying to acquire the intelligence of human brain. More precisely it can be said that machines are trying to replicate what human brains are doing. One of the major challenging problem in this context is the Face recognition problem. Human beings are capable of recognizing faces under varied conditions like frontal face, side pose, faces with expressions, age differences, occlusions etc. without much difficulty. But machines find it really difficult to overcome these barriers. For the computer to recognize faces one of the most critical step is the feature extraction. The face is analyzed by computers based on the features extracted. A lot of algorithms have been developed for feature extraction of facial images. Different algorithms use different logics and so the features extracted by different algorithms need not be the same. The accuracy of the face recognition depends entirely on the feature points selected by the algorithm. If the algorithm is capable of extracting the most critical points while eliminating redundant points, then the face recognition accuracy can be increased.

In this paper three feature extraction methods, SURF, Harris and FAST are applied on grayscale images and the experimental results are compared. A new method is proposed in which the feature extraction capabilities of these methods are enhanced by applying DSHVO filter to the images and converting them into pencil sketches before applying the feature extraction techniques. The results of the feature extraction methods thus obtained are compared with the result obtained with grayscale images and the optimal feature extraction method using pencil sketch images is recommended. So this paper also emphasizes the importance of pencil sketches in face feature extraction.

II. TECHNIQUES AND METHODS

A.Face Detection and cropping

One of the preliminary phase in any face recognition problem is the face detection [1]. The face area should be detected from the image so that we can eliminate the unwanted backgrounds from the image which will considerably simplify the feature extraction process by eliminating the chances of extraction of false points. The inherent features of the face are used for detecting faces. For eg. frontal faces will be having two eyes, nose and mouth. By checking the image for these features, faces in images can be detected.

Viola Jones Algorithm [2][3] is used in this paper for face detection. Viola Jones is an object detection framework. It can be used for detecting a range of objects which include faces, cars, any particular shapes etc. Viola Jones algorithm can also be used to detect new objects by training the algorithm with sufficient number of samples.

Viola Jones Algorithm is a four stage algorithm. The four stages are (i) Haar feature extraction (ii) Creation of an integral image (iii) application an Adaboost based learning algorithm and (iv) Classification using a cascading classifier Once the face is detected using Viola Jones algorithm the next step is cropping the face area. In this paper apart from detecting faces Viola Jones algorithm is used for detecting the eye, nose and mouth area inside the cropped face region [2]. This is done to mark the Regions of Interest.

B.Feature Extraction

Extraction of feature points is the most critical step in any recognition process. While the recognition process is

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initiated the image is represented by these feature points alone. The recognition is done by comparing the feature points extracted from the image with the feature points of the images stored in the database. So the accuracy of the recognition or recognition rate will entirely depend on the accuracy of the feature points extracted from the image. This is true for all recognition processes whether it is face recognition or any other object recognition. In this paper only face feature extraction is considered. A lot of factors affect the features extracted by any feature extraction method. Sharpness of the image, lighting, occlusion, backgrounds etc. are some of them. SURF, Harris and FAST feature extraction methods are very good feature extraction methods. In this paper the feature extracted by these methods are compared. As far as faces are concerned the main features are eyes, eyebrows, mouth and nose. One thing which is common about these features is that they show large variation in the pixel values. For e.g. consider moving a kernel/ window from the forehead region to the eyebrow region. Here the forehead region will be having light shades and eyebrow will be dark area. There is a definite line which separates the eyebrow region from the forehead region. Thus an edge is encountered at the border of eyebrow and forehead. So any algorithm that can be used to detect edges or corners can be used to detect eyebrows. Similar is the case with eyes, nostrils, mouth etc.

Points in the Region of Interest (ROI) are the points lying in these border areas. For e.g. the points lying in the eyebrow, eye borders, nostril region and mouth borders etc. Other points which are detected may be irrelevant. They are called the false points. One of the major reason for false points is the noise in the images because noises show a large variation from the surrounding area and can be misunderstood for edges or corners. A good feature extraction method must be able to detect maximum number of relevant points while eliminating the false points from being extracted. In this paper emphasis is given for the number of points in the ROI while extracting the features. There may be cases were the number of feature points extracted is more but most of the points are false points. In such cases the accuracy of detection will be low. Taking this into account the comparison is done using two criteria in two levels. Level 1 Comparison is based on the performance index which is based on the ratio of number of ROI feature points and total number of points extracted. Performance index of the method gives the accuracy of feature extraction. Level 2 Comparison is based on the number of ROI feature points detected or extracted by the specified method while considering the performance index also. Level 2 comparison gives a clear picture of which method is better when it comes to feature extraction.

