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A novel approach for nose-tip detection on 3D face images across pose

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***Abstract*- This paper investigates a novel technique for extraction of the nose-tip from three-dimensional face image in any pose, which is needed for nose-tip based face registration. The present technique uses weighted median filter for smoothing. No normalization process is applied and the system correctly detects nose-tips across any pose variations. In our system, at first the range images are thresholded using Otsu's thresholding algorithm, then filling of holes is done using interpolation method and after that smoothing is done using weighted median filtering mechanism. In the last and final step, nose-tip is detected using maximum intensity algorithm. To evaluate the performance of our approach for nose-tip localization, we have used FRAV3D, GavaDB and Bosphorus database. In case of FRAV3D database out of 542 range images, nose-tips were correctly located for 536 images thus giving 98.70% of good nose-tip localization, in contrast to the method without smoothing which accounted for only 521 face images. In case of GavaDB database, nose-tip was correctly recognized for 421 images out of 549 images thus giving 76.68% of good nose-tip localization in contrast to the method without smoothing which accounted for only 405 face images. In case of Bosphorus database the recognition rate for nose-tips was far better than FRAV3D and GAVADB because the present technique detects nose-tips correctly for 4476 images out of 4935 correctly with smoothing in contrast to the method without smoothing which accounted for only 4333 face images. The overall performance of the system is 90.27% with smoothing whereas the original system gave a performance of only 87.27%.From the results we can conclude that maximum intensity technique has great capabilities for nose-tip detection across variant poses and that Bosphorus database has given a better result than FRAV3D and GAVADB database.**

Keywords- Face Recognition, threshold, pose, smoothing, weighted median

I. INTRODUCTION

In recent years 3D(three-dimensional) face recognition has gained much popularity because 3D face meshes deliver a simple and flexible way to represent and handle complex geometric objects like 3D face mesh grids. With the advances in acquisition hardware and 3D recognition algorithm, 3D face recognition has become an important biometric modality. For a face to be correctly recognized it must be perfectly registered. The purpose of 3D face registration is to align different 3D face data into a common coordinate system. This alignment is usually done based on some features, for example, nose-tip, eyes etc which are invariant to pose, lighting conditions, expressions etc. Registration is a crucial step because the accuracy of this step will greatly influence the performance of the whole face recognition system. The accuracy of a 3D face depends on correct registration. In this paper, we have developed an algorithm to extract the feature i.e. the nose-tip which is an essential criterion for face registration. Due to environmental interference, it has been observed that the surface of a 3D model reconstructed from real-world data is often corrupted by noise. An important problem is to suppress noise while preserving the geometric features of the model. In this paper, we extend the idea of weighted median filtering scheme for smoothing noisy 3D faces. The main idea of our approach consists of applying weighted median filtering to points on mesh grids and then applying a feature detection algorithm i.e. locating the nose-tip on a 3D face in any orientation. The present work is an extension of smoothing by weighted median filtering done in our previous work [11]. Here, we discuss a comparison of our methods over previous smoothing[5] methods. In literature a number of smoothing techniques have been proposed in the past. Multiresolution analysis for smoothing is only based on wavelets for triangle meshes with subdivision connectivity. In contrast our method works on all types of 3D images. On the other hand, Laplacian methods work like high and low pass filters and their problem is that they reduces the surface curvature and tends to flatten the surface. So, the geometry is damaged. But in case of our proposed method of weighted median filters the geometry of our 3D image is not damaged. Also, median filters are simple and very effective tools for noise suppressing. The basic idea of the median filtering consists of simultaneous replacing every pixel of an image with the median of the pixels contained in a window around the pixel. The median filter[10] was once the most popular nonlinear filter for removing impulse noise because of it good denoising power keeping sharpness of the images intact, but the performance are unsatisfactory when noise ratio is high. On the other hand, our proposed method of weighted median filtering has uniform smoothing effect that suppresses noise to a great effect in contrast to median filters. Mean filters[2] are also powerful tools for noise suppression but sharp feature are not restored by mean filters. But in case of our weighted median filtering sharp features are restored by weighted median filtering. Gaussian filters[3] have a tendency of smoothing which is not uniform because they have a tendency of smoothing towards the central pixel. Also Gaussian filters have the disadvantage that they are less robust to noise elements. Here, in this case of our proposed algorithm the smoothing is uniform. Also, there are maximum value filters which is similar to a dilate function. Each 3×3 (or other window size) pixel is processed for the brightest surrounding pixel. That brightest pixel then becomes the new pixel value at the center of the window. In contrast, a minimum filter blurs the image by replacing each pixel with the difference of the highest pixel and the lowest pixel (with respect to intensity) within the specified window size. But in case of min and max filters the SNR ratio is very small i.e. the removal of noise is not very promising. But in case of our proposed algorithm we have obtained a smoothing which has removed maximum noisy spikes. Weighted median[1] filter apply median operation to each pixel regardless if the current pixel is contaminated or not, and can easily handle various types of noise. In our method, from the training set of 3D mesh image in any pose the face images have been smoothed [7] by weighted median filtering and the nose tip has been correctly localized as having the highest intensity value. A facial feature extractor, which uses the proposed smoothing technique, has been introduced in Section 2. A performance analysis of the algorithm is given in Section 3.Experimental results have been given in Section 4. Finally conclusion and future scope is given in Section 5.

