Scholars Journal of Engineering and Technology (SJET) **ISSN 2321-435X (Online)**
Sch. J. Eng. Tech., 2015; 3(4C):494-499 **ISSN 2347-9523 (Print)**
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Research Article

Collision Detection Optimization of 3d Landscape Design by LOD Algorithm

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Abstract: Focusing on the visual effect deficiency in the application of standard LOD algorithm for 3D landscape design, 3D landscape designing model based on terrain complexity collision and shading rendering is built in this paper. First, 3D landscape design models are devided into two categories, regular terrain and irregular terrain, and different rules are respectively adopted during model building. Then, select the LOD model scheduling index according to auxiliary viewpoint, estimate light occlusion by virtue of chebyshev inequality, finally complete the shading rendering optimization by establishing fuzzy variance shadow maps. Meanwhile simulation experiment was conducted, and the experimental results showed that improved algorithm had better visual effect compared to standard algorithm.

Keywords: LOD algorithm; 3d landscape design; collision optimization; terrain complexity; shading rendering

INTRODUCTION

With the rapid development of computer technology, architectural renderings cannot meet the requirements from the customers any more, and architectural animation is replacing architectural renderings gradually. Own to the development of 3D construction performance technology up to now, lots of new things emerged; also it made a significant contribution to the social reform[1-3]. As construction industry developed rapidly, 3D construction performance technology also showed a trend of dramatic development in recent years[4-6]. We have more chances to get access to digital technology because of the continuously advancement of sci-tech civilization, meaningly, the pace of life and life style has undergone great changes. Three-dimensional landscape design accelerated the rhythm of people's life to a great extent, the development of digital technology not only the performance of landscape design but also expanded its representative space, more and more virtual reality and audio-visual spectacle begin to appear in our life.

Currently, many domestic and international scholars carried on a great deal of research to build urban three-dimensional models[10]. First, we take foreign researches into discussion, in order to build the realistic environment, landscape research center in University of Toronto emphatically studied the landscape models, and high-reality urban landscape models were built [3]. After an in-depth study, Gruen and Xinhua from Federal Institute of Technology in Zurich developed a three-dimension city model named TOBAO[8], this model can solve the problems of 3D modeling effectively. Moreover, a system named Cyber City Modeler has been developed specially, thus interaction between the users can be accomplished. Then in domestic, 3d reconstruction of urban landscape is becoming a hotspot in the area of research, the researches mainly focus on the aspect of urban landscape 3D modeling, and some achievements have been achieved domestically. Based on landscape models expression principles and classifications in three-dimensional urban geographic information system, Guomin et al. focused on the abstract point-line-area, proposed a batch method for 3d-model construction by symbolic matching and triangulation[9]. Wang et al [7] put forward that rapid reconstruction of urban 3D landscape could be realized by urban 3D landscape model base. London Metropolitan University built the city 3d model by means of air survey and ground photography. ETH has built the 3D models of cities in european countries.

As automatically 3d space information extracting technology and 3D modeling technology develops rapidly, domestic scholars are paying more and more attention to urban landscape 3d reconstruction. Although we started relatively lately compared with foreign countries, with the help of international advanced technology, we still developed rapidly. The most convincing evidence is that 3DGIS has emerged in China; what’s more, 3D GIS urban planning management information systems have already been built in some cities.

In this paper, focusing on problems resulting in application of LOD algorithm in 3D landscape design, 3D landscape design model was proposed based on terrain complexity collision and shading rendering. The simulation experiment was also carried out, and experimental results showed that the model was highly effective.

3D landscape design based on LOD algorithm

Common data format of 3D landscape design is DEM digital elevation model that is terrain elevation value based on matrix network sampling. S o-called digital terrain model refers to that, using the known X, Y, Z coordinate points in any arbitrary coordinate, represent continuous ground surface by simple statistics. So DTM is the simple digital presentation of terrain surface

Digital terrain model is an ordered sequence of values, which describes the information space distribution of surface morphology. In a mathematical sense, the content and form of digital point surface model is indicated by application of following ordered set of two-dimensional function sequence values:

$$K_p = f_k(u_p, v_p), k = 1, 2, ..., m; p = 1, 2, ..., n \quad （1）$$

K_p Represents the value of k class ground characteristic information on NO. p terrain point; (u_p, v_p) is the two-dimension coordinate of NO. p terrain point, any horizontal coordinate on the map projection or column number of longitude, latitude and matrix can be selected and used; m refers to the number of ground feature information types, and it should be more than 1; n is the amount of terrain points.

In the formula (1), on the condition that $m = 1$, f_1 is the map of ground elevation, and (u_p, v_p) is the matrix column number, digital terrain model expressed by this formula is digital elevation model. Generally speaking, DEM is the most basic part in DTM, it is a discrete digital representation of the earth's land surface, terrain and landform.

In sum, the so-called digital elevation model is the finite three-dimensional vector sequence in the indicative area, and it can be represented by the following formula:

$$V_i = (X_i, Y_i, Z_i), i = 1, 2, ..., n \quad （2）$$

In the formula (2), X_i , Y_i represent the horizontal coordinate, Z_i is the corresponding elevation of (X_i, Y_i) .