For the comparison purpose images from Yale database [4] and JAFFE [5] database are used. This paper deals with frontal face images only. Expression changes, changes due to ageing, presence of occlusions etc. are beyond the scope of this paper. So some images in the Yale database are excluded from the feature extraction.

III. DIFFERENT FEATURE EXTRACTION METHODS

A.Feature extraction using SURF feature Extraction

In (Speeded Up Robust Feature) SURF a hessian based blob detector is used to detect and find the points of interest [6][7][8]. It is a modified version of the Scale-Invariant Feature Transform introduced by Lowe. The speed performance of SIFT is improved in the SURF extraction as the name suggests. SURF algorithm is invariant to rotation, lighting, translation and contrast. It can also detect images which are taken under different environmental conditions [9]. In SURF algorithm an integral image is created from the input image and then Hessian Blob detector is applied to this image to detect the interest points.

B.Feature extraction using HARRIS Feature extraction method

Harris Feature extraction algorithm is a corner detection algorithm [10]. It is a modified version of the Moravec's corner detector. This algorithm was proposed by Harris and Stephen. In this method a sum of squared distance (S) is used which is given by

$$S(x,y)=\sum_{u}\sum_{v} w(u,v)(I(u+x,v+y)-I(u,v))^2 \quad (1)$$

S should have a large variation for the point to be a corner.

C.Feature Extraction using FAST Feature extraction

Features from Accelerated Segment Test (FAST) feature extraction is also a corner detection algorithm. Here a circle of sixteen pixels around the candidate pixel is considered [11]. The intensity of the candidate pixel represented by Ip is compared with 12 out of the 16 surrounding pixels. If 12 contiguous pixels around the candidate pixel are brighter than (Ip+t) or darker than (Ip-t), where t is a threshold value then Ip is classified as a corner.

IV. FEATURE EXTRACTION ON GRAY SCALE IMAGES

A.Comparison of Feature extraction by SURF, Harris and FAST extraction methods

As stated in section II(b) comparison is done with two criteria. First one is the performance index based comparison. For each image the features are extracted by using SURF, Harris and FAST feature extraction methods. The total number of points extracted by each method is noted. Also the total number of relevant points ie the points in the ROI are recorded. ROI is regions in eye, nose and mouth area. These areas are extracted using Viola Jones Algorithm in the first phase itself. Number of relevant points are the points which lie in the ROI which is denoted as ROI feature points. All the points which lie outside this ROI are considered as false points. From these values the performance index is calculated as

$$\text{Performance Index} = \frac{\text{ROI feature points}}{\text{Total points}} * 100 \quad (2)$$

Performance index gives the percentage accuracy of the detection of ROI points of the feature extraction method.

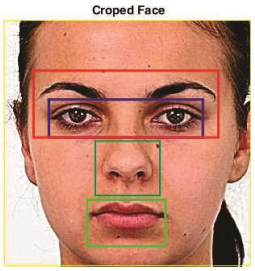


Fig 1: Cropped face showing Region of Interest

Table I Comparison of Number of points in ROI and performance index in grayscale images

Data Base	Image Name	No.of Points in ROI & performance index					
		SURF		Harris		FAST	
Yale Database	Subject 1	30	67%	20	100%	46	92%
	Subject 2	19	53%	6	75%	11	92%
	Subject 3	17	85%	3	100%	7	100%
	Subject 4	19	76%	7	100%	14	100%
	Subject 5	21	64%	11	85%	12	80%
	Subject 6	35	73%	16	100%	37	100%
	Subject 7	21	54%	7	100%	19	100%
	Subject 8	33	55%	3	30%	7	41%
	Subject 9	50	76%	10	91%	66	93%
	Subject 10	34	76%	9	100%	21	95%
	Subject 11	26	53%	16	64%	40	68%
	Subject 12	32	68%	21	78%	39	89%
	Subject 15	20	59%	4	67%	5	100%
JAFFE	KA.DI2.43	24	48%	8	100%	19	83%
	KA.DI1.42	31	55%	7	100%	21	84%
	KA.DI3.44	33	65%	5	100%	16	94%
	KA.FE1.45	33	65%	20	100%	27	93%
	KA.HA1.29	48	74%	42	95%	50	91%
	KL.NE1.155	34	81%	11	100%	36	100%
	KM.AN3.19	32	84%	20	95%	39	93%
	KR.AN3.85	35	67%	25	89%	33	89%
	MK.NE1.113	24	48%	18	90%	35	95%
	NA.NE3.201	28	72%	23	100%	27	96%

