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MODELLING OF PROCESS INFORMATION DISSEMINATION AND ITS IMPACT DYNAMICS TO MASS CONSCIOUSNESS

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ABSTRACT

The paper deals the problem of modelling information dissemination in the community and its impact on the mass consciousness. At the same time, the quality of information in the paper implies such categories as innovation, idea and opinion. To study the dynamics of information dissemination in society has been proposed system with a dynamic modelling approach, which allows to take into account a number of significant factors influencing the processes of information dissemination in society and the impact of this information on the mass consciousness. The proposed model reflects such factors as the probability of interest, interpersonal contact, media exposure, the likelihood of communication on the topic of information, the probability of forgetting, the number of contacts, an indicator of mass character and regularity of the media promoting a certain idea. The proposed simulation system with a dynamic model allows simulating various scenarios for the development of information dissemination processes in a community, identifying relationships between factors influencing the dynamics of information effects on mass consciousness, and under given initial conditions its practical implementation possible in the Anylogic simulation package. This paper contains the results of the application of original descriptions of human behavior models and scenarios at various levels of communication. Comparisons with other this kind systems have shown the advantages of the approach proposed by the authors. As a result of the conducted experiments, dependencies were revealed between the rate of acceptance of information by new members of the community and the frequency of contacts of persons who already perceived the information. The results of the work can be used in sociological, biological, economic, and socio-psychological studies of mass communication to predict various scenarios and control mass consciousness, for example, the process of promoting goods and services in a competitive market environment.

Keywords: *Diffusion Of Innovations, Information Dissemination, Public Opinion, Mass Consciousness, Interpersonal Communication.*

1. INTRODUCTION

Research on the processes of information dissemination and acceptance has shown that awareness of information is distributed through public communication channels, i.e. through the media, much faster than interpersonal communication [1]. Now the function of interpersonal communication is effectively implemented by social networks and mobile messengers [2],[3]. In connection with this, the importance of social networks and mobile messengers is growing as means of information disseminating and opinions that affect users of the Internet network [4]-[6]. Thus, it can be assumed that the more often a person uses social networks and mobile messengers, the greater is the likelihood that he will use them to obtain new information or use them to analyze the opinions of different people. Researching of public opinion in a social network is

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important for analyzing the information dissemination and development of public opinion. Recent years, the factors that effect of information dissemination process, including the feature of information [7]-[12], the network structure [13]-[16] and psychological behaviors [17]-[19] have attracted much academic attention. Respectively a certain amount of research experience has been accumulated in the field of information dissemination that includes modern mathematical models for managing mass consciousness [20]-[22] including through media [23],[24], social networks and mobile instant messengers [25]-[27]. One of such approaches is simulation modelling that provides a wide range of opportunities for the practical study of the information dissemination of in society and the impact of this information on the mass consciousness. Researchers have built certain models to explain the diffusion phenomenon, and others to predict future diffusion, all of which are based on machine learning.

Diffusion models are utilized to explain and reproduce the spread of information in the network. Researchers proposed some dynamics models from different perspectives to explore the process of information on social platforms [28],[29].

The process of information dissemination has the limits of possible changes due to limited resources, which is also characteristic of many other processes in nature and society. This is due to limitations in the capabilities and capacity of the social system. The *S*-shaped function consists of three levels of development: the first is slow growth, where the development base is formed, the second is sharp growth, and the third is slow growth, saturation. The speed of diffusion processes is determined by the factor of interpersonal communication between supporters of this innovation and those who still hesitate or have not heard anything about the innovation.

Some concepts of mass consciousness are based on different versions of the theory of infection. Their common feature is that the behaviour of the crowd is explained by one mechanism - the mechanism of infection. The notion infection refers to information dissemination, ideas, mood or behaviour of one participant of the crowd to others. G. Lebon [30] and V. Mac-Dougal [31] paid much attention to this mechanism. Also, to research this model, can be used approach including fuzzy [32]-[34].

