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Modeling Of Recreation And Tourist Attractions Development Using Soft Computing Methods

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Abstract: *The segmentation method of forecasting social-economic processes (development of cities and settlements, green tourism, infrastructure, population segmentation by interests and activities, recreation) in accordance with the applied fractal crystals growth methods in the fuzzy attraction potential field was proposed. The impact of model empirical parameters on the fractal structure fluctuation surface in the form of creating additional aggregation centers was investigated. The computer experiment gave a possibility to simulate structures which are well correlated with the experimental data received. This confirms the assumption that the main role in the formation of settlements available infrastructure plays, namely roads and existing centers of attraction. Received segments confirm the basic economic features of the existing infrastructure.*

Key words: *potential of attractiveness, fractal, fuzzy logic, molecular dynamics.*

JEL classification: L83, C53, R12

Introduction

Explosive development of tourist activity becomes a reason of concentration big capital in this industry – hotel networks are being created, tourist centers are being built, transport infrastructure and restaurant business are being developed etc.

Investing in tourism big capital seeks to gain maximum profit for the shortest time. Environment, natural resources, local populations are being apperceived as means for achieving its goal. No wonder, that massive increasing of uncontrolled visits to prominent natural complexes has negative impact on them and their local social and cultural environment: rare plants are being

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destroyed, trees are being cut down, water is being polluted, animal populations disappears or decrease considerably. Such kind of tourism refers as "cruel tourism" and is observed during last decades in many countries.

So, forecasting of tourism development becomes very important. To solve this problem existing methods of strategies development should be complemented by different mathematical models, which allow us to tackle specific tasks with construction of prognostic scenarios and creates the opportunity of more accurate multivariate prediction, formation and development of complex social and economic processes.

On the other hand, development of GPS-technology and different international programs of terrestrial space photography, creating digital maps allows everyone easy orientate on area, to receive topographical data about location, to plan routes, to receive foto of locality from space etc. This information opens huge opportunities to conduct research in area of GIS-technologies, architecture, sociology, economy and other fields. Foto of many localities made from space resembles crystal growth in a particular center (zones of entertainment, recreation, industry etc.) which is deformed under the influence of some potential field.

There is a need to use methodology of fractal crystal growth in the fuzzy potential field of attraction for predicting controlled social processes, say, in tourist and recreation activity, for example forecasting of spatial form of dwelling construction. It is important to stress pros and cons of modified diffusion-limited aggregation theory (DLA) and accidental rain (AR), to propose combined algorithms of this theory to avoid possible mistakes and to gain benefits from advantages.

The aim of this paper is to create and test methodology of crystal growth in the field of fuzzi potential attractiveness for prediction of social development processes in the context of tourist attractions. Forecasting of settlements which have geometric shape has been chosen as an example.

Relevance of the investigation is to develop the concept of weakly monitored forecasts of social processes, namely, cities and settlements growing; active development of green tourism; infrastructure creation, including tourist; segmentation of population by interests, jobs, rest etc. Suggested concept is based on methods of fractal crystal growth and molecular dynamics combined with the theory of fuzzy logic.

Creating of structure with growing surface is presented among the large number of notions which are actively studied by scince, especially in crystal growth in particular conditions, evolution of snowflakes in the atmosphere, controlled crystallization in some processes as an important component in metallurgy.

The growth of settlements is characterized by features which one can observe in physical processes of growing crystals, in particular:

- physical growth of "crystal" begins in some centre. As such centres we can keep in mind industry enterprises, historical and cultural places, touristic and recreation systems, ski resorts, entertainment centres, beaches etc.;

- cluster deformation in natural crystals is caused by diffusion in the potential field. The role of potential field in social processes is a function of territory attractiveness that depends from remoteness of infrastructure, innovation and investment climate, legal and other aspects. This territory can be constructed based on fuzzy logic theory.

In the process of development a free particle, which creates random movement is joining to the center of the cluster or for preliminarily treated particles. According to marketing surveys new recreation objects, buildings appear in close proximity to neighbors forming blocks similar to clusters. It follows that base processes of settlements changes are alike to processes which are evident in crystal growing. It enables to use DLA and AR theories and to determine specialization of separate segments and predict cash flow in the system.