Considering the subject 1 from table I it can be noted that performance index of Harris method is 100% and that of FAST is 92% and of SURF is 67%. This indicates that all feature points extracted by Harris method is in the ROI, only 92% of the extracted feature points by FAST method lies in ROI. While considering SURF method, the performance index is very low when compared with the other two methods. From the table it is clear that considering the performance index Harris and FAST approaches are much better when compared with the SURF method. When comparing Harris and FAST method the performance index of Harris method is better for subject 1. With some exceptions for almost all cases FAST method is better. So as far as performance index is considered the first choice for Face feature extraction is FAST feature extraction method as it has given much better results than the other two methods. Fig 2 shows a bar representation of the comparison of performance index for various images using the three feature extraction methods under discussion.

Before finalizing which method is good, one more criteria have to be considered. It is the number of ROI feature points extracted. Considering the performance index alone may not give the desired result when the robustness of the feature extraction is considered. This is because performance index gives only the percentage accuracy of the detected points. It does not consider the number of points detected in ROI. A good performance index does not ensure that the number of feature points extracted are sufficient for representing the face image with some degree of accuracy. There may be cases when only a few feature points are extracted in one method and all the feature points lie in the ROI. This will give a performance index of 100% while another method which has got a performance index of 90% has extracted more number of feature points in the ROI. Here if the number of ROI feature points extracted in this method is more when

compared with the method with 100% performance index then the second method should be considered since the performance index is not very low. This becomes relevant if the following example is considered. If method 1 extracts only 15 points and all the 15 points lie in the ROI and method 2 extracts about 65 points and 5 of them are false points, then it will be beneficial to consider method 2 over method 1 since more number of feature points are detected. In second case the performance index is 92.3 % only while in the first it is 100%. So there is a tie between the performance index and the number of ROI feature points. It is bad to compromise in any of these criteria beyond a point. If the performance index is very less, then that method should not be considered even if the number of points is much more when compared with other methods. This is due to the fact that in such cases eliminating the false points becomes a very tedious job. So while a comparison is made based on the number of ROI feature points extracted by each method the performance index is also included.

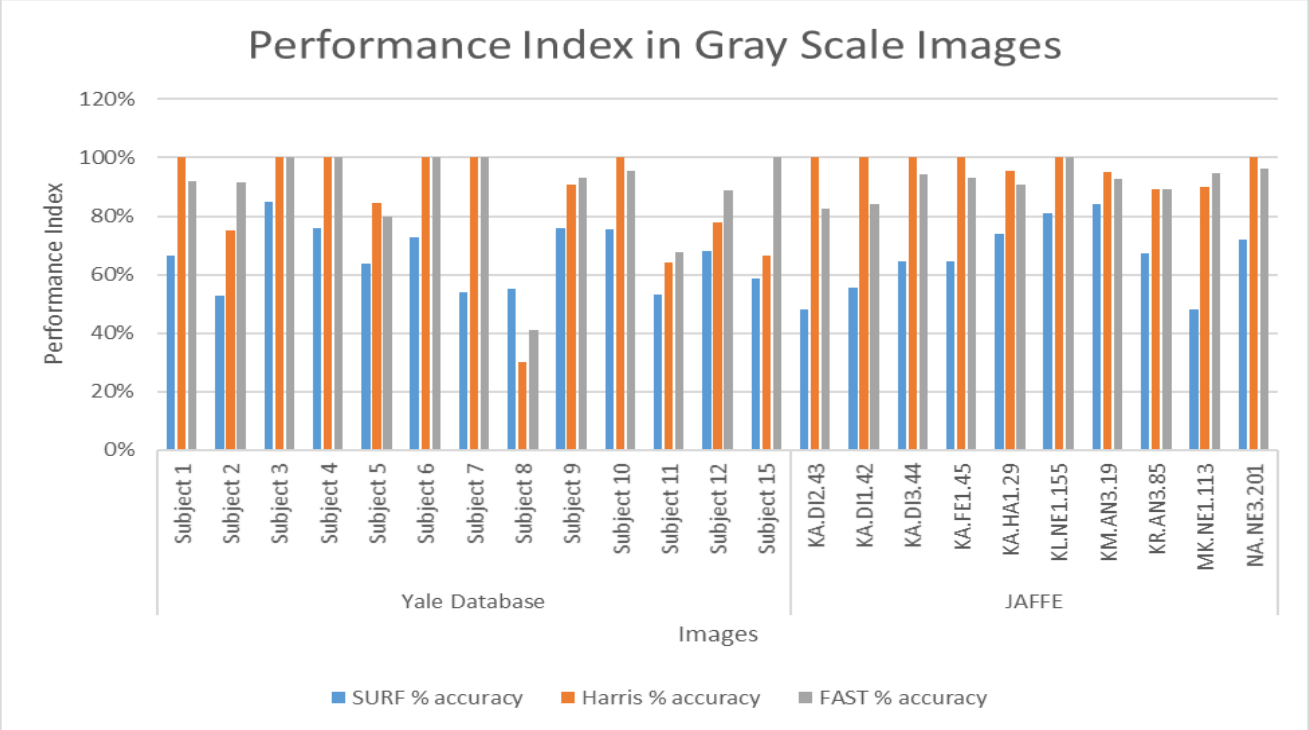
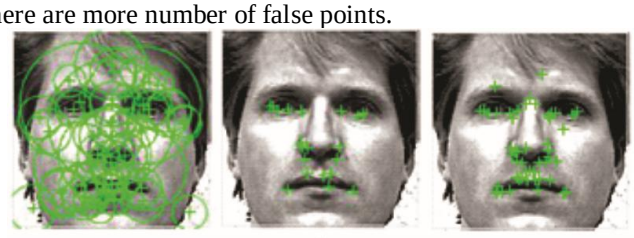


