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3D Face Recognition using Horizontal and Vertical Marked Strips

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Abstract: This paper presents a hybrid 3D face recognition method based on point cloud conversion method and horizontal and vertical stripes calculation method. For this method, first of all 3D face model is converted to point cloud. Then the face region is extracted from forehead to lips in the image by finding the nose tip. Next, the face region is normalized. After normalization, the face image is divided into horizontal and vertical strips which are used to calculate average rows and columns values. Then average values of rows and columns are taken and compared, as a result of which the minimum resulting average value is matched with the database. The proposed method has been applied on the GAVAB database. The outcome indicates the best classification with rows and columns values and also provides good recognition results over the previous similar methods.

Keywords: 3D, Face, Recognition, Point Cloud, Strips.

INTRODUCTION

Researchers have discovered that 3D face recognition schemes can accomplish comprehensively higher accuracy than the 2D face recognition methods. Comparing to 2D face recognition, 3D face recognition depends upon the geometry of the face, not only on textured data. Because of this fundamentally unusual scheme, the 3D face recognition has the potential to overcome the limitations of 2D approaches. The 3D geometry of the face is basically strong to unreliable lighting circumstances. Also, the modeling and manipulating the geometry of a face is much more expensive than the 2D scenario. In this paper, some horizontal and vertical stripes are marked over the face image and then the absolute value from the difference of the averaged values of the rows and columns is calculated and compared. Finally, the average values of rows and columns are calculated to find the minimum average value.

A lot of work is done already in 3D face recognition (Pan *et al.*, 2004, Blanz *et al.*, 2003, Blanz *et al.*, 1999, Chang *et al.*, 2003Berretti *et al.*, 2007 Mahoor *et al.*, 2009, Mousavi *et al.*, 2008), Moreno *et al.*, 2005,Beumier *et al.*, 2000, Beumier *et al.*, 2001, Chau *et al.*, 2000). Early work focused on the curve analysis (Phillips *et al.*, 2003, Rizvi *et al.*, 1998 and Phillips *et al.*, 2000, Gordon *et al.*, 1995, Gordon *et al.*, 1992) demonstrates a pattern based recognition process concerning curve computation from range data.

MATERIAL METHOD

The proposed method is quite effective and a different technique for recognizing the face by using stripes calculation. Before the calculation of these stripes the 3D face model is converted to point cloud in order to start the processing. It is an efficient technique to handle the neutral faces and also to recognize the expressions as well as to provide good recognition rate. This technique is being implemented in the following algorithmic steps which completely define the proposed 3D face recognition process.

1. First of all the 3D face model is converted to point cloud. This gives the range data of the model as in **(Fig. 1)**.

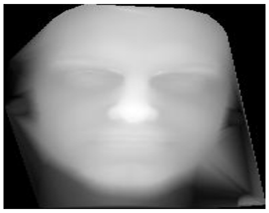

Fig. 1. 3D model converted to point cloud

2. After the conversion to point cloud, the maximum point is calculated which is basically the nose tip of the face, as in **(Fig. 2)**. This is done by finding the max (max (p)) of the range data P.

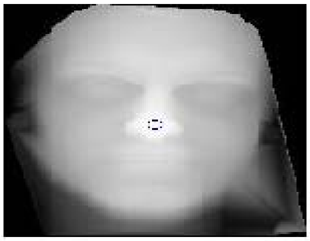

Fig. 2. Nose tip

3. Then use that tip of nose to crop out the face image and discard the irrelevant information as shown in **(Fig. 3)**.

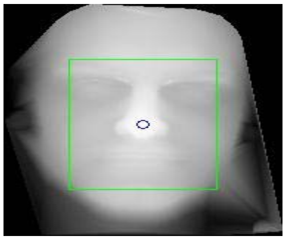

Fig. 3. Cropping region

4. After that, a complete face information is taken out on which further implementation of the proposed technique is applied as provided in **(Fig. 4)**.

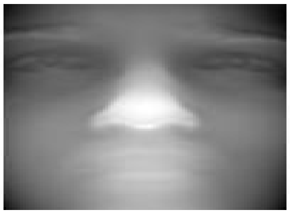

Fig. 4. Cropped out image

5. Then the cropped image is normalized by subtracting the peak point which is basically the nose tip of the face from all other values. It is done by using the following transformation as shown in **(Fig. 5)**.

```
for i ← n
 for j← m
    {
            m=max (ZI)
            PP=max (m)
            k(i,j)= PP-crpout (i,j)
    }
```

Where P_P is the peak value, n is the number of rows and m is the number of points.

Fig. 5. Normalized image

6. After normalization, the technique marks 14 horizontal and 14 vertical stripes on the normalized image as shown in **(Fig. 6)**.

