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Digital Simulation Research on Tree Dynamic Feature Capturing Information System Based on Image Processing

Lin Hong, Xu Weiheng [a*], Qiang Zhenping, Lu Ning, Yu Yueyun

School of Computer and Information science, Southwest Forestry University, Kunming 650224, ,P.R.China

[a]weihengx@gmail.com

Key words: dynamic simulation; OpenGL; virtual dynamic; simulation; dynamic characteristics; information system.

Abstract. This paper establishes tree model based on *L* system, and builds the wind field mathematical model added noise disturbance; focusing on the leaves dancing in the branches with the wind and leaves fall in motion; and it avoids the occurrence of the penetration phenomena in the leaf movement process because of using bounding sphere method in combination with the convex polyhedron detection method for collision detection. The whole system is developed by VC++ 6.0 environment combined with OpenGL tool, the simulation process is real and natural, which can meet the requirements of real-time. The proposed algorithm is applied to the leaves motion simulation when wind speed is not too large, the wind model should be improved for the more detailed research in the future, considering the condition of the branch breaking caused by wind speed and the complexity of the tree model structure.

1 Introduction

At present, in many areas of natural landscape such as games, architecture and other fields, the movement of plants, especially trees, has received extensive attention and application.

Most of the trees simulation focus on the movement of tree trunks and branches research today, and the movement of the leaves is seldom mentioned. Therefore, 3D model of the tree has been generated based on *L* system in this paper, and the two kinds of leaves movement rotation and fall in Perlin noise random wind field are studied, wherein, the rotation movement can be divided into two cases of the rotation when leaves in the branches and rotation in the process of falling.

2 Tree modeling method

At present, the methods of establishing the 3D model of the tree, the method of modeling based on *L* system has become a common modeling method for many researchers, because of its high degree of structure, the method is simple and easy to implement.

2.1 Basic principles of L system

In 1968, Lindenmayer designed out a formal language, which is *L* system that making a number of related research inspired, after that, in 1984 and 1986, Smith and Prusinkiewicz successfully took it as a tool to study plant model in computer graphics. Thereafter, it was used to simulation of plant leaves, plant hairs and specific plants such as bamboo and so on.

L system actually interprets the string as graphics, which is often called string rewriting system. In fact, it has to tell us: if we generate a kind of graphics, convert it to the corresponding string. Basic characters in the *L* system include "+", "-", "F", "[", "]". In the formation of a string we should note that: First, prepare one or a few initial letters as "seed"; second, given a set of generative rules, the whole iteration must be carried out according to the rules of rewriting. Repeatedly using the complex sub string to replace the "F" characters in the simple sequence, we can get a more complex target string.

When the *L* system uses a specific geometric meaning for each letter, the entire target string together is a meaningful graph, which can be used to obtain a complex fractal image.

2.2 Dimensional tree model of *L* system

According to the principle of the *L* system, assume that the initial direction is vertical, step is *d*, angle increment is σ, a set of production formula for the model is given:

$$\begin{aligned} &G = \{V, W, P\} \\ &V = \{F, +, -, [,]\} \\ &W : F[-F][+F] \\ &P = \{P_1\} \\ &P_1 : F \rightarrow F[+F]F \end{aligned} \tag{1}$$

In the formula (1), the character "F" is fractal graphics move *d* (*d* is step); "+" is the counterclockwise angle σ; "-" is the clockwise angle σ; "[" is the current information into the stack; "]" is the stack top information out of the stack. According to this rule, a replacement formula for the string is that:

$$F[-F][+F] \rightarrow F[+F]F[-F[+F]F][+F[+F]F] \tag{2}$$

By this method, a two dimensional tree model is generated.

2.3 3D tree generation in *L* system

Next, the two-dimensional tree is introduced into the three-dimensional space. There are two ways to achieve: method one, the two dimensional tree model for different angles of rotation, in order to obtain a three-dimensional model; method two, in the above rules focused on increasing the current direction upward rotation angle". After adding the '*' rule, the definition of *G* is shown as follows:

$$
\begin{aligned}
&G = \{V, W, P\} \\
&V = \{F, +, -, *, [,]\} \\
&W : F[-F]*[+F] \\
&P = \{P_1\} \\
&P_1 : F \rightarrow F[+F]*F
\end{aligned} \tag{3}
$$

Thus, the tree of the three-dimensional structure of a string replacement:

$$
\begin{aligned}
&W : F[-F]*[+F] \rightarrow F[+F]*F[-F \\
&[+F]*F]*[+F[+F]*F]
\end{aligned} \tag{4}
$$

The 3D tree model can be generated by repeated iteration. The shapes of trees in nature vary widely, model should also is the mix of the length and the thickness direction of each branch,which can not be stereotyped,. Therefore, the rotation angle can not take a constant value, we can take a certain range of random values.