Fig. 2 Comparison of performance index of SURF, Harris and FAST feature extraction methods

A performance index of 70% and above can be considered as a good one. When comparing number of feature points in ROI should be given more priority than performance index.

In table I consider subject 1 in the Yale data base. If performance index alone is taken as the criteria for selecting the right method for feature extraction, then Harris feature extraction method will be the first choice since the performance index of Harris is 100% while that of SURF and FAST are 67% and 92% respectively. But if the number of relevant feature points is also considered here Harris has detected the least number i.e. 20 points while that of FAST and SURF are 46 and 30 respectively. So considering both performance index and number of relevant points for Subject 1 in Yale database FAST feature extraction method with performance index 92% and number of relevant points 46 is the apt one. In the JAFFE data base KA.DI3.44 has the least number of feature points detected. For SURF, Harris and FAST the number of feature points extracted are 33, 5 and 16 respectively. Here also FAST will be the best algorithm that can be used because out of the 17 points detected 16 points lie in ROI and only 1 point is false point. While considering SURF even though the number of feature points in ROI is 33 it is only 65% of the total number of points extracted. i.e. there are more number of false points.



a b c

Fig 3 Comparison of ROI points detected by (a)SURF (30 points), (b)Harris (20 points) and (c)FAST (46 points) methods applied to subject 01 in Yale Database.

Here total number of points detected is 51. So number of false points is 18 which is very high when compared with 1 false point in FAST feature extraction method.

Fig. 3 shows the comparison of ROI feature points extracted from Subject 1 in Yale Database using SURF, Harris and FAST feature extraction methods.In SURF feature extraction number of ROI feature points extracted is 30 out of the total feature points of 45 that in Harris is 20 out of 20 and FAST is 46 out of 50.

Fig. 4 shows a bar representation of the comparison of number of ROI feature points for various images using the three feature extraction methods under discussion.

From Fig.4 it is very clear that more number of ROI feature points are extracted by FAST feature extraction method. For Harris the number of ROI feature points are less when compared with other two methods. There are some exceptional cases where the number of ROI feature points in SURF method is more than in FAST method. But in such cases when the performance index is considered the FAST method is giving much better results.

V. CONVERTING IMAGES TO PENCIL SKETCH

From the experiments done so far it is clear that the feature points are present in the corners and edges of the face. For example, to detect eyes the algorithm will be checking for immediate change in the pixel intensity values, i.e. from dark to bright or bright to dark region. Such regions are the corners or edges. Similarly, the points representing the mouth also lie at edges and corners. By applying Harris, SURF and FAST feature extraction this property of face has been utilized for finding the feature points. Even though the SURF, Harris and FAST methods have extracted feature points in all the images in the database in some images the number of feature points extracted seems to be insufficient.

