Combined methods for virtual surface treatment of relief

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Abstract. This article describes the automation of the process of creating a hybrid model of some portion of the surface of the earth's crust (generation of virtual landscape topography). Apply the optimal combination of the currently existing approaches for adaptive generation of landscape through landscape treatment of the surface generation based on the combined Voronoi diagram of the algorithm of diamond-square. The functional algorithm of landscape generation, its advantages and key characteristics are given. The advantages of the combined method, its optimization and possibilities are described. The conclusion shows the results of running the program code was called "the Program for processing the combined methods of the virtual surface topography", in which you can come to the conclusion that the CPU of the computer has decreased by twenty percent, and loading the computer's memory twice. The methods on the basis of which the virtual surface treatment is realized are painted and considered.

Keywords: 3D modeling, multimedia, dynamic handling threads, OpenGL, landscape generation, detail.

Introduction

Modern programmable graphics systems are able to visualize large spaces in real time with a high degree of detail and simulate the observed physical processes in the real world. These achievements are widely used in creating landscapes that require visualization of large spaces of different environments – sky, water, earth, vegetation.

At the same time, specialists in the field of landscape construction distinguish as the main trends of its development - the creation of complex systems covering all natural complexes necessary for the generation of the landscape.

Another trend in the development of the landscape is a constant update information in databases and models of environment generation with the appearance of information about new situations.

Also, the expansion of the fields of application of landscapes and their functionality put forward before the developers of training complexes requirements of standardization and modularity of individual systems of training complexes. The use of universal modules of landscape construction, methods of information processing and the use of databases will greatly simplify the development of new landscape maps.

Thus, faced with the task of developing models to automate the collection of and processing of information for natural and climatic complexes, which could be widely used in the creation of the landscape for a variety of areas of activity.

Particularly high demands are placed on the realism of the image of the environment in the visualization systems for the oil and gas sector of the economy, namely, should be provided:

- sufficiently detailed virtual model of objects and surrounding environment (sky, water and land surface);
- high quality of realism of the generated images;
- real-time operation that requires an update of the scene visualization at a rate of at least 30 frames per second;
- minimization of image change delay in response to operator's influence on controls;
- simulation of weather conditions (rain, snow, fog);
- high realism;
- display the scene of large spaces and at the same time high detail of the approximate objects of the scene.

Thus, the problem of environment generation is one of the most time-consuming and requiring significant computational resources in the generation of a three-dimensional surface relief.

Related work

German scientists under the leadership of Miao Yu created an application that allows you to identify and model the affected areas of the earth's crust caused by sudden large-scale geological disasters such as earthquakes, floods, volcanoes. The main purpose of this study is to offer an inexpensive and effective method based on the virtual construction of a three - dimensional landscape.

The main idea of the method is to use and transform the data obtained by integrating satellite images, aerial photography and geographic information system into three-dimensional models. [1]

The disadvantage of this development is that this application is adapted only for mountainous areas, as well as the results are schematic, which complicates the work with the application.

The paper [2] describes a method based on the Dijkstra algorithm and the mixing of layers, which are generated in accordance with individual characteristics. The method works much faster than many known methods, and, in some cases, is able to produce results with better quality, but has several disadvantages. They include a monotone form of slopes belonging to the same profile, and is based on the procedure of mixing textures, which significantly increases the time of generation of the landscape.

A team of scientists from Japan in article [3] presented an Appendix on automatic creation of a three-dimensional relief model from key contour polygons by direct calculations.

Based on the height-adjusted key contours, the contours are automatically generated, and thus the 3D elevation models are generated automatically. The proposed system performs physical modeling using a more realistic environment, such as the automatic creation of a three-dimensional model of the city and placing it on a three-dimensional terrain.

This application performs generation of plain terrain for urban development, which is not quite suitable for our requirements.

After analyzing the work on the subject, the generation of a three-dimensional landscape, it was chosen two optimal methods, which it was decided to synthesize together.

Below we describe what each of the selected methods is responsible for.

Diagram Voronoi

The construction of the diagram begins with the location of the key points on the landscape map. Next, the chart is built on the existing points, and several iterations are performed on it to get rid of too small polygons.

The structure of the landscape on the Voronoi diagram is reduced to creating a grid consisting of points shown in fig. 1. Its main property is irregularity, which allows the landscape based on the diagram not to look angular.