3 Collision detection

In the process of simulation, it can be seen that the leaves are clear and vivid, like the true leaves. But in the movement of leaves found a problem, the leaves fall in the process encountered another piece of leaves, inside a layer of leaves will not is shielding outer leaves the penetration phenomenon (shown in Figure 1), suggesting that in leaf movement in the process of collision detection is inevitable.

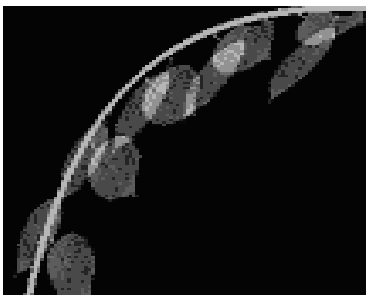

Fig. 1 The phenomenon of foliage penetration

Collision between the leaves occur in the following cases: leaves in the branches swing collide with each other and leaves fall collide with each other and leaves fall to the ground and ground collision. Leaves on the branches collide with each other is often a flash and, in a very short time; in addition, leaves fall instantly, although the collision, but due to the location of the ground have been identified, it is easy to control the leaves to the ground will not penetrate the ground, therefore, this paper will focus on on the leaves fall in the process of the collision and the collision is obvious and is likely to penetrate the phenomenon to occur.

Given the huge number of leaves, leaves shape changing, every leaf if according to its own shape and size to detect each other if a collision occurs, the amount of calculation can be described as a huge, the real-time of the simulation is not up to the requirement. Therefore, it is necessary to find a simplified

method to touch the collision detection. There are many methods for collision detection, because leaves the rotary motion of the motion trajectory similar to a ball, based on the bounding sphere detection algorithm to detect. This method is rough some, but can quickly identify a suspected collision leaves; in order to further detect the occurrence of collision, and then use the collision detection algorithm based on convex polyhedron of suspected collision leaves further testing. As a result, it not only ensures the real-time and accuracy of the standard.

Specific detection steps are as follows:

The first step, a bounding sphere algorithm can be used to find suspected collision leaves: Calculation of the two bounding sphere center distance d and a radius and r_i+r_j. When meeting $d<r_i+r_j$, two suspected collision can be thought.

The second step: using the method of convex polyhedron to further confirm the suspected collision leaves. The principle is to detect whether the point of a convex polyhedron falls into the interior of the other convex polyhedron, and if it falls into, then the collision of the two polyhedron is explained. For the occurrence of the collision of leaves, can be based on the depth of the value of the depth of the value of the small depth of the occlusion of the principle of the use of graphics z-buffer hidden algorithm, it will avoid the occurrence of penetration.

We select the section of the branches were simulated, figure 2 and Figure 2 is the movement of this section of the branches in the wind: two amplitude diagram in twigs and branches and leaves under the action of wind have varying degrees of shaking; Figure 2 and Figure 2, respectively, the interception of a monolithic leaves falling and more pieces of leaves fall at the same time the situation simulation.

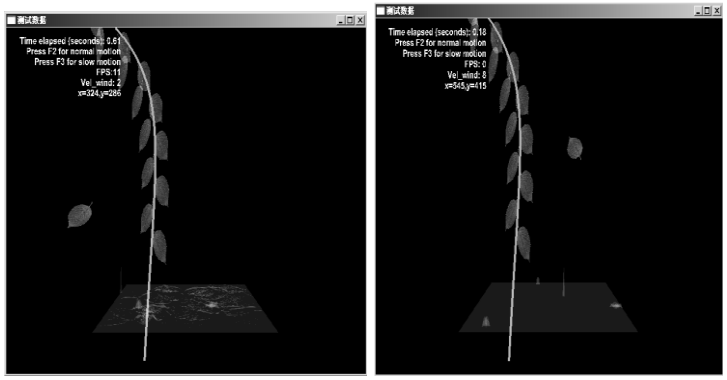

Fig.2 The movement of the leaves screenshot 1

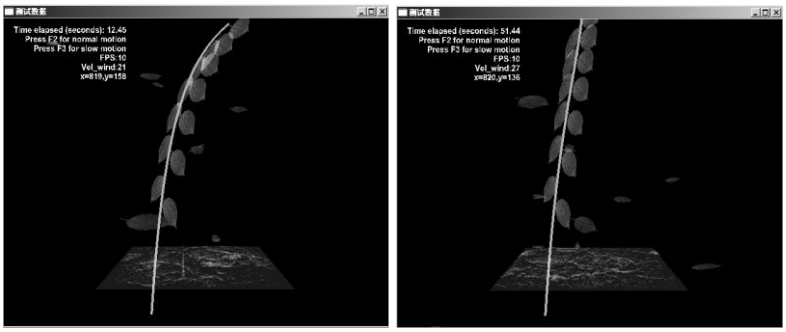

Fig.3 The movement of the leaves screenshot 2

Visual C++ 6.0 development platform is used in programming, combined with OpenGL rendering technology to simulate the effect of branches swaying in the wind, as shown in figure 4.