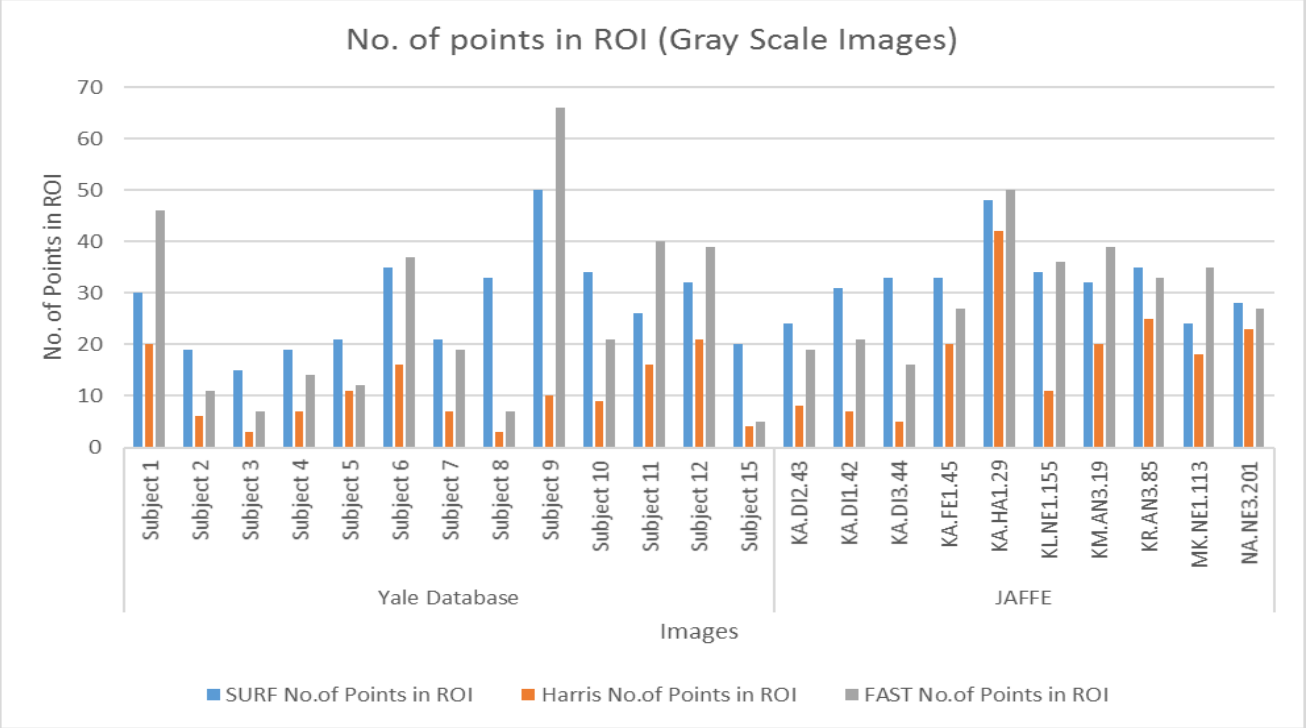


Fig 4 Comparison of number of ROI feature points using the three feature extraction methods under discussion

For example, consider feature extraction on subject 3 in the Yale database (see Fig. 5). Here both Harris and FAST has extracted very few feature points. Only SURF has shown an average performance. However, in this image the number of feature points extracted by all the three methods are insufficient. In the case of Harris and FAST not even a single point in the mouth has been extracted. For such images if the edges and corners are made more prominent then it should improve the feature extraction. One method by which the edges and corners can be enhanced is by converting the image to pencil sketches [12][13][14][15].

In the proposed method the edges and corners in the face are enhanced by applying a convolution filter thus improving the performance of the edge/corner detection algorithm. Convolution filters are applied to images for different purposes like detecting lines, sharpening images, embossing etc. For different purposes different types of filter kernels are used. Here a 2D convolution filter is used to enhance the edges and corners and convert the image to a pencil sketch. A convolution filter consists of a kernel or window with some weight values.

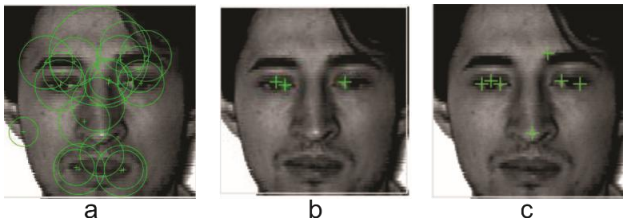


Fig 5 Feature points extracted by using (a) SURF-17points (b) Harris -3points (c) FAST – 7points feature extraction methods

When a convolution filter is applied to an image the central pixel of the kernel will be the weighted sum of the neighboring pixels. The kernel is moved throughout the image and each pixel is altered depending on the weights and the value of the neighboring pixels.

