The 3D Simulation Research of Apple Fruit

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Abstract. To simulate the apple fruit on computer effectively, analyze the characteristics of apple fruit shape and color, cubic b curve is adopted to fit the peripheral contour curve and then a model based on geometric method that use less parameters is put forward to construct apple fruit shape curve and calculate the coordinate points.The 3D simulation of the model proved that this model can construct apple fruit quickly and effectively.

Introduction

Apple is a kind of the most common fruits, it is delicious, healthy, and apple tree is easy to plant, so many people like to eat and plant them, apple has great economic value, too. This paper is committed to do some research about the geometric modelof apple fruit, and further, implement the 3D simulation on computer.

According to observe many apple fruit, it is found that most of fruits are nearly ellipsoid shape and their color are different by their species, most of them are red or green. For the aim to describe the apple fruit in a geometric method, several parameters are put forward, fruit shape index, the gradient of fruit axis, the height of fruit ridges and the place that the max value of fruit diameter cross with fruit axis, and so on.

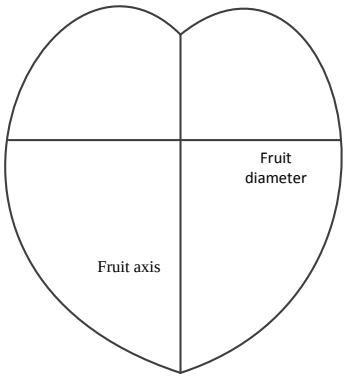


Fig.1 The meaning of fruit axis and fruit diameter

The construction of apple fruit 3D model

The model of apple fruit should be able to describe the shape effectively, and also can be controlled easily, for the two aims, the parameters of apple fruit model is the less the better.According to the characteristics of apple fruit shape, Bézier curve is used to describe its peripheral contour curve, considered the controllability, cubic Bézier curve is adopted. Acubic Bézier curve $P(t)$ can be defined as follow:

$$P(t)=\sum_{i=0}^{n} B_{i,n}(t)q_i, \quad 0 \le t \le 1 \qquad (1)$$

In Eq.1 q_i is a characteristic polygon that construct the curve, $B_{i,n}(t)$ is a Bernsteinbasisfunction.

Then, the function of peripheral contour curve can be deduced based on four control points. Let t ncrease from 0 to 1, and then a series of coordinate points can be calculated.

Through the above analysis, we know that the main parameters that inflect the shape of apple fruit is the max value of fruit axis and fruit diameter and their places. So we describe the process

that peripheral contour curve constructed as followed.

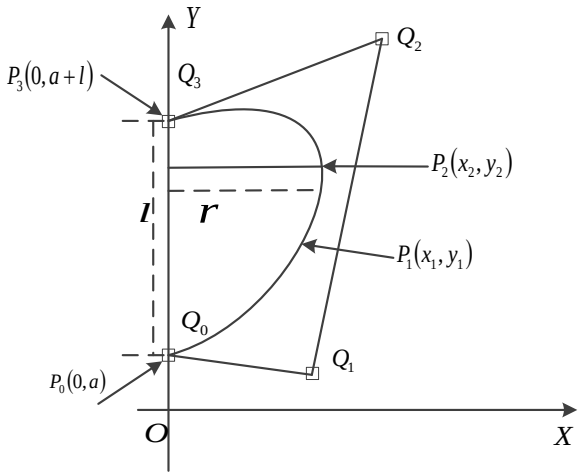


Fig.2 profile curve construction of apple fruit cross section

As shown in Fig.2, for the convenient of calculation, set the Bézier curve is in flat XOY, there are 4 type value points P_0, P_1, P_2, P_3 on Bézier curve. The distance between P_0 and P_3 is the length of fruit axis, its value is l, the X-axis part of P_2 is half of the max fruit diameter, its value is r, the Y-axis part of P_2 is the max fruit diameter on fruit axis, P_1 is any point on the curve. So the control points of Bézier curve can be deduced by these four type value points. Assume that control points are Q_0, Q_1, Q_2, Q_3, then Eq.2 is set up.

$$\left.\begin{aligned} P_0 &= Q_0 \\ P_1 &= \frac{8}{27}Q_0 + \frac{4}{9}Q_1 + \frac{2}{9}Q_2 + \frac{1}{27}Q_3 \\ P_2 &= \frac{1}{27}Q_0 + \frac{2}{9}Q_1 + \frac{4}{9}Q_2 + \frac{8}{27}Q_3 \\ P_3 &= Q_3 \end{aligned}\right\} \quad (2)$$

Q_0, Q_1, Q_2, Q_3 can be deduced by Eq.2, the Bézier curve can be drawn, so, the Bézier curve can be controlled by l and the coordinate of P_2. The number of points on Bézier curve can be changed through the changing of step, these coordinates information will be used to construct apple fruit surface.

