

# The Way of Modeling Chinese Character by Double Beta Spline-Curve

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**Abstract:** The exact expression of freeform surface has been the focus in the field of engineering technology, Double Beta spline-curve has its special characteristics, which has a lot of practical values in surface modeling and CAD. Especially on the improvement of area curve of ship's cross section, and on the design of ship's molded lines, or the research of fitting ship's molded lines, so double Beta spline-Curve has widely use prospect. This paper expounds the origin and characteristics of double Beta spline-curve, and develops a system named SMS for XView, which based on the double Beta spline-curve. The selecting ways of stroke controlled vertex of Chinese character are also introduced, Through modeling some Chinese characters in XView system for SMS, by which illustrate how the parameters influence the Chinese characters in modelling .

**Keyword :** Double beta spline-curve/surface; the controlled vertexes; Surface Modeling; Shading process; Chinese character; Ship.

## 1 Introduction

3D surface has an important significance in mold shaping, and the shape design of cars, planes, ships, and it's also has significant application for CAD. Ruled surface usually expresses with mathematics method, which surface is controlled by specific geometrical parameters. However, the complex free surface has no significant rules. It is difficult to be expressed by a few simple mathematical methods. Bezier surface, Coons surface and bicubic B surfaces are usually used to express a freeform surface in engineering field. Bicubic B is the most widely used one, because it has a few special characters, like simple structure, good continuity, and controllability locally, and other characteristics. But bicubic B spline-curves can only give free surface approximatively, it does not express free surface accurately. In order to solve this problem, we adopt double Beta spline-curve to express free curve.

Double Beta spline-curve(surface) is firstly put forward by Barsky. Double Beta spline-curve is promotion of the double bicubic B spline-curve, so it has some characteristics of the latter, such as cubic polynomial, simple structure and local control. At the same time, it is different from the double bicubic B spline-curve. First, it relaxes the request of surface smoothness, continuity from  $C^2$  to  $G^2$ ; second, it is controlled by controlled vertex, as well as the  $\beta_1$  and  $\beta_2$  parameter values<sup>[1]</sup>. In particular, the double Beta pline curve can be degenerated into general double bicubic B spline-curves. As the double Beta spline-curve has the above characteristics, it has a lot of practical values in surface modeling and CAD. Especially on the improvement of area curve of ship's cross section, and on the design of ship's molded lines, or the

research of fitting ship's molded lines, so double Beta spline-Curve has widely use prospect.

On the basis algorithm of double Beta spline-curve, a modeling system of double Beta spline-curve named SMS (Surface Modeling System) has been developed<sup>[2]</sup>. Based on SMS, the further research of shadowing process of 3D shape and curved surface joining together have been carried on, then the new version named SMS for XView is completed; based on SMS for XView<sup>[3]</sup>, this paper presents the method of selecting vertex array, and joining generated pictures together to form Chinese characters, and applying the double Beta spline-curve for Chinese characters modeling.

## 2 the definition and properties of double Beta spline-curve

The definition formula of double Beta spline-curve<sup>[1]</sup>:

$$Q(u, t) = \sum_{i,j}^{n,m} \left( \sum_{r=-2}^1 \sum_{s=-2}^1 V_{i+r, j+s} \cdot b_r(u) \cdot b_s(t) \right) \quad (1)$$

In formula (1)  $V_{ij} = [x_{ij}, y_{ij}, z_{ij}]$ ,  $i = 1, 2, \dots, n$ ,  $j = 1, 2, \dots, m$ , are controlled vertexes;

$b_r(u)$  and  $b_s(t)$  are Basis function of the Beta spline-curve

formula (1) can be replaced as:

$$Q(u, t) = \sum_{i,j}^{n,m} Q_{i,j}(u, t) \quad (2)$$

$$Q_{i,j}(u, t) = \sum_{r=-2}^1 \sum_{s=-2}^1 V_{i+r, j+s} \cdot b_r(u) \cdot b_s(t), \quad u, t \in D, \quad D = [0, 1] \quad (3)$$

Formula (2) shows the curve  $Q(u, t)$  pieced together by a series of curve blocks  $Q_{i,j}(u, t)$  according to the principle geometry continuity.

