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ABOUT THE MODEL OF THE ACTIVE SYSTEM*

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The problem of the active system modeling is researched. There are three sources of information to construct the models. The first source is the theory of the problem, the second one is experts in the field of problem, and the third one is data bases. The method considered in this article uses the third way. The nonparametric algorithm for modeling active element in the system is proposed. The results of the computer experiments are published.

Keywords: active system, nonparametric model, identification.

О МОДЕЛИ АКТИВНОЙ СИСТЕМЫ

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Исследуется проблема моделирования активной системы. Рассматриваются три источника информации для конструирования моделей. Первый – теория задачи, второй – эксперты предметной области, третий – базы данных. Метод, рассматриваемый в статье, основан на третьем подходе. Предлагается непараметрический алгоритм для моделирования активного элемента в системе. Представлены результаты вычислительных экспериментов.

Ключевые слова: активная система, непараметрическая модель, идентификация.

In this article we talk about constructing model of active systems. These are such systems which includes people as elements of considered system. We could find such kind of problem in marketing, industrial and different other spheres of our life. Usually it's necessary to predict of competitor strategy. In this case we can't ignore manly factor and we should create some adequate model describing behavior of the competitor. It would be better if the model will be mathematical and can be realized as automated program.

There are many ways to model a man. One of them considers all possible scenarios and models strategies for all scenarios. The good example of such systems is chess machine program. On May 11, 1997 computer Deep Blue beat the world chess champion after a six-game match [1]. It was victory of artificial intelligent over human mind. But chess is a game without stochastic events, which is happened every day in producing spheres of life. Poker game is more close to real situations. And group scientists from University Alberta research this game and create artificial intelligent which could beat a real person [2]. But their results are not yet impressive [3]. The competitive games are a good start point for intelligent system.

Another way is expert method. Here the experts in the field of researched problem help to construct systems [4]. It's simple way to use knowledge of experts for creating strategy. For example, consultant psychologist can be engaged to solve a crime. Today scientists combine artificial intelligent systems and expert methods [5]. It's necessary if we want to use evaluating power of computers.

The first couple approaches use information from knowledge of problem theory and people who work with researched system a long time. The third source of information is digital data base. Almost every system has information which can be measured. These measures are collected and learn models. For example, in marketing the collected data are used to model relation of client to product [6]. In this article the method based on such way is used to solve problem of modeling at the point identification theory [7]. The problem is solved by the new scheme of system. But at the first let's consider the general problem of identification.

The general problem of identification. The identification theory has many problem tasks. In this article the control problem task is researched, when we need to form strategy of system control. At the point of identification theory we have inertialess process as researched system. This processes are more actual in spheres of the problem.

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It's connection with a fact that the measurements of the variables are mad through significant period of time. In particular it's happened when step of discretization is larger than stability time of process. Let's consider the typical identification task of [8], in which the process belongs to the class of static and corresponds to the following scheme.

On the fig. 1 A is operator describing the process, $x(t) \in R^1$ is output scalar variable, $u(t) \in R^n$ is input vector variable, $\xi(t)$ is random action, $h^u(t)$ and $h^x(t)$ are noises executing in the measuring lines, u_t and x_t are measurements of input and output variables at the moment t, Control is a block of control system, $x^*(t)$ is desirable output. Type and distribution of the random action $\xi(t)$ are unknown. The random action is centered random variables with limited variance. The distribution laws of the noises $h^u(t)$ and $h^x(t)$ are also unknown, centered and have limited variance. We also don't know the structure of the operator A, but we know that it has an active element.

Mathematically the process can be shown as the equation:

$$x(t) = A(u(t), \xi(t)). \quad (1)$$

The task is to construct the control:

$$u(t) = A^{-1}(x(t), \xi(t)). \quad (2)$$

There are two ways to solve this task: identification in "narrow" and "wide" senses. The first way is used when structure of operator A could be defined and opposite operator A^{-1} is exist. The parametric model will be used to solve this task:

$$\hat{u}(t) = B_\alpha(x(t), \alpha), \quad (3)$$

when B_α is a parametric operator, α is a set of parameters.

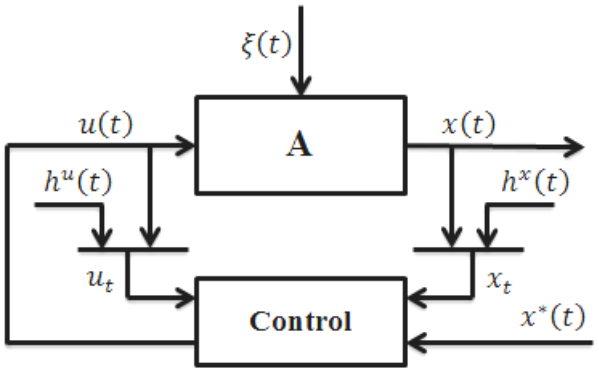

Fig. 1. Scheme of the process

The second way is used when structure of operator A couldn't be defined with necessary accuracy. The nonparametric model [9] will be used to solve this task:

$$u_s(t) = B_s(x(t), \vec{u}_s, \vec{x}_s), \quad (4)$$

where B_s is a nonparametric operator, $\vec{u}_s = (u_1, ..., u_s)$ and $\vec{x}_s = (x_1, ..., x_s)$ are time vectors.

