VISUALIZATION OF RIVER NETWORKS WITH COMPLEX FRACTAL STRUCTURES

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Abstract

Different boundary regions can be described by fractal dimension. However, when image data is limited, it is somewhat difficult to systematically calculate the fractal dimension of a surface. However, the dimension of a surface is sometimes approximated. It is possible to build a model of natural forms using L-systems or Lindenmayer systems. In this regard, Zarafshan allows the creation of complex structures of river networks based on simple rules. This can also be used in modeling river networks or waterways.

Keywords: fractal, fractal dimension, geometric dimension, scaled map, L-system method, geometric structure of river network.

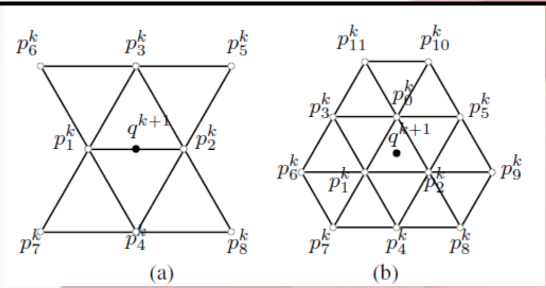
In this research work, a new interpolation partitioning scheme for river networks is presented. In this case, each network is not divided into separate networks, but rather the new ends of each network form another network. Using this refinement operator, the number of networks is increased by at least two times at each step. The edges formed are similar to each other and they form river networks in the form of a scheme.

In this case, after the partitioning process begins, M0 surfaces are created using the networks. With these created surfaces, a sequence of M1,..,Mn meshes can be calculated. In the limit, this sequence of meshes creates continuous surfaces. Each step step can be divided into two different aspects. First, a topological operation is performed. Therefore, new tributaries are added to the network and divided into branches. The partitioning is infinite and continues until a sufficient degree is reached to approach a flat boundary surface.

When a river network is divided by Mi+1, two types of edges can be distinguished. These are the even edges corresponding to the network vertices of the Mi networks and the newly introduced odd networks. The partitioning schemes can be roughly classified into 2, 3, 4 or 5, 6 interpolation schemes.

Interpolation partitioning schemes

The most popular interpolation partitioning scheme for river networks is the Butterfly scheme, which generalizes the partitioning scheme using broken lines at different points. The Butterfly scheme creates surfaces using networks that form river basins with all vertices having dimensions.



"Figure 1. Scheme for forming a river network."

In this case, a new edge region is created using q^k+1.

$$q^{k+1} = \frac{1}{2}\left(p_1^k + p_2^k\right) + 2w\left(p_3^k + p_4^k\right) - w\left(p_5^k + p_6^k + p_7^k + p_8^k\right),$$

The stress parameter w is usually equal to 1/16. If the function values are constant along one of these directions, the "Butterfly" scheme reduces to a different-point scheme.

$$q^{k+1} = \left(\frac{1}{2} + w\right)\left(p_i^k + p_{i+1}^k\right) - w\left(p_{i-1}^k + p_{i+2}^k\right),$$

The advantage of this method for dividing a river into branches is that it provides an easy way to calculate new tributaries. It does not require the calculation of equations with a high level of difficulty. However, this method also creates different edges of unequal size. It is proposed to generalize a different point scheme for dividing river basins with arbitrary topology using each broken line.

This research paper also presents the operators of the division scheme and shows how this division operator can be used in stepwise division.

In the improvement of the division, the division increases the number of tributaries in the basin by at least two times. The multiplication steps of this network lead to an exponential growth of the basin. In this research paper, the adaptive improvement technique is used. Therefore, only one rule is needed to calculate a new tributary. The stencil of the division scheme should be symmetric and as small as possible.

$$q^{k+1} = a\left(p_1^k + p_2^k + p_3^k\right) + b\left(p_4^k + p_5^k + p_6^k\right) + c\left(p_7^k + p_8^k + p_9^k + p_{10}^k + p_{11}^k + p_{12}^k\right)$$

Now we will visualize the river network using the geometric model developed in this scientific research work. This geometric model is used to create a river network. Using these angles, it is possible to create a river network based on an arbitrary angle. In the work, a software package has been developed to monitor the visualization process, in which it is possible to see visual images of the river network.

Figure 2. Block diagram of the algorithm for visualizing a river network with a fractal structure

Step 1.

In this step, you can see the first step of the river network formation. It shows the Angle values and the main flow steps and a visual representation of the river network using the software tool.

$\theta_{2i+1} = 0$

$\theta_{2i+2} = 0$

$q = 4$

that is, the visual representation of the river network when the right and left corner measurements are 0 and the number of steps is 4.

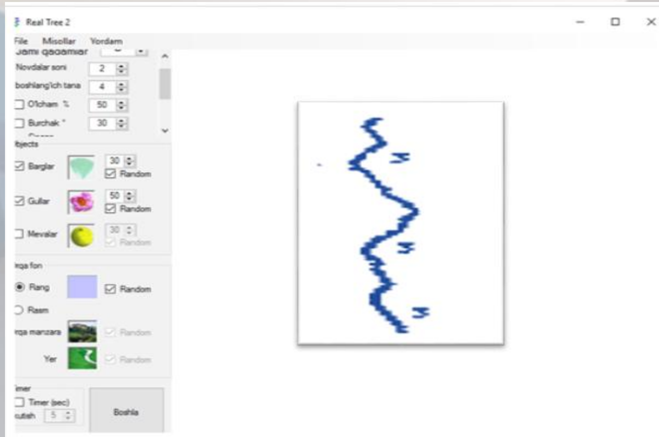


Figure 3. Visual representation of the river network in the first step

Step 2.

In this step, you can see the first step of the river network formation. It shows the Angle values and the main flow steps and a visual representation of the river network using the software tool.

$\theta_{2i+1} = 30$

$\theta_{2i+2} = 30$

$q = 12$

that is, the visual representation of the river network when the right and left angle measurements are 30 and the number of steps is 12.

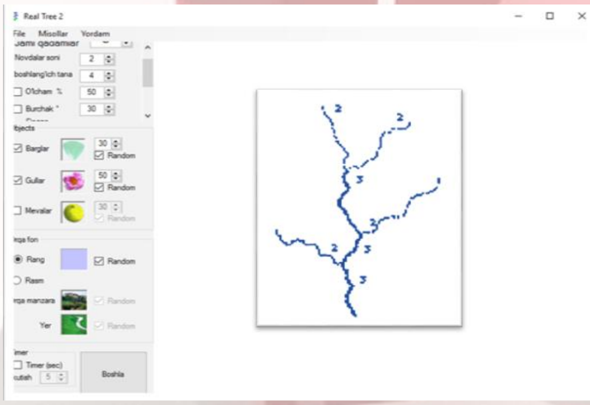


Figure 4. Visual representation of the river network in the second step

It can be seen that the use of software that automates the geometric modeling of images with complex fractal structures has increased the volume of product production by 6-9%. Reducing the cost of production, while reducing costs with the same income, leads to an increase in gross and net profit. The developed software tool has made it possible to achieve cost reduction through the use of new technologies.

CONCLUSION

Based on the L-system method and improved cell counting methods for measuring objects obtained from natural images with fractal structures, it was determined that the water level of the Zarafshan River and its banks have a fractal structure;

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