The calculation of apple fruit surface coordinates

In fig.3,assume that $P_0(x_0, y_0, z_0)$ is a random point on the Bézier curve, it rotated around Y-axis with θ angle, counterclockwise, then, there is Eq.3

$$\left.\begin{aligned} x &= |x_0|\cos\theta \\ y &= y_0 \\ z &= |z_0 \sin\theta| \end{aligned}\right\} \quad (3)$$

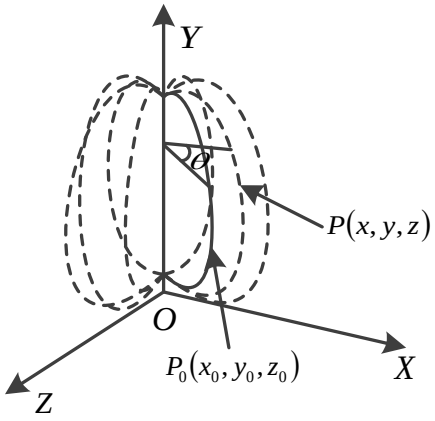
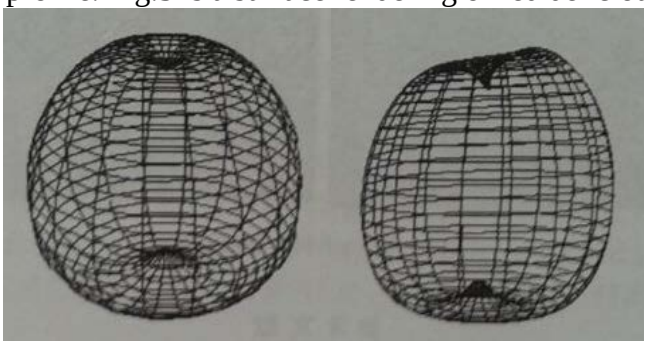


Fig.3 3D coordinate of apple fruit profile

θ will increase from 0 to 360 with a fixed step, then, all the 3D coordinates of points in Bézier curve will be deduced by Eq.3. Recorded them.

At last, grid these 3D coordinates values as a fixed sequence, the surface profile of appl e fruit has been constructed. Do linear perturbation to the fruit diameter and then the oblique type fruit grid can be constructed. As shown in Fig.4

Some kind of apple fruit have ridges on the surface of fruit, for example red delicious apple, through adding disturbance function to disturb parts of coordinates in a certain range to construct the surface profile. Fig.5 is a surface rendering of red delicious apple.



(a) middle-axis (b)oblique-axis

Fig.4. Grid surface off apple fruit

Fig.5 grid surface of red delicious apple

Simulation of apple fruit

On the basis of above grid surface, add color effect, the simulation result is shown in Fig.6

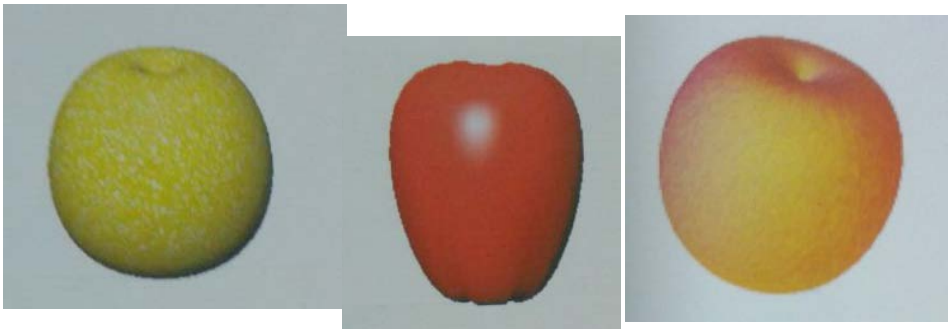


Fig.6 the simulation result of apple fruit with color effect

Summary

This paper put forward a new method to set up apple fruit geometric model, it is according to the characteristics of apple fruit, analysis its structure, and then adopt Bézier curve to construct the profile curve function, and then, with the basis of function, calculate the 3d coordinate of profile surface, as last, implement the simulation on computer.

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