II. PROPOSED ALGORITHM

A range image (Fig 1) is a set of points in 3D each containing the intensity of individual pixels. The technique also holds in case of 2.5D images which may be described as containing at least one depth value for every (x, y) coordinate. The acquisition process is described as follows:- Normally, a 3D mesh image is captured by a 3D camera such as a Minolta Vivid 700 camera and a range image is generated from the 3D mesh image. The image in our case is generally in the form of z = f(x, y). Next, some pre-processing methods is applied to eliminate unwanted details such as facial hairs, scars etc.

Figure 1. Face images; 2.5D range image

After the necessary features are located, the alignment of models is done using some translation and rotation process. In the last and final step a classifier is designed to test the validity of the designed dataset. Normally, a procedure for face recognition using range images is composed of seven steps, shown in Fig-2.The present technique makes use of the steps below:-

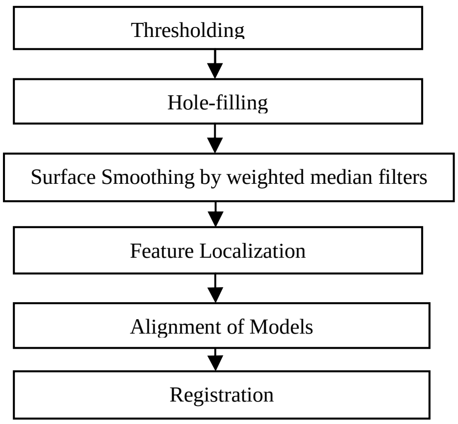
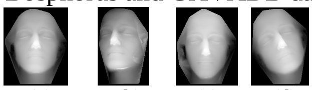


Figure 2. An overview of the proposed system

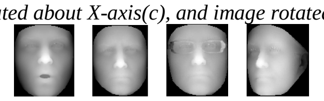
A. Facial Image Acquisition:- The present technique uses three face databases FRAV3D, GavabDB, and Bosphorus database[4]. We have considered 542, 549 and 5304 3D faces consisting of different poses (including rotation about x-axis, y-axis and z-axis) from the FRAV3D, GavabDB, and Bosphorus databases respectively. A range image is actually an array of numbers where the numbers quantify the distances from the focal plane of the sensor to the surfaces of objects within the field of view along rays emanating from a regularly spaced grid.

Different from 3D mesh images, it is easy to utilize the 3D information of range images because the 3D information of each point is explicit on a regularly spaced grid. Due to these advantages, range images are very promising in face recognition. The fig-3, fig-4, and fig-5 below show samples of range images that we have taken for testing from the FRAV3D, Bosphorus and GAVADB databases respectively.



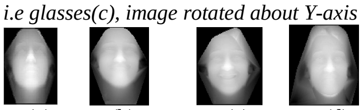
(a) (b) (c) (d)

Figure 3. Samples from the FRAV3D Database corresponding to a single person for frontal pose(a), image rotated about Y- axis(b), image rotated about X-axis(c), and image rotated about Z-axis(d).



(a) (b) (c) (d)

Figure 4. Samples from the Bosphorus Database corresponding to a single person(female) for frontal pose(a), sad_expression face(b), face with occulsions i.e glasses(c), image rotated about Y-axis at an angle of 20 degrees(d).



(a) (b) (c) (d)

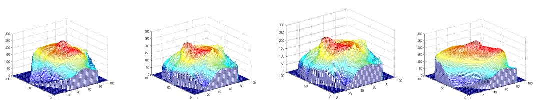
Figure 5. Samples from the GavaDB, corresponding to a single person(female) rotated about x axis(a), rotation and change in expression(b), face with occulsions i.e glasses(c), frontal pose with change in expression(d).

B. Thresholding:- Thresholding [2] is an important technique for image processing that one tries to identify and extract a target from its background on the basis of the distribution of gray levels or texture in image objects. The simplest method is a gray level image and it's background. Pixels with similar value in the neighborhood usually belong to the same region. For a gray level image f(x, y), bi-level thresholding is to transform f(x, y) into a binary image g(x, y) based on a threshold value, which can be expressed as:

$$g(x, y) = 0 \;\; if \;\; f(x, y) < T$$

$$= 1 \;\; if \;\; f(x, y) \geq T \;\; \ldots\ldots\ldots\ldots\ldots\ldots \; (1)$$

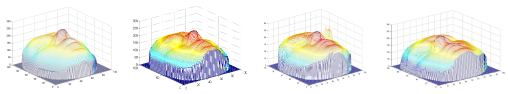
Otsu's method is an adaptive thresholding technique that is applied here. Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either falls in foreground or background. Otsu's method selects the threshold by minimizing the within- class variance of the two groups of pixels separated by the thresholding operator. After applying Otsu's method, 3D thresholded mesh grids corresponding to depth maps for the samples of FRAV3D, Bosphorus, and GavabDB databases, as shown in Fig 3, Fig 4, and Fig 5, are computed and shown in Fig 6, Fig 7, and Fig 8 respectively.