But development of settlements has defining features: crystallization occurs not in one centre as it is observed in natural phenomena. In real life several crystallization centers and regions are formed within investigating object and their geometry is very complicated. Potentially attractive territory in its turn has a complex shape. In many cities and megapolicies strategy of changes is influenced of peer review and approvals of relevant institutions. Changing of small settlements has probabilistic nature and is largely dependent on the attractiveness of the particular area. It implies that the classical methods of crystal growth such as imitation, dendritic and fractal magnification can be significantly modified.

Forecasting of geometry of settlement growth and their internal structure will allow plan the development of appropriate infrastructure and communications with the maximum economic benefits. There is a possibility to predict structure of new buildings in the vicinity of newly established tourism and recreation systems (TRS). This, in turn, will allow optimize the development strategy of TRS, determining the specialization of certain segments of the locality and predicting cash flows of the system (Durovich, 2003).

Model Of Potential Field

The potential field of territory attractiveness for development could be described using mathematical tools of fuzzy logic.

In general, the potential U is written as:

$$U = F(a_1, a_2, ..., a_n), \tag{1}$$

where a_i – input parameters; F – function that determines the form of potential.

The form of the function and choice of fuzzy inference algorithm[2] depends on the mechanism of construction of fuzzy production rules used in expert and management systems that are based on database formed by professionals in relative area or gained through learning of neural network, training set of which in turn based on experimental data as a set of fuzzy predicate rules. Fuzzy logic tools has been well approved itself in social and economic researchs, particularly in

[2] See review in: Leonenkov (2005).

calculations of integral indicators of efficiency (Petrenko and Kashuba, 2006), solving multicriteria problems (Chou et al., 2008), determining the competitive growth between regions in China (Ma et al., 2006). In paper (Vyklyuk, 2008a) the possibility of using Mamdani and Sugeno algorithms has been argued for estimating of recreation potential. It has been demonstrated that results obtained by these methods are well correlated with experts' ideas. Therefore, in our calculations we used one of these algorithms, namely Sugeno algorithm with Gaussian membership functions (D'yakonov and Kruglov, 2006). The choice of this algorithm is justified by the fact that if we have experimental database it is appropriate to use hybrid neural networks ANFIS (Adaptive Neuro-Fuzzy Inference System) which based on Sugeno method.

For Sugeno fuzzy inference we must have fuzzy knowledge base (Shtovba, 2007):

$$(x_1 = \tilde{a}_{1j}\ \Theta_j\ x_2 = \tilde{a}_{2j}\ \Theta_j \dots \Theta_j\ x_n = \tilde{a}_{nj}) \rightarrow y_j=b_{j0}+b_{j1}x_1+b_{j2}x_2+\dots+b_{jn}x_n,\ j=1,m; \quad (2)$$

where $x_1, x_2, \dots, x_n$ – input linguistis variables; $a_{1j}, a_{2j}, \dots, a_{nj}$ – terms of linguistic variables; Θ_j – logical operation that connects fragments of antecedent of j^{th} rule; → – fuzzy implication; $b_{j0}, b_{j1}, \dots, b_{jn}$ – real numbers.

Conclusions rules are specified by the linear function from the inputs:

$$dj = b_{j0} + \sum_{i=1,n} b_{ij} x_i\ . \quad (3)$$

Degree of input vector membership $X^*=(x_1^*, x_2^*, \dots, x_n^*)$ to values $dj = b_{j0} + \sum_{i=1,n} b_{ij} x_i^*$ are being calculated as:

$$\mu_{dj}(X^*) = \mu_j(x_1^*)\ \chi_j\ \mu_j(x_2^*)\ \chi_j \dots \chi_j\ \mu_j(x_n^*),\ j=1,m. \quad (4)$$

As a result, according to input vector X* get fuzzy set $\tilde{y}$:

$$\tilde{y} = \left(\frac{\mu_{d1}(X^*)}{d_1}, \frac{\mu_{d2}(X^*)}{d_2}, \dots, \frac{\mu_{dm}(X^*)}{d_m}\right). \quad (5)$$

