1D-7

Feature Distraction Based Upon Implicit Geometry Information of Facial Point Cloud

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1. Outline of PCs

In this paper, the PCs (Point Clouds) are derived from the range image camera, MINOLTA VIVID 700. The size of the range image is 200×200 pixels with 400×400 pixels image as color texture; the fixed focal distance is 1.5m.

In PCs there are explicit information and implicit information in which the former are the coordinates and color can be directly derived from range image camera while the latter are normal vectors and curvature. Normal vectors can be calculated with Plane Fitting Method[1] and curvature can be calculated with Parabolic Fitting Method[2].

Described by $P_i = (\mathbf{x}', \mathbf{cl}', \mathbf{nl}', \mathbf{cv}') \in PC$, $(i = 1 \cdots n)$ with coordinates vectors **x**, color vectors **cl**, normal vectors **nl** and curvatures vectors **cv**, the PCs have the following features: the only information of points available in a piece of range image is coordinates and color; points in one PC are located regularly (unevenly and unorganized without any rule after preprocessing). Noise and/or error is brought from measurement and the next processing needs to be eliminated in advance.

2. Pipeline of PC-based facial expression generation

The pipeline of PC-based facial expression generation proposed in this paper consists of six steps as follows: 3D Acquisition, Preprocessing, Global Face Motion, Local Face Motion, Interpolation of New PCs and Facial Expression Generation.

In the step of Global Face Motion, the two PCs of one face with different expressions will be matched together after the translation and rotation of one PC are decided with Iterative Closest Point (ICP) algorithm.

After the PCs are aligned and matched in the step of Global Face Motion, the partial movement of the different parts on the face will be simulated according to the step of Local Face Motion. As shown in Figure 1, every point $P_i = (\mathbf{x}', \mathbf{cl}', \mathbf{nl}', \mathbf{cv}') \in PC_1, (i = 1 \cdots n)$, at t=0, can find its one-to-many corresponding points Q_i^m in PC_2 at t=1 usually including Q_i and its neighbors. Then the point R_i at time $t = T \in (0,1)$ for intermediate frames can be decided to simulate the facial expression animation. More details are discussd in Ref.[3].

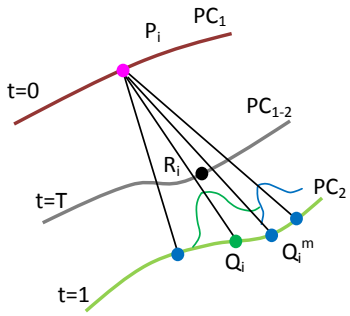

Figure 1. *Interpolated Point Cloud $PC_{1\text{-}2}$ from two Point Clouds PC_1 and PC_2.*

3. More Geometry Information of Face PC

If PCs can be segmented into different parts by facial features, it will enhance the precision and speed of searching process of corresponding points in different PCs. We extract more geometry information except of explicit information and implicit information mentioned above for this purpose.

Assuming that the point in PC is locally

fitted by parabolic surface, more geometry information of Face PC E, F and G for First Fundamental Form of surface and L, M and N for Second Fundamental Form of surface can be calculated as shown in equations (1).

$$\begin{gathered} r(u,v) = au^2 + buv + cv^2 + du + ev + f \\ r_u = 2au + bv + d \\ r_v = bu + 2cv + e \\ r_{uu} = 2a, \quad r_{uv} = b, \quad r_{vv} = 2c \end{gathered} \tag{1}$$

$r(u,v)$ is a parameterized parabolic surface; u,v are its two parameters; a,b,c are coefficients; $r_u, r_v, r_{uu}, r_{uv}, r_{vv}$ are gradients and second derivative at u,v directions individually.

Parameters of First fundamental form of surface:

$$E = 1 + r_u{}^2, \quad F = r_u r_v, \quad G = 1 + r_v{}^2 \tag{2}$$

Parameters of Second fundamental form of surface:

$$L = \frac{r_{uu}}{S}, \; M = \frac{r_{uv}}{S}, \; N = \frac{r_{vv}}{S} \tag{3}$$

$$S = \sqrt{1 + r_u{}^2 + r_v{}^2}$$

These 6 parameters are expressed by color image as shown in Figure 2.

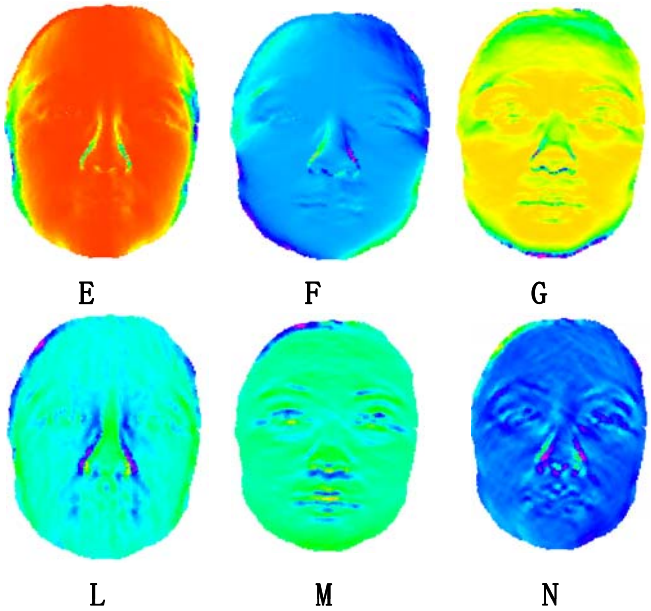

Figure2. *E, F, G, L, M & N of A Facial PC*

4. Feature Distraction

From Figure1, it can be seen that the face may be divided into different parts in the case that feature lines and points can be distracted. With Laplacian Edge Detection in Image Processing, the images in Figure 2 can be transformed into feature lines and points that indicate different parts of face as shown in Figure 3. Multi threads technology OpenMP has been used to shorten the calculation time from 2.5 hours to 0.9h with 13053 points in one face.

5. Conclusions

With feature lines and feature points distracted from PCs, PCs can be segmented into different parts which will enhance the precision and speed of searching process of corresponding points in different PCs by comparison with the method of considering geometry distances between points merely.

References

[1] H. Hoppe, T. Derose, T. Duchamp, J. Mcdonald, and W. Stuetzle, “Surface reconstruction from unorganized points”. Computer Graphics 26, pp.71-78, July 1992.

[2] B. Paul and C. JainRamesh, “Invariant surface characteristics for 3D object recognition in range images”, Computer Vision, Graphics, and Image Processing, vol. 33, No. 1, pp.33-80, Jan. 1986.

[3] MEI XUE, SHOGO TOKAI, HIROYUKI HASE, A New Method of 3D Facial Expression Generation Based upon Point Clouds, NICOGRAPH International 2012, Bali, July 2012,

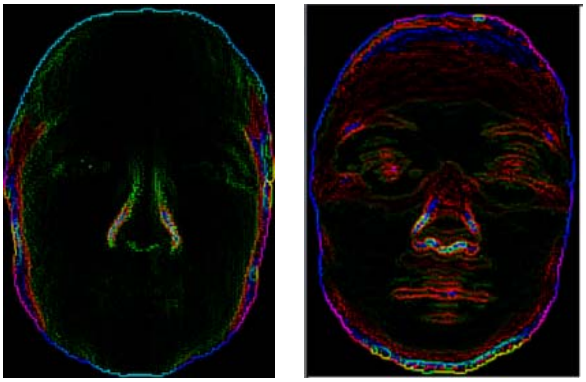

Figure3. *Feature Distraction from Images of E & G*