Model of System Recovery in Periodic Disaster and Reproduction

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***Abstract*-The systems of the type of "man-machine-environment" to the protection of natural and man-made disasters with different types of intensity as a classical simple flow, and with unstable source. The process of liquidation of the accident in all models takes place in several stages, with different intensities, and the possibility of multiple repetitions of steps in the case of "multi-disaster."**

The numerical and experimental results revealed that for the time dependence of the probability of states allow you to determine the time of the establishment of the dynamic processes in the HMS system with non-stationary flows of accidents and demonstrate the validity of estimation averaged probabilities of states for medium intensity events.

I. Introduction

Over the past ten years, the system of the "Man - Machine - Environment" (PHI), often referred to as "ergotis", stood out in a special class of human-machine systems (HMS), which includes some important system of economy, ecology, military affairs and life safety. These elements are always included in the majority of cybernetic systems, but considered only in terms of automated control, with a limited range of research methods, such as queuing theory and reliabilities [1]. The most relevant of the HMS system is the protection and restoration of health as a result of actions of the operator [2]. They constitute a separate class of systems in most cases have the Markov property, but cannot be fully described using SMO techniques (in the absence of such a concept as "all") or theory of reliability (no concept of "reserve") [3]. The problem, therefore, is relevant to the theoretical and practical points of view [4].

II. Problem statement and analysis of the literature

A closed-type system "man-machine- environment" in which there is, perhaps, the source of transient events affecting the operation of the subsystem "machine" and health subsystem "man", whose task is this an accident or a catastrophe, to eliminate [5]. Use an approach that can be likened to the approach of thermodynamics, namely - we want to describe the behavior of complex systems using macroscopic observables [6]. The method to achieve this goal will serve the principle of maximum information entropy, developed in general Jaynes [7]. The difficulty of the problem of generalization of the principle of the system far from thermal equilibrium and non-physical system lies precisely in an adequate choice of restrictions. [8]

The base model for the entire system with Markov property [9] and, possibly, the events of varying intensity [10] "people--machine environment" used. The productivity of this approach is confirmed by the fact that the formula for the Erlang-type variable service time in the QS proven and already used half a century [9].

In our University (UOT) our researchers try hard to investigate in most/all branches of science [11-36] and hence the purpose of this research was to determine the likelihood of conditions and characteristics of the HMS system protection subsystem as a whole.

To achieve this, the following problems are solved:

- Study the dynamics of stable equilibrium systems with protection and transient in them [37].
- Conducting numerical experiments for the state probabilities in different structures HMS-systems [38].

Methods of research include the theory of Markov chains with discrete state space and continuous time, Kolmogorov solution of differential equations and algebraic systems to limit the probability and numerical analysis.

III. Static model

Consider a team of professionals, which eliminate some damage in the subsystem "Machine" in n stages (drawing without loss of generality, let n = 3).

The system in this setting is completely static and discrete circuit, both in the states, and on time.

$$Z = \sum_i C_i P_i$$

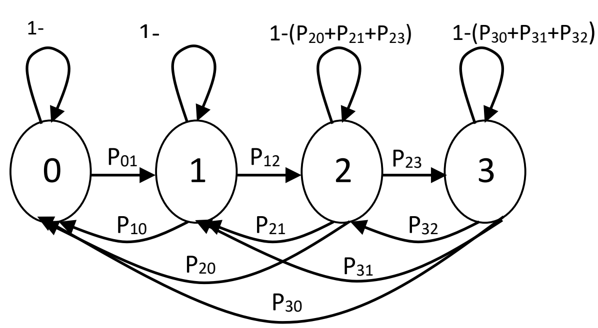

Fig. 1 Graph diagram of a system state recovery in three stages.

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Transition probability matrix of this system is given in [16]. The probabilities P01 and the likelihood of "reverse" transition P_{32}, P_{31}, P_{21} (See Fig.1) are observable variables, and determine the frequency and capacity of the accident and all the rest - manageable.

As follows from the ergodic theory of Markov chains transition matrix for such HMC in k steps - P_k is - converges rapidly, particularly suitable for practical purposes an accuracy of 1% - when k <10 (according to the results of numerical sweep for 10 real systems). In the limit - it is a stochastic matrix with identical rows.

Limit state probabilities determine the normalized average time spent in a given state, and hence the cost (loss) from the accident and its elimination as a whole, as the expectation. If the control parameters transition probabilities are given as to the protection of the cost function, then naturally arises the problem of optimizing the overall average losses as a result of the accident at the given C_i - specific cost conditions:

This problem of minimizing costs is linear in the unknown probability of the state, but they are not independent variables. Their dependence on the controlled variables - transition probability matrix P is polynomials k-th degree. Function and limitations is not convex. Numerical methods are able to find several local minima.