Double Beta spline-curve is composed of two groups of interlaced Beta spline-curve, the accumulation of the effects of each Beta spline-curve of the parameters  $\beta_1$  and  $\beta_2$  lead the effects to double Beta spline-curve. Define  $\beta_1=1$ 、 $\beta_2=0$ , the double Beta spline-curve transform to bicubic B spline-curve. The Surface may not go through the controlled points, and the shape of the surface is seems like pulled by 16 controlled points around. Therefore, in addition to the spatial distribution of controlled vertex array, the final shape of double Beta spline-curve is also controlled by the parameters  $\beta_1$  and  $\beta_2$ .

Therefore, the selection of controlled vertex array has important effects to double Beta spline-curve's shape.

## 3 Introduction of SMS for XView system

SMS system is a 3D surface modeling system which adopts double Beta spline-curve for modeling. SMS for XView adopts advanced Object-Oriented

Programming (OOP) and popular Graphical User (GUI) technology, and reunion the structure of SMS by analyzing, OPENWINDOW environment, which is on SUN4/60 working station, is used for developing the new version of the SMS system. It is easy to transplant, and has the more friendly graphical interface. Basis on the former parts of curve computation and curve generated, SMS for XView adds curve shadowing process and the piece together rules of double Beta spline-curve, it can generate complex shapes, and the results have a strong sense of reality.

#### 4 Chinese characters of basic strokes on selection

The Chinese characters are the earliest words in the history of characters development, it's basic forming elements are the strokes. Chinese characters developed from Seal character into official script, regular script, and it changed the irregular curve and well round line into a flat of founder stroke<sup>[4]</sup>. So the regular script has more linear form strokes. Stroke is the smallest unit in Chinese character, which starts when the pen writes to, and end when the pen writes off. There are five forms: Hen (一), Su (丨), Pie (丿), Na (㇇), and Zhe (㇇ and ㇏). The first four kinds are simple, and the fifth is complex. After analysis, it is easy to see Zhe consists on the first four forms. So Hen (一), Su (丨), Pie (丿), Na (㇇) are defined to be the basic stroke.

#### 5 Main idea of controlled vertex selection of Chinese basic stroke<sup>[5]</sup>

No matter the characters are shown by screen or printer, each character is on a certain position, which means every character has a word-position,  $(x_0, y_0)$  is used to show the bottom-left coordinates of the word-position (AS the Chinese characters are shown as a flat figure, z coordinate is 0, so usually avoids). The position of a single stroke in the whole Chinese characters is defined by the beginning-position, and the ending-position. So the beginning-position, and the ending-position are defined to be center positions, and its coordinate adopts the coordinate locally. So an array named float stroke is used to express the local coordination  $x, y (x_i, y_i), i = 1, 2, \text{and} \dots, n$ .

In fig.1, squareness expresses the whole area of a Chinese character, the word-position is controlled by the bottom-left coordinate of the squareness point o  $(x_0, y_0)$ , and the positions of the stroke are controlled by the center control points  $(x_1, y_1)$  、  $(x_2, y_2)$  。

Fig.2 shows the transverse distribution of the controlled vertex of the stroke. Use plane A ( in figure 1) to split the stroke,  $0 \sim 7'$  are transverse controlled vertexes, and controlled by plane A, and Beta spline-curve shape is shown on this section roughly.

Fig.3 shows longitudinal distribution of the controlled vertex of the stroke. Use plane B (in figure 1) to split the stroke,  $0 \sim 4$  are longitudinal controlled vertexes, and controlled by plane B, and Beta spline-curve shape is shown on this section roughly.

Fig. 4 shows the spatial distribution diagram of stroke controlled vertex.