Convolutional filters can be designed with different weights. The output image will be depending on the weights selected for the convolutional filter. Here a Double Sized Scaled Horizontal Vertical Oblique (DSHVO) filter is used. This filter alters all the neighboring pixels. i.e. this

convolutional filter will alter horizontal, vertical and diagonal pixels based on the weights in the kernel. Also instead of using a 3x3 kernel here a 6x6 kernel is used which will be giving a nearly pencil sketch image when applied to a gray scale image. All the values above 255 in the filter are clamped to 255. When considering the 36 entries of the kernel, it is easy for the pixel value to go beyond 255 if the value is slightly greater than 0 itself. This will make the image very dark.

The Double sized Horizontal Vertical Oblique Filter is represented as

$$Ob' = [I, I, I; I, -8I, I; I, I, I] \quad (3)$$

where I=[1, 1; 1, 1]

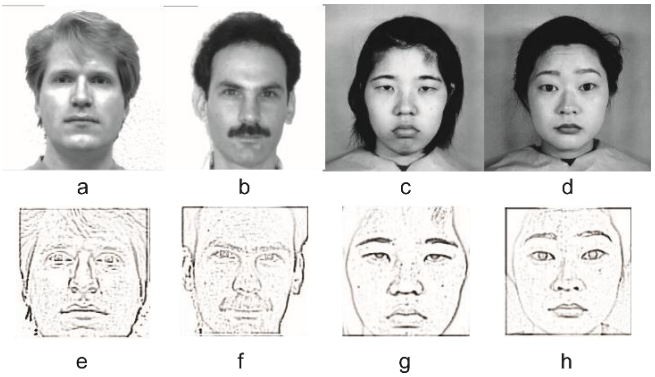


Fig 6 (a & b) subject 1 & 2 of Yale database, (c) KL.NE1.155 (d) KM.AN3.19 (e to h) represents the corresponding pencil sketches

This filter is scaled by dividing all the pixels in the kernel by 8. ie to get scaled filter Ob'/8 should be calculated.

The proposed filter is applied to all the images in the Yale and JAFFE database. Fig. 6 shows the result of applying the proposed filter to Yale and JAFFE database images. Only sample images are shown.

From Fig. 6 we can see that the conversion of images into pencil sketches has considerably highlighted the feature points like eyes, eyebrows, nostrils and mouth. Also the filter has helped to remove the background shades in the JAFFE database images Fig.6 (c & d).

A.Feature extraction on Pencil sketches

By applying the DSHVO filter the images are converted to pencil sketches. The next step is to apply the feature extraction method. The three feature extraction methods are applied to the pencil sketches. The number of ROI feature points extracted by each method for the pencil sketch images in Yale and JAFFE database are tabulated and the results are compared. Also the Performance index of the images for each method are obtained.

Table II shows the Number of ROI feature points and performance index of Pencil Sketch images. From the table it can be inferred that the response of FAST method is very high. i.e. FAST feature extraction method is extracting the maximum number of ROI feature points. The Number of ROI feature points in case of Harris and SURF methods are almost same. But when the performance index is considered the response of Harris and FAST method is much better than that of SURF.

When considering the both the number of ROI feature points and performance index of these 3 methods the pencil sketch approach is giving a good result. Even though the performance index in pencil sketch images is less than in grayscale the reduction in performance index when compared with the increase in the number of ROI feature points is much less. An average performance index of 70 % and above is achieved for Harris and FAST methods with a very few exceptions.

B.Comparison of Feature extraction on pencil sketches with Gray scale images

As discussed in section V the conversion of grayscale images to pencil sketches should improve the prominence of the edges in the face and this should improve the feature extraction method. For comparison purpose the same image that is illustrated in fig 5 is used here to depict the change in the number of ROI feature points detected. Fig 7 shows the feature points extracted for the Yale database image of subject 3. From the figure it is clear that converting the image to pencil sketch has no improvement in the case of SURF method while it has shown considerable improvement in Harris (i.e. from 3 to 10 points) and FAST methods (7 to 33 points).