Another object of optimization is not based on cost-Trial, and internal features of the HMS system, proposed in [18]. It uses the entropy approach [7, 8]:

$$S_i = -\sum P_i \ln P_i \to \max \qquad \sum P_i = 1, \quad 0 < P_i < 1 \qquad (1)$$

S_I function is separable convex upward in each variable, which means that a maximum of only convex domain.

Obtained in [18] for the result of entropy and probability of health conditions of the operator, eliminate the accident: {1.02, {$p_1 \cong 0.51$, $p_2 \cong 0.31$, $p_3 \cong 0.18$}}, at least does not contradict common sense. However, because not closed subsystem "man", the validity of the application of the principle of maximum entropy here cannot be strictly proved [19].

In this case, the system is closed, but the complex relationship of P (p_{ij}) makes the task much extreme.

III. Model HMS system with variable intensity of accidents

Here the model of [16] the cases Poisson streams for accidents, events with variable intensity λ (t) of two types: with a limit as $t \to \infty$ and periodic.

Based on the Floquet-Lyapunov theorem, it shows that in most major non-autonomous systems of Kolmogorov average state probability $\frac{1}{T}\int_0^T P_i(t)dt$ can be obtained with sufficient accuracy from the formulas of stationary probabilities for the averaged intensities $\lambda_0 = \frac{1}{T}\int_0^T \lambda(t)dt$. Example results are summarized in the following table:

TABLE 1

$\lambda(t)$	$\bar{\lambda}$	P_0	P_1	P_2	P_3
0.5+0.1Sin(t)	0.514	0.0267	0.135	0.277	0.563
0.5+0.5Sin(t)	0.572	0.021	0.121	0.27	0.588
$\lambda_0 + \sin^2(t)$	0.519	0.026	0.134	0.276	0.565

V. Rationing of health state of the subsystem "Man"

Next, consider the concept of physiological norms for the various parameters of the living organism. It is necessary to construct a restriction entropy maximization problem, which is the right side of the present standards. Some of them, such as the normal body temperature, are conventional. Others, such as normal blood parameters may vary depending on the viewpoint of physiologists and medical professionals. Single point of view on this issue is not, and moreover, the result depends on the normalization parameter vector. Of course there is the problem of choosing a suitable norm of the vector that does not contradict the traditions of physiologists. For the definition of the word "norm" in the physiological sense, will be quoted, as opposed to the word for a mathematical vector norm.

Consider a set of parameters of human blood, the liquidator of the accident. They are characterized by the vector of the blood parameters. It is necessary to highlight the "center" of the cluster and to evaluate the radius of the plurality of sets of the liquidators, in a state of physiological "norm".

This is set in a variety of animal physiology called "natural resistance". For its evaluation, the following norms of the vectors: Euclidean, Computer experiment was carried out by mathematical programming packages Mathematica and Statistica.

To achieve this goal following tasks:

a) The normalized vectors from the formula parameters

$$\alpha^0_{i,j} = \frac{\alpha_{i,j} - \mu_j}{\sigma_j} \qquad (2)$$

Where i - number of the liquidator,

j - number of the parameter

μ_j - The expectation of the j-th parameter

σ_j - The standard deviation of the j-th parameter;

b) found a statistical distribution of each parameter;

c) revealed the degree of correlation;

d) built steam regression equation;

e) the distribution of animals found radii for different metrics in the feature space by the formulas:

$$r_i = \sum_j |\alpha_{i,j} - \mu_j| \quad r_i^0 = \sum_j |\alpha_{i,j}{}^0| \tag{3}$$

$$r_i = \max_j |\alpha_{i,j} - \mu_j| \quad r_i^0 = \max_j |\alpha_{i,j}{}^0| \tag{4}$$

as well as the above metrics;

f) given the choice physiological "normal" boundaries, consider:

1) range has a standard deviations distribution r;

2) has a radius $k \cdot \sigma$ for different k;

g) Compare the results by the number of "normal" individuals in the feature space, depending on the selected metric.

