

Application of Bezier Curves in Knitting Industry CAD/CAM Systems

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Abstract - This paper treats the problems related to the curves usage for presentation of knitting objects patterns. The possibilities of Bezier curves application are investigated. Two functions drawing Bezier curves are represented. Their application for a graphics representation of knitting products' patterns is given, too. The paper shows the possibilities of their usage in CAD/CAM systems in knitting industry automation. The examples of functionality are given. Bezier curves may be used to form necklines and sleeves as cuts of knitting products. This method gives us a good precision using three or four control points.

Keywords - Bezier curves, computer graphics, CAD/CAM systems, knitting industry.

I. INTRODUCTION

Computer Aided Design is one of the most important applications of Computer Graphics. CAD/CAM systems development is closely related to a usage of computer graphics software algorithms. To realize the CAD/CAM systems software the developer has to use mathematical methods and algorithms for screen representation of designed objects. The kind of these objects determines the proper methods and algorithms applied in the particular CAD/CAM system.[4]

Knitting products and knitting structures are designed in CAD/CAM systems for knitting industry automation. Because this paper does not treat the problems related to knitting structures representation, these kinds of methods will be not discussed.

Usually, as designed objects the patterns of knitting products are represented with straight-line polygons. [4],[5] This manner of pattern representation is used because of following reasons:

- It is possible for the knitting products size to have a little tolerance in limits of ± 1 cm.
- It is easier to process straight-lines than curves.
- Knitting machines are not so precise in material production. This precision depends on a knitting machine performance called fine or gauche. The performance is related to the number of needles per inch or cm. It determines a loop size and a thread thickness, too.

Because of these reasons the patterns of knitting products are described as straight-lines polygons without curves. If there is curve section, the workers form it additionally by cutting material.

Cutting material to form products is not a good solution for modern knitting production. More over, modern knitting machines are precise and they have great abilities to knit products by Fully Fashion (FF) method. It imposes usage of curves in graphics representation of knitting products in CAD/CAM systems.

This paper treats the problems related to Bezier curve application in knitting object pattern design. Functions drawing Bezier curves are created. These functions will be used for a graphics representation of knitting products' patterns. The paper shows the possibilities of their usage in CAD/CAM systems in knitting industry automation.

II. BEZIER CURVES

A Bezier curve in its most common form is a simple cubic equation that can be used in any number of useful ways. Originally it was developed by Pierre Bezier for CAD/CAM operations. [1],[2],[3]

Bezier curves are defined using m control points, known as knots. Two of these are the end points of the curve, while the others effectively define the gradient at the end points. These points control the shape of the curve. The curve is actually a blend of the knots. This is a recurring theme of approximation curves; defining a curve as a blend of the values of several control points. [2],[10]

A Bezier curve is represented in parametric form as:

$$\begin{aligned}x &= p_x(t) \\ y &= p_y(t)\end{aligned}\quad (1)$$

Let (x_0, y_0) , (x_1, y_1) , ..., (x_m, y_m) be control points. The Bézier parametric curve function is of the form:

$$\begin{aligned}p_x(t) &= \sum_{i=0}^m C_m^i t^i (1-t)^{m-i} x_i \\ p_y(t) &= \sum_{i=0}^m C_m^i t^i (1-t)^{m-i} y_i\end{aligned}\quad (2)$$

A parameter t value varies from 0 to 1.

The value of the coefficient C_m is:

$$C_m^i = \frac{m!}{i!(m-i)!}\quad (3)$$

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Using the vector form the formula (1) is represented as:

$$P(t) = \begin{bmatrix} p_x(t) \\ p_y(t) \end{bmatrix} \quad (4)$$

Then, Bezier curve given as formula (2) is represented as:

$$P(t) = \sum_{i=0}^m C_m^i t^i (1-t)^{m-i} P_i \quad (5)$$

For better graphics interpretation let us transform this formula as:

$$P(t) = (1-t)^m P_0 + \sum_{i=1}^{m-1} C_m^i t^i (1-t)^{m-i} P_i + t^m P_m \quad (6)$$

For computer presentation the equation (6) is better than (5) because there is division by zero if $i=0$, or $i=m$. Moreover, the function $n!$ for $n=0$ is not defined.

The examples for graphics representation of Bezier curves are given on fig. 1.

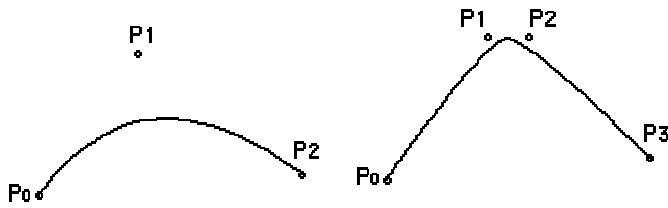


Fig.1. Examples of Bezier curves

III. BEZIER CURVES GENERATION FUNCTIONS

Using formula (6) let us present the equation for three control points. The value of $P(t)$ is determined by the following equation:

$$P(t) = (1-t)^2 P_0 + 2(1-t)t P_1 + t^2 P_2 \quad (7)$$

Using four control points, the equation (6) is represented as:

$$P(t) = (1-t)^3 P_0 + 3(1-t)^2 t P_1 + 3(1-t)t^2 P_2 + t^3 P_3 \quad (8)$$

Using Visual C++ 6.0 and Microsoft Foundation Class Library the function drawing Bezier curves are created. The following functions Bezier2 and Bezier3 draw Bezier curves with three and four control points, respectively.

