The 3d Visualized Model of Apple Blossoms

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Abstract. To construct the 3D visualized model of apple flower, study the apple flower organs and construct their mathematical models,and then construct the 3D model of flower stalk, receptacle, calyx, corolla, stamens and pistildividually, at last, with the construction of 3D model of inflorescence, the whole 3D visualized model of apple flower is constructed completely.The virtual simulation model proved that the 3D visualized model is realistic, it can indicated the apple flower on computer truly, this model can be used in teaching, the electronic commerce and other areas.

The structure of the apple flower

A single apple flower is constructed by flower stalk, receptacle, pistil, stamens calyx and petals, flower stalk is the transmission channelof nutrients from stem to flower. pistil and stamens calyx and petals are grow on receptacle， the shape of receptacle is just like a concave cup, and there are five pieces of calyxes, they are green and grown on receptacle. The corolla are pink and constructed by 5 petals, the numbers of stamens is 20 to 30, and pistil is 3 to 5.

According to the structure of apple flower morphological characteristics, The geometric model of apple flower is constructed separately.

The mathematical description and model of flower stalk, receptacle, pistil and stamens

According to the research of flower stalk, receptacle, stamens and pistil, we found that these organs are all tubular, theirs cross section are round, and the whole organ has a center axis, so, we can construct theirs model through curve fitting, only two parameters are needed. And, for the aim that describing nature curve shape of these organs, use B spline curve to fit the center axis. Now, the 3D coordinates of any point on cross section can be calculated in the help of the 3D coordinates, the tangent and the radium of cross section. The specific methods is shown in fig.1

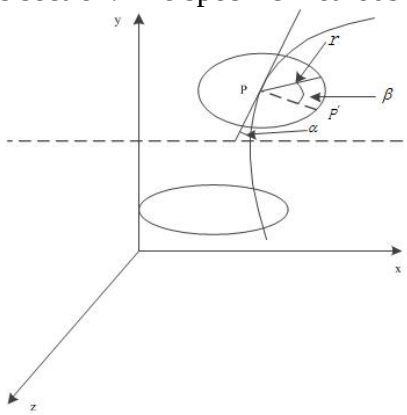

Fig.1 The 3D coordinate of flower stalk curve outline point

In fig.1, the point $P(x_0, y_0, z_0)$is a point on the center axis, α is the angle between the tangent of point P and axis OX , point P rotate in cross section as angle β , radium r and directioncounterclockwise, then

$$\begin{cases} x = x_0 + r\cos(\pi/2 - \alpha)\cos\beta \\ y = y_0 + r\sin(\pi/2 - \alpha)\cos\beta \\ z = z_0 - r\sin\beta \end{cases} \quad (1)$$

The value of β increased for 0 to 360 with a certain step, that means all outline points of the point on axis can be calculated, then with the help of this algorithm we can got all of the outline points of the center axis which length is l, recorded these information grid them as a certain sequence, thenthe curve surface outline is drawn.

Flower stalk and filaments of stamens have the same shape, that means formula.1 can also describethe shape of them, now, r is a constant value. The visualized model is shown in fig.2

Fig.2 The model of stamens

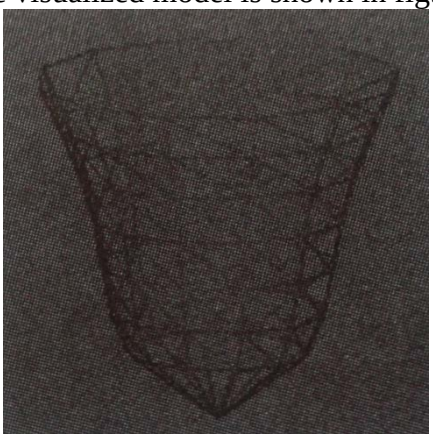

Fig.3 the surface of receptacle

The receptacle is just like a concave cup, so, its radium is monotone increasing, and it can be calculated through a monotone increasing function $r = l^{1/2}$. But the thickness of the pistil is not changed monotonous, so, its cross section radium should be confirmed by a piecewise function as shown in formula2. The 3D simulation of receptacle is shown in fig.3

$$\begin{aligned} r &= -\frac{36r_1}{L^2}l^2 + \frac{12r_1}{L}l, l \in [0, l_0] \\ r &= -\frac{2r_1}{5L}l + \frac{r_1}{2}, l \in [l_0, l_1] \\ r &= -\left(l - \frac{9}{10}L\right)^2 + r_2, l \in [l_1, L] \end{aligned} \quad (2)$$

In formula 2, if we know the max radium of the bottom cross section r_1, the max radium of the top cross section r_2 and the center axis length L, the cross section radium of pistil could be calculated, as shown in fig.4, and the 3D simulation of pistil is shown in fig.5.