TABLE 2

RESULTS OF CALCULATIONS ACCORDING TO THE EQ. (3)

	1 Var1	2 Var2	3 Var3	4 Var4	5 Var5	6 Var6	7 Var7	8 Var8	9 Var9	10 Var10
1	36,270703									
2	56,224346									
3	41,021936									
4	39,928214									
5	37,398128									
6	41,816706									
7	50,097241									
8	42,689438									
9	30,169820									
10	30,966717									
11	37,280228									
12	122,273049									
13	55,388808									
14	54,080950									
15	52,530140									
16	60,086358									
17	60,839719									
18	27,383328									
19	30,640331									
20	75,236714									
21	34,037536									
22	37,072539									
23	36,648829									
24	98,221813									
25	75,260738									
26	40,323639									
27	43,061914									
28	47,180808									
29	42,675406									
30	38,463898									
31	47,980202									
32	53,083403									
33	32,540371									
34	43,314632									
35	49,277979									
36	27,796479									
37	60,334808									
38	40,334804									

These results build distribution:

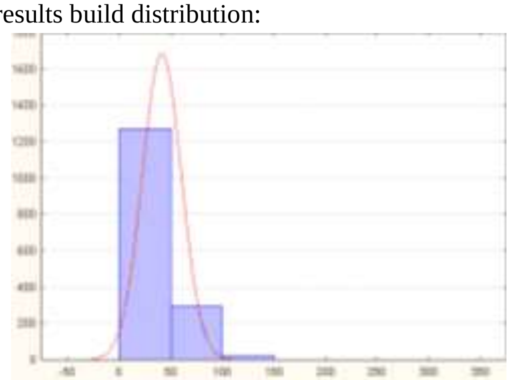

Fig. 1- Distribution of the radius by the Eq. (3)

TABLE 2

RESULTS OF CALCULATIONS ACCORDING TO THE EQ. (4)

	1 Var1	2 Var2	3 Var3	4 Var4	5 Var5	6 Var6	7 Var7	8 Var8	9 Var9	10 Var10
1	0,25									
2	0,5									
3	0,25									
4	0,25									
5	0,25									
6	0,25									
7	0,25									
8	0,25									
9	0,25									
10	0,25									
11	0,25									
12	0,5									
13	0,25									
14	0,25									
15	0,25									
16	0,5									
17	0,5									
18	0,25									
19	0,25									
20	0,5									
21	0,25									
22	0,25									
23	0,5									
24	0,25									
25	0,5									

These results build distribution:

After analyzing the results, found that there are parameters strongly correlated with each other, there is little correlated, there are not correlated with each other. This confirms the need to normalize the vector, rather than each parameter individually.

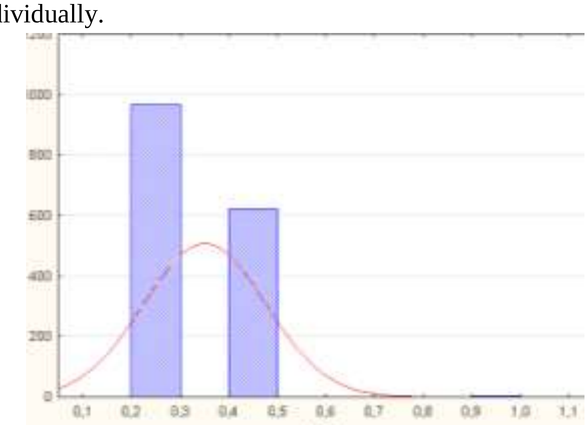

Fig. 2- Distribution of the radius by the Eq (4)

Calculating the fashion for the values obtained by the formula (3), we get that the scope of the "norm" included 12.48% of the sample. Similarly, calculating fashion to the values obtained by the formula (4), we find that the sphere became 60.66% of the sample.

Calculate the value of the radius as the mathematical expectation M[r] to the values obtained by the formula (3). We find that it is under the value of the radius gets 61.1% of the sample.

Calculate the value of the radius of the sphere as a M[r] to the values obtained by the formula (4). Divide the number of values obtained range of 50 values and calculate the expectation in each sample. Under this "biological normal" range gets 56.66% of the sample.

The research results of the entropy model showed that the amount of entropy in the control group of healthy liquidators lower than the rate of entropy in the same group (conditionally workable) during and after an emergency. In the treatment groups, which found violations of the physiological norm, entropy index increased in 1.08-1.29 times. This indicates that the harmful processes of creating conditions conducive to an increase in the amount of information related in turn to the creation of greater uncertainty. The recent results confirmed what references [39-51] have achieved.

VI. Conclusions

To eliminate accidents stationary problem in the most general formulation of the problem as described in the Markov chain optimization - minimizing the cost of protection and the average losses from the accident.

The resulting numerical experiments for the time dependence of the probability of states allow you to determine the time of the establishment of the dynamic processes in the HMS system with non-stationary flows of accidents and demonstrate the validity of estimation averaged probabilities of states for medium intensity events.

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