The information has great potential to influence public opinion. With the advent of Internet technology, the volume of transmitted information has grown and the availability and influence of this information have increased accordingly. However, the abundance of information received exceeds our consumer ability. The information must compete for our limited attention. Research of new information (expansion of ideas or innovations) dissemination dynamics in social and biological communities is very important for many areas. The dynamics of the diffusion of information is closely related to the mass consciousness and is determined by the information processes occurring in the social system and is in direct interaction with social processes in the state, region, significantly influencing their development [35].

In [36]-[38], to research of new information diffusion dynamics in society (on a set of interacting agents - automata), two modified models were considered: the “Diffusion of Innovations” model [39] and the “Naming Game” model [40]-[42], which considers the expansion of opinions in the graph of social interactions, whose vertices are individuals (agents), each of which has a list of opinions.

In paper [43] authors, propose a method (TMIVM) to measure the mutual influence between users at the topic level. The method associates two vectorization parameters for each user-an influence vector and a susceptibility vector-where the dimensions of the vector represent different topic categories.

The primary goal of information diffusion analysis is to illustrate the diffusion process. The epidemic model is the first choice for this research (e.g., SI, SIS, SIR). It utilizes a model to simulate information diffusion but is not very accurate. Therefore, more statuses are added to the basic epidemic model, and although the resulting models are more accurate, they are still not fit for real social networks when considering users’ different behaviors, as an individual’s behavior can affect information diffusion. Such factors are important when building a diffusion model [44].

Despite the fact that the mechanism of formation and dissemination of information was known earlier, research in this area is relevant and constantly requires further development because of some problems are not sufficiently well solved and there are become new problems in the field of information dissemination and appear new research tools.

Many additional factors could be involved in information diffusion models, such as network structure, mutual information, user behaviors, probability of interest, interpersonal contact, media exposure, the likelihood of communication on the topic of information, the probability of forgetting,

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the number of contacts, an indicator of mass character and regularity of the media promoting a certain idea, etc.

In our proposed model takes into account such factors as the probability of interest, interpersonal contact, media exposure, the likelihood of communication on the topic of information, the probability of forgetting, the number of contacts, an indicator of mass character and regularity of the media promoting a certain idea. The closest approach is observed in [36]-[38], but this paper did not take into account the innovativeness of opinions and competition for the community's attention and this is very important to take into account, because people's attention is limited.

2. RESEARCH METHOD

Consider a community of people with a population of *N*. Suppose that each person can contact each member of the community. Denote by *S* the number of people able to receive information, *Y* is the number of people who accepted the information, therefore, *SY* is the rate of increase in the number of people who accepted the information, *YS* is the decrease rate of the number of people who accepted the information, based on this, we obtain the following equation (1) which determines the speed (rate) of change in the number of people able to receive information:

$$\frac{dS}{dt} = YS(t) - SY(t) \quad (1)$$

The following equation (2) of the system determines the rate of change in the number of people accepting the information:

$$\frac{dY}{dt} = SY(t) - YS(t) \quad (2)$$

Further, denote by *a* the probability of one person being interested in information for a single time interval during interpersonal contact, *b* is the probability that one person is interested in information for a definite time interval, as a result of media exposure. *M* is an indicator of mass and regularity of mass media propagating certain information, *N* is the maximum possible number of people capable of receiving information, *g* is the probability of forgetting information during time interval, *p* probability of people's contact information, k_0 the probability of receiving information through one contact, k_1 is the average number of acquaintances with one message in the media during time interval, k_2 is the probability of accepting information under the influence of the media, *n* is the number of contacts of a person who have already received information.

The following equation (3) of the system determines the rate of increase in the number of people who accepted the information:

$$SY(t) = S * (a * Y + M * b)/N \quad (3)$$

Equation (4) determines the rate of decrease in the number of people who accepted the information:

$$YS(t) = g * Y \quad (4)$$

Equations (5) and (6) determine the values of the probabilities of accepting information during interpersonal contact and as a result of media exposure:

$$a = p * k_0 * n \quad (5)$$

$$b = k_1 * k_2 \quad (6)$$

Let *y* be the number of people with an innovative idea. Suppose that the information carrier contacts with *n* people during appropriate time interval, which with probability k_1 shares information: in this case $k_1 = k_0 p$. In other words, a carrier of information spreads information $k_1 n$ to people, where $k_1 n$ is the mathematical expectation of the number of people who accepted the idea.