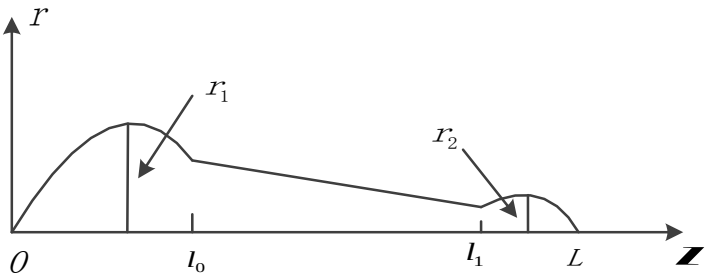

Fig.4 The radium of pistil section

Fig.5 the visualized model of pistil

The mathematical description of calyx and petals

The shape of calyx and petal are similar, so, we use cubic B-spline curves to fit the frame of the petal and calyx. One B-spline curve is use to fit the midvein line, and the other two are used to fit the outline on left and right. As shown in fig.6, if the length and the width of the calyx are known, the frame can be constructed. And then catch a team of points with the same space, then grid these points in a certain order, then the curve surface grid is shown before your eyes.

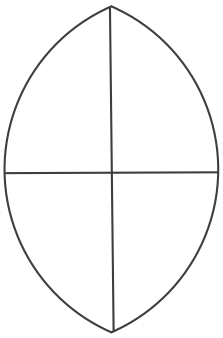

Fig.6 the geometric model of petal

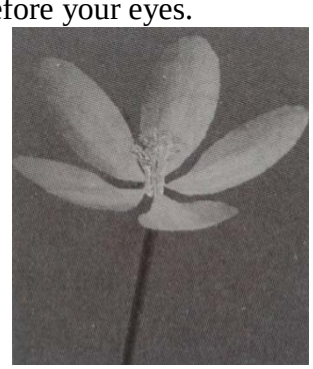

Fig.7 The simulation of a single blossom

The model of a single flower

According to the mathematical description of every organ, the geometry model of every organ have constructed. Then, combine these model with the topologyinformation of apple flower, a single flower model is constructed. The position of calyx, petal, pistil and stamen on the receptacle is confirmedin polar coordinates.

For the aim that the model is more similar to the real one, random functions are imported in the description of the angle between calyxes, the bend degree and so on. As shown in fig.7

The model of inflorescence

The inflorescenceof apple blossoms is cyme, every inflorescence has 5 to 8 flowers, the middle flower will blossom first, the others blossom at last, then, the structure of inflorescence is constructed as shown in fig.8, rotation angle, branching angle, the length of pedicel and the size of flower are used to construct the model. As shown in fig.9

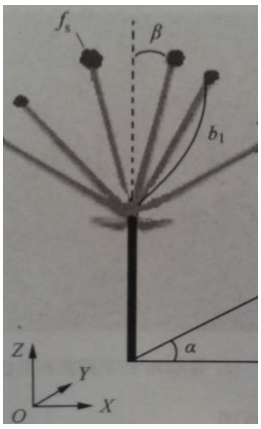

Fig.8 the structure of inflorescence

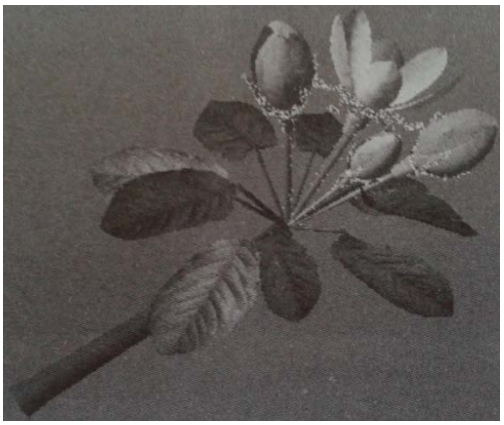

Fig.9 the 3D simulation of apple blossom

Summary

In this paper, the visualized model of apple blossoms is constructed through analyzing the geometry structure of every organ of the apple blossoms, according to their nature structure, use different geometry model to describe them, and at last, visualize the model on computer. The simulation result indicate that the model can describe the apple blossoms truly and effectively.

Reference

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