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Visualization Research on Realistic Forest Scene

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Abstract

The three-dimensional visualization of virtual forest scene is a key technology for forestry informationization. Due to the large amount of calculation of large-scale forest scene, most research methods or softwares tend to adopt simplified tree models, which make user's experience not friendly and sense of reality poor. In this paper, a hierarchical parameter modeling method under the restriction of biometric is preferred, which can guarantee both the authenticity of the data and the speed of modeling process. Model library based on a serial of tree models of different level of detail is established, which can provide convenience for rendering forest. With the support of powerful SpeedTree SDK, the speed and accuracy of rendering will get effectively balance.

Keywords: sense of reality, forest scene; visualization.

1. INTRODUCTION

In recent years, applications of virtual natural scene have widely used in computer games, military simulation, digital media and so on. Computer modeling techniques and visualization techniques which set trees and forests as primary research objects have been developed rapidly. However, due to the amount of calculation for large-scale forest scene, most research methods or softwares tend to adopt a simplified tree model. But they had always been complained with unfriendly user experience and poor sense of reality. So research on the real-time simulation of forest scene with realistic trees' models is a hot problem to be solved.

1.1 Modeling and rendering methods of single tree

The difficulties of using computer to simulate trees in nature mainly lies in two points. On the one hand, the variety of trees in nature leads to the wide differences in appearance. On the other hand, each single tree owns very complex constructure and the characters of each part of it are variant, which increases the difficulty of modeling of each type single tree.

At present, the modeling methods for single tree can be summed up in three categories: based on the growth process, based on the parameter property, and based on the image. Modeling method based on the growth process focuses on the self-similarity during the growth process of the trees, usually designs some simple growth rewrite rules and iteratively generates all kinds of high precision models according to these rules. The

disadvantage of this method is not beautiful enough and large amount of calculation. The famous A-System (Anono et al., 1984), L-System (Lindenmayer, 1968), IteratedFunction System (Barnsley, 1988), Particle System (Reeves and Blau, 1985), and the relevant methods developed on such basis methods all belong to this type modeling technology (Xue et al., 2009; Ding et al., 2008; Yue, 2014; Wang et al., 2011). Modeling method based on parameter property adopts converting the appearance characteres of one tree to manydiscrete attribute parameters, which controled tree's modelsby adjusting these parameter values artificially. Simple is the most remarkable advantage of this method. But the biomass features are not accurate enough commonly. Weber (Weber and Penn, 1995) put forward a parameterized method ontree modeling. Shi et al., (2008) proposed a parameterized tree modeling method with the restrition of morphological structure characteristics. Li and Chang(2013) introduced how to design models using parameters in the SpeedTree software. Method based on image creates tree's model through processing the texture data which was pre-specified to obtain the image information from multiple perspectives, and then using them to replace the real tree. The billboard technology (Remolar et al.,2002), the level image technology (Shade et al.,1996), and the body texture technology (Neyret, 1998) are all such modeling methods. The advatage using modeling method based on images is that the visual effect obtained is relatively rich. But the negative aspect is the geometric structure can't control easily.

1.2 Simulation method of forest scene

There are many technologies in modeling and rendering single trees. But when it comes to reveal the laws or the overall effect of forest ecosystem, simulating the forest should be one of the key technologies to satisfy the demands of forest management and landscape roaming.

Forest scene contains thousands of objects, therefore it is necessary to take effective accelerating measure to improve the rendering efficiency.Commonly there are two ways: one is using point or line to simplify the model geometry, the other is a simplified method based on image preprocessing. For the former, Daniel(2005) put forward to set a line on the model as a columnar branch of the tree and a point as a leaf. Daniel (2005) proposed multi-prismatic as thick trunk and line as thin one. Deussen and Coklitz(2002) used a point to represent a plant at remote site while a polygon to represent a near one. Such methods with point or line drawing need to deal with nodes geometric transformation, as a result the rendering speed is slower than the filling polygons.When pulling tree model extremely close to the observer, it will lose a lot of detail informations, especially for leaves. Chen et al., (2000) adopted polygon, texture, and body texture to replace different plants respectively. Han and Tan (2012) applied L-system combining with observed data to construct the plant model, what's more, using LOD technology to simplify the geometry of branchesand leaves according to distance from viewpoint during the process of real-time rendering.Behrend and Colditz (2005) designed usingbillboards cloud to simulate plant model, and through adjusting billboard images dynamicly to transform the content of the scene. A method based on hierarchical image was put forward (Luch and Camahort, 2004), which calculated image of each level, processed structure data and stored the texture information with 6 images for one plant in advance. Chen et al., (2012) tried a new method which combined image deformation and dynamic texture technologies to realize forest graphing. Methods preferred above can indeed make the rapid of rendering faster than before, but it is really easy to generate distorted images when the distance from the model to the viewpoint is small and the details of plant can not be expressed richly which should be due to the simplification of individual model.