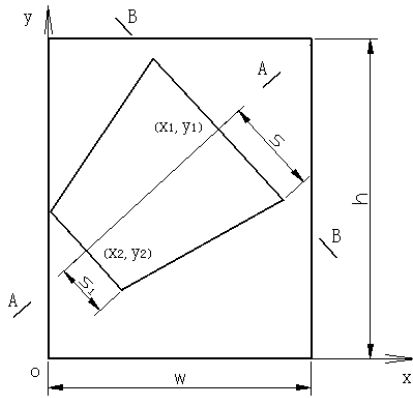


Fig.1 Flat surface sketch diagram of stroke

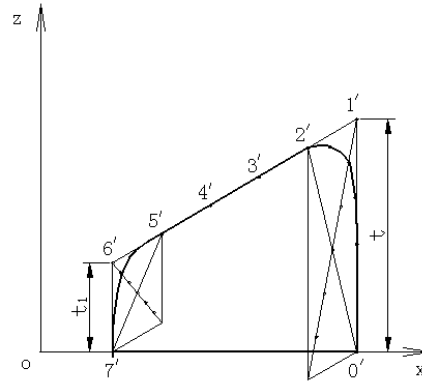


Fig.2 A-A Enlarge diagram

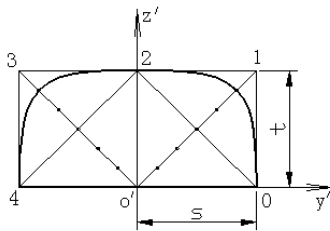


Fig.3 B-B Enlarge diagram

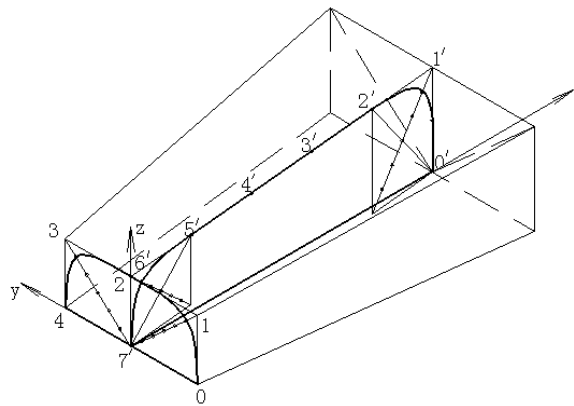


Fig.4 The enlarge space diagram of distributed stroke  
Controlled vertexes

parameter description:  $w$ —words width;  $t$ —words thickness, the thickness of the thickest end of stroke ;  $t_1$  — the thickness of the thinnest end of stroke ;  $e_1=h/w$ —height/width;  $e_2=t/w$ —thickness/width;  $e_3=s/t$ —stroke/thickness;  $n$ —stroke center control point number,  $n \leq 10$ ;  $s$ —stroke half wide, half-width of the thickest end of stroke;  $s_1$ —half-width of the thinnest end

From the figure 1 ~ figure 4, stroke is double Beta spline-curve, by which two groups Beta spline-curve of the longitudinal and transverse B, A section. The longitudinal and transverse controlled vertexes of the surface were selected vertexes 5 and 8 severally; We define the word-position as  $(x_0, y_0)$  , word width as  $w$ , ratio of height to width as  $e_1$  , thickness to width as  $e_2$ , stroke to thickness as  $e_3$  , the half width of the thinnest end of the stroke as  $s_1$  , the thickness of the thinnest end of the stroke as  $t_1$ , which are the basic stroke controlled parameters, and will be stored in an array float control<sub>2</sub>[8]; an array int control<sub>1</sub>[2] is used to show the number of points between the longitudinal and transverse controlled vertexes; Adopting float array[3][5][8] to show 3D coordinates of controlled vertexes; the triple vertex method is used to consult the curve's borders of up, down, left and right, and the digital is 3. Changing array float control<sub>2</sub>[8], float stroke[10][2] value can be got a series of basic stroke accordingly: When  $y_1=y_2$  and  $s_1=s$ ,  $t_1=t$ , Hen will be gotten; When  $s_1=0$ ,  $t_1=0$  and  $x_1 < x_2$ ,  $y_1 < y_2$ , Su will be gotten; When  $s_1=0$ ,  $t_1=0$  and  $x_1 > x_2$ ,  $y_1 > y_2$ , Pie will be gotten; When  $s_1=0$ ,  $t_1=0$  and  $x_1 < x_2$ ,  $y_1 < y_2$ , Na will be gotten; When  $s_1$ ,  $t_1$  take nonzero, more

strokes will be gotten. The basic reason is that the controlled vertex coordinates have been changed. According to the idea, we get N-S figure (figure 5), the selection controlled vertex strokes, and then the N-S figure will be programmed, entry controlled parameters and work, and controlled vertex array files will be worked out (figure 6).

