

## Simulation of automatized system of radiation monitoring

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### Summary

In this paper for simulation of the automated system of radiation monitoring of the environment the concept of constructing measurement tools using mathematical apparatus of Markov chains was offered. This concept is implemented as a software package for PC. Using the modeling program package, a virtual system of measuring complex devices gamma-radiation, converting the signal transmission and reception of signals was constructed. A software package for remote control of an automatized system of radiation monitoring "ECOMON" was compiled. The software package is implemented in the programming language Delphi v.5.0 for personal computer type IBM PENTIUM.

### Introduction

In carrying out environmental monitoring by application "ECOMON" set [1,2,3], for data collection and processing, there is a need information exchange with external devices, visualization, mathematical processing and documentation of data. To achieve this goal, the priority is to use a PC as a measurement and the creation of complex software for data collection and processing of measurements and tests, which is a natural part of systems designed for measuring, testing and control. In other words, there is a need to simulate a virtual complex.

Let us consider the operation of the EKOMON set as a complex system, using the mathematical apparatus of Markov chains [5]. Let there be some physical system  $S$ , which may take a variety of state of  $S_i$ . If the state of the system changes over time randomly, the sequence of states can be considered as a random process. In our case, we choose an ecosystem as a physical system.

Let us consider the set aspects of the individual forecasting of ecosystem. Enter the following restrictions:

1. Region of environmentally acceptable states of ecosystem is divided on some finite number of states with successively decreasing, but acceptable values of the objective function. Moreover, each state corresponds to some of the environmental safety of  $P_e$  of component subsystems and elements of the set  $J$  (of controlled parameters  $e_j$ ) is set in the relevant on each of  $P_e$  so that defining the lower  $P_e$  the state has the smaller number of the element  $J \{0, 1, 2, \dots, k\}$  (here: "0" has means  $P_e = 0$ , while the other numbers- $P_e \neq 0$ ).
2. Ecosystem is observed in discrete instants of time  $n_i = 0, 1, 2, \dots, n$  with interval  $\Delta t$ . The result of control is to define  $e_j\{t_j\}$  and prediction of time of its possible move to the state  $P_e = 0$ .

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3. The sequence of states  $\{e_n\}$  in instants of time  $n_i = 1, 2, \dots, n$  is a simple Markov chain with initial distribution

$$F_0(i) = P\{e_0 = i\}, i \in J_{(1)} \quad (1)$$

And matrixes of transition probabilities

$$\left. \begin{aligned} P_0 &= \left\| P_{ij}(0) \right\| \\ P_1 &= \left\| P_{ij}(1) \right\| \\ P_2 &= \left\| P_{ij}(2) \right\| \end{aligned} \right\} \quad (2)$$

For all matrixes there are next conditions:

- $P_{ij0}^{(n)} > 0, \forall i \in I$  and some  $n$ , where  $P_{ij0}^{(n)}$  is a probability of move of ecosystem object from state “ $i$ ” to state “ $0$ ” in  $n$  instants of observations (environmental control), i.e. the system (independently from the state) reaches  $P_e = 0$ ;
- $P_{\infty} = 1$ , i.e. the system independently cannot get out of state  $P_e = 0$ ;
- $P_{ij} = 0, i \dots k$ , i.e. the system cannot move from state “ $i$ ” to state “ $j$ ” (if  $j > i$ ), and level  $P_e$  cannot increase with the lapse of time;
- time interval  $\Delta t$  between transitions from one state to another is follow exponential law distribution with parameter  $\lambda(n)$  which takes on a fixed value in each time of observation  $n$ . In this case  $\lambda(n)$  is the intensity of the transition from one state to another, which is the probability density of transition anthropogenic processes of development of the natural-technical geosystem (NTG). By its physical meaning  $\lambda(n)$  is closed to the intensity of the transition  $e_i (P_e \neq 0) \rightarrow e_j (P_e = 0)$ .

With the known initial probability distribution of the state of  $F_0(i)$  and transition matrixes state of NTG at time  $n$ , is described by the state vector  $R_{mt}(n_i)$ , i.e.

$$R_{mt}(n_i) = F_0(i) \prod_{kt=0}^n \|P_{ij}(k_i)\| \quad (3)$$

Here:  $F_0(i) = [P_0, P_1 \dots P_k]$  is the initial probability that system is a state “ $i$ ”;  $\|P_{ij}(k_i)\|$  is the transition matrix at time  $k_i$ .

Elements of the transition matrix can be determined taking into account the adopted restrictions by the formula

$$P_{ij}(n_i) = \begin{cases} 0, & i < j \\ \exp(-i\lambda(n_i)\Delta t), & i = j \\ C_i^{i-j} \exp((-i\lambda(n_i)\Delta t)[1 - \exp(-i\lambda(n_i)\Delta t)]^{i-j}, & i > j \end{cases} \quad (4)$$

However, when the individual prediction the intensity of the transition is still unknown in (3). On the basis of statistical data about the objective function ( $P_e$ ) of ecosystem can be assessed only its mathematical expectation  $M[\lambda(n_i)]$ . Therefore, for the individual prediction of ecosystem state it is offer to correct the vector  $R_E$  of probabilities of the state on the observed state space. This state space is set of somehow transformed controlled parameters  $k$  in univariate function reflecting the dynamics of measuring the state of the system at time  $n_i = 0, 1, 2, \dots, n$ .

