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FACIAL EMOTION TRANSFORMATION USING LOCAL WARPING METHODS

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ABSTRACT: In this research paper mainly focused on to applied local warping techniques to construct a frame work of image-based morphing for facial expressions animation with low quality. From the experience we tend to obtained in numerous spatial transformations, the local warping methods are a lot of adequate for facial expressions morphing. We have a tendency to utilized two transformations that may handle local deformations: piecewise polynomial trans-formation and radial basis function transformation. The simulation results are satisfactory. The facial warping techniques may be applied to varied applications, like face recognition, authentication, dynamic imagery, speech (action) semantic animation, multimedia and virtual reality construction, low-bandwidth video conference image trans-mission, and intelligent man-machine interface.

1. INTRODUCTION

Facial expression warping is sometimes applied in animation and it plays a vital role in special effects. Many models has been proposed to simulate actions of facial expressions. The direct way is to construct a 3D facial model. However, it's tough to create applicable 3D facial model by using single 2d face image. Researchers advocate that the information of a 2d gray-scale image is lots enough for facial expressions processing [7, 1]. They regard 2d facial image as a 2d object model, then warp the facial expressions directly in 2d space. We tend to adopt their methodologies and develop this work.

In order to get a good approximation to actual facial expressions with computer, it's necessary to research the structure of the face. A wide used theme for de-scribing facial expressions was developed by ekman and his colleagues in 1977. The system named FACS (Facial Action coding System) describes the set of all potential basic actions (Action Units) performable on an individual's face and their effects on facial expressions. Every facial expression is expressed as a collection of action units. Parke proposed another well-known model in facial animation: key-frame system and parameterized facial model[9]. There are alternative models like Platt model supported underlying facial structure[10], and also the Nahas model that relies on the B-spline[8].

We turned to search out 2d spatial transformations and used them for facial expressions warping [3, 11]. we have a tendency to regard the input 2d facial image as a 2d object, and used spatial trans-formations on the image plane to get the facial expressions results. Warping defines a mapping function that establishes a spatial correspondence between all points in a supply image and its distorted counterpart (destination image). The schematic diagram is shown in Figure 1. The mapping function f(x; y) is obtained in keeping with some reference points in supply image (indicated within the left-hand side in Figure 1) and counterpart of reference points in destination image (right-hand side in Figure 1). Global transformations that impose a single mapping function upon the entire image usually don't account for local geometric distortions. We tend to tried to seek out methodologies of local transformation to implement the facial expressions application. In we've got to search out these sub regions of the facial image. Distinct control points are the points whose mapping is preset. we used two local transformations: one is linear piecewise polynomial transformation, and therefore the alternative is radial basis functions transformation. Through computer simulations we tend to finished that the local warping strategies are a lot of appropriate for facial expressions morphing. Contrast to Parke’s plan, we have a tendency to initial specify the acceptable set of parameter values then the expressions intermediate are produced in period of time with warping techniques in keeping with those new anchor points in-between, wherever these new anchor points are calculated by interpolation.

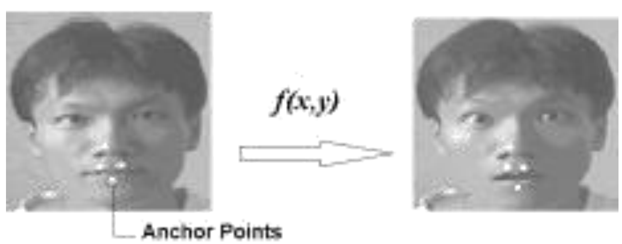


Figure 1. The schematic diagram of warping process.

2. Linear Piecewise Polynomial Mapping

Linear Piecewise Polynomial (LPP) Transformation is usually applied to image registration issues [4]. Image registration is that the method of overlaying two pictures of identical scene. control points are uniquely recognizable points whose mapping is preset, just like the reference points (anchor points) that represented before. In piecewise polynomial transformation, control points are a number of the special reference points like line intersections, center of gravity of closed-boundary regions, or high curvature points, in a picture. The mapping method is conveniently expose because the surface fitting problem that finds a surface function to suffer control points. the concept of LPP transformation is, instead of using one global mapping function to register the entire image, however employing a variety of local mapping functions, every tuned to map well in local neighborhoods. Then by gathering these piecewise local mapping functions, a global mapping function is obtained.