The probability of communication of the information carrier with a person without information equals y/N, the probability of receiving information as a result of communication is the product of this probability multiplied by k_1. Consequently, the probability of receiving information at least once in *n* contacts can be approximately expressed by the formula:

$$q \approx k_1 n \frac{y}{N} \quad (7)$$

The mathematical expectation of the number of people who received the information from previously accepting people is equals to the product of *q* and the number of people without information:

$$q(N - y).$$

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In this case, the mathematical expectation of a change in the number of people who took information for a single time interval described by the following equation:

$$\frac{dy}{dt} = a\frac{N-y}{N}y \qquad (8)$$

3. RESULTS

In papers we have analyzed [45]-[48] used various tools and approaches for modelling the if information dissemination. The practical implementation of information dissemination model implemented in simulation package Anylogic [49]. The choice of this tool is justified by the fact that this environment is one of the most promising simulation environments. This model allows simulating various scenarios for the development of information dissemination processes and studying the effect of model parameters on them. A general view of the interface model of information dissemination and its impact on the mass consciousness is presented in Fig.1.

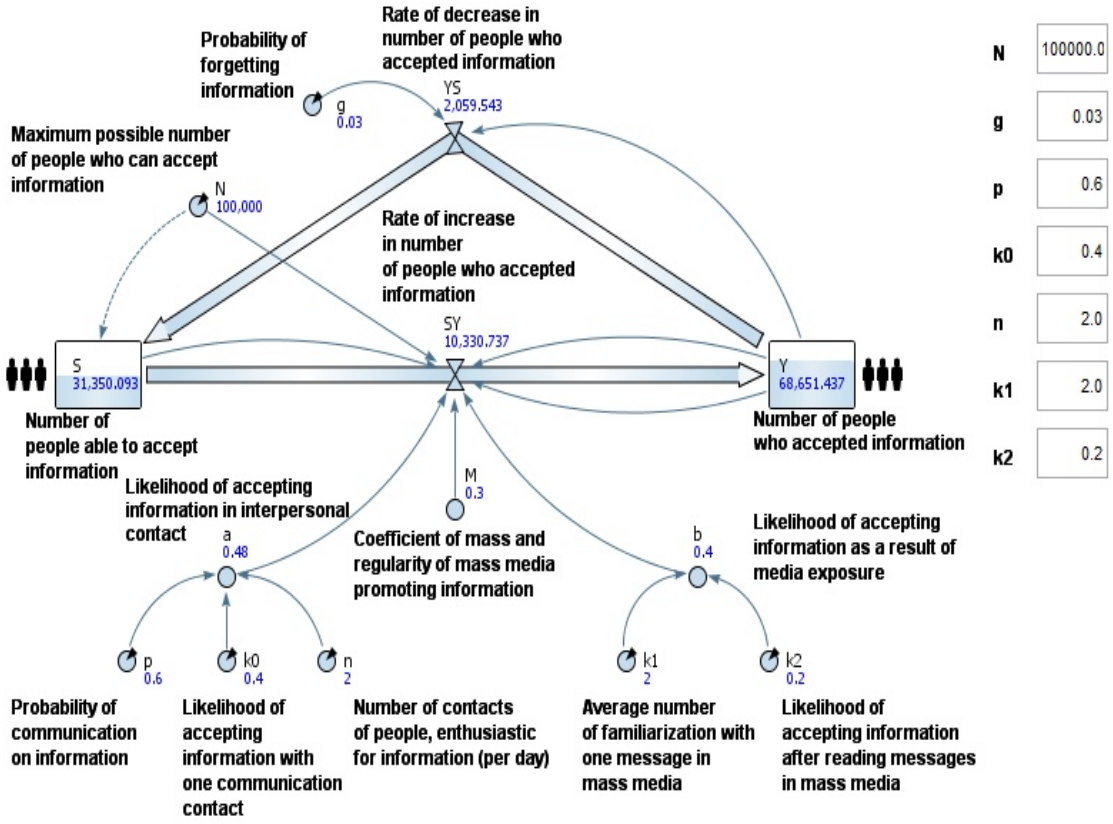

Figure 1: General view of the interface of the distribution model and the influence of information on the mass consciousness

