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ENERGY EFFICIENT CONTROL OF COMPLEX BIOTECH OF OBJECTS

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Abstract. Based on theories of random processes, games and the adoption of statistical solutions have been developed energy-efficient automation systems for a complex biotechnical object - a poultry house, where the use of intelligent algorithms is foreseen for the formation of management strategies. The application of such a system leads to a decrease of the energy component in the structure of the cost of products down to 13%.

The core of such a system is the knowledge base, the production rules of which allow to predict natural perturbations on the poultry house, and, using the payment matrix and the Hurwitz criterion, choose the best management strategy of the electrical engineering complex of the poultry, which maximizes the profit of production.

Key words*:* natural perturbation, automation, intellectual control system, payment matrix, Hurwitz criterion.

Introduction

Agricultural sector of Ukraine saturated complex biotechnological facilities where production technology requires significant energy costs.

Formulation of problem

These include poultry, greenhouse plants, enterprises producing mushroom products.

Since the conditions of use of traditional stabilization systems for automatic control of the production cost of poultry products power up to 20% for greenhouse complexes - 80%, and mushroom products - up to 50%.

It is clear that under the constant rise in the cost of energy media manufacturers interested in using energy efficient algorithms that enable a significant reduction in the fate of energy in the cost structure of production.

The solution to the abovementioned problem is possible by taking into account the results of prediction of natural disturbances and their compensation acting on the object.

Analysis of recent research results

For example poultry consider one of the embodiments of intelligent algorithms that are able to maximize profit, primarily by saving energy, using stochastic processes, games and statistical decisions. The structure of the system shown in Fig. 1.

Its characteristic feature is the presence of two levels of control:

- I-level – process, which is implemented for standard control criteria (eg, minimization linear Integrated Quality Score transition [4, 5]):

$$\int_0^{oo} ydt \Rightarrow min, \quad (1)$$

where: y – the output value of the regulated object; t – time.

Expression (1) minimizes power consumption for keeping the output value of control object at a given level of technology.

- II-level - production, for which is realized as profit maximization criterion:

$$P = I - C \Rightarrow max, \quad (2)$$

where: P – profit of production; I – income through sales of production; C – production costs, including at the expense of energy costs to maintain the necessary technological parameters.

The basis of the above system structure that implements the specified criteria control object is its knowledge base, which is constantly interacting with the database, forms the criteria according to the expressions 1, 2.

As mentioned, the knowledge base is implemented on the basis of the theory of random processes, since the poultry houses are natural disturbances that vary randomly by law (eg temperature). Such natural disturbances succeeded classified according to their individual images (classes), as shown in Fig. 2 [6].

Purpose of research

The aim of our work is creating energy efficient systems automate complex biotechnological facilities operation which is carried out through the use of intelligent algorithms.

