SIMULATION MODELS IN DECISION MAKING PROCESS OF CRISES SITUATION SOLUTION

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ABSTRACT

We developed new methods of simulation the internal structure and dynamics of spatial phenomena, such as settlements, floods, fires, etc. A comparative analysis of techniques such as stochastic mathematical (the midpoint displacement, the trees of Pythagoras, the three-dimensional surface and the relief of Mandelbrot) and physical (discrete and continuous diffuse-limited aggregation) fractals in the simulation of spatial structures was conducted.

Key words: Fuzzy Logic, Fractal, Potential Fields, Diffuse-Limited Aggregation.

АННОТАЦИЯ

В работе разработаны новые подходы к моделированию внутренней структуры и динамики распространения пространственных явлений, таких как населенные пункты, паводки, пожары, и т.д. Проводится сравнительный анализ таких методов, как стохастические математические (метод смещения срединной точки, деревья Пифагора, трехмерные поверхности и рельефы Мандельброта) и физические (дискретная и непрерывная диффузно-ограниченная агрегация) фракталы при моделировании пространственных структур.

Ключевые слова: Нечеткая логика, фрактал, потенциальные поля, агрегация ограниченная диффузией.

1 GENERAL PRINCIPLES OF CRISIS MANAGEMENT

1.1 METHODS AND TECHNIQUES OF CRISIS MANAGEMENT

Simulation of spatial structure and dynamics of distribution of such phenomena as floods, fires, crowd of people, urban sprawl, deforestation, and others like that

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requires fast, quantitative, adequate mathematical methods and techniques at making decision. The low level of adequacy of classic mathematical models puts before researchers a question about development and introduction modern methods of mathematical design. Some example studies [1-3] show all these processes can be described by the methods of diffusion simulation and fractal geometry. And the potential fields of co-operation between people by the methods of SoftComputing [4].

This paper describes investigational possibilities of using mathematical tool of four types of mathematical and two types of physical fractals for spatial distributing simulation of the urbanized systems which are specialized on recreation services. The object of research was a tourist township Vorokhta (Fig.1.a).

First type of fractal: based on the stochastic filling of cells of the deformed flat grate. Deformation of the grate is simulated by Brownian displacement of middle point [5] and by the gradient of the potential field probability of urbanization (Fig.1.b). This field was calculated using Fuzzy Logic tool [6]. All entry parameters of the field and information for models are obtained exceptionally from GIS systems. The received fractal is resulted on Fig.1.c.

Next fractal: the tree of Pythagoras which implemented by the recursion systems of iteration functions (RSIF) and affine transformations of initiator [2]. Algorithms of construction plural initiators, account of the potential field, account of limitations and spatial overlap are developed for the construction of fractal (Fig.1.d).

Next fractals present three-dimensional relief. The horizontal sections of heights determine the dynamics of spatial distribution of urbanization. The first surface is built using systems of iteration functions (SIF) by affine transformation of flat matrices (Fig.1.e). Other is a Brownian surface of Mandelbrot that present a variety of three-dimensional motion of Brownian particle in the probabilistic field (Fig.1.f).

These fractals relate to the different classes of models and built using absolutely different mathematical and algorithmic approaches. Table1. gives basic criteria for which the comparative analysis of these fractals is conducted.

From a table evidently, that all recent considered approaches allow to build fractals with high enough degree of exactness. Classic approach has the least exactness which is widely used for the simulation of underlying structure of settlements – stochastic fractal on the basis of deformed Brownian motion by the knots of net. Approaches offered by an author are more precisely.

For a form of the first two types of fractals account mainly probabilities of urbanization fields. Preeminently it plays role of limitation border of the city. Therefore these approaches do not allow simulating the dynamics of development. Their basic setting is determination of underlying structure and symmetry of cities.

