Specific Face Feature Extraction for the Model of Facial Expression

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Abstract: The specific face features extraction method based on the cubic B-Spline control curve approach is proposed. It will provide to the three dimensional modeling and recognizing the facial expression. The outline curves of eyes, nose and mouth are extracted by the integration of the region segmentation with morphological image processing and canny edge detection approach. These outline curves are reproduced into B-Spline curves with the desired number of points. The matching of the curve of input image and the various expression curves in a predefined data set is operated. Through the experimental results with acceptable errors, the proposed method work adequately.

Keywords: B-Spline Control Points, Canny Edge Detection Method, Facial Expression, Outline Curves, Region Segmentation.

I. INTRODUCTION

The recognition and synthesizing of the human facial expression is important in many application areas contain the natural facial expressions for characters in films, games, various virtual environments, and facial avatars in instant communication programs and so on. Then the facial feature extraction work is occupied the essential role for improving the accuracy of facial expression recognition and synthesizing. The simple and first extraction method of specific facial features of a face is developed based on the cubic B-Spline curve and control points. The region segmentation with morphological image processing and canny edge detection approaches are applied for extracting the outline curves of the specific face features. There are some related approaches of generating and recovering the specific face features. There are some related approaches of generating and recovering the control points of the curve in two dimensional spaces [1]-[4]. A first rational Bezier curve generation method using modified Digital Differential Analyzer (DDA) has been introduced by H. Hama [1].

The cubic [1]-[2] is modified to detect the control points of a curve. M. M. Sein and H. Hama [2] proposed a B-Spline control points finding method for a free curve or a set of points in 2D and 3D space. Their algorithm starts from separating the given closed curves into four areas as 1:2:2:1 ratio. Some feature extraction techniques [5]-[6] have been used the Haar wavelet and Gabor wavelet transform. These techniques are relatively complex and difficult to construct the 3D model using these features. In our method, the specific facial features are extracted from the given image to provide the facial expression recognition. Roughly, a face is segmented into three parts horizontally. Morphological processing and canny edge detection methods are applied to obtain the outline curve of eyes, nose and mouth region. The slope following and iteratively computing, the cubic B-Spline control points can be estimated from the extracted outline curves.

The cubic B-Spline control points finding method [1]-[2] is modified to detect the control points of a curve. The curve of a segment can be reproduced with the desired number of control points. A B-Spline curve \( P(t) \) of degree \( n \) can be defined in terms of a set of control points \( Q_i \) \( (i=0,1,...,n) \) with the parameter \( t(0\leq t \leq 1) \).

\[
P(t) = \sum_{i=0}^{n} B_{in}(t)Q_i
\]

(1)

Where, each term in the sum is the product of a blending function \( B_{in}(t) \) and the control points \( Q_i \). \( B_{in}(t) \) is called Bernstein polynomial.

The cubic B-Spline curve \( P(t) \) can be reduced into matrix form from (1) by assuming \( n=3 \) as:
The edge detection is performed after enhancing stages of skewing, cropping, resizing, gray-scale converting and noise filtering. Canny edge detecting method is applied to extracted the outline of the eyes, nose and mouth regions. Furthermore, morphological processing is used for removing the some unwanted parts. The extracted edges of the eyes, nose and mouth region are shown in Fig. 3(a), Fig. 3(b) and Fig. 3(c), respectively. The B-Spline control points are computed from these outline curves. Next the B-Spline control points computation is performed for extracted outline curves. To easy and convenient, the control points are computed for the open curves. Then, the closed outline curve is separated roughly into two or more parts according to their max - min X-Y values as shown in Fig. 4.

The reproduced cubic B-Spline curve is created by the slope following and iterating algorithm. These B-Spline curves can reproduce the curves with the desired number of points.

\[
m = \frac{y_2 - y_1}{x_2 - x_1} \quad \text{angle } \theta = \tan^{-1}(m)
\]

The variation angles in the segment are shown in Fig. 5.

