UDC 004.942:519.876.5

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**About hybrid diffusion models of information distribution processes**

*It is discussed a technique for constructing a model and a method for finding solutions in the problem of imitating the process of information dissemination based on the use of a boundary value problem for a differential equation in partial derivatives. It is proposed to use the analogy technique for modeling information dissemination processes. A method for constructing hybrid models is proposed.*

The tasks of analytical processing of modern information flows and their influence require solving the problems of studying the dynamics of information dissemination processes based on modeling and forecasting tools. The development of models and methods for modeling information processes makes it possible to effectively solve important problems of predicting the development of events in society. A constructive method for analyzing the dynamics of information dissemination processes can be proposed based on the use of a fundamentally new toolkit using the method of analogy and hybrid models, which allows adequately reflecting the state of the dynamic component of the disseminating information process [1-4].

We will model changes in the level (concentration) of information in a population with the help of the diffusion equation, assuming that this process is similar to the spread of a substance (infection) over a specific time period $t \in [0,T]$ and can be described by a scalar equation

$$\partial u / \partial t = -k(t) \partial^2 u / \partial x^2 , \tag{1}$$

with the initial condition $u(x,0) = 0$ , $0 \le x \le 1$ , and the boundary conditions $u(0,t) = u_0 \ge 0$ , $u(1,t) = 0$ , $t \in [0,T]$ , where $k(t)$ is the coefficient characterizing the rate of information penetration.

We believe that the contingent of the target population is formed of 3 subgroups based on the perception of information. We identify the part of the population that is sensitive to the influence of information $y_1(t)$ , the part which is already under the influence of information $y_2(t)$ and the part which is indifferent to information influence $y_3(t)$ . Then, using the Bailey model [1], the dissemination of appearance information

$$\dot{y}_1(t) = -y_1(t) y_2(t) , \quad \dot{y}_2(t) = y_1(t) y_2(t) - y_2(t) , \quad \dot{y}_3(t) = y_2(t) , \tag{2}$$

with the initial condition $y_1(0) = y_1^0 ; y_2(0) = y_2^0 ; \ y_3(0) = y_3^0$ , where $y_1(t)$ is the part of the population that is sensitive to the influence of information, $y_2(t)$ is the part which is already under the influence of information, $y_3(t)$ is the part which is indifferent to information influence, and cure and disease rates are considered to be 1, $y_1(t)+y_2(t)+\ y_3(t)$ =1, $t\geq 0$, there a system of differential equations that describes the process of information dissemination in the target population can be written. Their solutions determine the dynamics of the rate values of individual subgroups.

With such assumptions, the maximum threshold value of the part of the population that is affected by the information, $x_\Gamma$, $0\leq x_\Gamma(t)\leq 1$, will depend on the time, so we have $0\leq x\leq x_\Gamma(t)$, $x_\Gamma(t)=y_1(t)+y_2(t)$, where $y_1(t)$, $y_2(t)$ – are the components of the solution of system (2). In this case, the coefficient of information penetration $k(t)$ will be proportional to the rate of change of the part of the population that is considered to be susceptible to the influence of external information, i.e.

$$k(t)=\mu\dot{x}_\Gamma(t),\ \mu>0. \tag{3}$$

Given the cumulative nature of the information dissemination process in society, we will search for a partial solution of the diffusion equation (1) in the form

$$u(x,t)=\int_0^x X(\xi)d\xi+at, \tag{4}$$

where the parameter $a$ for the impact over time for each point in time $t$ is considered proportional to the rate of change of magnitude $x_\Gamma(t)$, i.e. $a=\alpha\dot{x}_\Gamma(t)$, $\alpha>0$.

The function $u(x,t)=\alpha\left( x/\mu\,(x_\Gamma(t)-x/2)+\dot{x}_\Gamma(t)t\right)\,(1-x_\Gamma(t))$ satisfies equation (1) and the initial and boundary conditions, which makes it possible to consider it as a general solution of the diffusion equation.

Similar results can be obtained in the study of the dynamics of propagation processes based on the use of hybrid models in the presence of external information impact on the process and, as noted above, by observing the quantitative composition of the target groups within which information is disseminated.

Simulation of changes in the level (concentration) of information within a target group within a specific time interval $t\in[0,T]$ taking into account the external sources or means of influence we will carry out by means of the inhomogeneous scalar diffusion equation

$$\partial u/\partial t=-k(t)\partial^2 u/\partial x^2+f(x,t) \tag{5}$$

with initial conditions $u(x,0)=0$, $0\leq x\leq 1$, and boundary conditions $u'_x(0,t)=g(t)$, $u'_x(x,t)=0$, $x_\Gamma(t)\leq x\leq 1$, $t\in[0,T]$, where $k(t)$ is the coefficient characterizing the rate of information penetration, which is proportional to the rate of change of a part of the population that is considered vulnerable to the influence of external information, i.e. $k(t)=\ \mu\dot{x}_\Gamma(t)$, $\mu>0$, and $f(x,t)$ - function which describes the influence of external sources of informational flow at time $t\in[0,T]$, $g(t)$ - the function determines the input rate of change of the information level, $0\leq x_\Gamma(t)\leq 1$ determines the proportion of a group that is or may be influenced by information at time $t\in[0,T]$

and the behavior of magnitude $x_{\Gamma}(t)$ is described by the system of equations (2).

It is clear that the formalization of external influence in the form of a function $f(x,t)$ requires many complex factors (for example, the influence of the media, rumors, the quality of information). To obtain models, it is necessary to take into account the level of information exchange within the group and to model the external influence in the form of some dynamic characteristic using analogies of physical processes.

## Conclusions

This paper proposes an approach to the construction of hybrid mathematical models of the dynamics of information processes propagation in the target population, taking into account and without taking into account the impact on the process of information dissemination by external sources and other means.

Formalization is based on the idea of using hybrid mathematical models, which consist of the diffusion (penetration) equation based on a differential equation in partial derivatives and dynamic models, that describe the processes of change in the size of the contingent of the information dissemination environment. A scalar solution for a one-dimensional representation of a group contingent is considered. Some cases of formalization of external influence on the process of information dissemination are considered.

Examples of numerical experiments to evaluate the level of impact based on the application of this approach are given, and their results are analyzed. The comparative analysis allows to confirm the existence of sufficient adequacy of model data and data obtained as a result of real observations of the processes of change in the perception of information within specific target population groups.

In our opinion, the proposed options for hybrid systems of the dynamics of the distribution of information levels based on the diffusion equation using special dynamic models are of certain interest and can be further refined taking into account new formal and informal relationships that use various ways of formalizing the external information influence.

## References

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