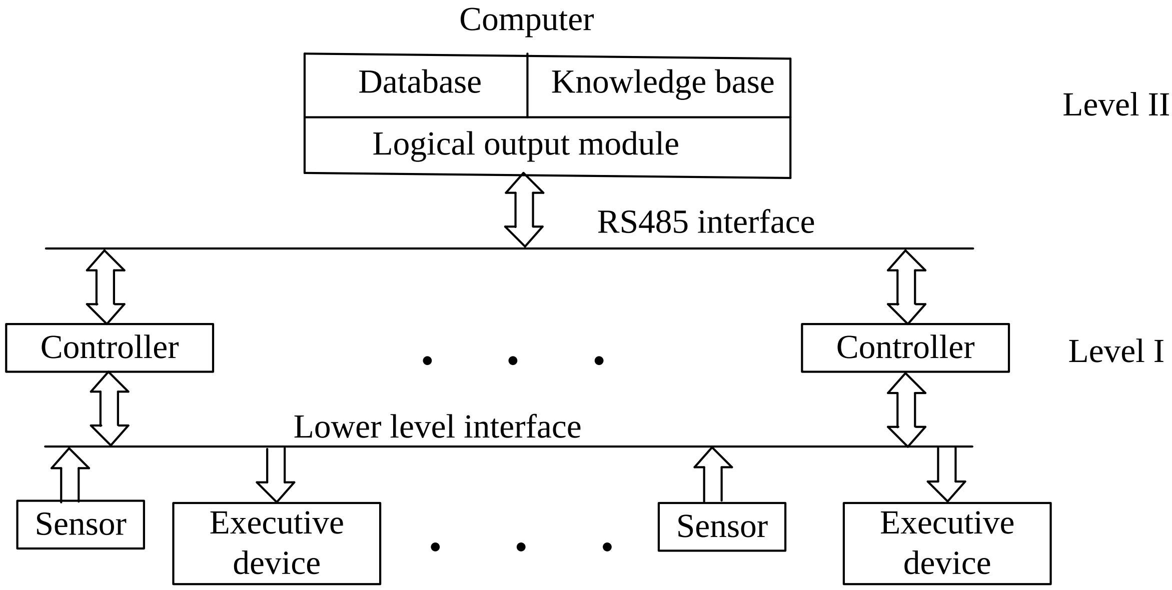

Fig. 1. Simplified diagram of energy saving system of production of poultry.