The description of controlled parameters
Entry controlled parameters
for(i=0;i<nud;i++)
block[0][i][0]=x0+x1; block[1][i][0]=y0+y1;
block[2][i][0]=0; block[0][i][7]=x0+x2;
block[1][i][7]=y0+y2; block[2][i][7]=0;
for(j=1;j<nlr-1;j++)
block[0][2][j]=x0+x1-dx*(j-1);
for(i=0;i<2;i++)
block[0][i][j]=x0+x2+k2*s1+(x1-x2-k2*s1+k2*s)*(6-j)/5;
for(i=3;i<5;i++)
block[0][i][j]=x0+x2-k2*s1+(x1-x2+k2*s1-k2*s)*(6-j)/5;
for(i=0;i<nlr;i++)
block[2][0][i]=0; block[2][4][i]=0;
for(i=1;i<nlr-1;i++)
for(j=1;j<nud-1;j++)
block[2][j][i]=t1+(6-i)*(t-t1)/5;
for(i=1;i<nlr-1;i++)
for(j=0;j<2;j++)
block[1][j][i]=y2+y0-k1*s1+(y1-y2+k1*s1-k1*s)*(6-i)/5;
for(j=3;j<5;j++)
block[1][j][i]=y2+y0+k1*s1+(y1-y2-k1*s1+k1*s)*(6-i)/5;
block[1][2][i]=y2+y0+dy*(6-i);
for(i=0;i<3;i++)
for(j=0;j<nud;j++)
for(k=0;k<nlr;k++)
output block[3][5][8]

Fig.5 The N-S diagram of selected stroke controlled vertexes

The numbers of the surface  
A B C D E F G H  
Coordinate x  
Coordinate y  
Coordinate z

Explanation: A is Processing method of the border of up; B is Processing method of the border of down; C is Processing method of the border of left; D is Processing method of the border of right; E is longitudinal points between the controlled vertices; F is lateral points between the controlled vertices; G is Longitudinal control vertices; H is lateral controlled vertices.

Fig.6 The basic brush stroke control top array document

For example, define the coordinate of the two stroke center controlled points of the stroke  $(x_1, y_1)$ 、 $(x_2, y_2)$  as  $(-120, -140)$ 、 $(-90, -75)$  accordingly, word-position  $(x_0, y_0)$  as  $(0, 0)$ , w as 100, h/w  $e_1$  as 1.4286,  $e_2$  as 0.1,  $e_3$  as 0.5,  $s_1$  as 6,  $t_1$  as 6. Through operating the program, importation data documents will be gotten (figure 7).

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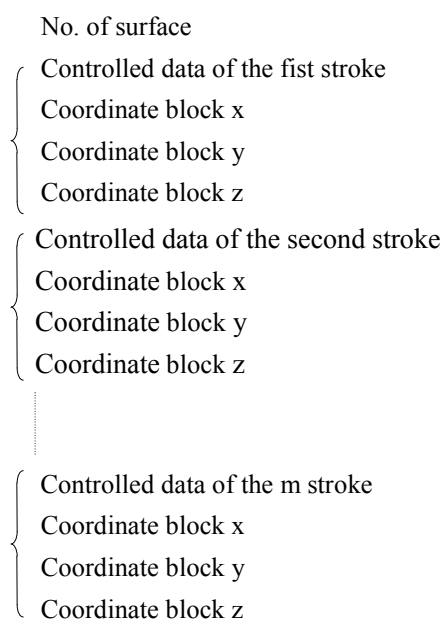
1
3 3 3 3 5 5 5 8
-120.0000 -129.0796 -122.3532 -115.6269 -108.9005 -102.1741 -95.4478 -90.0000
-120.0000 -129.0796 -122.3532 -115.6269 -108.9005 -102.1741 -95.4478 -90.0000
-120.0000 -120.0000 -114.0000 -108.0000 -102.0000 -96.0000 -90.0000 -90.0000
-120.0000 -110.9204 -105.6468 -100.3731 -95.0995 -89.8259 -84.5522 -90.0000
-120.0000 -110.9204 -105.6468 -100.3731 -95.0995 -89.8259 -84.5522 -90.0000