1.3 Overview of the method in this paper

In order to solve the equilibrium problem between rendering efficiency and modeling precision, we use the tree model library technology combined with LOD technology to implement the simulation of large-scale forest scene. Different tree models ordered by their species are contained in the tree model library. For each tree type, according to the biomass data that is measured in actual growth environment, the single tree model is constructed with better realistic visual effect. At the same time, in order to satisfy different demand of observation distance, we designed multiple models for each tree based on different level of detail. Thus when it is prepare to generate a large-scale forest scene, individual tree model with specified precision can be called from the library directly, therefore the efficiency of drawing can be raised greatly.

2. VISUALIZATION OF SINGLE REALISTIC TREE

2.1 Hierarchical structure and parameters definition of the single tree

From external morphology point of view, a tree can be divided into four levels of description, root, trunk, branches and leaves, shown in Figure 1. Generally speaking, the trunk of every tree is only one. But when it comes to branches or leaves, there can be several levels according to the location of growing points.

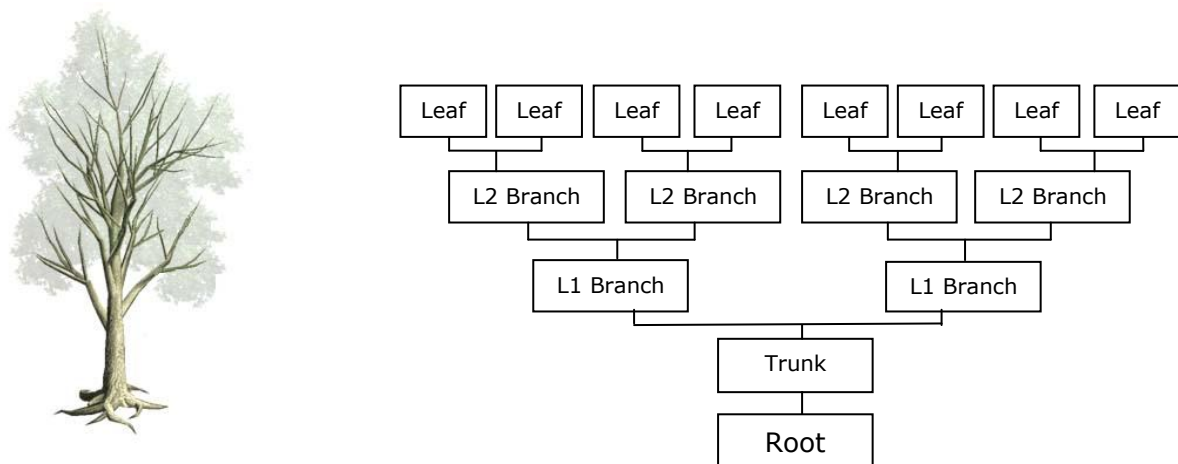


Figure 1. Hierarchy structure of a tree

Thus, the hierarchical structure and parameters of a tree can be defined as follows.

- ✧ Root (length, radius, bifurcation number, bifurcation angle, material)
- ✧ Trunk (height, radius, flexibility, growth angle, material)
- ✧ Branch (level, growing start point, growing end point, length, radius, flexibility, growing angle, material)
- ✧ Leaves (level, growing start point, growing end point, coverage area, size, material)

2.2 Measurement of real biomass data

Two ways can be adopted to obtain the biomass data of plant. One is calculating based on the reasoning formula (Wang et al., 2016), the other is measuring at realistic growing site. The latter was adopted in this paper and Poplar 107 was set as an example plant according to the need of our simulation. Morphological character data of many poplars was gathered in a forest in Henan Province, China. During the measurement process, the poplar tree was divided into several growth units according to the positions of branches at first, and then the length, diameter and weight of each unit was measured respectively.