The active element of the researched system could be considered like as an uncontrolled input variable of the process. But in this case we ignore the fact that it's active and has own strategy. Further the interesting scheme of active element modeling is proposed.

The control of active system. In our problem the active element is real person, competitor. Therefore the competitor tries to find the optimal strategy too. He can use some procedures for evaluating optimal own control. These procedures form certain rules and dependences into system. When we use the general models, such dependences stay unconsidered. The simplest way to consider the active element in the constructed model is to evaluate the optimal strategy for competitor. Then scheme of the process will be changed (measuring lines aren't shown).

On the fig. 2 Active Element is just block evaluating estimation $\mu_s(t)$ of the competitor strategy's variable $\mu(t) \in R^k$, $x_u^*(t)$ and $x_\mu^*(t)$ are our and competitor's desirable outputs. It should be differed estimation $\mu_s(t)$ and value of competitor's real choice $\mu(t)$. The block Active Element is a part of control system in our case.

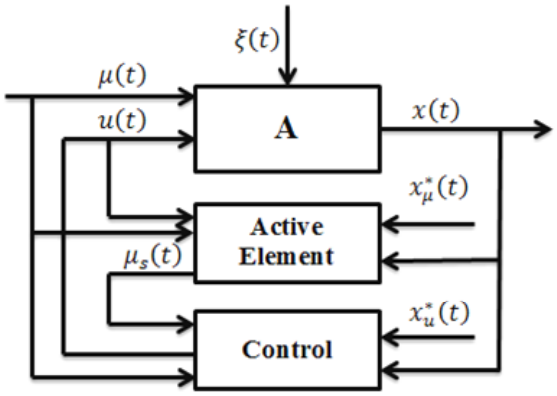

Fig. 2. Scheme of the active process

Let's imagine that we have samples x_i, u_i, μ_i, $i = 1, 2, ..., s$, when s is a volume of samples. At the first we need to estimate $\mu_s(t)$ for evaluating the control. For example, we could use nonparametric estimation of [10]:

$$\mu_s(t) = \frac{\sum_{i=1}^{s} \mu_i \Phi\left(\frac{x_i - x_\mu^*(t)}{c_s^x}\right) \prod_{j=1}^{n} \Phi\left(\frac{u_i^j - u^j(t)}{c_s^u}\right)}{\sum_{i=1}^{s} \Phi\left(\frac{x_i - x_\mu^*(t)}{c_s^x}\right) \prod_{j=1}^{n} \Phi\left(\frac{u_i^j - u^j(t)}{c_s^u}\right)}, \quad (5)$$

where $\Phi(\cdot)$ is kernel function and c_s are smooth parameters. The current value $u^j(t)$ is usually evaluated as the last value u_s^j or as mean of some the last values in marketing sphere.

Then it is necessary to estimate control. We could also nonparametric estimation:

$$u_s(t)=\frac{\sum_{i=1}^{s}u_i\Phi\left(\frac{x_i-x_u^*(t)}{c_s^x}\right)\prod_{j=1}^{k}\Phi\left(\frac{\mu_i^j-\mu_s(t)}{c_s^u}\right)}{\sum_{i=1}^{s}\Phi\left(\frac{x_i-x_u^*(t)}{c_s^x}\right)\prod_{j=1}^{k}\Phi\left(\frac{\mu_i^j-\mu_s(t)}{c_s^u}\right)}. \quad (6)$$

If the competitor actions not optimal or competitor's term of optimality is different, then we can consider previous values of all variables as input variables of blocks Active Element and Control. In other words, we try to estimate of competitor's behavior. Otherwise the researched process becomes inertial in this case.

The numeracy experiment. Let's consider a simple experiment, when $u(t)$ and $\mu(t)$ are scalar variables. The object is described equation:

$$x(t)=\sin(u(t))\cos(\mu(t)). \quad (7)$$

The desires outputs equal $x_u^*(t)=0.2$ and $x_\mu^*(t)=-0.2$. Controlling starts at the 10^{th} point, before control is random. The control for competitor is evaluated by formula:

$$\mu(t)=x_u^*(t)-\frac{1}{10}\sum_{i=1}^{10}u_{s-i}. \quad (8)$$

If we use ordinary control without considering active element, then we obtain:

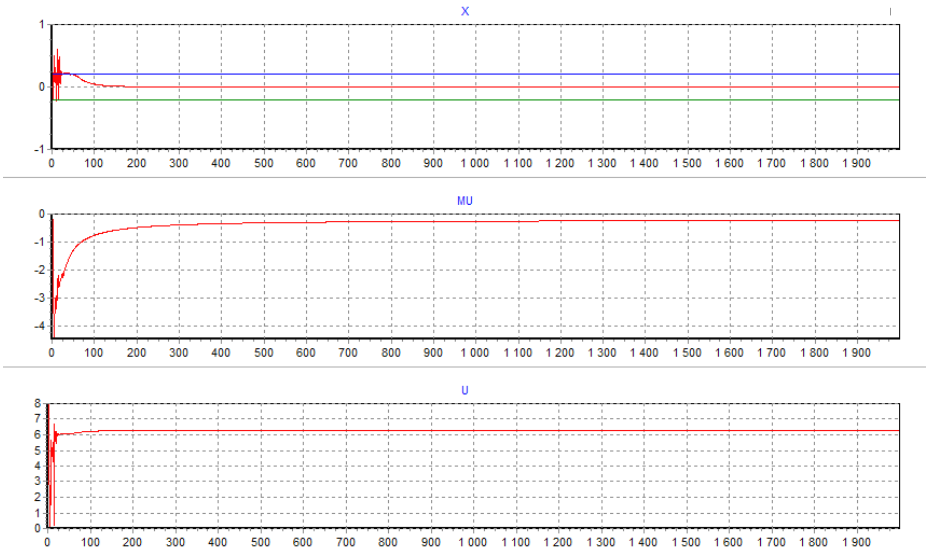

Fig. 3. Results of experiments without block Active Element

Otherwise we use the Active Element for constructing control system:

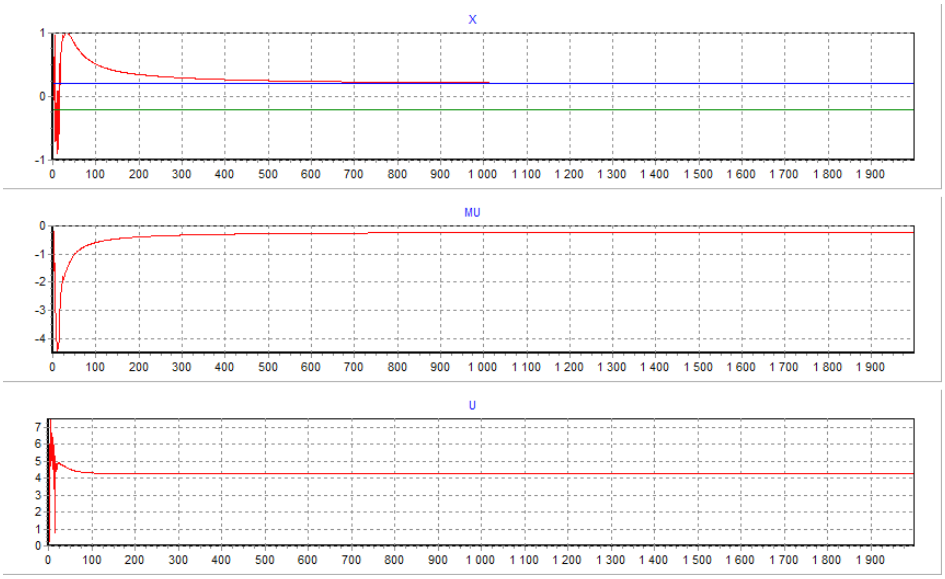

Fig. 4. Results of experiments with block Active Element

On the figures we can see, that two controls compare with each other. And when we consider, the active element out control system is stronger than competitor's control system.

Conclusion. The problem of active system modeling was researched. There are different approaches to model such systems. We used identification theory approach for solving the problem. According this approach it's necessary to construct control system and reach the desired value of output variable. The problem is difficult because of competitor. The competitor is another control system at the point identification theory. If we use ordinary way to construct control system the desired value isn't reached. The new scheme including the active element for constructing control system is proposed. It helps to predict behavior of competitor. The proposed approach works that desired value is reached.

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ПРИМЕНЕНИЕ АЛГОРИТМА SPACE COLONIZATION ПРИ ТРЕХМЕРНОМ МОДЕЛИРОВАНИИ СЛОЖНЫХ ПРИРОДНЫХ ОБЪЕКТОВ

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Для создания моделей лесной растительности используются особые методы и алгоритмы. Изучение процесса роста растений требует более мощных инструментов моделирования для того, чтобы описать и смоделировать различные процессы функционирования растений. В последнее десятилетие наиболее часто для решения подобных задач используется формализм L-систем. Основная идея L-систем (Линденмайер системы) – постоянная перезапись элементов строки, L-система оперирует со строкой символов по специальным правилам, начиная с первоначальной простой аксиомы, позволяя генерировать различные объекты с фрактальной структурой. Рассматривается адаптация L-систем и Space Colonization алгоритма на языке Python, популяр-