This method divides the entire image into some triangular regions (planes) that refer to the input of control points, said ”triangulation”[6]. Each triangular patch is independent with on overlapping. Triangulation is that the process that tessellates the convex hull of a group of N distinct points into triangular regions. It connects neighbor control points to create a planate graph that doesn't have crossing line segments. Though several configurations are potential, we tend to are interested interest} to find an optimum triangulation that have the optimal neighborhood. The optimal neighborhood is within the sense that points within a triangular patch are nearer to its three peak vertices than to it of the other triangular patches. Lawson[5] had proposed three criteria to optimize an arbitrary triangulation.

Given n distinct corresponding control points in two im-ages of identical scene, [(ui; vi); (xi; yi)]; i = 1; : : : ; n. (ui; vi) are control points within the supply image, and (xi; yi) are corresponding ones within the destination image. when optimal triangulation is proceeded, the source image is split into many independent triangular patches. Then our work is to determine piecewise linear mapping function for each triangular patch: x = f(u; v); and y = g(u; v), wherever [u; v] is that the pixel of the input image similar to warped pixel [x; y]. f and g represent the x-coordinate mapping function and y-coordinate mapping function, severally.

The problem is posed as finding a surface that passes through (ui; vi; xi), and another surface that passes through (ui; vi; yi). we tend to currently think about the case of fitting the triangular patches with linear interpolation, i.e., a plane. every tri-angular region have three peak points that are control points. For X-component coordinate, according these three given control points, the equation of a plane that pass through these three points(u1; v1; x1), (u2; v2; x2), and (u3; v3; x3) is given by,

$$Au + Bv + Cx + D = 0$$

where

$$A = \begin{matrix} v_1 & x_1 & 1 \\ v_2 & x_2 & 1 \\ v_3 & x_3 & 1 \end{matrix} ;\ B = ;\ \begin{matrix} u_1 & x_1 & 1 \\ u_2 & x_2 & 1 \\ u_3 & x_3 & 1 \end{matrix} ;$$

$$C = \begin{matrix} u_1 & v_1 & 1 \\ u_2 & v_2 & 1 \\ u_3 & v_3 & 1 \end{matrix} ;\ D = ;\ \begin{matrix} u_1 & v_1 & x_1 \\ u_2 & v_2 & x_2 \\ u_3 & v_3 & x_3 \end{matrix}$$

Then, we will confirm the X-component coordinate of the other points that within the triangular patch. and therefore the Y-component coordinate is set equally.

3. Radial Basis Functions Transformation

In this section, we tend to introduce another local warping technique using radial basis functions. Radial basis functions (RBF) warping regards the entire image as a 2D object that consisting of some radial basis functions that are created by the anchor points, and those functions could affect one another. RBFs are planned usefully in R^d ! R dimensional transformation. Because the input image could be a two dimensional object, and have n pixels, we would like to search out a R^2 ! R^2 dimensional transformation: T (ui) = x_i, for i = 1,2,….n, wherever ui, xi are denoted because the input vector and output vector severally, u_i, xi € R^2. We need a combine of transformation T = (Tx(u; v); Ty(u; v)) to realize R^2 ! R^2 transformation. the foremost easy format of the radial basis functions transformation is that the pure radial sum:

$R(u) = \sum^n_{i=1} a_i g(\|u - u^i\|)$, wherever g is an univariate radial basis function, and ||.|| denotes the euclidean norm on R^d. The feature of radial basis function is that, for every data point u^i can have an equivalent impact on all points of equal distance to that. Bookstein[2] has planned the thin-plate splines that could be a subclass of radial basis functions (RBF) for image registration, and instructed that RBF provides an attractive framework for image warping. However thin-plate splines has global impact that doesn't suitable for facial expressions warping. Arad[7] used Gaussian function with local impact to handle local warping of facial expressions. This is often a lot of appropriate for our neighborhood requirement that pixels leave off from the anchor point should have non impact from the anchor point. Moreover, Gaussian function have a locality parameter σ which will alter the local influence. Therefore, we tend to use Gaussian-like radial functions to implement our facial expressions warping.