(a) (b) (c) (d)

(a) Frontal pose (b) Rotated about y-axis(c) Rotated about x-axis (d) Rotated about z axis

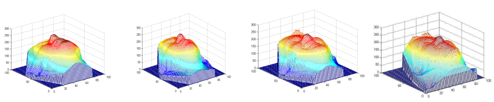
Figure 6. Mesh-grids after thresholding from FRAV3D



(a) (b) (c) (d)

(a) Frontal pose (b) sad_expression face (c) face with occulsions i.e glasses (d) image rotated about Y-axis at an angle of 20 degrees.

Figure 7.Thresholded images are shown from Bosphorus Database.

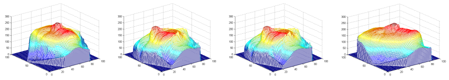


(a) (b) (c) (d)

(a)Image rotated about x-axis (b)Expression face (c)Smiling face (d) Frontal pose with expression

Figure 8. Thresholded images are shown from GavaDB Database.

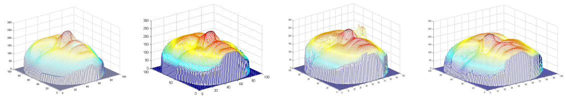
C. Hole-filling:- This step is usually done if the 3D data which has been acquired from the scanners contains some missing parts i.e. holes. Normally, we performed hole filling using interpolation method. But in our case not much of the figures either from FRAV3D, GavabDB or Bosphorus databases contained missing parts. The hole-filled mesh grids corresponding to Fig 6, Fig 7, and Fig 8 are shown in Fig 9,Fig 10 and Fig 11 respectively.



(a) (b) (c) (d)

(a) Frontal pose (b) Rotated about y-axis (c) Rotated about x-axis (d) Rotated about z axis

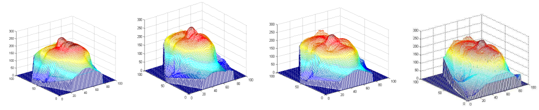
Figure 9. Mesh-grids after hole-filling from FRAV3D



(a) (b) (c) (d)

(a) Frontal pose (b) sad_expression face (c) face with occulsions i.e glasses (d) image rotated about Y-axis at an angle of 20 degrees

Figure 10. Mesh-grids after hole-filling from Bosphorus database



(a) (b) (c) (d)

(a)Image rotated about x-axis (b)Expression face (c)Smiling face (d) Frontal pose with expression

Figure 11. Mesh grids after hole-filling from the GavaDB database

D. Surface Smoothing:- Surface smoothing refers to the fact that noisy spikes and other various deviations are sometimes caused on the 3D face image by noise and other several other factors. So some type of smoothing techniques are to be applied. In our present technique we have extended the concept of 2D weighted median filtering technique to 3D face images. The present technique performs filtering of 3D dataset using the weighted median implementation of the mesh median filtering. The weighted median filter is a modification of the simple median filter.

Weighted median filtering: - Weighted Median (WM) filters are the filters that have the robustness and edge preserving capability of the classical median filter and resemble linear FIR filters. In addition weighted median filters belong to the broad class of nonlinear filters called stack filters. This enables the use of the tools developed for the latter class in characterizing and analyzing the behaviour of Weighted Median filters in noise attenuation capability. Applications of weighted median filters include idempotent weighted median filters for speech processing, adaptive weighted median and optimal weighted median filters for image and image sequence restoration.

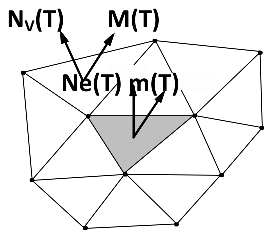


Figure 12. Original mesh triangle

Fig. 12 shows an oriented triangle mesh. Let T be a mesh triangle, n(T) be the unit normal of T, A(T) be the area of T, and C(T) be the centroid of T of the mesh triangle. Let us divide the set of neighboring triangles of a given triangle in two subsets: -The set of mesh triangles Ne(T), the set of mesh triangles sharing an edge with T and the set of mesh triangles Nv(T) sharing a vertex with T. We have assigned weights 1 to triangles of Ne(T), and weights 1 to triangles of Nv(T) (Fig.7).The triangle in Fig.13 shaded in black is the median. Positive weights tend to smooth the 3D images. On the other hand, negative weights distort the noise elements. After the entire filtering operation, we select the median of the mesh triangle.

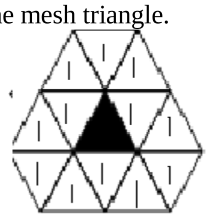
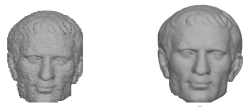


Figure 13. Various weights allocated to triangles of mesh

Fig. 14 shows the effect of smoothing.