From the data we can see that the height of a 3-years Popular 107 is about 8-14 metres with the diameter of 7-15 centimetres at breast height. Figure 2 shows that the diameters of the selected 3-years tree are different with the change of heights and the trend curve is nearly linear.

In order to illustrate the morphological characters of Poplar 107 better, some detailed data of this tree are listed in Table 1 and Table 2. Branches grow from the points which start at about 1/3 of the trunk and end at about 80% of it with the branching angles about 30°-45°. Relative to other growth units of the 3-year poplar 107, branches grown from the second growth unit are longer, with larger average diameter and heavier weight, and therefore they decide the crown of the tree. Most of the diameter data of branches is among 1-4cm and length data is no more than 4m. After data analysis on the branches from third growth unit, the amount distribution curves of branches with different length has been displayed in Figure 3.

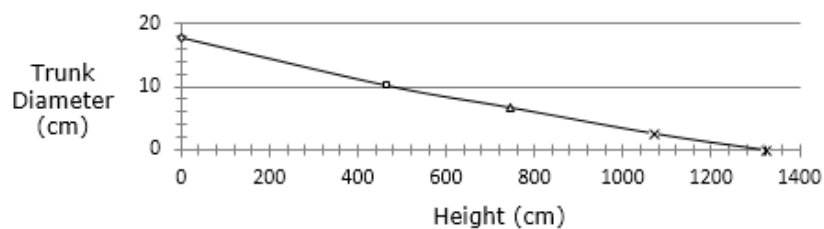


Figure 2. Trend curve of diameter with height of trunk

Table 1 Measured data of trunk

Growth Unit	Length (cm)	Diameter (cm)	Weight(g)
1	467	17.8	44708
2	280	10.1	14327
3	321	6.7	6839
4	256	2.5	550

Table 2 Measured data of branches

Growth Unit	Amount	Length (cm)	Diameter (cm)	Weight(g)
1	26	214	21	360
2	22	237	24	501
3	56	62	10	40

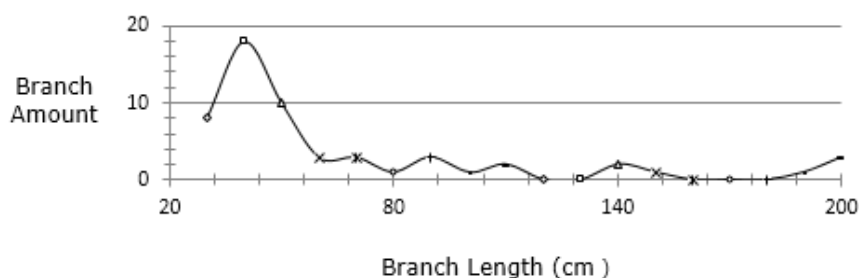


Figure 3. Distribution curve of the branch amount with different length

2.3 Simulation of single tree

Under the constraint of measured data described above, according to the natural hierarchical structure, notes in each level can be established for a single tree. For each node, the corresponding characteristic parameters are set respectively according to the measured data, whereas the change tendency of the parameters through the curve description. In order to increase the diversity, a random seed is added to help generating different instances of the same tree model. Single tree modeling result is showed in Figure 4.



Figure 4. Model of popular 107

3.RENDERING OF REALISTIC FOREST SCENE

3.1Drawing process of forest scene

SpeedTree SDK is one software belong to SpeedTree software suit published by Digimation Company, which can support programmers to redevelopment using it. It provides application interfaces for other 3D platforms. SpeedTree SDK is used with OpenGL in this paper to design the strategy of drawing forest scene, illustrated by Figure 5.