Table II: Comparison of Number of ROI feature points and performance index of Pencil Sketch images

Data Base	Image Name	No.of Points in ROI & performance index					
		SURF		Harris		FAST	
Yale Database	Subject 1	40	68%	44	98%	102	74%
	Subject 2	28	57%	26	81%	46	87%
	Subject 3	16	52%	10	100%	33	89%
	Subject 4	15	71%	15	94%	57	90%
	Subject 5	10	45%	10	71%	52	75%
	Subject 6	25	71%	29	100%	87	76%
	Subject 7	15	63%	13	100%	77	87%
	Subject 8	27	44%	11	29%	27	33%
	Subject 9	54	64%	47	82%	129	76%
	Subject 10	12	60%	10	100%	50	93%
	Subject 11	25	74%	39	78%	96	69%

	Subject 12	32	65%	47	75%	108	86%
	Subject 15	9	31%	8	62%	50	81%
JAFFE	KA.DI2.43	31	78%	22	88%	71	68%
	KA.DI1.42	15	31%	20	87%	77	70%
	KA.DI3.44	29	81%	17	89%	81	79%
	KA.FE1.45	29	74%	24	89%	67	61%
	KA.HA1.29	51	78%	41	84%	95	74%
	KL.NE1.155	27	71%	28	97%	78	83%
	KM.AN3.19	30	73%	32	89%	77	85%
	KR.AN3.85	24	65%	31	84%	75	86%
	MK.NE1.113	30	77%	30	77%	77	84%
	NA.NE3.201	26	79%	23	88%	64	88%

a b c

Fig 7 Feature points extracted by using (a) SURF-16points (b) Harris -10points (c) FAST – 33points feature extraction methods

One of the most considerable improvement in the Harris and FAST method is that the feature points in the mouth region are also detected in the pencil sketch while in the grayscale not even a single point in the mouth region was detected. Also the number of ROI feature points detected has increased more than 4 times in the FAST feature extraction method by converting the image into pencil sketch.

C.Difference table

Converting the grayscale images to pencil sketches has shown changes in the number of points extracted by the three feature extraction methods. In order to compare the results obtained in pencil sketch images with grayscale images the difference in the number of ROI feature points have to be evaluated.

For this comparison the difference values are taken and tabulated. The table thus obtained is named as the ROI feature point difference table (Table III).

The Difference Value (D_v) is calculated as

$$D_v = RF_p - RF_g \quad (4)$$

where RF_p =Number of ROI feature points in pencil sketch and RF_g = Number of ROI feature points in gray scale

Table III Comparison of Difference values by SURF, Harris and FAST Methods

ROI feature point difference table				
		SURF	Harris	FAST
Yale Database	Subject 1	10	24	56
	Subject 2	9	20	35
	Subject 3	1	7	26
	Subject 4	-4	8	43
	Subject 5	-11	-1	40
	Subject 6	-10	13	50
	Subject 7	-6	6	58
	Subject 8	-6	8	20
	Subject 9	4	37	63
	Subject 10	-22	1	29
	Subject 11	-1	23	56
	Subject 12	0	26	69
	Subject 15	-11	4	45
JAFFE	KA.DI2.43	7	14	52
	KA.DI1.42	-16	13	56
	KA.DI3.44	-4	12	65
	KA.FE1.45	-4	4	40
	KA.HA1.29	3	-1	45
	KL.NE1.155	-7	17	42
	KM.AN3.19	-2	12	38
	KR.AN3.85	-11	6	42
	MK.NE1.113	6	12	42
	NA.NE3.201	-2	0	37