At the same time, it is interesting not only to simulate the transition of users from one state to another with a certain probability in discrete time. It is also significant and implementable to take into account the influence of the information forgetting factor on the process of information dissemination in society. Fig. 2 demonstrates that the dynamics of persons who accepted the information is presented in the form of an *S*-shaped curve used analog according to the concept of E. Rogers [39]. In addition, to verify the effectiveness of the model were given experiments on numerical modelling and analysis of the results with the influence of various parameters.

For example, time plots reflecting the dynamics of the number of persons able to receive information *S* and receiving information *Y*, (Fig.2) under the following initial conditions:

$p=0.6;$	$g=0.03;$
$k_0=0.4;$	$S(0)=100,000;$
$k1=2;$	$Y(0)=3$
$k1=0.2;$	$M=0.3;$

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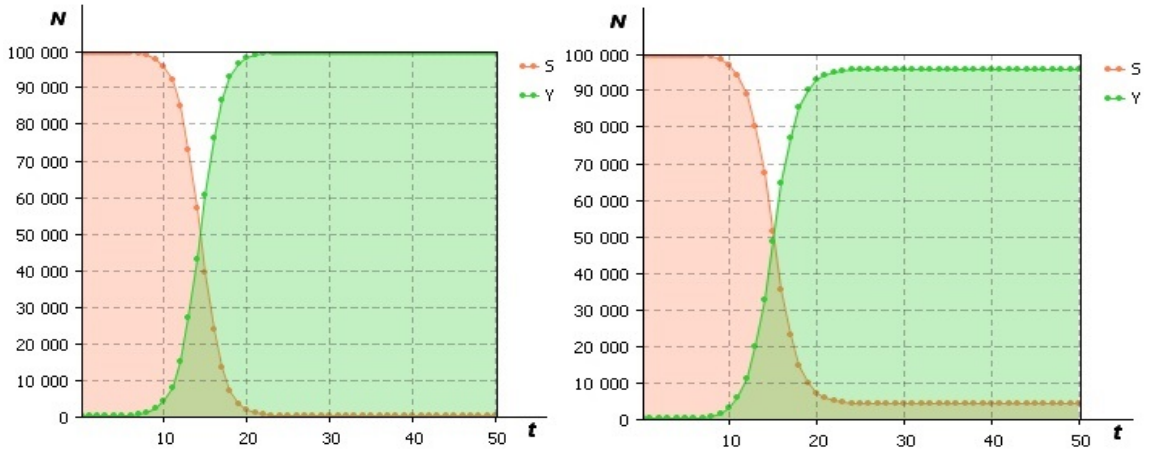
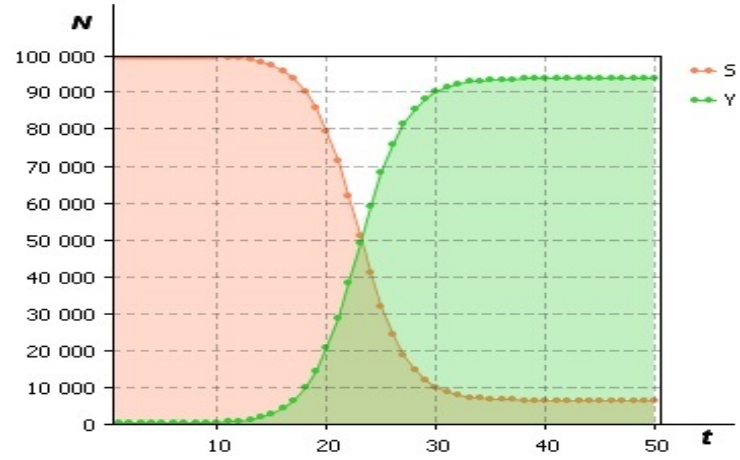