However, the pure radial total is that the collection of all radial basis functions. It so can't reproduce polynomials. We tend to add an polynomial element to it.

$$T(\bar{u}) = \sum_{i=1}^{n} a_i g(\|\bar{u} - \bar{u}^i\|) + p_m(\bar{u}), \quad p_m(\bar{u}) \in \Pi_m \quad (1)$$

Where II_m is that the space of all algebraic polynomials of degree at the most m on R^d. In our application of facial expression warping, one among the natural scene distortion is "affine" that features scaling, rotation, shearing, and translation within the whole image. Another distortion in facial features warping is local distortion on facial organs, and may be realized by radial element with Gaussian-like mapping functions. Therefore, we tend to mix the affine mapping function into polynomial element. Thus, our radial basis functions transformation(RBFT) appearance like:

$$T(u) = R(u) + A(u) \qquad (2)$$

where R(u) is that the radial a part of transformation, and A(u) is that the affine a part of transformation. We need two pair of functions to realize R^2 ! R^2 transformation. Thus

$$T = (T_x(u,v), T_y(u,v)) \qquad (3)$$

$$= (\alpha_1 + \alpha_2 u + \alpha_3 v + \sum_{i=1}^{n} a_i g_i(u,v), \beta_1 + \beta_2 u + \beta_3 v + \sum_{i=1}^{n} b_i g_i(u,v))$$

Our goal is to calculate α1, α2, α3, β1, β2, β3 of the affine half, and α_i, β_i that are coefficients of the radial part. we tend to illustrated a way to solve these coefficients in below.

Given n radial anchor points $P_1 = (u_1, v_1)$, $P_2 = (u_2, v_2)$,…, $P_n = (u_n, v_n)$ within the euclidean plane, and defined initial three anchor points $P_1 = (u_1,v_1)$, $P_2 = (u_2,v_2)$, $P_3 = (u_3, v_3)$ are affine anchor points, and also the others are radial ones. From these input information, we've got to resolve affine coefficients α_i, β_i first. Then we will acquire the impact of affine part A(ui). The impact of radial part comes from Equation 2 that

$$R(u_i) = x_i - A(u_i), i = 1, 2,\ldots n \qquad (4)$$

After the affine part A(x) is obtained, we tend to turn to compute the radial part R(x). The radial anchor points are $P_4 = (u_4; v_4)$, $P_5 = (u_5, v_5)$,…,$P_n = (u_n,v_n)$ in our previous example, and their corresponding destination positions are

$P'_4 = (x_4, y_4)$, $P'_5 = (x_5, y_5)$,… $P'_n = (x_n, yn)$. Let $x_{ij} = |P_i - P_j|$ will be the distance between anchor point i and j. From Equation 4, we get:

$$\begin{bmatrix} x_4 - A(u_4) \\ x_5 - A(u_5) \\ \vdots \\ x_n - A(u_n) \end{bmatrix} = \begin{bmatrix} g(0) & \cdots & g(r_{4n}) \\ g(r_{51}) & \cdots & g(r_{5n}) \\ \vdots & \ddots & \vdots \\ g(r_{n4}) & \cdots & g(0) \end{bmatrix} \begin{bmatrix} a_4 \\ a_5 \\ \vdots \\ a_n \end{bmatrix} \qquad (5)$$

for x-coordinate, equally for y-coordinate. Then, with Equation 2 we tend to build the radial basis functions transformation wherever all coefficients are get from Equation 5. The affine a part of radial basis functions transformation is employed to overcome changes of viewpoint and scaling. The radial part is employed to handle local distortions of facial expressions.

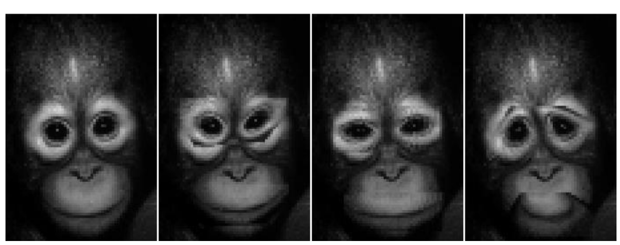


Figure 2. Synthesis images after various perspective warping

4. Simulation Results and Animation

4.1 Warping with Global Transformation

We have enforced the angle, bilinear, and two-degree polynomial transformations to facial expressions warping. Figure 2 presents the results of perspective transformation on monkey face images. As we've got discussed in Section 1 that, the attitude transformation may be a global transformation methodology. but the facial expression modification possesses local effects, we have a tendency to so cut the most deformation regions (eyes and mouth) of face image and perform perspective warp individually with various pairs of mapping points (anchor points). Figure 2(a) is that the whole original image, and Figure 2(b)(c)(d) are the synthesis images that replace the corresponding eyes regions and mouth regions with varied warping results. the general presentation wasn't satisfactory within the sense that the boundaries of deformation regions are apparent.