In this series, when planimetric positions of all the plane vectors are arrayed as regular grid, it can be simplified to one dimensional vector sequence.

$$\{Z_i, i = 1, 2, ..., n\} \quad （3）$$

In many application cases, the terrain data is nostly large scale, so the data volume of DEM is also very large, but not all the data can be imported into the memory in the runtime, therefore, in general case, LOD algorithm and clipping method is applied in real-time wander and rendering algorithm for various terrains, and thus reducing the number of drawings and realizing real-time rendering.

The selected terrain LOD model is normally dynamic, continuous level of detail model, and it will not generate explicit level of detail. But during the rendering process, level of detail related to the points of sight could be produced automatically. In accordance with terrain rendering model, continuous LOD models can be divided into two kinds: continuous LOD models based on irregular grid and regular grid.

Continuous level of detail algorithm based on regular grid can be described as follows:

Firstly, elevation function $z(x, y, t)$, $x, y, t \in R$ the parameters are representations of time, distance, proportion and some other factors. The role of this function is to mix different level of details on the same domain of definition, thus realizing continuous change of the grid is realized, and the variety is caused by time or by the distance to point of sight.

Secondly, elevation functions $z(x, y)$ in the domain R^2 , it is used to describe the terrain by different levels of detail in different areas. When the terrain is described by discrete level of detail, due to different resolution, two adjacent terrain patches cannot align completely at the boundaries, so there may be cracks in the border of the terrain patches. If the vertical height values cannot remain the same, height Z also cannot keep continuous.

Again, distribution function of polygon $n(v, A)$, for any given domain $A \subset R^2$ and corresponding points of sight, format of polygon is continuous. The images are in discrete state, define the continuous formula $\omega(\delta, n)$, in the fomula

n is continuous, in this case, only when certain $\varepsilon \le 1$, $\delta \to 0$, $\omega(\delta, n) \to \varepsilon$, in other words, as for sufficiently small view points, there could be at most one triangle in area A, along with the change of points of sight., the number of ultimately drawn triangles will present a continuous state.

In the early time, function of GPU was imperfect, thus continuous level of detail models have widely been paid attention. Although this model sacrifices some CPU time, the simplification result is very good, so it can be widely used in real-time rendering of terrain scenes.

Resolution presented by LOD algorithm has the characteristics of global consistency, so the models have high quality, and there will not be a situation of data redundancy. But, this algorithm occupies too much memory space, and the amount of real-time calculation is relatively large, there are also some shortcomings in terms of generation speed, so it is not flexible and there will be some tiny triangles, in addition, there are limitations in visual effects other management shortcomings.

Ooptimization of collision detection bases on complex topography

Collision optimization related to varied terrain

In this paper, 3D landscape design models are devided into regular forms and irregular forms, and different rules are adopted to build different kinds of models:

Firstly, we discuss about the regular terrain.

Theory of terrain complexity computation related to regular grid model can be stated as follows: by virtue of 3×3 gird, take the center of the grid as origin, build space rectangular coordinate based on the right-handed system, thus 8 adjacent space planes are formed, specific information is shown as follows:

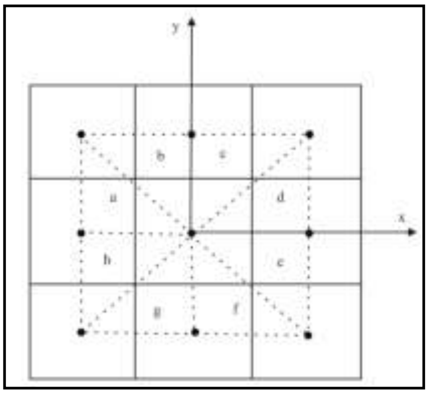

Fig-1: Regular grid terrain complexity calculation

For plane a 、b 、c 、d 、e 、f 、g 、h, caculate the angle between two planes respectively on basis of counterclockwise, and use the cumulative result to evaluate the complexity degree of grid terrain. Space dihedral angle calculation formula is adopted to caculate the cosine value, then the angle is determined. The following formula is applied during caculation.

$$\cos\beta = \frac{|a_1a_2 + b_1b_2 + c_1c_2|}{\sqrt{(a_1^2 + b_1^2 + c_1^2)} + (a_2^2 + b_2^2 + c_2^2)} \quad (4)$$

(2) Irregular terrain

Taking a certain triangle mesh as the center ternary, find out the frontier between the same dedicine in turn, in other words, the angle between normal vectors of adjacent triangles has to been firgued our, as shown in the figure below:

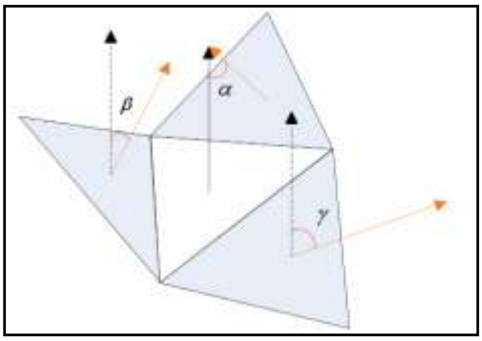

Fig-2: Irregular terrain complexity calculation

The average value is regarded as the quantized value of terrain complexity; the following formula is used for caculation.

$$cf = (e^{\cos\alpha} + e^{1-\cos\beta} + e^{1-\cos\gamma})/3 \qquad (5)$$

In this formula, cf represents terrain complexity degree of the current triangle mesh, and replace the angle value with exponential function e, to simplify caculation and analysis.