To obtain result value of output $\tilde{y}$ must be defuzzificated, calculating equilibrium amount:

$$y = \sum_{j=1,m} \mu_{dj}(X^*) d_j\ . \quad (6)$$

In this paper we used Sugeno method of 0-th order, when logical inference is constant:

$$(x_1 = \tilde{a}_{1j}\ \Theta_j\ x_2 = \tilde{a}_{2j}\ \Theta_j \dots \Theta_j\ x_n = \tilde{a}_{nj}) \rightarrow y=dj,\quad j=1,m. \quad (7)$$

As input parameters of fuzzy attractiveness potential we proposed to choose distance to the nearest road and distance to the nearest crystallization center by road.

Let the transport networks of study area would be given as array (Vyklyuk, 2008b):

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$$w_f\left(x_{f1}, y_{f1}, x_{f2}, y_{f2}\right),\ f = \overline{1,n}\,, \tag{8}$$

where n – number of road vectors on study area; $x_{f1}, y_{f1}, x_{f2}, y_{f2}$ – coodinates of road vector.

Then distance from point h with coordinates x, y to the nearest road can be estimated according to the next consideration: look at the triangle with vertices $A(x,y)$, $B\left(x_{f1}, y_{f1}\right)$, $C\left(x_{f2}, y_{f2}\right)$ with sides defined as:

$$a = \sqrt{\left(x_{f1} - x_{f2}\right)^2 - \left(y_{f1} - y_{f2}\right)^2}\ ; \tag{9}$$

$$b = \sqrt{\left(x_{f1} - x\right)^2 - \left(y_{f1} - y\right)^2}\ ; \tag{10}$$

$$c = \sqrt{\left(x - x_{f2}\right)^2 - \left(y - y_{f2}\right)^2}\ . \tag{11}$$

The height of the triangle to the line, which a side a belongs to (road segment):

$$h'_f = \frac{2\sqrt{p(p-a)(p-b)(p-c)}}{a}\,; \tag{12}$$

$$p = \frac{a+b+c}{2}\,. \tag{13}$$

Segments a_1 and a_2 which define distance from the base of the height to the vertices B and C respectively and coordinates of the base of the height $\left(x'_h, y'_h\right)$ can be calculated as

$$a_1 = \sqrt{b^2 - {h'_f}^2}\ ; \tag{14}$$

$$a_2 = \sqrt{c^2 - {h'_f}^2}\ ; \tag{15}$$

$$x'_{fh} = x_{f1} - \left(x_{f1} - x_{f2}\right)\frac{a_1}{a}\,. \tag{16}$$

The height (12) is the shortest distance to the road in the case if point $\left(x'_{fh}, y'_{fh}\right)$ lies in road segment f. In the other case the shortest distance to road will be defined as

$$h_f = \begin{cases} a_1 + a_2 = a,\ h'_f\,, \\ a_1 + a_2 > a \ \ and\ \ b < c,\ b, \\ a_1 + a_2 > a \ \ and\ \ b > c,\ c. \end{cases} \tag{18}$$

Coordinates of intersection point respectively

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$$\left(x_{fh}, y_{fh}\right) = \begin{cases} a_1 + a_2 = a, \ \left(x'_{fh}, y'_{fh}\right), \\ a_1 + a_2 > a \ \ and \ \ b < c, \ \left(x_1, y_1\right), \\ a_1 + a_2 > a \ \ and \ \ b > c, \ \left(x_2, y_2\right). \end{cases} \quad (19)$$