-140.0000 -135.8094 -123.1447 -110.4799 -97.8152 -85.1504 -72.4856 -75.0000
-140.0000 -135.8094 -123.1447 -110.4799 -97.8152 -85.1504 -72.4856 -75.0000
-140.0000 -140.0000 -127.0000 -114.0000 -101.0000 -88.0000 -75.0000 -75.0000
-140.0000 -144.1906 -130.8553 -117.5201 -104.1848 -90.8496 -77.5144 -75.0000
-140.0000 -144.1906 -130.8553 -117.5201 -104.1848 -90.8496 -77.5144 -75.0000

0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 10.0000 9.2000 8.4000 7.6000 6.8000 6.0000 0.0000
0.0000 10.0000 9.2000 8.4000 7.6000 6.8000 6.0000 0.0000
0.0000 10.0000 9.2000 8.4000 7.6000 6.8000 6.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
    
```

Fig.7 Basic stroke importation data document

## 6 Getting the controlled vertex array of the Chinese characters<sup>[6]</sup>



Explanation: m is the controlled parameters in a increased main program. It shows that the total strokes of basic Chinese characters.

Fig.8 Chinese characters control top array documents of diagram

As we know, each character is made up by one or more basic strokes. So a character's vertex array file can be gotten by applying sub programs of basic stroke tautologically.

First of all, we take one Chinese character of any scripts in the Chinese character data base, and write neatly on the coordinate paper by enlarge ratio .And then fine the coordinates of every stroke's center controlled points by reading the coordinate of the character on coordinate paper, and get the controlled parameters of each basic stroke, and then write a program which can realize the function of combining the sub programs of each stroke's controlled vertex. Finally, run the main program, and get the controlled vertex files (figure 8).

## 7 Chinese characters Beta spline in modeling

After Getting a Chinese character controlled vertex files, we entry the data into the SMS for XView system, and set the system parameters of the visual angle  $\theta$ ,  $\varphi$ ,  $\beta$ , source light position and graphic showing mode, the system will begin to calculate surface. According to the inputting data, the system calculate character's curve by double Beta spline-curve formula, which also work outthe functions like blanking、shadowing process of the curve. After completing the calculation, the results will be shown.

The following examples are some Chinese characters molded by SMS for XView systems with double Beta spline-curve modelling method. The related parameters are shown in figure 9:

Observer perspective:  $\theta=90^\circ$ ,  $\varphi=60^\circ$ ; Surface reflection coefficient:  $K_d=0.7$ ;

Surface specular reflection coefficient:  $K_s=0.5$ ; Smooth factors:  $n=1$ ; parameters  $\beta$ :  $\beta_1=1$ ,  $\beta_2=0$ ;

Graph showing style: stereogram.

Figure 9 is a picture of character "和", it consists of nine double Beta spline-curves joining together, totally has 7776 parallelograms.



Fig.9 Stereogram of “和” ( $\beta_2=0$ )



Fig.10 Stereogram of “和” ( $\beta_2=100$ )

## 8 The adjustment modelling experiment of the Chinese character

Other parameters remain unchanged, only adjust  $\beta_2$  to 100, and then get a picture like figure 10 shows.

We can see in figure 10, almost each corner position is the distributed controlled

vertex. "和" is composed of a series of flats, comparing with figure 9, both of them have almost the same in controlled points and parameters, the only difference is  $\beta_2$ .

The first two examples illustrate changing  $\beta_1$  and  $\beta_2$  have effects on the pictures, proving the nature of the double Beta spline-curve.