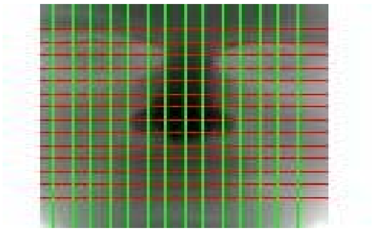

Fig. 6. Stripes marked on the normalized image

7. Then the sum of the horizontal and vertical marked stripes is taken by using equations 1 and 2.

$$a_n = \sum_{i=0}^{13} Z_{n,i} \quad \ldots \quad (1)$$

$$b_n = \sum_{i=0}^{13} Z_{i,n} \quad \ldots \quad (2)$$

where a_n, b_n are the sums of rows and columns.

8. Maintain the database using all the above steps except the step 7. Perform following calculation to take the sum of the rows and the columns by equations 3 and 4.

$$D_r - \sum_{i=0}^{13} A_{r,i} \quad \ldots \quad (3)$$

$$D_c = \sum_{i=0}^{13} A_{c,i} \quad \ldots \quad (4)$$

Where D_r, D_c are the sums of the rows and columns of the database and r, c are the number of the stripes.

9. Then subtract the sum of rows of the input from the sum of rows of the database $M_r = (D_r - a_n)$. Also take the absolute of the answer.

10. Then subtract the sum of columns of the input from the sum of columns of the database $\boldsymbol{M_c = (D_c - b_n)}$. Take absolute of the answer.

11. Now take the averages of the difference of the rows and the columns by using equations 5 and 6.

$$avg_r = \sum_{m=0}^{13} P_m / 14 \quad ..(5)$$

$$avg_c = \sum_{m=0}^{13} C_m / 14 \quad ..(6)$$

12. At the final step, find the index of the avg_c, avg_r as index=min (avg_c) and index=min (avg_r).

13. The step 12 will give the matched index of input model from database. Good results are obtained by applying the above mentioned steps of the proposed technique and recognition rate is also improved as compared to previous techniques and methods. In the next section nose is extracted from the face to recognize the face and also to further improve the results.

A. Feature Extraction

Although much work has already been done on the features extraction (Gordon, *et al.*, 1992) of face, the proposed method is unique in that it extracts the nose from face and then does some processing on it to recognize the face. For this, it crops the nose on the basis of nose tip. After detecting the nose tip as done in the step 2 of previous section, it crops the nose as: $\boldsymbol{[r_m, c_m] = find(P == max(max(P))}$. This equation will give the row and column of the nose tip. After that, $\mathbf{r_x = c_m - 23, r_y = c_m - 30}$ will give the point for cropping the required area as shown in **(Fig. 7)**.

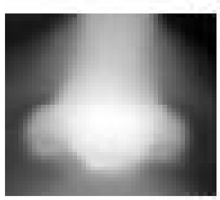

Fig. 7. Extracted nose

Step 5 is performed to normalize the nose. This basic step will give us the reference points regarding the peak value more closely to each other. Which will recognize more accurately as the reference points of the different models of a subject is minimized as in **(Fig. 8)**.

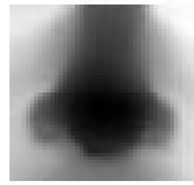

Fig. 8. Normalized nose

Finally, **min (z)** will give the minimum points of the nose. Then take the average of the **min (z)** as **avg [min (z)].** Next take the difference of the input average max (z) and database average max (z). For this use {**diff [dbavg (min (z)] -diff [inavg (min (z)]}.** The minimum difference will be the matched model.

RESULTS AND DISCUSSION

The proposed technique is tested with Gavab database which consists of three-dimensional face models of 61 characters (45 males and 16 females). From these sets, 5 different models were selected as test images.

The following tables show the results of the proposed method and also compare them with different existing techniques. It is found that the proposed technique produced good results than the other approaches i.e., 96.67% on the neutral expressions (table I) and 91.8% on the facial expressions (table II) which are far better than the previous techniques. The results for the expressions are further improved by 95.08% using the feature extraction **(Table 3)**.

Feature extraction method gives good results and accuracy towards the facial expression by using 3D face recognition. In the feature extraction, extracting the nose of the model as the expressions does not affect the nose and gives more accuracy towards recognition.