Where, Q0, ..., Q4 are the control points of the curve C1 and θ and Φ are the variation angles for the curves of destination part C1. The angle and slope variations of the control points of each curve are computed by the above (4). If the values of the differences between the angles from an input curve and other curves are sufficiently small, select this pair as a matched pair of same facial expression.

\[
P(t) = [B_0(t) \ B_1(t) \ B_2(t) \ B_3(t)]Q
\]

Where \(Q = [Q_0, Q_1, Q_2, Q_3]^T\), \([B_0(t) \ B_1(t) \ B_2(t)]\)

\[
B_3(t) = [1 \ t \ t^2 \ t^3]S,
\]

\[
S = \frac{1}{6}
\begin{bmatrix}
1 & 4 & 1 & 0 \\
-3 & 0 & 3 & 0 \\
3 & -6 & 3 & 0 \\
-1 & 3 & -3 & 1
\end{bmatrix}
\]

**III. SEGMENTATION AND CURVE EXTRACTION**

In this section, the outline curves of the specific facial segments are extracted from the acquired face image. Firstly, segmentation of a face is considered. The face is divided into three parts as upper, middle and lower part. The upper part contains the left and right eyes. The middle part contains the nose and mouth region is included in the lower part of a face. Fig. 2(a) shows the input face and its segmented parts are shown in Fig. 2(b).

**Figure 2.** Segmented parts of a face.

**Figure 3.** Extracted outline curves.
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The slope variation, angle and ratio of the height and width of the mouth measurement are computed from the reproduced cubic B-Spline curve of these outline curve features. The computing slope variation, width and height of the mouth are illustrated in Fig. 6, for example. Let us assume that $\alpha$ and $\beta$ are the angles which are inclined with the horizontal line. The slope variation or angle $\gamma$ can be defined as:

$$\gamma = \alpha + \beta \tag{5}$$

![Figure6. The variation parameters of a mouth.](image)

Similarly, the parameters of the facial features are computed for other facial expressions. The correct facial expression of an input facial image can be determined by these computed parameters.

### IV. EXPERIMENTAL RESULTS

The download standard face expression dataset (JAFFE) contains the seven facial expressions is applied in our experiments. These are happy, surprise, disgust, fear, neutral, sad and angry expression of human behavior. Fig. 7 shows the different expression of a female individual. The reproduced B-Spline curves and its computed variation parameters are described in Table 1. The width and height are measured by pixels and angle is in degree.

![Figure7. Illustration of the seven facial expressions.](image)

<table>
<thead>
<tr>
<th>Mouth</th>
<th>Angle</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>🧐</td>
<td>65</td>
<td>36</td>
<td>16</td>
</tr>
<tr>
<td>🧐</td>
<td>53</td>
<td>33</td>
<td>15</td>
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<tr>
<td>🧐</td>
<td>58</td>
<td>34</td>
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</tr>
<tr>
<td>🧐</td>
<td>63</td>
<td>35</td>
<td>18</td>
</tr>
</tbody>
</table>

![TABLE1. Computed Variation Parameters For Different Expressions](image)

Figure8. Same expression face images of the different individuals.

![Figure8. Same expression face images of the different individuals.](image)

Figure9. The extracted curves for the related individual of above figure.

<table>
<thead>
<tr>
<th>TABLE2. Computed Variation Parameters For the Happy Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>🧐</td>
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The same expression facial images of different individual are described in Fig. 8. The extracted curves for this happy expression in each individual are shown in Fig. 9. Table 2 shows the reproduced B-Spline curves and its computed variation parameters.

### V. CONCLUSION

The motivation of our proposal is to generate the effective facial feature extraction system for facial expression recognition and simulation works. The contribution of the paper is the use of the cubic B-Spline curve representation for feature extraction. Moreover, an algorithm of the facial expression is developed based on the variation parameters of the outline curve features. The effectiveness of the proposed method can be confirmed through the experimental results. It would like to consider the three dimensional B-Spline curve for detecting the facial expression as an extension of this work. Furthermore, the more outline curves of the facial feature will be used for improving the expression recognition accuracy.

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