Then the shortest distance to the nearest road defines as

$$h = \min_{f=\overline{1,n}} \left(h_f\right). \quad (20)$$

To calculate the shape of potential field of attraction one may make use of method of mapping the recreational potential (Kyfyak et al, 2007). For this purpose map of territory T is covered by rectangle $\Pi = [a,b] \times [c,d]$. Obviously that rectangle Π contains the set (territory) T ($T \subset \Pi$). Rectangle Π is devided into segments $\Delta = \Delta_x \times \Delta_y$, where

$$\Delta_x = \bigcup_{k=0}^{N} \{x_k\}; \quad (21)$$

$$\Delta_y = \bigcup_{l=0}^{M} \{y_l\}; \quad (22)$$

$$x_k = x_o + kh_x, \ k = \overline{0,N}; \quad (23)$$

$$y_l = y_0 + lh_y, \ l = \overline{0,M}; \quad (24)$$

$$h_x = \frac{b-a}{N}; \quad (25)$$

$$h_y = \frac{d-c}{M}. \quad (26)$$

For every mesh point value of input parameters are being defined. Obtained matrixes are input parameters of fuzzy function of potential field of attraction (1). The result of calculations is matrix that determines the shape of territory T potential.

Modified method of the "accidental rain" (AR) has been used for modeling of central part of settlements evolution (Pietronero, 1985).

AR model was proposed by Wald and Sutherland[3]. In this model parts move by randomly determined paths. In (Pietronero, 1985) it was shown that the best adjustment with experiment is provided by model in which clustering center is located in the center of the investigated area and particles (candidates for aggregation) start to move from the large neighborhood toward the center of circle. Each particle starts from random point and moves by random chord connecting in a collision with a base line or cluster which grows. AR model generates ramified spherical structures.

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[3] See: Pietronero, 1985.

If there are n clustering centers it is necessary to estimate normalized weight w_i for each center. If the locality has a few centers of attractiveness, weighting factors could be calculated as relative amount of people which visited such objects for a certain period of time:

$$w_i = \frac{S_i}{\sum_{i=1,n} S_i}, \tag{27}$$

where S_i – amount of people which visited object i.

According to AR algorithm, the particle moves by random chord to one of the clustering centers. Clustering center for each particle is being choosen randomly depending on the size of the normalized weight w_i (Tomashevskyi, 2005). To avoid the appearance of empty areas (Vyklyuk, 2008c) after aggregation of the particle its copy is created ("transparent particle"), which continues its movement to the center, not reacting to crystallized particles. As soon as it gets into the area where in small radius R there are no aggregate particles (ie particle has got into empty area), "transparent particle" has been assigned the status of "ordinary particle", and the accretion algorithm is continued according to classic rules.

The impact of potential field is taken into account as follows: initial potential field of the analized region is normalized; probability of aggregation is defined as probability of two independent events, namely presence of aggregated particle near and "opportunity" of aggregation at a given point on the side of the normalized potential field $U(x,y)$. In our calculations the certainty $P_a(x,y)$ of staying close to the moving particle of aggregated cluster was assumed to be equal to 1, if the aggregated atom is on the neighbor verge of cell, 0.5 – if the aggregate atom is located close to the diagonal, and 0.01 – otherwise. Then probability of particle aggregation is defined as

$$P(x,y) = U(x,y) \cdot P_a(x,y). \tag{28}$$

Nonzero probability of aggregation $P_a(x,y)$ in zone where there are no aggregated particles within the nearest neighborhood, enhances impact of the potential field on the form of created cluster, but contributes to the emergence of separate centers of aggregation.

For modeling of periphery of locality the matrix of created structure is devided into matrix of the central part of locality which consists of particles with the closest neighbors, and matrix of free particles. The first matrix is considered as the single aggregation center, and particles set by the second matrix keep moving in the potential field according to the diffusion-limited aggregation model (DLA).

Classic DLA model is very simple: particles which carry out random movement form a cluster as the result of aggregation. That is to say particle starts the motion from a randomly selected remote point and joins to center point of clustering or to previously aggregated particles.

Intensive computer studies have demonstrated that as a result of this process complex branching fractals are being created (Pietronero, 1985; Crownover, 1995), which have a spherical shape.

In our case particle should move in the potential field which has an impact on the shape of a fractal. One can use methods of molecular dynamics for modeling this movement (Perez-Martin et al, 2004; Sibona et al, 2003; Moon and Hwang, 2003).