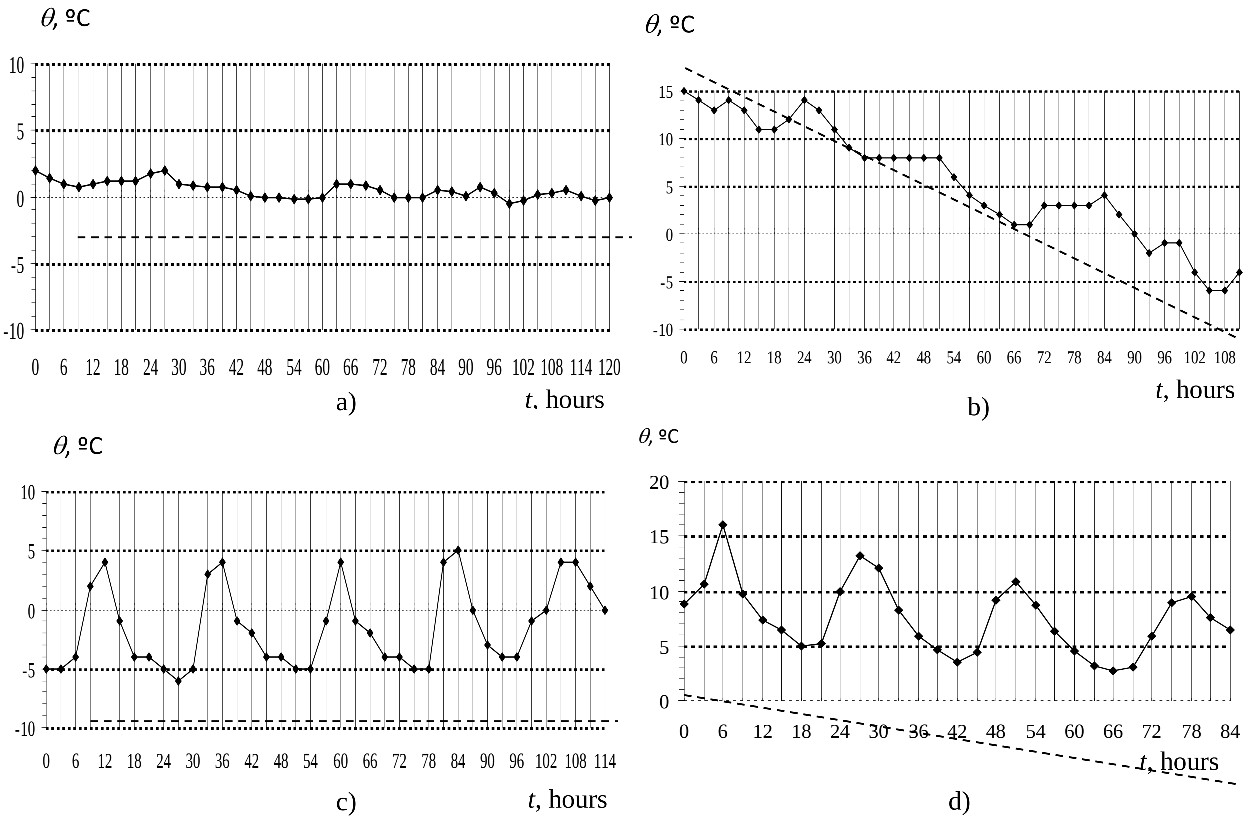

Fig. 2. Images (classes) of natural perturbations affecting poultry: a) - with stable mathematical expectations (class 1); b) - with variable mathematical expectations (class 2); c) - with a deterministic component with constant daily period and averaged amplitude of oscillations, constant mathematical expectations (class 3); d) - with variable mathematical expectations and periodic fluctuations (class 4).

Results of research

Mathematical models such images can be represented as:

$$\theta_i = u_i + W_i + S_i + \varepsilon_i, \qquad (3)$$

where: ε_i – the random component is characterized by correlation functions of gray and pink noises $R(\tau) = D \cdot e^{-\alpha|\tau|}$ and $R(\tau) = D \cdot e^{-\alpha|\tau|} cos(\beta\tau)$ in accordance; cyclic frequency of oscillations $\omega = \frac{2\pi}{T}$, where the period of oscillation is always a day – 24 hours; u_i – trend; W_i – regular fluctuations; S_i – periodic fluctuations.

o predict natural disturbances developed methods of reproduction. For this purpose, used the method of forming the filters, which use stochastic Ito equation [7, 8]:

$$\frac{dX(t)}{dt} + \alpha X(t) = A \cdot V(t)$$

and

$$\frac{d^2X(t)}{dt^2} + \beta\frac{dX(t)}{dt} + \gamma X(t) = , \\ = B\left[\frac{dV(t)}{dt} + \xi V(t)\right] \quad (4)$$

where: $X(t)$ – stationary random process with zero mathematical expectation; $V(t)$ – white noise with single intensity; α, β, γ, ξ, A, B – steel coefficients, which are determined from the statistical characteristics of the classes of images.

Specified possible to determine the transfer function shaping filter:

$$W_\theta(s) = \frac{\sqrt{\frac{D\alpha}{\pi(\alpha^2+\beta^2)}}\left(\frac{1}{\sqrt{\alpha^2+\beta^2}}s+1\right)}{\frac{1}{\alpha^2+\beta^2}s^2 + \frac{2\alpha}{\alpha^2+\beta^2}s+1}, \quad (5)$$

where: α, β, D – statistical characteristics of the corresponding class of natural perturbation.

Playing images of natural disturbances conducted using software environment MATLAB. Structural diagram of playback implementations temperature perturbation characteristics of stationary and quasi-stationary areas shown in Fig. 3, and sample playback changes in air temperature, which is the realization of a random process with regular oscillatory component – Fig. 4.

The system is based on the analysis of natural disturbances and the biological component states predicted natural perturbations and forms the basis for this management strategy, using game theory (nature) and statistical solutions.

The game describes the nature of the payment matrix is shown in Fig. 5.