Then examine selection scheduling of LOD models by auxiliary viewpoint range. Because there are differences between terrain complexity amd viewpoint range on numerical digit, if we only apply the linear equations to express the weight, then the linear parameters should be determined. In this paper, sum value of two highest digits resulted by linear additivity is adopted to select weight proportion. When caculating the terrain complexity degree, weight threshold of viewpoint range and weight of the current terrain, we can use the following formula.

$$w_i = td(cf_i) + td(d_i) \qquad (6)$$

$td()$ Represents the digital function for evaluation of the highest digit.

In addition, the weight indication range of LOD models on different levels can be expressed as the follows:

$$W_i = \{w_i \mid w_i \subseteq [w_i \min, w_i \max)\} \qquad (7)$$

In this formula, $w_i \max = w_{i-1} \min$, it means that the LOD range on all levels is a continuous collection.

Shading rendering of 3D landscape design model

In order to reduce the sawtooth and smooth the shadow edge, fuzzy variance shadow maps are built. Because deep expectation and variance has rendered to texture, restore, the area will get restored after texture filter, then turn back into M1 and M2.And it can be defined as follows；

$$\begin{aligned} M_1 &= E(x) \\ &= \int_{-\infty}^{+\infty} xp(x)dx \end{aligned} \qquad (8)$$

$$\begin{aligned} M_2 &= E(x^2) \\ &= \int_{-\infty}^{+\infty} x^2 p(x)dx \end{aligned} \qquad (9)$$

Based on the formulas mentioned above, we can figure out expectation μ and σ^2 variance:

Pixel distribution can be refleted by the variance. Utilizing chebyshev inequality, we can compute the upper boundary value, and estimate the condition of light occlusion according to the calculation.

$$\mu = E(x) = M_1 \qquad (10)$$

$$\sigma^2 = E(x^2) - E(x)^2 = M_2 - M_1^2 \qquad (11)$$

Let x be a random variable, under the condition that $E(x)$ and $D(x)$ both exsit and $t > \mu$, then we can come to the following formula:

$$P(x \geq t) \leq P_{\max}(t) \equiv \frac{\sigma^2}{\sigma^2 + (t-\mu)^2} \qquad (12)$$

We look forward that the results of formula (32) can realize real-time executive of the filter, because it can caculate the upper boundary value of one loudness, and fix the failure depth in a certain area-depth t after the caculation.

Suppose ther is a closed plane, define its depth as d_1, bulid a shadow with the depth of d_2 on this plane. If there is a pixels filter, and filtration percentage is represented by p, then we can come to the following formula:

$$\mu = E(x) = pd_2 + (1-p)d_1 \qquad (13)$$

$$E(x^2) = pd_2^2 + (1-p)d_1^2 \qquad (14)$$

$$\begin{aligned}\sigma^2 &= pd_2^2 + (1-p)d_1^2 - (pd_2 + (1-p)d_1)^2 \\ &= (p-p^2)(d_2-d_1)^2\end{aligned} \qquad (15)$$

By means of these values and according to formula (32), $P_{\max}$ can be figured out:

$$\begin{aligned}P_{\max}(d_2) &= \frac{\sigma^2}{\sigma^2 + (\mu - d_2)^2} \\ &= \frac{p-p^2}{1-p} = p\end{aligned} \qquad (16)$$

Consequently, $P_{\max}$ can be regarded as approximately the true render value P.

3 Algorithm performance simulation

In order to test the performance of the improved algorithm, the article focuses on a certain 3D landscape, standard LOD algorithm and improved algorithm is used respectively for modeling and rendering, The results obtained by two methods appear as shown below:

Fig-3: Three-dimensional landscape bulit by standard LOD algorithm

Fig-4: Three-dimensional landscape bulit by improved LOD algorithm

Thus it can be seen that the improved algorithm has a better three-dimension visual effect compared to standard algorithm.

CONCLUSIONS

Urban three dimensional landscape model is vivid three-dimensional representation for the city, and it shows sense of high reality, makes it easier for the users to achieve visual perception, further more, it contributes to expanding the urban planning and designing and broadening the administrators' horizons, meanwhile, improving the scientificity of urban planning and infrastructure designing. In sum, it is conducive to sustainable development of the city. This paper focused on the open problems in 3D landscape designing by LOD algorithm, and based on terrain complexity collision and shading rendering, 3D landscape designing model is bulit by improved LOD algorithm. In order to verify the validity of the model, simulation experiment was conducted, and the experimental results showed that improved algorithm had better visual effect compared to standard algorithm.

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