(a) *(b)*

Figure14. (a) Noisy Model (b) Smoothed Model

The weighted median filtering scheme [1] described below is a simple and useful modification of the basic median filter. Consider a set of samples(x_0, x_1... x_{n-1}) and positive weights (w_0, w_1,...w_{n-1}). It is evident that the elements with higher weights are more frequently selected by the median filter. The present algorithm for smoothing works as follows:-

Function Weighted Median (Input mesh)

Step 1:-Input the mesh grid.

Step 2:- Initialize a weight matrix w consisting of positive weights with 27 elements.

Step 3:- Build the neighbourhood. The neighbourhood of the mesh grid should be a cubic power of an integer (e.g. 3×3×3=27, 5×5×5=125) depending on the filter's window dimension (3×3×3,5×5×5 and so on) The structuring element coefficients h(i, j, k); i, j, k=1,…,N. The coordinates i, j, and k correspond to 3D coordinates x, y, z. In the present algorithm, we have taken the neighbourhood to be consisting of 27 elements.

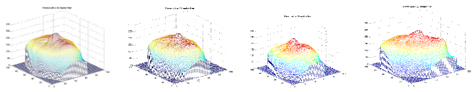
Step 4:- Perform the processing on the median pixel surrounded by the neighborhood points.

Step 5:- Now sort the 27 elements.

Step 6:- Return the median element i.e. the 14th element.

End Function

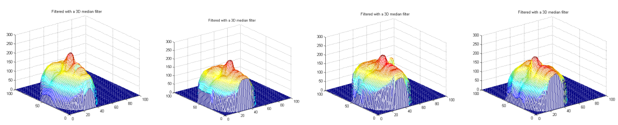
The algorithm was run for 100 iterations and considerable smoothing was obtained. After smoothing the results corresponding to Fig 9, Fig 10, Fig 11 are obtained in Fig 15, Fig 16 and Fig 17 respectively.



(a) *(b)* *(c)* *(d)*

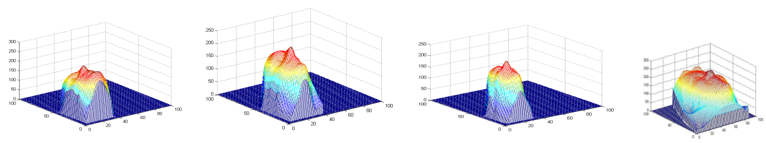
(a) Frontal pose (b) Rotated about y-axis(c) Rotated about x-axis (d)Rotated about z axis

Figure 15. Mesh-grids after smoothing from FRAV3D



(a) Frontal pose (b) sad_expression face (c) face with occulsions i.e glasses (d) image rotated about Y-axis at an angle of 20 degrees

Figure16. Mesh-grids after smoothing from Bosphorus database



(a)Image rotated about x-axis (b)Expression face (c)Smiling face (d) Frontal pose with expression

Figure17. Mesh grids after hole-filling from the GavaDB database

E. Feature Localization:- Faces have a common general form with prominent local structures such as eyes, nose, mouth, chin etc. Facial feature localization is one of the most important tasks of any facial classification system. To achieve fast and efficient classification, it is needed to identify features which are mostly needed for classification task.

- *Surface Generation:*-The next part of the present technique concentrates on generating the surface [8] of this 3D mesh image. For the nose tip localization we have used the maximum intensity concept as the tool for the selection process. Each of the 542 faces (including rotation in any direction in 3D space namely about x-axis, y-axis and z-axis) in the FRAV3D database has been next inspected for localizing the nose tip. A set of fiducial points are extracted from both frontal and various poses of face images using a maximum intensity tracing algorithm. As shown in Fig.10, the nose tips have been labeled on the facial surface, and accordingly, the local regions are constructed based on these points. The maximum intensity algorithm used for our purpose is given below:-

Function Find_Maximum_Intensity (Image)

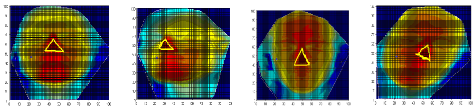
Step1:- Set max to 0

Step 2:- Run loop for I from 1 to width (Image)

Step 3:- Run loop for J from 1 to height (Image)

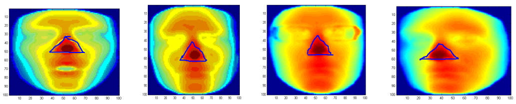
Step 4:- Set val to sum (image (I-1:I+1,J-1:J+1))
Step 5:- Check if val is greater than max.
Step 6:- Set val to val2
Step 7: - End if
Step 8:- End loop for I
Step 9:- End loop for J

The 3D surfaces thus generated for FRAV3D, Bosphorus and GavaDB are shown in Fig 18, Fig 19, and Fig 20 respectively.



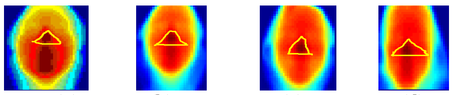
(a) (b) (c) (d)

Figure 18. Surface Generation with nose localized from the FRAV3D Database.