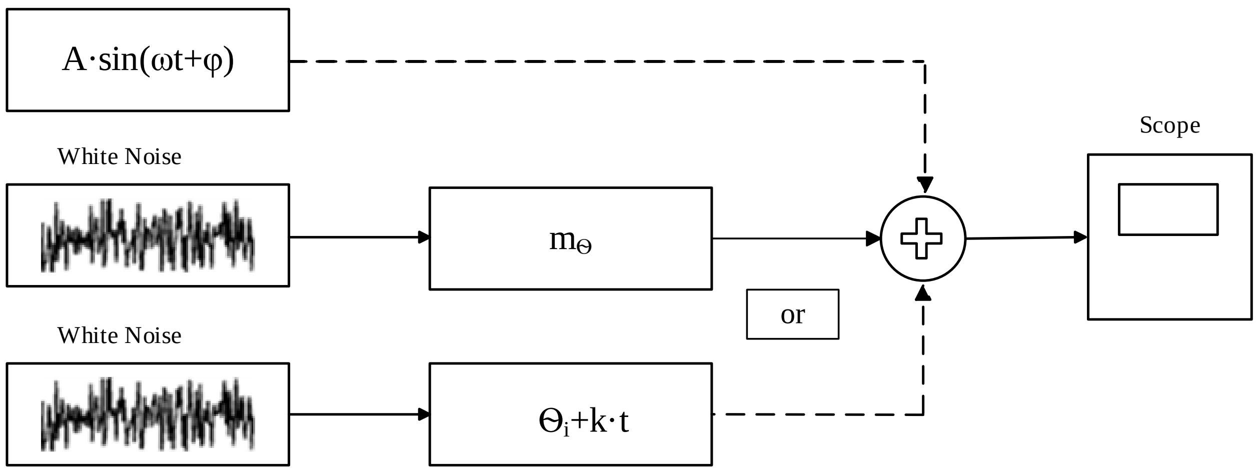

Fig. 3. Structural scheme for reproduction of possible realizations of natural temperature disturbances.

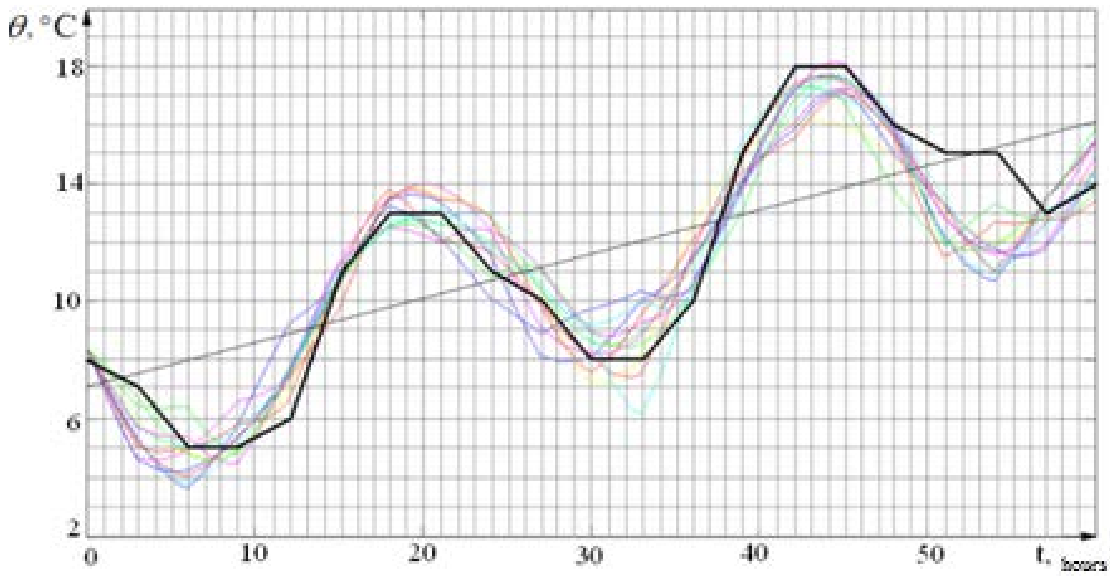

Fig. 4. An example is the reproduction of temperature changes for the image of the 4th class of perturbations.

A_i	N_j			
	N_1	N_2	…	N_n
A_1	a_{11}	a_{12}	…	a_{1n}
A_2	a_{21}	a_{22}	…	a_{2n}
…	…	…	…	…
A_m	a_{m1}	a_{m2}	…	a_{mn}

Fig. 5. Payment matrix of the game with nature (for the subsystem of the adoption of management strategies).

In this game lines A_i – system management strategies, and column N_j – nature strategies (possible implementation of changes in air temperature). Items of payment matrix a_{ij} – profit from the production of eggs, which can be obtained by applying A_i control strategies while implementing the strategy of nature N_j. In the present system of value a_{ij} defined by the expression:

$$a_{ij} = C_{ce} \cdot N - (C_f \cdot M + C_e \cdot E), \quad (6)$$

where: C_{ce}, C_f and C_e – the cost of chicken eggs, feed units and 1 kWh respectively; N – the number of eggs dropped during the development of the strategy of nature N_j; M – the amount of feed consumed by all chickens in this poultry house during the same period; E – quantity kWh electricity consumed during the development of a management strategy A_i.