Table 1. Results of neutral expressions

Method	Space	HIT	MISS
Moreno (Moreno *et al.*, 2005)	60	77.9%	22.1%
Mahoor (Mahoor *et al.*, 2009)	61	72%	28%
Berretti (Berretti *et al.*, 2007)	61	81%	19%
Mousavi (Mousavi *et al.*, 2008)	61	91%	9%
ICP (Chang *et al.*, 2003)	61	62.3%	37.7%
3D-RGD (Chang *et al.*, 2003)	61	75.4%	24.6%
Proposed work	**61**	**91.8%**	**8.2%**

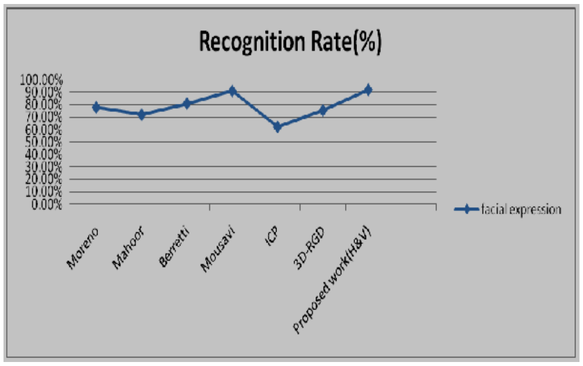

Fig. 9. Recognition Rate of Horizontal and Vertical Stripes

(Fig. 9) shows the graph of recognition rate using the horizontal and vertical stripes calculation of neutral faces having no expressions.

Table2. Results of facial expressions

Method	**Space**	**HIT**	**MISS**
Moreno (Moreno *et al.*, 2005)	60	90.16%	9.84%
Mahoor (Mahoor *et al.*, 2009)	61	95%	5%
Berretti (Berretti *et al.*, 2007)	61	94%	6%
Mousavi (Mousavi *et al.*, 2008)	61	91%	9%
ICP (Chang *et al.*, 2003)	61	70.5%	29.5%
3D-RGD (Chang *et al.*, 2003)	61	86.9%	13.1%
Proposed work	**61**	**96.67%**	**3.33%**

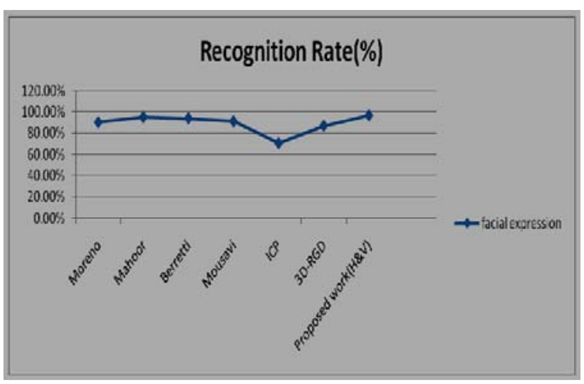

Fig. 10. Recognition Rate of Horizontal and Vertical Stripes

(Fig. 10) shows the graph of the recognition rate using the horizontal and vertical stripes calculation of face expressions.

Table3. Results of facial expressions using Horizontal and vertical stripes and feature extraction

Method	**Search**	**HIT**	**MISS**
Moreno (Moreno *et al.*, 2005)	60	77.9%	22.1%
Mahoor (Mahoor *et al.*, 2009)	61	72%	28%
Berretti (Berretti *et al.*, 2007)	61	81%	19%
Mousavi (Mousavi *et al.*, 2008)	61	91%	9%
ICP (Chang *et al.*, 2003)	61	62.3%	37.7%
3D-RGD (Chang *et al.*, 2003)	61	75.4%	24.6%
Proposed Work (H and V)	**61**	**91.8%**	**8.2%**
Proposed Work (feature)	**61**	**95.08%**	**4.92%**

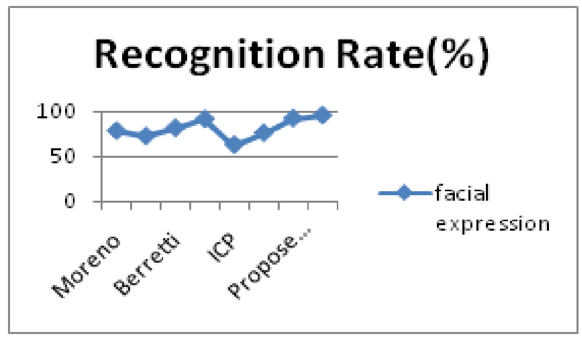

Fig. 11. Improved recognition by feature extraction shows the graph of the recognition rate using the feature extraction.

CONCLUSION

In this paper, a feature extracting scheme is designed to achieve the robustness to severe expressions. The satisfactory recognition rates using the proposed method demonstrate the efficiency of the horizontal and vertical stripes feature points on 3D faces as well as the effectiveness of feature extracting scheme which eliminates the need of an extensive set of reference faces for each individual in the training set. This work also demonstrates that quality recognition rates are attained exclusive of the use of complex methods.

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