(a) (b) (c) (d)

Figure 19. Surface Generation with nose localized from the Bosphorus database.



(a) (b) (c) (d)

Figure 20. Surface Generation with nose localized from the GavaDB database

F. Alignment of Models:- After feature localization, based on the extracted features we have aligned the extracted face model. This alignment [14] with the major axes greatly simplifies the task for registration. These features are then used for coarse alignment and scale normalization. To eliminate the tilt along Y-axis, the image has to be rotated and that rotation can be obtained by multiplying the original pointcloud image by the matrix given as follows:-

$S_i^{'} = M_y * S_i$ where

$$M_y = \begin{bmatrix} -\sin(theta) & 0 & \cos(theta) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin(theta) & 0 & \cos(theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

To eliminate the tilt along X-axis, the image has to be rotated and that can be obtained by multiplying the original pointcloud image by the matrix given as follows:-

$S_i^{'} = M_x * S_i$ where

$$M_x = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(theta) & -\sin(theta) & 0 \\ 0 & \sin(theta) & \cos(theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

To eliminate the tilt along Z-axis, the image has to be rotated and that can be obtained by multiplying the original pointcloud image by the matrix given as follows:-

$S_i^{'} = M_z * S_i$ where

$$M_z = \begin{bmatrix} \cos(theta) & -\sin(theta) & 0 & 0 \\ \sin(theta) & \cos(theta) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

By calculating this matrix for a variety of rotations an orientation which maximizes the symmetry can be chosen. So this pre-processing is actually essential for finding the correspondence between two surfaces which would finally help in registration.

III. PERFORMANCE ANALYSIS OF THE PROPOSED ALGORITHM

In accordance with the method that we have discussed so far, we hereby also present a performance analysis for that method. In Fig 21, an original 3D image from the FRAV3D database has been shown. Next we compare our method with five different filters that we have implemented and those are shown in Fig 22, Fig 23, Fig 24, Fig 25 and Fig 26. These are benchmark filtering methods namely, Min, Max, Gaussian, maximum and minimum filters. We have selected the noisiest image from the FRAV3D database in this case and we have shown that our weighted median filter performs much better than the other benchmark filtering methods, shown in Fig 27.

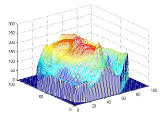


Figure21.Original noisy image from FRAV3D Database

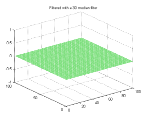


Figure 22. 3D image after being smoothed by min filter

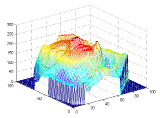


Figure 23.3D image after being smoothed by max filter

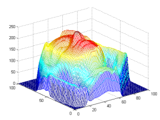


Figure 24. 3D image after being smoothed by Gaussian filter

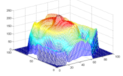


Figure 25. 3D image after being smoothed by Mean filter

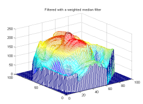


Figure 26. 3D image after being smoothed by weighted median filter

Now let us analyze the performance of our method, comparisons with other method are summarized below:-

- Min filter is not working on 3D.
- Max filters smoothing effect is not satisfactory.
- Gaussian filters smoothing quality is good but edges are not preserved
- Mean filters also does not preserve edges
- Weighted median filters smoothing quality is better than Gaussian and Mean filters and also edges are preserved.

IV. EXPERIMENTAL RESULTS

The testing phase has been performed on the FRAV3D database itself and it contains a comparison of the present algorithm using smoothing as compared to the algorithm without smoothing. The data set contains 542 faces out of which 282 faces were in neutral pose, 94 faces were rotated about z axis, 94 faces about y axis and 72 faces about x axis.

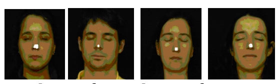


Figure 27. Some samples in frontal pose from FRAV3D Database

A. *Frontal pose:* - The first test was made on the face models in frontal pose only (Figure. 27) (models simulate un-supervised conditions during acquisition). During this test all face models (only frontal poses selected consisting of 282 faces) were accepted and nose tip were correctly localized.

B. Before smoothing :- The images were not smoothed and nose tips correctly recognized.

C. After smoothing: - The images were smoothed and nose tips correctly recognized.

TABLE I. NOSE LOCALIZATION IN FRONTAL POSE

Table1	Nose-tip localization in frontal pose			
	No. of Nose Tips	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
	282	282	100%	0%

B. Rotation about Y-Axis:- The second test was performed on the face models taking the faces rotated about Y axis, some of them are shown in Fig 28.

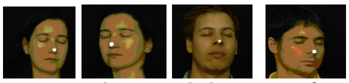


Figure 28. Some samples rotated about y-axis from FRAV3D Database

- Before Smoothing:-During this test 94 non-frontal images were considered and nose-tips were correctly localized for 85 faces, shown in Table 2.