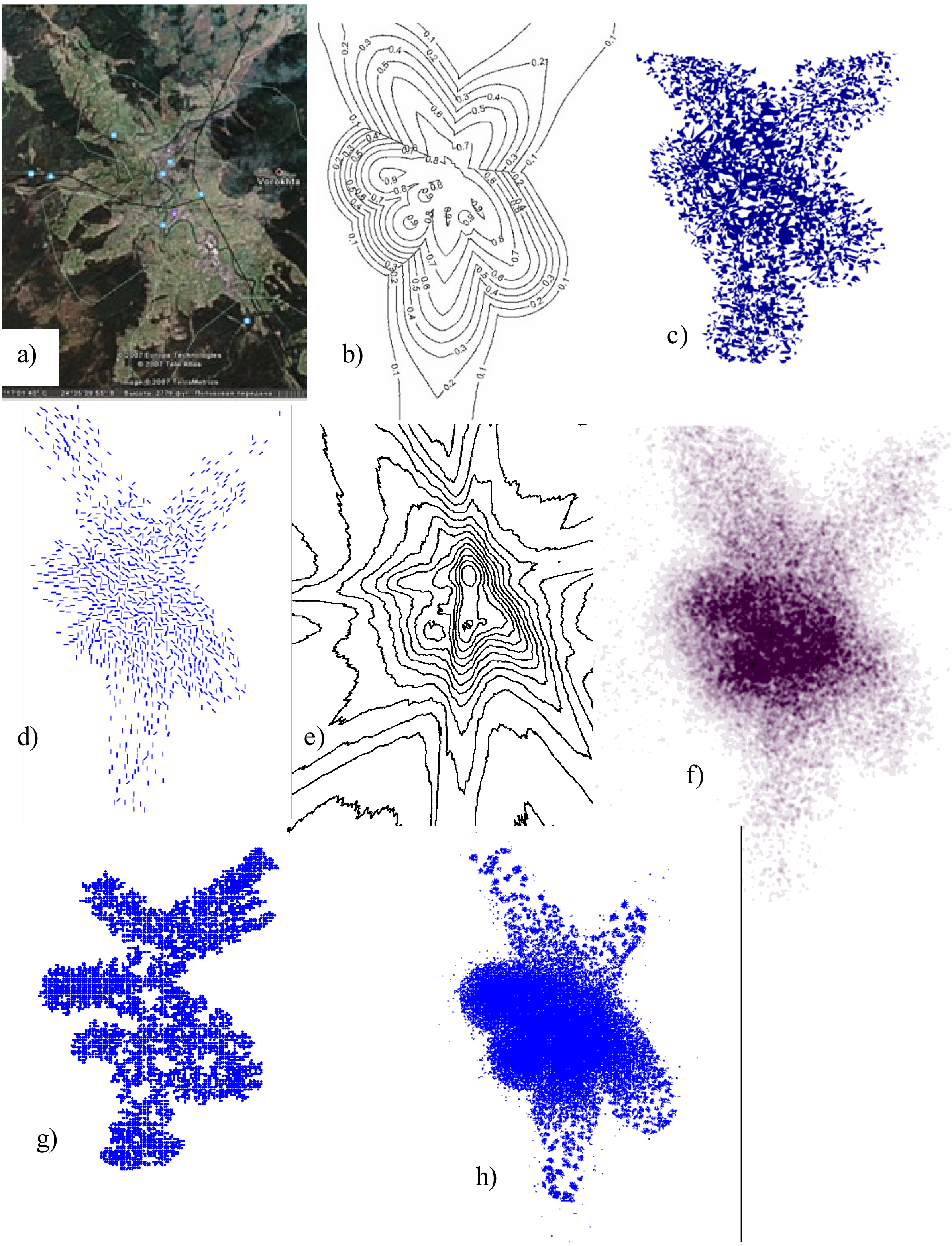

Fig. 1. Vorokhta

a) picture from space, b) Fuzzy field of urbanization probability, c) method of middle point displacement, d) the tree of Pythagoras, e) SIF 3D relief, f) Brownian surface, g) CUM, h) combined CDLA

Table 1. A comparative analysis of mathematical fractals in the tasks of spatial development simulation of tourist settlements.

Assessment criterion	**Brownian grid**	**RSIF**	**SIF 3D relief**	**Brownian surfaces**	**CUM**	**Combined CDLA**
Exactness	83%	86%	89%	85%	88%	92%
Checkout time	2 sec	1 sec	25 min	1 sec	15 min	14 min
Growth dynamic	–	–	+	+	+	+
Internal structure	–	+	–	+/–	–	+
Segmentation	+	+	–	+	+	+
Analogies	quarters	houses	boundary	–	urbanized territory	urbanized territory

However classic approach which well showed oneself at the simulation of large settlements badly represents the underlying structure of small townships, in particular orientation of building collinear to the vectors of roads. It is because of elementary particle in the first approach is associated with a quarter or group of houses, and in RSIF the segments of the last level of recursion are associated with a separate house. Therefore recursion affine fractals are more adequate at the simulation of small townships and villages.

Two next approaches based on three-measurable fractal relief and additive affine relief has most exactness on evidentness. Due to affine transformations on large matrices a checkout time grew sharply. It is necessary to notice that these fractals also have the greatest level of abstraction. A fractal is a surface of the horizontal cuts which demonstrate the dynamics of settlement growth. A cut of the proper level is forecast border of the city on the certain stage of development. The probabilistic field only determines direction of breaking of the surface and does not play imitational role. This feature makes impossible the classic methods of settlement segmentation because whole planes are build which do not have analogues in settlements. Such approach allows tracing development of the city from beginning, but not enables to obtain information about an underlying structure or symmetry.

The last fractal is characterized by speed of construction and possibility to take into account the dynamics of development, but is not such evident as previous. The strongly cut surface does not enable to present it as horizontal lines. In this case they will be like a plenty of small «islands». And it will complicate determination of fractal dimension and exactness. Presentation of the fractal as points of different color allows showing the dynamics of development; however it is impossible to conduct an analogy between a point and a house because points do not represent the real symmetry of settlement. They are only the indicators of building density. However segmentation of building by classic methods without problems can be implemented in such fractals.

Cellular Urban Model (CUM) [7, 8] is widely using for the dynamics simulation of spatial distribution. It is based on the theory of discrete diffusely limited aggregation and implemented by asynchronous cellular automata (Fig1.g.). Basic advantages of this model are possibility to simulate the dynamics of growth of settlements and get the correct form of periphery which well conforms to the experiment. Every aggregate point is examined as an analogue of the urbanized territory. However this model has following disadvantages: long time of calculation, presence of «empty» areas and impossibility to simulate an underlying structure.

For overcoming these basic failings we are develop our own method that unites two approaches: method of the «Casual rain» and model of continuous diffusely limited aggregation (CDLA) [9]. It allowed for a short time simulate an origin and development of the city from the moment of foundation (Fig.1.h). As we can see from a table, this model shows the greatest level of exactness and deprived lacks of CUM.

It is possible to draw a conclusion that developed and approved approaches allowed to simulate an underlying structure and dynamics of development of small

settlements. However association of two first types of mathematical fractals with three-dimensional relief for a receipt a fractal which represents simultaneously internal symmetry and dynamics of development is impossible. It is explained by absolutely different mathematical approaches, different types of analogies and conclusion of simulation result. Unlike them the use of physical fractals allows to simulate with high exactness the dynamics of development from an origin and to forecast an underlying structure.

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