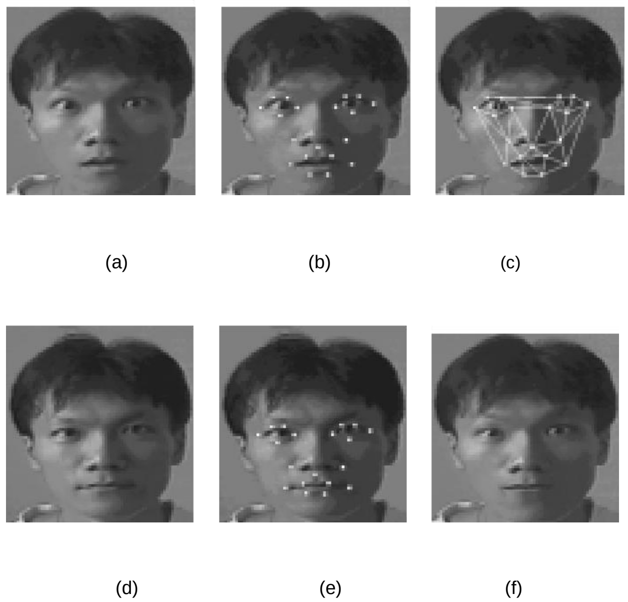


Figure 3. Fear expression to normal expression warping with Linear Piecewise Polynomial transformation.

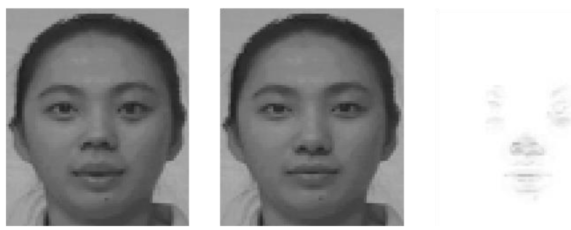
4.2 Warping with Linear Piecewise Polynomial Transformation

We have enforced the LPP methodology to facial ex-pression warping with the procedure of triangulation and mapping as illustrated in Section 2. we tend to used a re-cursive algorithm to work out the best triangulation efficiently[6]. This rule applies the technique of "divide-and-conquer". It recursively splits control points into halves using their x coordinate values, till every set contains only three or two points. Then merge these subsets into larger subsets using Lawson's criteria and therefore the convex hull algorithm. Then, a linear mapping (affine mapping) is performed on every triangle patch.

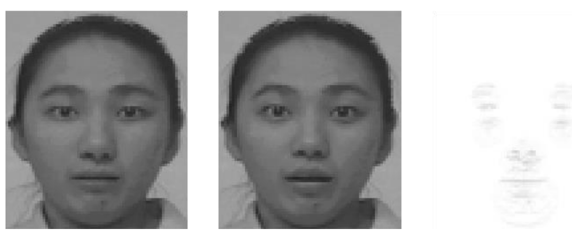
We used a man's facial image during this demonstration. Our goal is to warp a concern expression to the traditional expression. Figure 3(a) is that the source image of concern expression, and Fig-ure 3(b) is that the source image with its control points. Fig-ure 3(d) is that the desired reference image of normal expres-sion, and Figure 3(e) is that the image with its desired control points that correspond to the control points within the source image Figure 3(b). Figure 3(c) is that the results of best tri-angulation from the source image Figure 3(b). Finally we tend to got the ensuing image as shown in Figure 3(f). so as to look at the local effects of LPP warping, we tend to calculated the distinction between the first image and therefore the crooked image, and therefore the distinction image is premeditated in Figure 4(c), wherever Figure 4(a) is that the supply image (re-plotted from Fig-ure 3(a)), and Figure 4(b) is that the ensuing warped image (re-plotted from Figure 3(f)). From Figure 4(c) area unit able to} see that the only changes are placed within the triangular patches, whereas the remainder of the image isn't affected.

(a) (b) (c)

Figure 4. The difference image Linear Piece-wise Polynomial transformation result and the original image.



(a) (b) (c)



(d) (e) (f)

Figure 5. Difference images of RBF warping.