Suppose, at the time t particle is in the point $(x_1(t), x_2(t))$ and moves at the speed $(v_{x1}(t), v_{x2}(t))$. Then on the axis projection the particle will be under force action described by the following equation:

$$\vec{F}(t) = -grad(U). \tag{29}$$

For correct influence of the potential field and prevent a sharp increase of speed authors propose to consider the motion of particles in a medium with viscous friction. Analogue is the movement of bodies in air resistance forces of which at subsonic speeds is proportional to speed

$$\vec{F}_l = -\beta\vec{v}, \tag{30}$$

where β – resistance factor.

Considering that during small time Δt the force remains constant acceleration, velocity and position of the particle at time $t + \Delta t$ are being calculated

$$\vec{a}(t) = \frac{\vec{F}(t) - \beta\vec{v}(t)}{m}; \tag{31}$$

$$\vec{v}(t + \Delta t) = \vec{a}(t)\Delta t + \vec{v}(t); \tag{32}$$

$$x_i(t + \Delta t) = \frac{a_{xi}(t)\Delta t^2}{2} + v_{xi}(t)\Delta t + x_i(t); \tag{33}$$

where m – weight of the particle (Gould and Tobocnik, 1996; Kaplan, 2006).

Aggregation of particles occurs when while moving it is faced with the cluster center or previously aggregated particles. In case if input parameters of fuzzy potential which have local content restrictions prevent aggregation (beach, marsh, pond), the particle is removed from the calculation.

As empirical parameters of this theory are the particle weight and the resistance coefficient of the medium. Weight m in physics – measure of inertia of the body. Namely, the bigger weight of body, the less impact of potential field on it. Reduced weight leads to an increase in acceleration towards the maximum gradient of the potential field (Fig. 1). That is, the lighter particles tend to roads, while heavy particles will aggregate in crystallization centers. In forecasting the complex social structures such as settlements, the weight can be interpreted as a measure of investment capacity of certain object in settlement (resort, hotel, office, cottage, villa etc) or infrastructure (supermarket, shop etc). The density of the medium can be interpreted as a measure of investment

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promotion of the region. Fig. 2 shows predicted fractal structures in such approximations: crystallization center is located in the center of explored region; the straight horizontal road crosses crystallization center. In experiment we used particles with weights $m = 0.1$ (Fig. 2a) and $m = 0.01$ (Fig. 2b). Viscous friction coefficient was $\beta = 0.0001$.

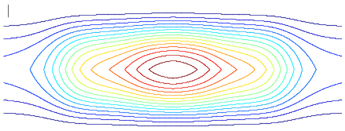


Fig. 1. Potential field of attractiveness in the approximation: Center-road

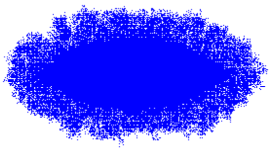
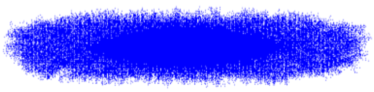
a)  b) 

Fig. 2. Fractal in the approximation: Center-road, $\beta = 0.0001$
a) $m = 0.1$, b) $m = 0.01$

From the figures it is clear that the fractal structure formed by particles with weights $m = 0.01$ is more elongated along the road structure then $m = 0.1$. Therefore, they confirm our assumption about interpretation of particles' weight. So, investment powerful objects gravitate to centers of attractiveness and objects of small and medium businesses a significant impact causing transport routes. The viscosity of the medium also plays a significant role in the growth of fractal. By increasing the resistance coefficient β (reduction of investment promotion of the region) the absolute velocity of the particles decreases and geometric form of increasing fractal will be mainly determined by the gradient of the potential field (29) and will be weakly dependent from the initial velocity of the particles. The maximum change of the gradient is directed to the road, therefore the trajectory of the particles at the initial stage of fractal growth can be described as damped oscillations perpendicular to the road with a gradual movement of the particles to the center of attraction (Fig. 3a). From this figure we can see that the amplitude of light particles fluctuations subsides more quickly in contradistinction to heavy (Fig. 3b). That is, the trajectory of the particles with greater weight will have a chaotic fluctuating character, determined by random initial conditions. The trajectory of light particles are weakly dependent from the initial velocity and is determined mainly only by coordinate of initialization.