The function drawing a Bezier curve using three control point is:

```
void Bezier2(CDC *pDC, CPoint P0, CPoint P1, CPoint P2)
```

```
{
    double t, dt, x, y;
    pDC->MoveTo(P0);

    dt=0.1;
    t=0;
    while (t<=1)
    {
        x=(1-t)*(1-t)*P0.x+2*(1-t)*t*P1.x+t*t*P2.x;
        y=(1-t)*(1-t)*P0.y+2*(1-t)*t*P1.y+t*t*P2.y;
        pDC->LineTo(CPoint((long)x,(long)y));
        t+=dt;
    }
}
```

The function drawing a Bezier curve using four control point is:

```
void Bezier3(CDC *pDC, CPoint P0, CPoint P1, CPoint P2,
CPoint P3)
{
    double t, dt, x, y;

    pDC->MoveTo(P0);

    dt=0.1;
    t=0;
    while (t<=1)
    {
        x=pow((1-t),3)*P0.x+3*pow((1-t),2)*t*P1.x
+3*t*t*(1-t)*P2.x+t*t*t*P3.x;
        y=pow((1-t),3)*P0.y+3*pow((1-t),2)*t*P1.y
+3*t*t*(1-t)*P2.y+t*t*t*P3.y;

        pDC->LineTo(CPoint((long)x,(long)y));
        t+=dt;
    }
}
```

The parameters P_0, P_1, P_2, P_3 represent control points. $CPoint$ is a class describing a point with x, y -coordinates. The parameter pDC is a pointer to Device Context (DC) corresponding to the monitor as an output device.

To find a current position of x, y the function Bezier2 uses the equation (7), and function Bezier3 uses the equation (8). The value of the t -parameter varies from 0 to 1 with a step $dt=0.1$. Because these functions are used for graphics representation of knitting object patterns the precision related with dt value is enough.

IV. APPLICATION OF BEZIER CURVES GENERATION FUNCTIONS

Using the fact that the seizures of knitting products allow a little tolerance, the most CAD/CAM systems in knitting industry do not use the curves for graphics representation of knitting patterns. [7],[8],[9],[11]

In most cases the presentation of these objects as straight-line polygons is allowed but using the curves give us better

precision. Forming sleeves and necklines requires curves usage as graphics objects.

The example for the Bezier2 function usage is shown on fig. 2. The drawing of neckline and sleeve is an application of this function. The positions of the control points are given, too.

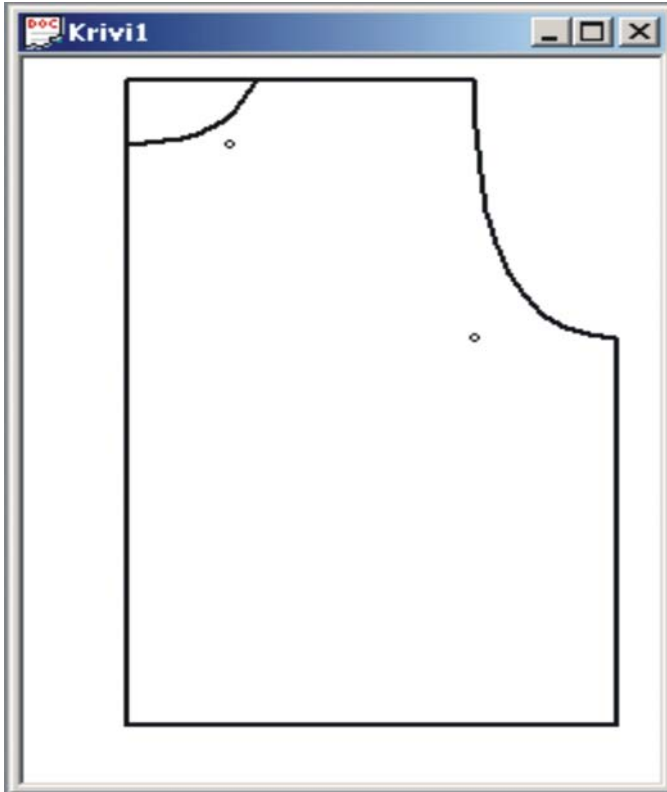


Fig. 2. Knitting pattern using Bezier2 function

Figure 3 present the forming of a neckline by using Bezier3 function. In comparison to previous example the neckline is formed more precisely but the difference is not great. It means that the usage of four control points has the approximate precision as the usage of three control points.