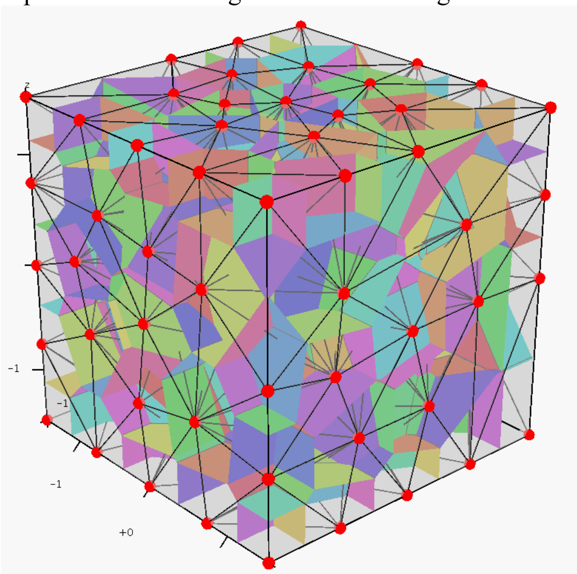

Fig. 1 – building a landscape based on the chart Voronoi

After that, the polygons are selected, which are planned to be filled with water. The height of the points belonging to the remaining polygons is assigned as a value equal to the shortest distance to the water. [4-5]

Algorithm diamond-square

Next, the diamond-square algorithm is connected in which the heights are set at the ends of the segment and these heights are divided by a point located in the middle of a certain Voronoi diagram, which divides the segment into two segments. This point is shifted by a random variable and then the split and shift for each of the resulting sub-segments are repeated. Division will occur as long as the segments will not be equal to one pixel (see figure 2). It is important to remember that random displacements should be proportional to the lengths of the segments on which the partitions are made. For example, if you split a segment length l-the point in the middle of it will have a height equal to:

$$h = (h_L + h_R) / 2 + \text{random}(- R * l, R * l); \quad (1)$$

where h_L and h_R — heights at the left and right ends of the segment;

R defines the "roughness" of the resulting polyline and is the main parameter in this algorithm);

The next step is to divide the whole map into four equal squares. In each of the available squares, the value in one of the corners is known.

The point in the middle is obtained by averaging the heights of all 4 angular points, and each Central point on the side of a large square — by averaging a pair of points lying at the ends of the corresponding side. For the best effect, you can set the noise factor — that is, randomly move the center point up or down. This operation can be repeated until then, until you get the best kind for the received sub-squares (fig. 2). [6-7]

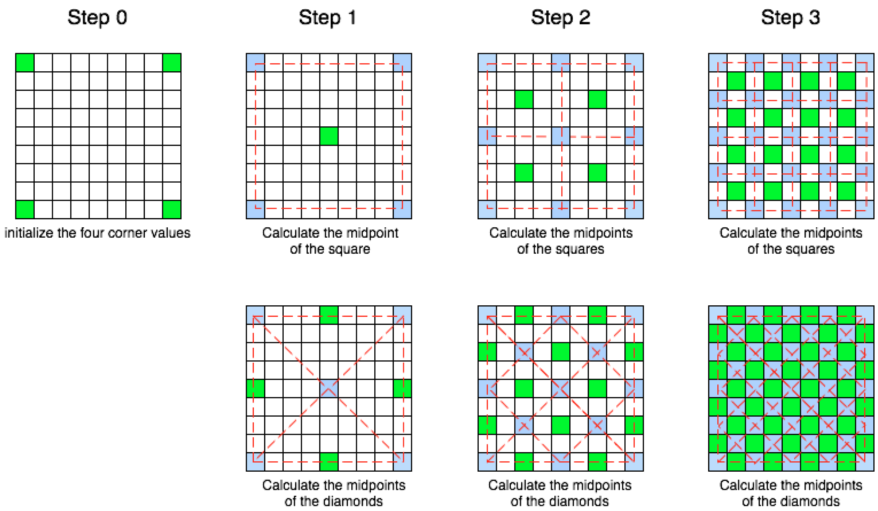

Fig. 2-Algorithm of splitting a segment by a point in the middle into two sub-segments

Combine approaches for adaptive generation of landscape.

One of the main points when combining a chart Voronoi and the diamond-square algorithm is to remember (and write to the cache the necessary data) all the elevation values that have been calculated. This allows you to shorten the computational processor a few times.

The next step is to determine whether the triangle point is the center of one of the large, squares, and what is the size of this shape. Calculate the least significant bit, which is not zero for any of the coordinates-this is the desired size of the shape. In order to determine whether the shape was a triangle — check that both coordinates were exposed to this bit. Both coordinates are zero-indexed.