Other parameters remain unchanged, only adjust the graphic displaying to wireframe, as figure 11 shows.

Compared figure 11 with figure 9, stereogram has the strong sense of reality, it can show different light and shade of the body, due to changing the light position and the view angle, wireframe doesn't have this change, which just shows space net after blanking, the distribution of the parallelogram graphics can be clearly seen from wireframe.

Using SMS for XView system, picture can be arbitrary rotation, designers can examine it from different angles and get kinds of graphs.



Fig.11 Wireframe of “和”



Fig.12 Stereogram of “曲” ( $\theta=90^\circ$ )

When  $\beta_1=1, \beta_2=0$ , examples of the horizontal Angle  $\theta$  and vertical Angle  $\varphi$  (in figure 12, 13).

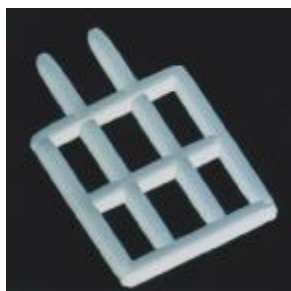


Fig.13 Stereogram of “曲” ( $\theta=60^\circ$ )

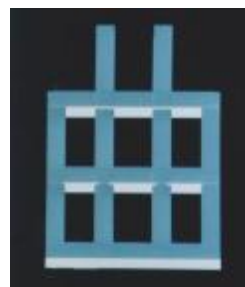


Fig.14 Stereogram of “曲” ( $\theta=90^\circ$ )

In figure 12, when  $\theta=90^\circ, \varphi=60^\circ$ , stereogram of "曲", it consists of 7 double Beta spline-curves joining together, 6048 parallelograms compost altogether.

In figure 13, when  $\theta=60^\circ, \varphi=60^\circ$ , stereogram of "曲".

Compare 12 with 13, figure 13 has more stereognostic sense. Because when horizontal view angle  $\theta=90^\circ$ , the thickness of "Shu" in Chinese characters does not perform, we only find the thickness change of "Hen", "Pie", "Na" according to the change of vertical Angle  $\varphi$ , and when horizontal view angle  $\theta \neq 90^\circ$ , the thickness of "Shu" will perform.

The flowing are some examples of when  $\beta_1=1, \beta_2=100$ , the results with different vertical view angle  $\varphi$  and horizontal view angle  $\theta$  (figure 14, 15 16).



In figure 14,  $\theta=90^\circ$ 、 $\varphi=60^\circ$ , stereogram of "曲"

In figure 15,  $\theta=80^\circ$ 、 $\varphi=60^\circ$ , stereogram of "曲"

In figure 16,  $\theta=60^\circ$ 、 $\varphi=60^\circ$ , stereogram of "曲"

Compared with figure14, 15 and figure 16, with  $\theta$  changing, so is the thickness of "Su". The smaller  $\theta$ , the more obvious the thickness of "Su".

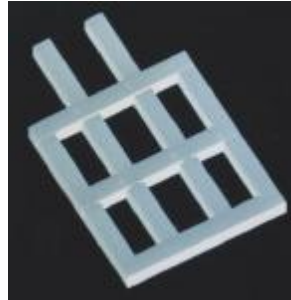


Fig.15 Stereogram of “曲” ( $\theta=90^\circ$ )

Fig.16 Stereogram of “曲” ( $\theta=90^\circ$ )

## 9 Conclusion

This paper puts forward the method of selecting controlled vertexes of the basic Chinese characters strokes, which has some advantages like small workload, easily calculating. Joining basic strokes together to form Chinese characters, can get the Chinese outline by double Beta spline-curve. The method in this paper accords with the Chinese characters structure, and it can realize real-time control in modeling of Chinese characters with some advantages like controllable, geometrical invariability and fast generation, etc.

Molding Chinese characters is only one application using of double Beta spline-curve's function. Double Beta spline-curve can also be widely used for the design of ship's molded lines controlled parameters  $\beta_1$  and  $\beta_2$  has significant effect to the shape of double Beta spline-curve, so, through studying controlled parameters  $\beta_1$  and  $\beta_2$  can improve the shape of area curve of ship's cross section, which can also used for the design of ship's molded lines and the fitting ship's molded lines. By the research on related design system, computer program can simulate some work like ship mathematical lofting and manual smoothing, which can improve the application use of double Beta spline-curve on ship design area.

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