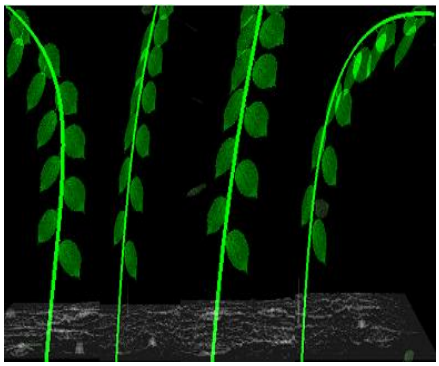

Fig. 4 Effect after rendering

4 Leaf movement analysis

Figure 5 is leaf simple graph model, the texture of the real leaves is pasted on the block diagram when programming, including petiole and leaf, it becomes a rotational translational but also realistic strong leaves.

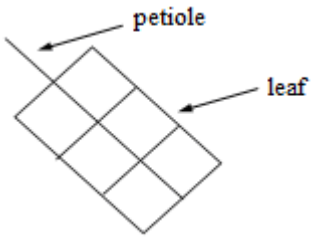

Fig.5 Leaf simple graph model

This paper mainly studies three kinds of leaves motion, leaves fall, leaf move round petiole and the leaves on the branches rotation with branches sway. The rotation of the leaves in the wind is different in different situations: when the leaves are hanging in the branches and leaves around petiole shaft to rotate; while the leaves are wind blew off the ground in the process of leaves around the two symmetrical shaft to rotate.

According to the classical Newtonian mechanics, the movement of the leaves should be classified as acceleration movement, so the Euler integral method can be used to solve the motion of the leaves. Figure 6 is the movement of leaves and branches, as well as the simulation results of the whereabouts of the leaves.

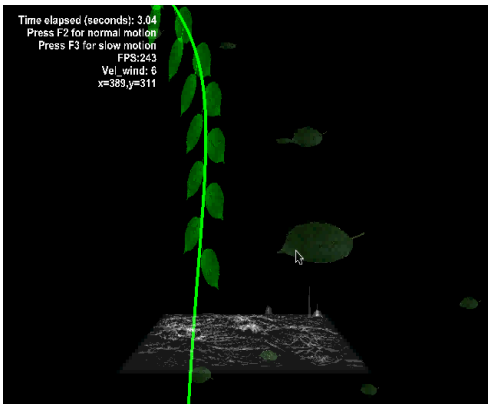

Fig. 6 The leaves move with the branches and the leaves falling

5 System implementation

the OpenGL graphics library is used to initialize the 3D scene, the method of the sky bounding box is used to set up the environment of the tree, the tree branches are drew in a cylinder and texture method. Figure 7 is a tree under the wind action changes the branches bent to different simulation screenshot. From the figure can be seen when a gust of wind blowing, the bending of the bough more powerful, the breeze blows is branch bending degree significantly weakened.

Fig.7 (a) The simulation graph of tree under the action of wind

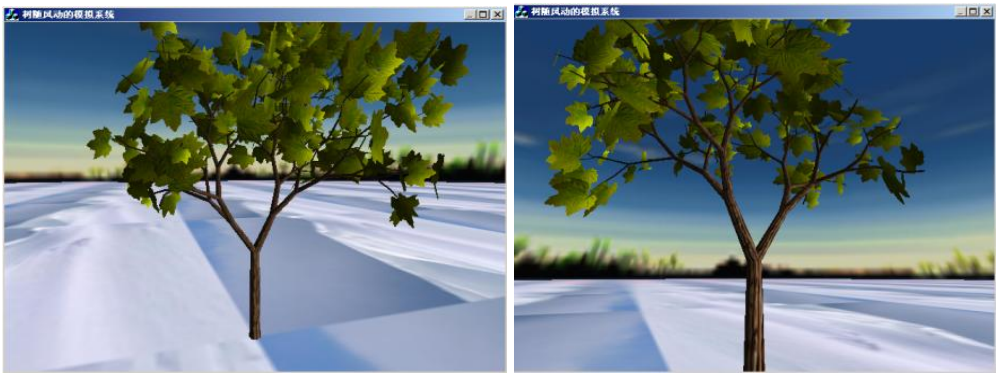

Fig. 7 (b) The simulation graph of tree in the breeze

Fig.8 is the simulation motion picture of tree under the action of wind with different size and direction, the simulation of real time, the effect is realistic.

Fig.8 The simulation motion picture of tree

6 Conclusion

In order to simulate dynamically the movement of the trees in the wind, firstly, the 3D model of the tree has been established in this paper on the basis of the fractal principle of *L* system, and considering the wind effect, stochastic wind field mathematical model is established, and the rotation angle method is used to simulate the movement of branches. Finally, the tree leaves movement have been analyzed. Using VC++ 6.0 and OpenGL as the development tool, the system simulation of the tree with the wind has been realized, the trees swaying in the wind realistic effect has been effectively simulated.

This algorithm in the paper is suitable for the simulation of the vast majority of tree species. In the more detailed research in the future, we can further improve the wind model and increase the structure complexity of the tree model.

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