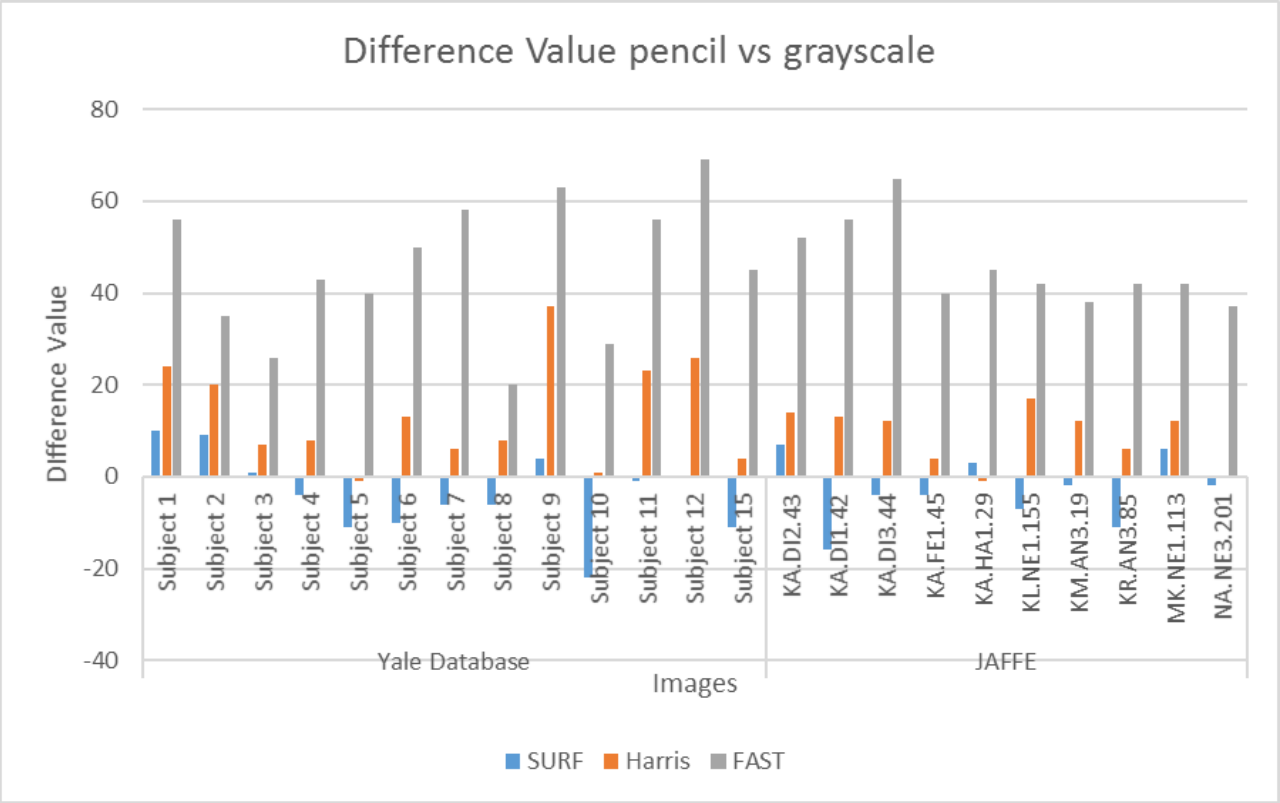


Fig 8 Bar chart showing the difference values when comparing the No. of ROI feature points in pencil sketch vs grayscale

A positive difference value indicates the improvement in the feature extraction. So as per the assumptions made so far a positive difference value is desirable and a negative value is highly undesirable because a negative value indicates that the conversion of image from grayscale to pencil sketch has weakened the feature extraction method.

From Fig. 8 we can see that converting the gray scale image into pencil sketch has decreased the performance of SURF method. For most of the images the difference value is negative indicating a downgrading of the performance of SURF method by a small value. For Harris and FAST methods all the difference values are positive indicating an improvement in the performance. Harris and FAST method shows an improvement in the number of ROI feature points extracted. Table IV shows the average difference value obtained by SURF, Harris and FAST methods.

Table IV Average Difference Values for Yale and JAFFE Database images

Image	Difference Values Average		
	SURF	Harris	Fast
Yale Database	-3.62	13.54	45.39
Jaffe	-3	8.9	45.9

Taking into consideration these facts FAST is the optimal feature extraction method. It has got maximum enhancement.

VI. CONCLUSION

In this paper three different feature extraction approaches are applied to grayscale images. The feature extraction methods used are SURF, Harris and FAST feature extraction methods. These are applied to images in Yale and JAFFE database and their performance index and number of feature points in ROI are obtained. From the comparison it is clear that the FAST method gave very good results. So it can be concluded that when using gray scale images FAST feature extraction method is the optimal method. An attempt has also been made to increase the accuracy of these methods by converting the grayscale images to Pencil sketches before the application of the feature detecting algorithms. It was found that the conversion to pencil sketch has helped to bring considerable increase in the detection rate and accuracy of detection by Harris and FAST methods. A comparison test is done with the performance index and number of ROI feature points extracted by Grayscale and pencil sketch images by these methods. For the comparison test a difference table was tabulated and based on difference values it was found that FAST method gave maximum accuracy when compared with Harris and SURF methods. When considering all the images tested here SURF gave an average difference value of -3.31, for Harris it is 11.22 and for FAST it is 45.65.

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