TABLE II NOSE LOCALIZATION IN NON- FRONTAL POSE

Table 2	Nose-tip localization in non-frontal pose				
	Viewpoint around Y-Axes	***No. of Nose Tips***	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1	+30	10	8		
2	+30	10	10		
3	- 30	21	18	90.4%	9.57%
4	+38	21	21		
5	-38	16	12		
6	+40	16	16		

- After Smoothing:- The results obtained after smoothing are shown in Table 3.

TABLE III NOSE LOCALIZATION IN NON- FRONTAL POSE

Table 3	Nose-tip localization in non-frontal pose				
	Viewpoint around Y-Axes	***No. of Nose Tips***	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1	+30	10	9		
2	+30	10	10		
3	- 30	21	20	96.80%	3.19%
4	+38	21	21		
5	-38	16	15		
6	40	16	16		

C. Rotation about Z-Axis:- The third test was performed on the 94 face images rotated about Z axis; some of them are shown in Fig 29.

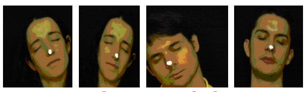


Figure 29. Some samples rotated about z axis from FRAV3D Database

- Before smoothing:- The results obtained before smoothing are shown table 4:-

TABLE IV NOSE LOCALIZATION IN NON- FRONTAL POSE

Table 4	Nose-tip localization in non-frontal pose				
	Viewpoint around Z-Axes	***No. of Nose Tips***	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1	+18	13	13		
2	- 18	13	13		
3	+30	9	9		
4	-30	9	9	97.87%	2.127%
5	+38	16	16		
6	-38	16	16		
7	+40	9	8		
8	-40	9	8		

- After smoothing:- Now after smoothing the algorithm succeeded in removing one of the fallacies caused due to noise and the other was untreated. The results are shown in Table 5.

TABLE IV NOSE LOCALIZATION IN NON- FRONTAL POSE

Table 5	**Nose-tip localization in non-frontal pose**				
	Viewpoint around Z-Axes	***No. of Nose Tips***	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1	+18	13	13	98.93%	1.06%
2	- 18	13	13		
3	+30	9	9		
4	-30	9	9		
5	+38	16	16		
6	-38	16	16		
7	+40	9	8		
8	-40	9	9		

D. Rotation about X-axis:- The fourth test was performed on the 72 face models selected from the face models of the FRAV3D database with rotation about X-axis, some of them are shown in Fig 30. During this test 72 face models were considered and nose-tips were correctly localized in 57 cases, shown in Table 6.

Figure 30. Some samples rotated about x axis from FRAV3D Database

- Before Smoothing:- The results obtained before smoothing are shown in the following Table 6.

TABLE VI NOSE LOCALIZATION IN NON- FRONTAL POSE

Table 6	**Nose-tip localization in non-frontal pose**				
	Viewpoint around X-Axes	***No. of Nose Tips***	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1	+5	12	12	89.58%	10.41%
2	- 5	12	12		
3	+18	15	15		
4	-18	15	15		
5	+40	9	4		
6	-40	9	4		

- After Smoothing:- Now after smoothing the algorithm succeeded in removing one of the fallacies caused due to noise and the other was untreated. The results are shown in Table 7.

TABLE VII NOSE LOCALIZATION IN NON- FRONTAL POSE

Table7	**Nose-tip localization in non-frontal pose**				
	Viewpoint around X-Axes	***No. of Nose Tips***	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1	+5	12	12	97.22%	2.85%
2	- 5	12	12		
3	+18	15	15		
4	-18	15	15		
5	+40	9	8		
6	-40	9	8		

Next we present the results for the GavaDB database.The GavaDB database are less noisy than Frav3D database.In this case we have also considered how precisely the algorithm detects the nose-tip.The GavaDB has 9 scans for each person , around X-axis,Y-axis,frontal scans and scans with gestures.

*E. Frontal pose:-*The first test was made on 305 face models in frontal pose as shown in Fig-31.We have taken all the elements in frontal pose with gestures and without gestures. During this test all face models were accepted and nose tip were correctly localized.

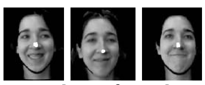


Figure 31. Some samples in frontal pose from GavaDB Database

- Before smoothing:- The images were not smoothed and nose tips correctly recognized.

- After smoothing: - The images were smoothed and nose tips correctly recognized.

TABLE VIII NOSE LOCALIZATION IN FRONTAL POSE

Table8	Nose-tip localization in frontal pose			
	No. of Nose Tips	*No of nose-tips correctly detected*	*% of Success*	*% of Failures*
1.	305	305	100%	0%

F. Rotation about Y-Axis:- The second test was performed on 122 face models taking the faces rotated about Y axis, some of them are shown in Fig 32.

Figure 32. Some samples rotated about y-axis from GavaDB Database

- Before Smoothing: - In this case technique give satisfactory results for large poses.The nose-tips were correctly detected for 19 face models.The results obtained before smoothing are enlisted in Table 9.