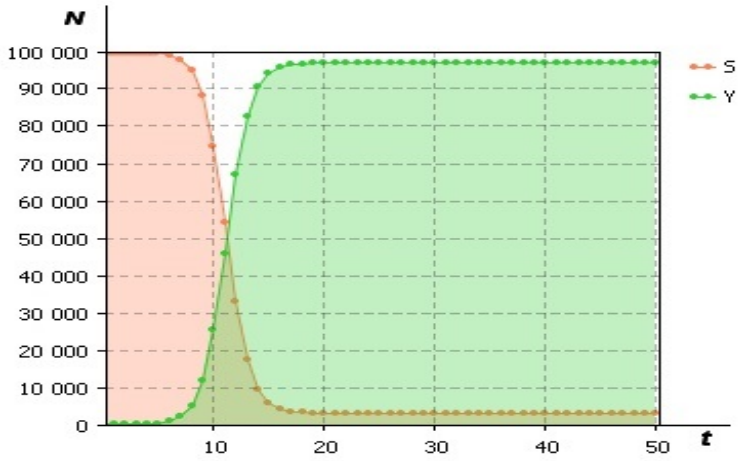
a *b*

Figure 2: Dynamics of the number of persons capable of receiving information S and receiving information Y: a – without information forgetting factor, b - with information forgetting factor

Fig. 3 shows the time graphs obtained from the results of the experiment. Taking into account the information forgetting coefficient (g=0.03) and two contacts per day (n=2), the rate of information acceptance will reach its maximum in 32 days, six contacts per day (n=12) the rate of information acceptance will reach its maximum within 6 days.



n=2



n=4

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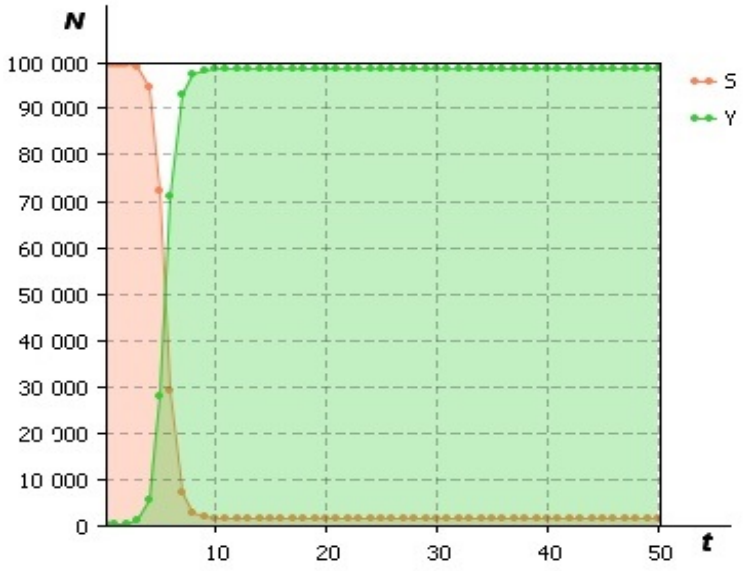
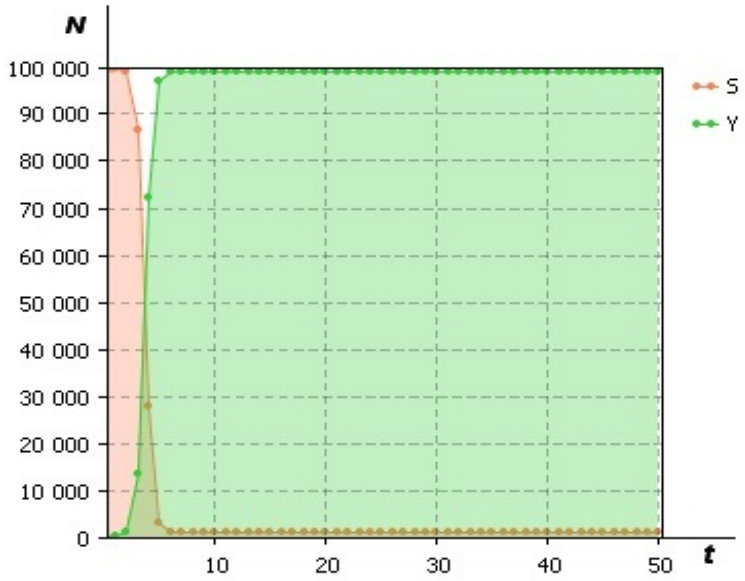