After analyzing the work of the program, we obtain that the landscape length of 100x100 km, there was a decrease in the load on the processor of the system unit by about 20%, and the use of computer memory of about 50%. The results were measured by the standard Windows "Task Manager" tool.

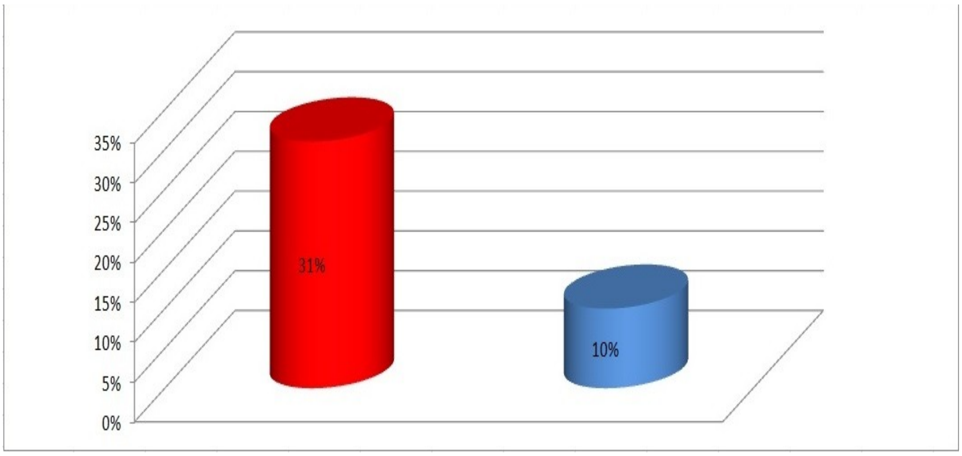

Fig. 4 – the Load on the CPU % when running landscape generation without the use of the combined method of virtual processing of the terrain surface (red diagram) and after application of the combined method of virtual processing of the terrain surface (blue graph)

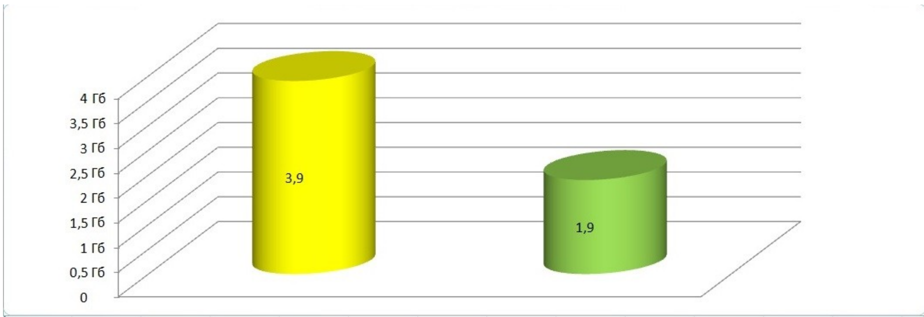

Fig. 5-Load on the computer memory in gigabytes during landscape generation without the use of the combined method of virtual surface treatment of relief (yellow diagram) and after the use of the combined method of virtual surface treatment of relief (green diagram)

Thus, assessing the overall result of the developed program obtained an increase in processor performance and reduced memory costs from 20 to 50% compared to the standard algorithms used, which is very effective at large dimensions of the landscape and relief details.

The obtained results confirm the feasibility of using the developed algorithm for the implementation of the software product and its application in practice.

For the experimental study, we used the educational data center of the Orenburg state University. Used the device includes four core processor Intel Core i5 4440 processor with a frequency of 3.1 GHz, 16 GB RAM frequency 1600 MHz, graphics card NVIDIA GeForce GTX 960 memory 4GB, hard disk 1 TB, drive DVD±RW\ Windows 10, keyboard, mouse, 23-inch monitor with a resolution of 1920x1080. The result of the program testing is shown in fig. 6.

Fig. 6 – Results of the program

Conclusion

The resulting algorithm combined methods of virtual processing of the terrain surface based on the Voronoi diagram and the algorithm of diamond-square when the virtual surface treatment relief for artificially generated landscapes have helped to reduce the load on the system block of the computer and as a consequence to reduce the economic costs for the enterprises OOO "Algoritm" JSC "Metalliz". Applying the most realistic results, which allow to obtain the diamond-square algorithm and Voronoi diagram, both high performance of the system and good image quality with a strong approximation and at a strong distance are obtained.

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