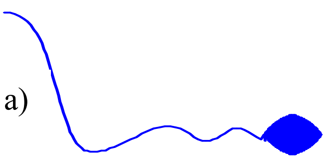
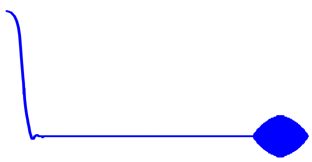
a)  b) 

Fig. 3. The trajectory of a particle in a potential field-center road $\beta = 0.001$:
a) $m = 0.01$, b) $m = 0.001$

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When modeling fractal by 100000 particles with weights $m = 0.1$ in the medium with viscous friction $\beta = 0.001$ the structure is being created which has the similar shape as the potential field (Fig. 4a). An interesting effect is observed during the fractal modeling by light particles. Due to the mentioned features of motion of particles with the weight drawing near the center of aggregation the number of particles moving along the road dramatically increases. This creates a situation that resembles a “traffic jam” on the roads. Such fluctuation leads to aggregation of particles in these areas. As a result, at some distance from the center of aggregation additional area of aggregation are being formed (Fig. 4b). A similar effect is being observed in cities and regional centers, in a neighborhood of which cottage settlements are being created along the roads. Such settlement has not, as such, the center of attraction for development.

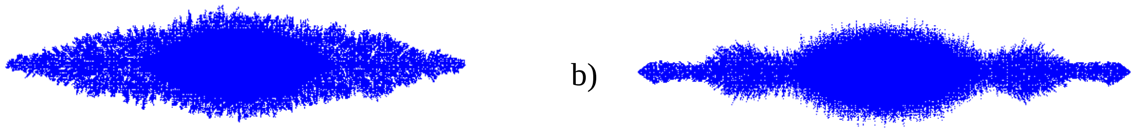

Fig. 4. Fractal in the approximation: Center-road, $\beta = 0.001$
a) $m = 0.1$, b) $m = 0.01$.

The difference between obtained fractal structures is a tool for determining both the external and internal structure of the obtained crystals.

Suppose there are N types of businesses or infrastructure elements that are described by weights $m_i, i = 1 \div N$ and relative quantity p_i. Types N and their quantity can be determined by statistic data, cluster analysis or expert estimation (Durovich, 2003). The economic situation in Ukraine is characterized by the fact that the value of investment promotion in the region is greater for large businesses. It means that capital increasing reduces the number of obstacles for doing business. In this paper next suggestion has been used: the value of viscous friction is inversely proportional to the weight of the particle ($\beta_i \sim 1/m_i$). Fractal growth is modeled according to the DLA with approximations:

- index i of weight of particle m_i is being chosen randomly according to the relative number p_i; value β_i is being determined;
- aggregation occurs on particles with weight equal to or greater than the weight of the moving particle. That is, strong investment objects displace small businesses (Durovich, 2003).

Computer simulation

To test the model experiment has been conducted in which the fractal structure of settlements has been modeled: Sudak-Novyi Svit, Novoselytsia and Kitsman. The choice of these settlements was motivated by the presence of distinct suburban cottage sites (Fig. 5-7). These localities have geographical features:

- Sudak-Novyi Svit is situated on the seashore, it has significant historical and cultural heritage and there is only one access road (Fig. 5);
- Novoselytsia is district centre; it has two acces roads that are located at an acute angle to each other; cottage site has been created on only one of these roads (Fig. 6);

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- Kitsman is district centre; the main places of attraction are located in the centre of the city; state road has a few turns and crosses the city center (Fig. 7).

In calculating of the potential field as input parameters for fuzzy model using algorithm Sugeno were selected distance to historical and cultural centers, administrative objects, roads, distance to the nearest object and geometry of the coast (Sudak-Novyi Svit). Relief peculiarities were not considered.

Fig. 5. Sudak-Novyi Svit

Fig. 6. Novoselytsia

Fig. 7. Kitsman

In calculations using modified DLA such approximations were used: initial speed of particle has been choosen randomly; mirror boundary conditions have been used (Gould and Tobochnik, 1996). That is, particle appeared on the opposite side after crossing the brink of studied area, keeping all other dynamic parameters. The experiment used a particle with weights $m_1 = 1;\ m_2 = 0.1;\ m_3 = 0.01$. Relative number is become $p_1 = 0.1;\ p_2 = 0.2;\ p_3 = 0.7$. Viscous friction coefficient was $\beta_1 = 10^{-5}$, $\beta_2 = 10^{-4}$, $\beta_3 = 10^{-3}$.