TABLE IX NOSE LOCALIZATION IN NON-FRONTAL POSE

Table9	Nose-tip localization in non-frontal pose				
	Viewpoint around Y-Axis	*No. of Nose Tips*	*No of nose-tips correctly detected*	*% of Success*	*% of Failures*
1.	+90	61	18	15.57%	84.44%
2.	-90	61	1		

- After Smoothing :- The results obtained after smoothing are enlisted in the following Table-10. After smoothing, the images were smoothed perfectly and the nose-tip identification improved in only 8 cases. The deviation from the original nose-tip was much less after the image was smoothed.

TABLE X NOSE LOCALIZATION IN NON-FRONTAL POSE

Table10	Nose-tip localization in non-frontal pose				
	Viewpoint around Y-Axis	*No. of Nose Tips*	*No of nose-tips correctly detected*	*% of Success*	*% of Failures*
1.	+90	61	26	22.13%	77.86%
2.	-90	61	1		

*G. Rotation about X-Axis:-*The third test was performed on 122 face models taking the faces rotated about X axis, some of them are shown in Fig 33.

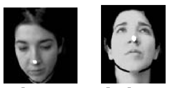


Figure33 . Some samples rotated about x-axis from GavaDB Database

- Before Smoothing: - The nose-tips were correctly detected for 84 face models.The results obtained before smoothing are enlisted in Table 11.

TABLE XI NOSE LOCALIZATION IN NON-FRONTAL POSE

Table11	Nose-tip localization in non-frontal pose				
	Viewpoint around X-Axis	*No. of Nose Tips*	*No of nose-tips correctly detected*	*% of Success*	*% of Failures*
1.	+35	61	60	68.85%	31.14%
2.	-35	61	24		

- After Smoothing: - The results obtained before smoothing are enlisted in Table 12. The results were improved in this case by 4 figures.

TABLE XII NOSE LOCALIZATION IN NON-FRONTAL POSE

Table12	Nose-tip localization in non-frontal pose				
	Viewpoint around X-Axis	*No. of Nose Tips*	*No of nose-tips correctly detected*	*% of Success*	*% of Failures*
1.	+35	61	61	72.95%	27.04%
2.	-35	61	28		

H. Rotation about Z-Axis:- There are no face models rotated with respect to z-axis in GavaDB database. Next, we present results that we have obtained for the Bosphorus database.

I. Frontal pose: -The first test was made on the face models in frontal pose only, some of them are shown in

Fig-34. Nose-tips for all the 3744 faces were correctly localized, shown in Table 13.

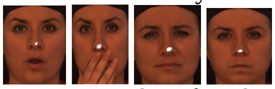


Figure 34. Some samples in frontal pose from Bosphorus database

- Before smoothing:- The images were not smoothed and nose tips correctly recognized.
- After smoothing: - The images were smoothed and nose tips correctly recognized.

TABLE XIII NOSE LOCALIZATION IN NON-FRONTAL POSE

Table13	**Nose-tip localization in frontal pose**			
	No. of Nose Tips	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1.	3780	3780	100%	0%

*J. Rotation about Y-Axis:-*In this test, 525 3D images rotated about Y-axis, some of them are shown in Fig 35, were considered, detail is shown in Table 9.In this test the faces were rotated in positive direction of y-axes in angles of 10,20 and 30 degrees and negative direction of 45 degrees.

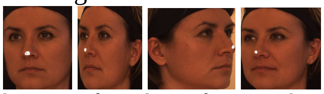


Figure35. Some samples in non-frontal pose from Bosphorus database with images rotated about y-axis.

- Before smoothing:- The images were not smoothed and nose tips correctly recognized in 274 cases out of 525 face models

TABLE XIV NOSE LOCALIZATION IN NON-FRONTAL POSE

Table14	**Nose-tip localization in non-frontal pose**				
	Viewpoint around Y-Axis	***No. of Nose Tips***	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1.	+10	105	74	70.47%	29.52%
2.	+20	105	75	71.4%	28.57%
3.	+30	105	78	74.28%	25.7%
4.	+45	105	10	9.52%	90.47%
5.	-45	105	1	0.95%	99.04%

- After smoothing:- The images were smoothed and nose tips more correctly specified in 295 cases out of 525 cases.

TABLE XV NOSE LOCALIZATION IN NON-FRONTAL POSE

Table15	**Nose-tip localization in non-frontal pose**				
	Viewpoint around Y-Axis	***No. of Nose Tips***	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1.	+10	105	96	91.42%	8.57%
2.	+20	105	94	89.52%	10.47%
3.	+30	105	86	81.9%	18.09%
4.	+45	105	13	12.38%	87.6%
5.	-45	105	6	5.71%	94.2%

J.Rotation about YZ -Axis:- In this test, 210 3D images rotated about YZ-axis, some of them are shown in Fig 36, were considered, detail is shown in Table 9.

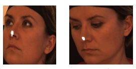


Figure 36. Some samples in non-frontal pose from Bosphorus database with images rotated about yz-axis.

- Before smoothing:- The images were not smoothed and nose-tip were correctly localized in case of 74 cases out of 210 face models.The details is shown in the table 16.