n=8



n=12

Figure 3: The rate of acceptance of information, depending on the frequency of contacts of persons interested in information, per day

Our experimental modeling results show that the mechanism of forgetting information has a significant effect on the saturation of message distribution and may even lead to cessation of distribution under certain conditions. These results may be of interest for use in research and controlling the spread of epidemics.

Modelling the process of information dissemination, the distribution of agents in space is not uniform; over time, agents with the same ideas are combined into stable groups.

In fig. 8 shows the result of numerical modelling of these processes on a plane at different points in time, from which it can be seen that over time the community breaks up into some groups of agents, approximately constant in number, which can migrate along the plane.

Following the paper [36] and Fig. 4 (a, b), we can say that when a new idea arises, society does not perceive it equally, but can split into groups of those who perceive the new idea and those who do not.

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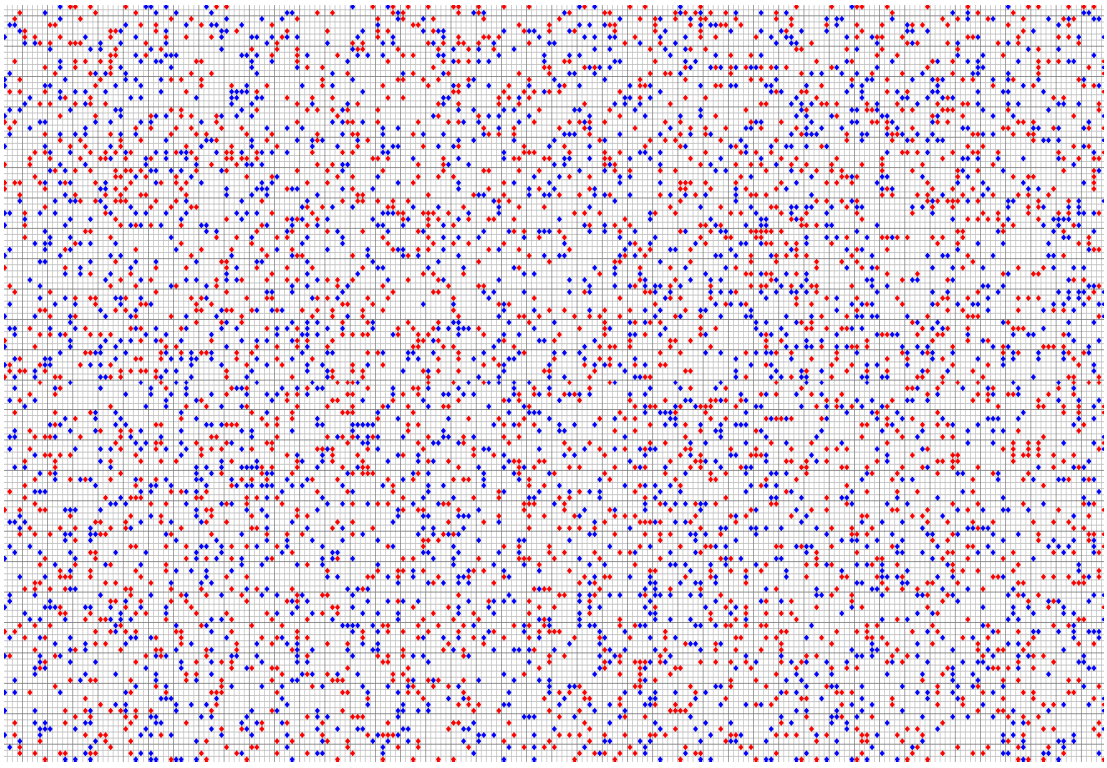
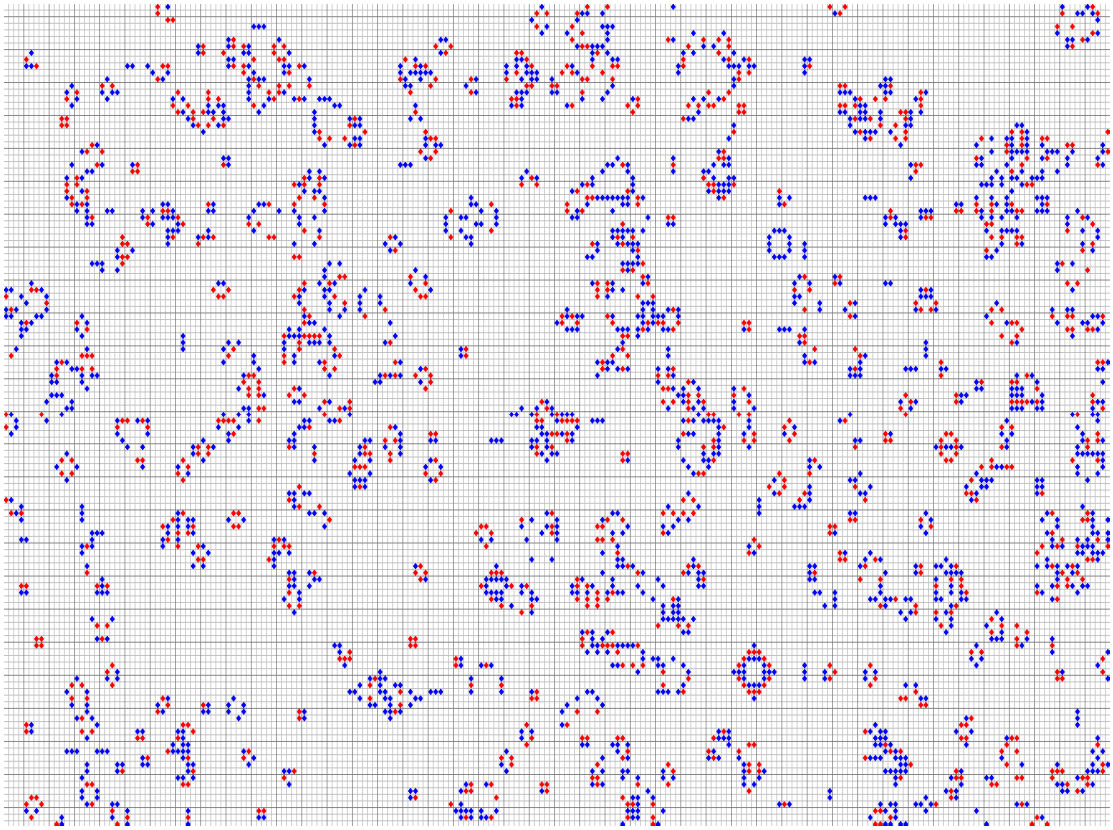


