Description of the information process as a discrete stream.

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Abstract. The work considers the forecasting of the process of functioning of a dynamic complex system, which is a big problem because of the considerable volume of information circulating in it and many random factors affecting its operation. In this paper, the structure of the information process described in the form of a discrete information flow is considered. To determine portions of the information flow information for the formation of a control action, these flows are identified and structured based on determining the dimension of the attractors of dynamical systems in finite-dimensional spaces. To manage a discrete information process, the number of control checks that make it possible to determine the duration of this process predicts it. In this case, the pieces of information and time intervals for each portion of the discrete information stream are considered the same. As a result of the conducted researches the program complex on formation of predicted parameters of training with definition of portions of training information is developed. The paper gives comparative results of the duration of training - experimental and predicted.

1. Introduction

For any complex system (CS), predicting its parameters under stable operation is a difficult task because of the large amount of information circulating in it and the set of random factors affecting the process of its functioning. Such behavior of dynamic systems corresponds to a state of chaos, self-organized criticality, bifurcation [1-6]. When the CS is in a state of chaos, the behavior of such a system can be described only if the initial conditions are known, i.e. the state of the CS depends on the input parameters, which in turn, when measured, have a certain error. Predicting the functioning of nonlinear dynamical systems is a complex problem due to nonlinearity and local instability of dynamics. In systems with chaotic processes, a small initial error varies exponentially with time, which prevents a long-term forecast. This problem can partly be solved by using simple autonomous dynamic systems without the use of stochastic models [7-14]. CS can be represented in the form of a discrete information flow, described based on the formation of predicted parameters, where it is possible to influence the process with the help of control actions with the determination of the duration of time and its portion, considering that the time intervals are the same between each other. The stability of the functioning of the CS in the form of a discrete information flow will be described based on the concept of strange attractors.

CS functioning as fractals develop on the verge of chaos and their functioning is described by deterministic chaos. Forthom, long-term forecasting is important. In complete lychaotic systems, prediction is possible in a time interval that depends on the Kolmogorov K-entropy.
The aim of the work is to investigate the behavior of a complex dynamic system based on fractal (behavior of dynamical systems with strange attractors) dimensions, defined system indicators of such a system, characterized by the chaotic and naturally random behavior of the deterministic model.

2. Theoretical part

The dimensions of the attractor will be determined in terms of the measure of the dimension of the set \(A\). To do this, we take a set \(A\) that is a subset of a Banach space \(B\). We cover the set \(A\) with balls \(A_j\) whose radius \(\varepsilon_j\) does not exceed a certain value \(\varepsilon\), that is, \(\varepsilon_j = \text{diam} A_j \leq \varepsilon\).

Define \(\mu_d (A, \varepsilon)\):

\[
\mu_d (A, \varepsilon) = \inf_{d>0} \left( \text{diam} A \right)^d = \inf_{j} \varepsilon_j^d.
\]

And the radius of the balls is smaller than \(\varepsilon\) over all coverings of the set \(A\).

Hence, by a Hausdorff measure of dimension \(d\) of \(A\):

\[
\lim_{\varepsilon \to 0} \mu_d (A, \varepsilon) = \mu_d (A),
\]

For a set \(A\), the dimension is defined \(d_H\) as follows:

\[
d_H = \inf \{d : \mu_d (A) < \infty\}.
\]

Let us consider other approaches to determining the dimension of attractors of dynamical systems in finite-dimensional spaces \(R^m\).

The fractal dimension of the attractor \(A\) is \([1, 6]\).

We will consider other approaches to determining dimension attractors dynamic systems in finite-dimensional spaces \(R^m\).

Fractal dimension of an attractor \(A\) is \([1, 6]\)

\[
d_F = - \lim_{\varepsilon \to 0} \frac{\log_2 M(\varepsilon)}{\log_2 \varepsilon},
\]

where: \(M(\varepsilon)\) - number of spheres radius \(\varepsilon\), covering sets \(A\).

For this approach fractal dimension \(\varepsilon\), covering sets \(A\).

If the attractor has heterogeneity of structures dimensions they unite in continual family of dimensions of Renya and is defined as follows \([3]\):

\[
d_q = \lim_{\varepsilon \to 0} \frac{1}{q-1} \log_q \left( \sum_{i=1}^{N} p_i^q \right),
\]

where: \(p_i\) - hit probability in \(i\) to fractal component; \(\varepsilon\) - radius of the spheres covering an initial compact set; \(q\) - dimension.

We will define dimensions of attractors dynamic system on below to the given approach. For dynamic system the trajectory of her functioning in a look is set \(y(t) = (y_1(t), y_2(t), ..., y_n(t))\) in time points \(t = \tau_j, \tau > 0, j = 1, ..., N\) on an attractor. We will assume that the phase space is broken into fragments with the party \(l\) discrete.
For each fragment with number \( i \) there is a certain sequence of points \( y(0), y(1),..., y(N_i) \) ( \( N_i \) — number of points the sequence) being in this fragment.

In this case the probability of hit a point an attractor in a fragment will decide on number

\[
P_i = \frac{N_i}{N}.
\]

Very often correlation dimension is defined on the basis of logarithming an asymptotic ratio

\[
C(l) = \frac{\log N(l)}{\log l} \rightarrow 0 \quad [2, 4, 9].
\]

Considering the fact that expressions for determination of fractal dimensions contain limit transitions, these calculations for determination of correlation dimension make for dynamic systems from big \( N \) and small values \( l \).

As is well-known even at the final sequence of measurements in dynamic system the stochasticity can appear [9, 11].