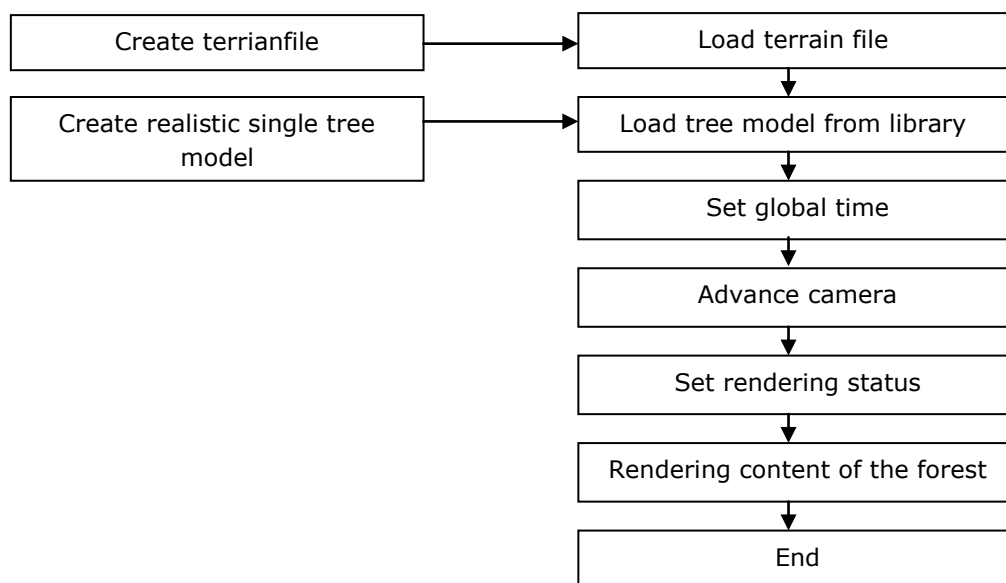


Figure 5. Rendering strategy of forest scene

First, a terrain file should be loaded into system, which has done beforehand. Then from the model library, compiled model of each single tree is imported into our system. After that, some global parameters should be set correctly, such as time. Updating the position of camera is a key step because it decides what content will be showed on screen later. Now rendering is begin. During the process of rendering scene, rendering status is set and the depth prepass is executed at first, then content inner of view field according to calculation right now, begins to be rendering, which may contains thousands of trees additional with a part of visible terrain and grass. General speaking, it is not important what order rendering should obey, but from the visual sence, the largest viewport position should be rendered firstly for supporting Z axis pre-cutting of some hardware to accelerate rendering speed and improve rendering capabilities.

3.2 LOD technology

To improve drawing efficiency of large-scale forest scene, LOD technology is applied in our system. Details of each model called from model library are gradually reduced from near to far according to the distance from the point of tree to the viewport. Table 3 describes the strategy of LOD. For the trunk or branch part of tree model, the lesser triangles will be contained at the lower LOD level by decrease gradually the number of segments of trunk or amount of branches. For the leaves part of tree model, with leaving far away from viewport, two key points are take to ensure details reducing smoothly. On is to make the amount of leaves shrink to less little by little. The other is to let other leaves get bigger gradually so as to maintain the size of the canopy. When the size of the bigger leaves grow to enough large, it will stop until the former leaves are completely disappear. When it reaches a certain distance, the whole tree will be completely replaced with two billboards.

Table 3 Strategy of LOD

Value of LOD	Single tree model chosen
1.0	High-precision 3D model with the richest details
[1.0, 0.0]	Transform from high-precision 3D model to low-precision 3D model
0.0	Low-precision 3D model
[0.0, -1.0]	Low-precision 3D model fade out, billboard model fade in
-1.0	Completely billboard model

3.3 Result of experiment

The forest scene has been simulated based on SpeedTree 5.0 and OpenGL and the result is showed as Figure 6. It records a randomly distributed forest which includes 20000 popular 107 trees. We can see from the image, models near to us contains more details rather than the far ones. During the process of rendering this forest scene, the initial time cost 8.6 second, and the rate of frame has reached 47.1 fps.



Figure 6. Rendering result of a randomly distributed forest

4. CONCLUSION

A realistic forest scene rendering method is proposed in this paper. First of all, a model of a single tree is established applying hierarchical parameter modeling method based on measured biological data. And then more models with different detail level of this single tree is produced according to our LOD strategy. Finally, according to the mapping strategy, a large-scale forest scene can be rendered out through calling such models from library quickly without amount of calculations. Method in this paper can solve the balance problem to some extent between speed and precision of rendering large-scale forest scene. In the future, method can be improved on the jump phenomenon occurred at the LOD level change instant.

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