At research of the region Sudak-Novyi Svit received fractal consisted of about 74 000 aggregated particles. The overall structure of the obtained fractal reflects all features of the region that was modeled (Fig. 5, Fig. 8). Fractal growth at modeling of this region reminds the projection of physical crystal growth on the plane. The main objects of attraction are located along the coast and near the road. As it was shown in Figure 8, included restrictions impede the growth of fractal in the sea zone.

Figure 8 clearly displays the segmentation of the infrastructure of the investigated region. The figure shows that the most expensive infrastructure consists of particles $m=1$ located along the coastline and surrounds major historical and cultural centers of attraction in Sudak, that is covers the area that has the most attractiveness. Infrastructure of medium class is located close to the expensive elements and creates a small gap compared with expensive infrastructure objects, despite the fact that the initial amount of aggregated particles with weight $m=0.1$ twice bigger then with weight $m=1$. So, evidently that large business absorbs medium business. Penetration of middle-class elements in the area with expensive infrastructure is not essential, which is not true for a small business. Elements of small businesses that correspond meet the weight $m=0.01$ located far from the main centers of attraction and gravitate to the road. Figure 8c shows that this segment covers both surroundings of investigated region and "leaks" through expensive elements of infrastructure. A similar pattern is actually observed, especially at resorts where small shops and kiosks are located in the most prestigious and expensive places near the sea or the center of attraction.

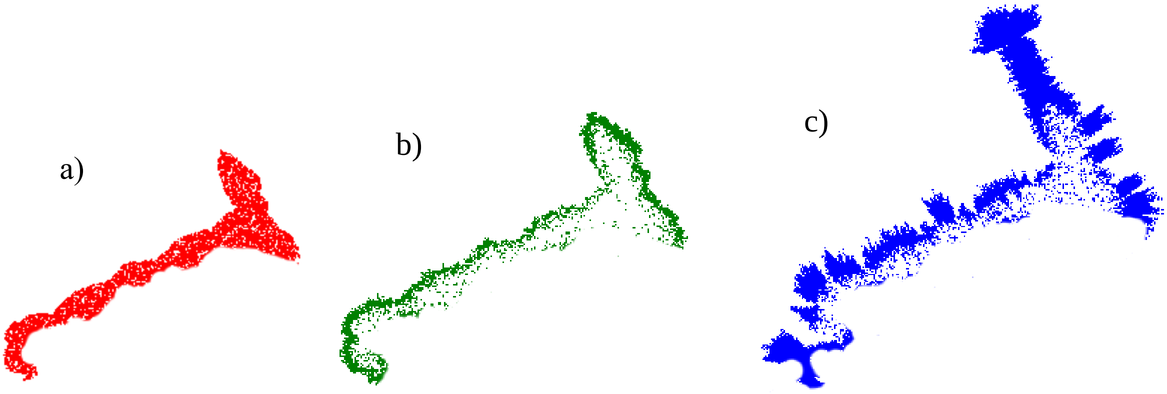

Fig. 8. Segments of fractal structure of Sudak and Novyi Svit
a) $m=1$, b) $m=0.1$, c) $m=0.01$

As it was mentioned above, the coast can be reached by one access road. From Figure 8b is clear that centre of aggregation has been created with light particles at the entrance to the explored region. As we can see in Figures 5 and 8c theoretically obtained center of aggregation correlates well by distance to the coast and size with the cottage settlement. The differences of shape can be explained by considering of territorial restrictions.

Obtained during the simulation fractal structure of settlements Novoselytsia (41000 aggregated particles) and Kitsman (30000 aggregated particles) repeat the main peculiarities of the internal structure which have been observed for the region Sudak-Novyi Svit (Fig. 9, 10). That is to say entities of big business are taking over most investment attractive areas, displacing medium business. Entities of small business and households on the one hand gravitate to roads and go away from the center, forming a cottage settlement, and on the other hand penetrate actively through subjects of big business.