Items of payment matrix game with nature are based on cost of production, energy, concentrated feed and biological features component (egg production and feed intake).

For class predicted natural perturbations of some statistical characteristics are reproduced using the method of forming filter 10 implementations, of which 3 are selected, taken by the strategy of nature. To compensate for natural strategies used 5 management strategies.

Optimal management strategy carried out by analyzing payment matrix using Hurwitz criterion. It gives a weighted average profit with little risk, based on the conditions [6]:

$$Hu = \max_{i}(\chi \max_{j} a_{ij} + (1-\chi)\min_{j} a_{ij}), \quad (7)$$

where χ – the optimism coefficient, which can reach values from 0 to 1.

When χ = 0 this criterion degenerates into extreme pessimism Wald criterion (the precautionary principle and reinsurance), and at χ = 1 – first criterion maksymaksnyy absolute optimist. Quite high precision forecasting and reproducing images of temperature perturbations (natural strategies) even the first stage of the recognition algorithm and found a significant ability of birds to adapt to the environment, gives grounds for optimism grant ratio values greater than 0.5, that is confidently rely on the favorable outcome of the decision. The proposed control system adopted value χ = 0,75. The effectiveness of such a decision confirmed by experimental research management system in a production environment. Increasing factor to 0.8 and reduced to a value less than 0,

The proposed control system has reduced energy component in the cost structure of poultry products by 10 - 13%.

Conclusions

1. Typical stabilization algorithms of management strategies biotech facilities in terms of expensive energy becomes ineffective.
2. Natural disturbances can be classified as relevant images (classes) that represent a combination of deterministic and random components.
3. Playing images of natural disturbances carried out on the basis of shaping filter, which allows to predict these natural disturbances.
4. Using game theory (game with nature) allowed to build a matrix of payment and determine Hurwitz criterion based on the best strategy for the control object.

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ЕНЕРГОЕФЕКТИВНІ СИСТЕМИ КЕРУВАННЯ СКЛАДНИМИ БІОТЕХНІЧНИМИ ОБ’ЄКТАМИ

В. П. Лисенко, В. М. Решетюк, К. В. Наконечна

Анотація. На основі теорій випадкових процесів, ігор та прийняття статистичних рішень розроблена енергоефективна системи автоматизації для складного біотехнічного об’єкта – пташника, де для формування стратегій керування передбачено використання інтелектуальних алгоритмів. Застосування такої системи призводить до зменшення енергетичної складової в структурі собівартості виробленої продукції до 13% [1, 2, 3].

Основу такої системи складає база знань, продукційні правила котрої дозволяють прогнозувати природні збурення на пташник та, використовуючи платіжну матрицю та критерій Гурвіца, вибирати найкращу стратегію керування електротехнічним комплексом пташника, що максимізує прибуток виробництва.

Ключові слова: природні збурення, автоматизація, інтелектуальна система керування, платіжна матриця, критерій Гурвіца.

ЭНЕРГОЭФФЕКТИВНЫЕ СИСТЕМЫ УПРАВЛЕНИЯ СЛОЖНЫМИ БИОТЕХНИЧЕСКИМИ ОБЪЕКТАМИ

В. Ф. Лысенко, В. М. Решетюк, К. В. Наконечная

Аннотация. На основе теорий случайных процессов, игр и принятия статистических решений разработана энергоэффективная системы автоматизации для сложного биотехнического объекта – птичника, где для формирования стратегий управления предусмотрено использование интеллектуальных алгоритмов. Применение такой системы приводит к уменьшению энергетической составляющей в структуре себестоимости производимой продукции до 13%.

Основу такой системы составляет база знаний, продукционные правила которой позволяют прогнозировать природные возмущения на птичник и, используя платежную матрицу и критерий Гурвица, выбирать наилучшую стратегию управления электротехническим комплексом птичника, максимизирующий прибыль производства.

Ключевые слова: природные возмущения, автоматизация, интеллектуальная система управления, платежная матрица, критерий Гурвица.