Figure 4 is an example of drawing a sleeve by using of Bezier3 function.

As it is shown by the examples the Bezier curves may be used to form necklines and sleeves in pattern of knitting products. The curve has a good precision. Is not necessary to use more than four control points. The main problem is the estimation of control points' positions. An interactive method is recommended to find the proper x,y-coordinates of control points.

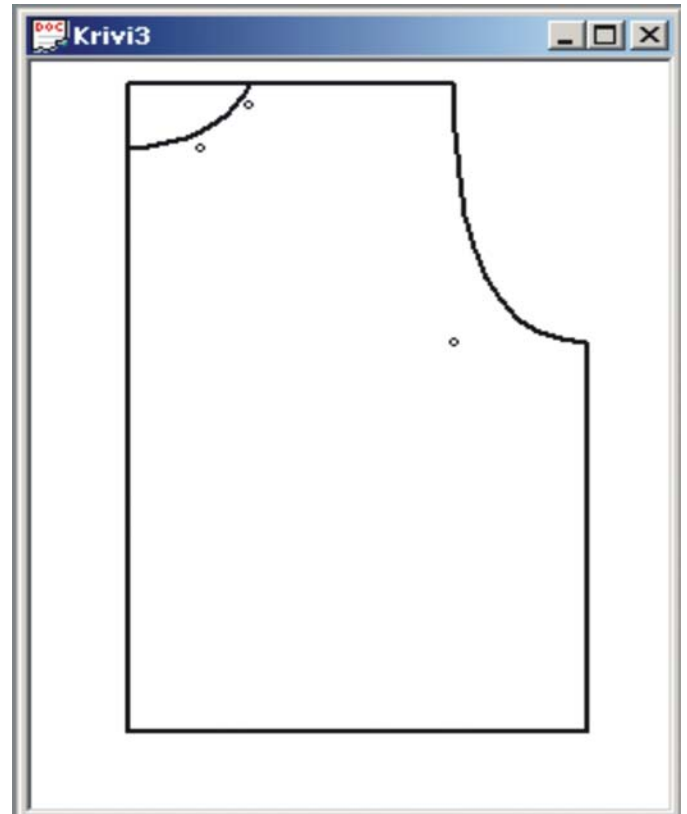


Fig. 3. Knitting pattern using Bezier2 and Bezier3 functions

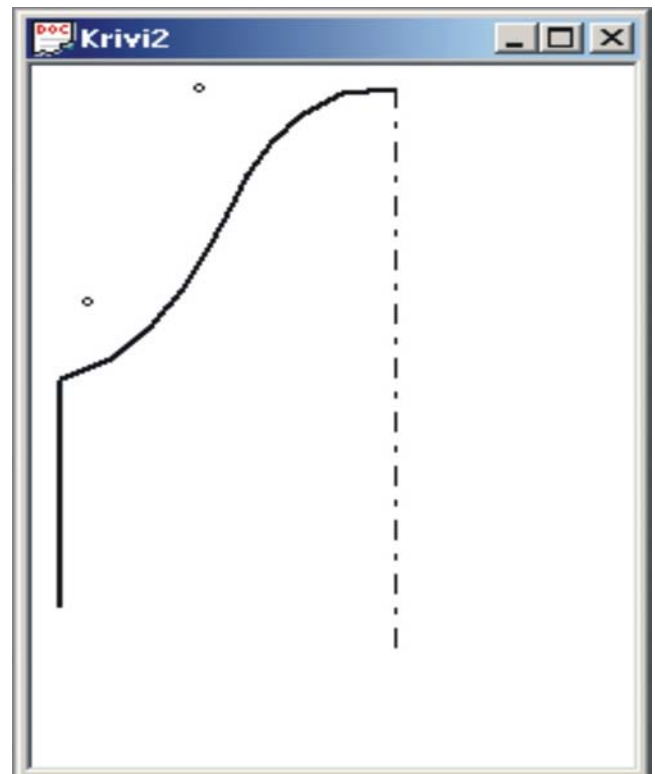


Fig. 4. Knitting pattern using Bezier3 function

V. CONCLUSION

For a graphics presentation of knitting objects patterns in CAD/CAM systems straight-lines polygons are used usually. To show these patterns more precisely, it is necessary to apply curves as polygons' sections. This paper treats the problems related to the curves usage for presentation of knitting objects patterns. The possibilities of Bezier curves application are investigated.

This paper presents two functions for drawing Bezier curves and their application for a graphics representation of knitting products' patterns. The paper shows the possibilities of their usage in CAD/CAM systems in knitting industry automation. The examples of functions application are given.

Bezier curves may be used to form necklines and sleeves in pattern of knitting products. This method gives us a good precision using three or four control points. To estimate the proper x,y-coordinates of control points an interactive method is recommended.

The presented functions have an application in CAD/CAM systems in knitting industry. The Bezier curves may be used successfully in automation of the other branches of textile industry as tailoring, embroidery.

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