In this case, the Markov chain with transition probabilities defined by formula (4) is modeled.

On default the chain has  $N_p = 15$  states enumerated the numbers  $0, \dots, 14$ , set the parameters  $DT = 0,2$ ,  $LAM = 0,2$  and a uniform initial distribution.

All these values are shown in the dialog window immediately after the start of the program. After set of all these variables, you can follow the evolution of the Markov chain in discrete moments of time  $N = 0, 1, 2, \dots$ , pressing any key. These transition probabilities result in the evolution of the chain to increase the probability of zero state (the state of the most ecological risk) to 1 and decreasing to 0 with the probabilities of other states.

### **Automatized system of radiation monitoring**

For the proposed automatized system of radiation monitoring ECOMON, we used the concept of construction of the measuring tools - virtual devices. Virtual device is a board, installed in computer (in the slot ISA or PCI) or external device connected via some port (in this case parallel) together with appropriate software. Depending on your card and software, the user receives a measurement device for a given task. We use the PC interface module with the mobile device standard GSM [6,7].

The block-diagram of the algorithm of ECOMON is presented in Figure 1. For development of this algorithm, we used the method of iterative design based on the use of RAD-tools and systems for automatically generating source code based on the established formal model [8.] Later, in the following iterations (2÷5), the program is detailed step-by-step that led to the realization of specific features.

Software of ECOMON has the following objectives:

- providing of accepting and communications of data and commands via a cellular communications;
- Initial processing of measurement data, including conversion of signals to physical values and averaging;
- Write data to disk for long-term storage;
- Receiving commands from the operator and display data on the screen during the system operation and for metrological verification and certification.

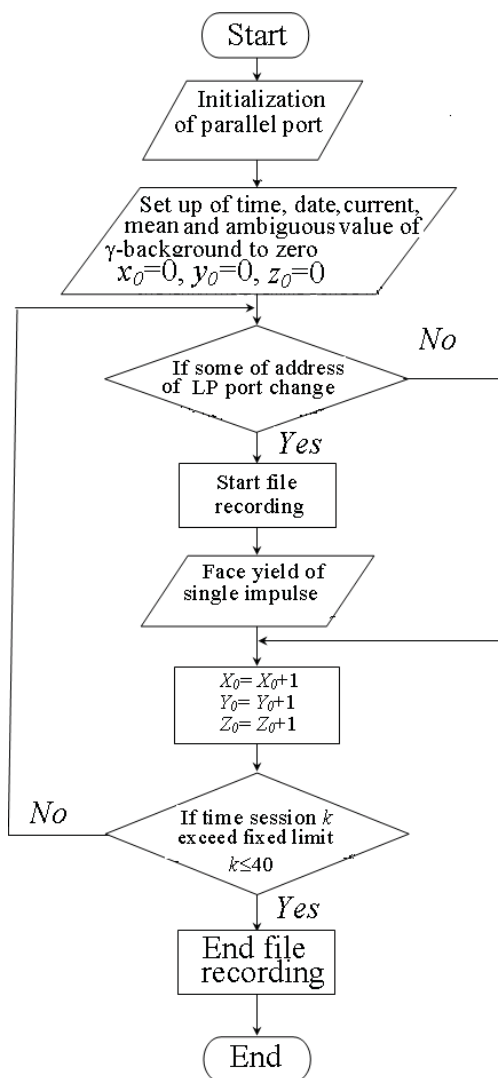


Figure 1: The block-diagram of the algorithm of ECOMON.

To solve these problems a software package of ECOMON was developed [9]. The program is written in the programming language Delphi v.5.0. The data in the program enter through the module interface to the parallel LPT-port. A programming language Assembler is used for data reading from port.

The ECOMON software runs under WINDOWS 95/98/ME operating system. It is designed to record data to the system via a hardware interface (board conjugation), the display of recorded data in graphical and tabular format, the recording of

the data in a common database. According to results a map of the natural radiation background certain areas is compiled. In the program, the number of pulses entering in the LPT-port is measured for a period of time (40 seconds) and the calculated natural background radiation, which is immediately written in a text file.

The program is divided into several parts:

- Main menu;
- The panel for the temporary output of a chart or table of values, which depends on the selected mode;
- The panel for the visual control (increase, decrease) the appearance of charts in real time;
- Additional panel, which shows the period of the information pulses, the number of pulses per period, as well as the mode of measurement program (background radiation).

This software is proposed to use in the future as the program of automatized environmental monitoring system, for analyze, forecast the spread of pollution, taking into account the actual meteorological parameters.

### **Conclusion**

In this paper for simulation of the automatized system of radiation monitoring of the environment the concept of constructing measurement tools using mathematical apparatus of Markov chains was offered. This concept is implemented as a software package for PC. Using the modeling program package, a virtual system of measuring complex devices gamma-radiation, converting the signal transmission and reception of signals was constructed. A software package for remote control of an automated system of radiation monitoring "ECOMON" was compiled. The software package is implemented in the programming language Delphi v.5.0 for personal computer type IBM PENTIUM.

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