TABLE XVI NOSE LOCALIZATION IN NON-FRONTAL POSE

Table16	**Nose-tip localization in non-frontal pose**				
	Viewpoint around YZ-Axis	***No. of Nose Tips***	***No of nose-tips correctly detected***	***% of Success***	***% of Failures***
1.	+20	105	54	51.42%	48.57%
2.	-20	105	20	19.04%	80.95%

- After smoothing:- The images were smoothed and nose-tip were more correctly specified in case of

88 cases.The details is shown in the table 17.

TABLE XVII NOSE LOCALIZATION IN NON-FRONTAL POSE

Table17	Nose-tip localization in non-frontal pose				
	Viewpoint around YZ-Axis	*No. of Nose Tips*	*No of nose-tips correctly detected*	*% of Success*	*% of Failures*
1.	+20	105	54	51.42%	48.57%
2.	-20	105	20	19.04%	80.95%

K. Rotation about X -Axis:- The first test for this database was made on the 420 images rotated about x-axis, some of them are shown in Fig. 37.

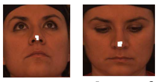


Figure 37. Some samples in frontal pose from GavaDB database

- Before smoothing:- The images were not smoothed and nose-tip were correctly localized in case of 241 models out of 420 models .The details is shown in the table 18.

TABLE XVIII NOSE LOCALIZATION IN NON-FRONTAL POSE

Table18	Nose-tip localization in non-frontal pose				
	Viewpoint around X-Axis	*No. of Nose Tips*	*No of nose-tips correctly detected*	*% of Success*	*% of Failures*
1.	+10	105	49	46.66%	53.33%
2.	+20	105	78	74.28%	25.7%
3.	-10	105	53	50.47%	49.52%
4.	-20	105	61	58.09%	41.90%

- After smoothing:- The images were smoothed and nose-tip more correctly specified in case of 313 models out of 420 models.The details is shown in the table 19.

TABLE XIX NOSE LOCALIZATION IN NON-FRONTAL POSE

Table19	Nose-tip localization in non-frontal pose				
	Viewpoint around X-Axis	*No. of Nose Tips*	*No of nose-tips correctly detected*	*% of Success*	*% of Failures*
1.	+10	105	69	65.71%	34.28%
2.	+20	105	92	87.61%	12.38%
3.	-10	105	68	64.76%	35.23%
4.	-20	105	84	80%	20%

V. CONCLUSION AND FUTURE SCOPE

In this paper, we have presented a novel technique for localization of nose-tip in 3D face images. Thus we have already proved that the present technique with smoothing has shown better performance than our previous technique with out smoothing.This should make a more robust template set and increase the systems matching capabilities. With a better model we will also consider methods for matching arbitrary three-dimensional training data thus leading to face registration.In future, registration and recognition of registered 3D face images would be considered.

REFERENCES

[1] G. Arce and J. Paredes, “ Image enhancement and analysis with weighted medians” Proceedings in Nonlinear Image ImageProcessingAcademicPress,2001.

[2] H.Yagou,Y. Ohtake, A.G. Belyaev , “Mesh Smoothing via Mean and Median Filtering Applied to Face Normals” Proceeding GMP’02 of the Geometric Modeling and Processing Theory and Applications (GMP'02) IEEE Computer Society ashington,DC,USA@2002.

[3] A.Adams,N.Gelfand,J.Dolson,M.Levoy,“Gaussian KD-Trees for Fast High-Dimensional Filtering” Proceedings of ACM SIGGRAPH 2009.

4] http://www.frav.es/databases

[5] N.Pitas, I.Pitas, “3-D Image Processing Algorithms” published by John Wiley & Sons, 2001.

[6] A.Salah,L.Akarun, “3D face feature localization for Registration” Proceedings of Springer,2006 and published by Annals of Telecommunication.

[7] M.Fournier,J.Dischler,D.Bechmann,“3D Distance Transform Adaptive Filtering for Smoothing and Denoising 3D meshes” Proceedings of the 4th international conference on Computer graphics and interactive techniques in Australasia and Southeastst Asia.

[8] F.Tsalakanidou, D.Tzovaras, M.Trinzis,“Use of depth and Color eigenfaces for recognition”, Proceedings of Pattern

Recognition Letters, Volume 24,Issue 9-10, June 2003, pages 1427-1435.
[9] Q.Huang,W.Gao,W.Cai,"Thresholding technique with adaptive window selection for uneven lighting image", Proceeding of Pattern Recognition Letters,Volume 26,Issue 6, 1 May 2005, pages 801–808.
[10] W.Ping, L.Junli, L.Dongming, C.Gang,"Fast and reliable switching median filter for highly corrupted images by impulse noise" Proceedings of the International Conference on Circuits and Systems, ISCAS, IEEE International Symposium on 27-30 May, 2007.
[11] P. Bagchi, D. Bhattacharjee, M. Nasipuri, D. K. Basu, "A novel approach for nose tip detection using smoothing by weighted median filtering applied to 3D face images in variant poses" Proceedings of the Int. Conference on Pattern Recognition, Informatics and Medical Engineering, Salem, Periyar University, March 21-23, 2012.