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As we can see in Figure 9c obtained fractal structures predict creation of two new centres of aggregation very close to the centre of settlement. When compared with the Figure 6 it is evident that the upper center of aggregation repeats this cottage settlement by size and shape. However, the botto centre does not have real analogs. This may indicate about the potential attractiveness of this area for development. And this in turn, is a scientific basis for the planning of development strategy of this region.

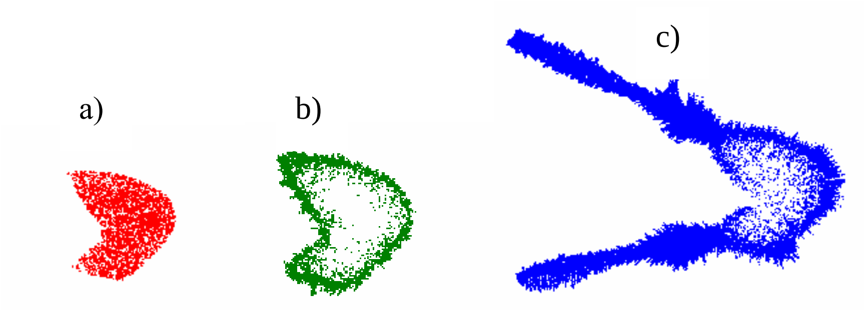

Fig. 9. Segments of fractal structure of Novoselytsia

a) $m=1$, b) $m=0.1$, c) $m=0.01$

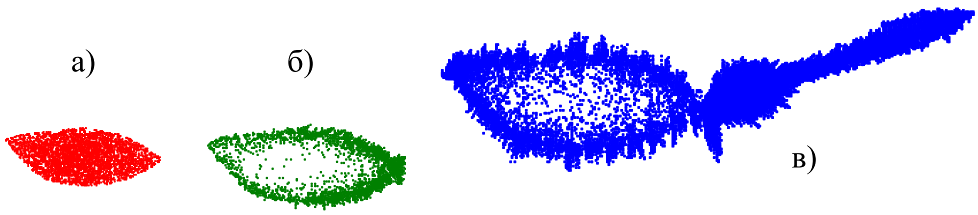

Fig. 10. Segments of fractal structure of Kitsman

a) $m=1$, b) $m=0.1$, c) $m=0.01$

In Figure 10c one can observe the formation of clearly defined cottage settlement on the outskirts of town with a distinct peak (shoulder) in the place of turn of the road. As it shown in Figure 7 this peculiarity of geometrical structure of the settlement is actually observed in photos from space. Figure 7 shows that there is another settlement at a certain distance from the district center. In Figure 10c in this neighborhood thickening of fractal structure is really observed. So, this territory has potential attractiveness for construction. Somehow this fact led to the emergence of the new settlement in this neighborhood. And now for the simulation of real structure of this region, centers of attraction of newly established settlement should be considered.

The similarity of the theoretical structures and obtained segments from the experimental data confirms the validity of the proposed method for prediction and segmentation and is the foundation for further theoretical and practical researches.

Conclusions

Paper suggests the algorithm for calculating of fractal growing in fuzzi potential field using modified method of the "accidental rain" (AR) and diffusion-limited aggregation theory (DLA). Authors have shown that taking into account of elements of the molecular dynamic apparatus, viscous friction force and constraints in the DLA model can adequately describe particle motion in a fuzzy potential field.

In the computer simulation the fractal structures have been obtained which are good coordinated with the available experimental data. This confirms the assumption that the main role in the formation of settlements available infrastructure plays, namely roads and existing centers of attraction. Received segments confirm the basic economic features of the existing infrastructure.

It has been shown that the aggregation centers which were created due to fluctuations repeat real cottage settlements in studied regions by form and basic characteristics.

A high correlation between experimental and obtained by calculations data proves the adequacy of the proposed methodology and allows using it for further forecasting of geometric shape as well as internal structure of settlements. Research and analysis of new centers of aggregation appearance is a scientific basis for the planning of regional development strategy.

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