4.3 Warping with Radial Basis Function Transformation

We demonstrate the local influence of radial basis warping in Figure 5. Figure 5(a) is the warped image from nor-mal expression to surprise expression, and Figure 5(b) is the source image. Figure 5(c) is the difference image of Figure 5(a) and Figure 5(b). Similarly, Figure 5(d) is the resulting warping image from surprise expression back to normal expression, and Figure 5(e) is the source image. We can see from Figure 5(c) and Figure 5(f) that radial basis functions have great locality, since the only change in these pictures are in the region of eyes and mouth where really changes in human facial expression various, while the rest of the image does not change such as hairs, neck etc.

The sigma value of Gaussian function plays an important role of local influence in RBF Warping. We engaged the experiments with several different sigma values on the image shown in Figure 6. By changing the value of, we obtained different results. Figure 7(a), (b), (c) are the resulting warping image of values 10, 15, 25, respectively. We observed that the larger the value changes, the area affected became wider. The selection of sigma values of RBF warping are subjective. They depend on the size of facial image and the location. From the image size point of view, the sigma values in a 145 175 facial image are about 5, and ones in a 237 250 facial image are about 10 in our experiments. From the location point of view, the affected regions of facial muscles are not the same, such as the influences of eyes are smaller than ones of the mouth. In our experiments, the local deformation of mouth is the largest. Therefore, the sigma values of anchor points that locate near mouth is greater than ones of anchor points that locate in other places of face.

It also requires some experimental techniques to define the amount of anchor points and the location of anchor points. We illustrate this phenomenon in Figure 8. Figure 8(a), (b), (c) are the input image with different amount of anchor points 12, 4, and 1 respectively. All sigma values of anchor points in Figure 8 were set to 10. Figure 8(g), (h), (i) are the warping results with 12, 4, and 1 anchor point, respectively. We prefer to use less anchor points as we could, due to the speed of computation. Large amount of anchor points will reduce the performance in real time warping implementation.

Figure 6. The original baby image.

Figure 7. Different sigma values of RBF Warp-ing. (a) = 10**, (b)** = 15**, (c)** = 25**.**

4.4 Facial Expression Warping Animation

We also developed an animation warping tool. Figure 9 and Figure 10 show the interface and the final pose of the animation, respectively. Users can define the number of frames before the processing of warping. We use the equivalent interpolation method that equalizes the difference distance of anchor points at each frame. Moreover, our animation warping is not like the morphing processing that has the target image to interpolate frames, it only warps from source image. We first specify the appropriate set of parameters and then the expressions in-between are produced in real-time with warping techniques according to those new anchor points in-between, where these new anchor points are calculated by interpolation.

Figure 8. RBF warping with different amounts of anchor points.

Figure 9. The Interface of the animation tool

Figure 10. The final pose of animation.

The animation results of LPP and RBF warping are gratifying. In our experiments, the computation speed of LPP warping is faster than that of RBF warping. Because RBF warping with Gaussian function consumes much time in the exponential calculation. The solution is to use look-up table of the order of the image size in order to avoid direct Gaussian calculation.

5. Conclusions

In recent years, facial expressions warping was applied some interesting visual effects on multimedia. We have constructed a frame work of facial expression animation with less efforts of preprocessing by using local warping methods. From the experience we obtained in various spa-tial transformations, the local warping methods are more adequate for facial expressions warping. We used two transformations that can deal with local deformations: one is “Linear Piecewise Polynomial Transformation” and an-other is ”Radial Basis Function Transformation”. Due to the warping of facial expressions is local deformations that constructed by several muscles, using local transformations produces a good approximation to actual face.

The main difference of anchor points (control points) be-tween radial basis functions warping and piecewise polyno-mial warping is that, it must at least three anchor points ex-ists in piecewise polynomial warping if we have to handle local distortions (three points form a triangle), while only one anchor point is needed in radial basis warping. Fur-thermore, due to the computation complexity, the anima-tion speed can achieve in real-time with piecewise polyno-mial method. Traditionally, warping was applied to correct geometric distortions such as the distortion of viewing ge-ometry. In this paper, we applied warping for human fa-cial expressions. The facial warping techniques are also required for various future applications, such as face recog-nition, criminal identification, authentication in secure sys-tem, dynamic imagery, speech (action) semantic animation, multimedia and virtual reality construction, low-bandwidth video conference image transmission, and intelligent man-machine interface.

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