a



b

Figure 4: Results of numerical modeling on the plane

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In papers of A.Baronchelli [50], [51], F.Murzin [52] dedicated to information diffusion used the dictionary of innovations. But, the problem of dictionary optimization was not considered in these papers. However, such a problem has a very definite interest, especially in the case of a large dimension of the dictionary, such is real dictionary problems. Under this assumption, we discuss the mentioned problem. First of all, we endow the dictionary with a structure: we assume that the dictionary is divided into pages, the number of which is equal to $h>1$ and each page of the dictionary has its own length, i.e. the page number s has the length d_s, $s = 1,2, ..., h$. At the same time, the innovations of the dictionary can be moved across the pages of the dictionary subjecting to the following conditions: the total length of innovations located on one page of the dictionary does not exceed the page length. Each innovation is located only one page of the dictionary. Because the resource of any system, including the dictionary one, is limited, we assume that the dictionary memory is organized in the form of a two-level memory, the first level of which is the dictionary itself, the second level is its RAM, where the innovation is actually processed. We will not specify the detailed nature of innovations processing, we will only say that these can be some corrections, insertions, deletions, text replacements. The amount of RAM in the dictionary, at any moment of the computational process, is significantly less than the volume of the dictionary itself, where the innovations themselves are located (first-level memory). In our case, this volume is determined by the size of the working set at the current time of the computational process and we believe that a constant is known that limits the size of the resident set of dictionary pages at any time in the process. Thus, in our case, the strategy of exchanging pages between the dictionary and its RAM is the strategy of the working set P. Denning [53]. As the well-known strategy, working set strategy approximates the locality of the computational process, our goal is to optimize the structure of the dictionary and improve the locality of the process, reducing the number of page faults due to the redistribution of innovations over the pages of the dictionary. Thus, our problem is to find the distribution of innovations over the pages of the dictionary in order to minimize the quality functional. The functional is the average number of page faults calculated by $l \geq 1$ runs are often used as such kind of the functional. Known methods for solving related problems, such as the problem of program segmentation [54], the optimal network structure problem, etc., these methods include first of all, cluster, as well as graph and combinatorial-analytical approaches. By the way, the problem on relocating innovations of the dictionary, over pages of the dictionary, in order to minimize a cost functional is known *NP*-hard problem. That is why the problem above has a fundamental interest.

Note, cluster technique [55]-[58] and etc., which in spite of improvements in experiments, by functional gave anyway approximate solutions with unknown accuracy. That is to say the cluster approach does not estimate how the obtained solutions far or close to unknown exact (optimal) or the best solution of the initial problem. Success of such kind of researches depends on an appropriate choice of a similarity measures. One more approach also using cluster conception based on Zhuravlev's approach to classification [59]-[62] was proposed in [63] and connects with special algebra construction over cluster algorithms. Then the main problem is reduced to solvability of the special operator equation.

The special interest is the application for solving the dictionary problem by the neural network approach [59],[61]. Thus, the problem of optimizing the functioning of the dictionary innovations by the alteration of the dictionary structure via relocating over pages of the dictionary is an interesting problem as a discrete extreme problem.

4. DISCUSSIONS

The paper is devoted to the research of the problem of information dissemination and its impact on mass consciousness. In the context of research, it is an interesting problem of optimization two-level dictionary of innovations. We can notice related for the last mentioned problem is the problem of reorganization multiagents groups in order to prevent disease epidemic distribution under contacts among agents for both of the problems. It is possible to construct mathematical non-linear models including functional and constraints which are assigned acceptable solutions to the problems.

5. CONCLUSION

The main goal of this paper is to model various scenarios of the development of information dissemination in social communities. Interpersonal communication is often a key factor influencing the adoption of new information. Problems of modeling the processes of information dissemination in society is one of the urgent topics of modern innovative research in the field of IT. The models

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under research are especially useful for describing web-based applications.

The experiment revealed a significant relationship between the rate of acceptance of information by new members of the community and the frequency of contacts of people already interested in the information. Information dissemination models can correctly describe, for example, the dynamics of distribution and substitution of technologies, goods, the spread of new teaching methods, the dynamics of the level of criminal processes. Therefore, the study of this area is essential for predicting various scenarios and managing mass consciousness in order to promote goods and services in a competitive market environment. Also in modern conditions of complication of problems of ensuring the security of the state, society and each individual member of society, given the development of Internet technologies and social networks.

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