This statement is based on the following reasoning. The attractor cannot be variety (a strange attractor). We will consider continuous dynamic system with discrete time of change on \( M \) — compact variety. Such dynamic system on \( M \) there is a diffeomorphism \( \varphi : M \rightarrow M \) in which point \( x_0 \in M \) at the moment of \( t = n \), through \( n \) iterations will pass into a point \( \varphi^n(x_0) \in M \).

In dynamic systems measurement is understood as the smooth material function set on \( M \) \( y : M \rightarrow R \). Measuring \( y(\varphi_t(x)) \) at the movement of the dynamic system described: \( \varphi_t(x), x \in M \) in various time points \( t_k \) we have to in sizes \( y(\varphi_{t_k}(x)), k = 1, 2, ..., N \), to obtain information on initialdynamic system on \( M \). This problem is solved on the basis of Takens's theorems [11].

First theorem of Takens.

Let \( M \) — compact variety of dimension \( m \) and \( F \) — the vector field on \( M \), and \( y \) — the smooth material function set on \( M \). Then display \( \Phi_{F,y}(x): M \rightarrow R^{2m+1} \), determined by equality

\[
\Phi_{F,y}(x) = (y(x), y(\varphi_1(x)),..., y(\varphi_{2m}(x))), \quad x \in M,
\]

where: \( \varphi_t \) - the stream generated by the field \( F \), the stream generated by the field \( M \) in space \( R^{2m+1} \).

Second theorem of Takens.

Let \( M \) — compact variety of dimension \( m \) and \( \varphi : M \rightarrow M \) — smooth diffeomorfizm, and \( y \) — the smooth material function set on \( M \). Then display \( \Phi_{F,y}(x): M \rightarrow R^{2m+1} \), determined by equality

\[
\Phi_{F,y}(x) = (y(x), y(\varphi_1(x)),..., y(\varphi_{2m}(x))), \quad x \in M,
\]

there is a variety investment \( M \) in space \( R^{2m+1} \).

In the second theorem of Takens the dynamic system for discrete time is considered. The dynamic system is set by means transformation \( \varphi : M \rightarrow M \), an \( \varphi^{2m} \)(\( x \)) — be \( 2m \) — iteration of a point \( x \), or her situation in time point \( t = 2m \).

The provided Takens's theorems allow to define taking into account the received dimension of a strange attractor number phase variables at the movement dynamic system. At small or final dimensions, a strange attractor function quality has final number of the variables corresponding to dimension phase space.

Considering the fact that for a strange attractor the set of his trajectories is small Takens's theorem it is impossible to use, but fractals with fractional hausdorfovy dimension can be enclosed in space \( R^d \), where \( d \) it is rather big.
We will consider that at an experiment at the movement dynamic system the variables defining this movement are received. Then the correlation dimension is defined as follows. We will choose a vector component \( x_j(t) \) from \( x(t) = (x_1(t), x_2(t), \ldots, x_m(t)) \) — solution vector some system of the nonlinear equations we will also make a vector \( \xi(t) \) looks which carries out an investment of the stream generated by system in \( R^{2m+1} \) at identical metric properties space \{\{x(t)\}\} and \{\{\xi(t)\}\}:

\[
\xi(t) = (x_j(t), x_j(t+\tau), \ldots, x_j(t+2m\tau)), \quad \tau > 0
\]  

(9)

When carrying out an experiment the dimension an attractor dynamic system is unknown and, therefore, the correlation dimension an attractor is defined for \( m = 2, \ m = 3 \) etc. on the basis of the expression given below:

\[
d^*_m = \lim_{\varepsilon \to 0} \frac{\ln C_m(\varepsilon)}{\ln \varepsilon}
\]  

(10)

where

\[
C_m(\varepsilon) = \lim_{N \to \infty} \frac{1}{N^2} \sum_{i,j=1}^{N} \exp \left( e^{-\|\xi^*_{i,j} - \xi^*_{i,j}\|} \right)
\]  

(11)

- the generalized correlation integral.

In expression (10) \( d^*_m \) increase is defined \( m \) until \( d^*_m \) it won’t be considerable will change around \( d^*_2 \) at some \( m = m^* \).

In this case \( d^*_m \) will be correlation dimension of an attractor:

\[
d_m = d^*_m,
\]  

(12)

Apparently when carrying out process calculation the right parts system of the nonlinear equations didn’t take part. In this regard sequences \{\{x, (i\tau)\}, i = 1, N\} it can be representable in the form temporary series observations, which can be not connected with any system of the equations. The received results can characterize investment spaces. And for everyone it is possible to define correlation dimension an attractor.

On the basis temporary series observations, it is possible to define an interval predictability these or those parameters on an attractor. A measure predictability is the sum positive indicators of Lyapunov which are a quantitative measure speed running system [12].

Let \( y_0 \) — initial value a trajectory \( f^N(y_0) \), where \( f \) — the function setting display, \( N \)— number iteration, \( y_0 + \delta \) — indignant initial value, \( \delta \) — initial error or mistake. From a point \( y_0 + \delta \) there is a trajectory \( f^N(y_0 + \delta) \). On \( N \) step iteration differ at a size

\[
\left| f^N(y_0) - f^N(y_0 + \delta) \right|
\]  

(13)

Expression (13) can be simplified believing that it will be equal to the work an initial error on some coefficient [2, 7]

\[
\left| f^N(y_0) - f^N(y_0 + \delta) \right| = \delta \cdot e^{N\lambda(y_0)}
\]  

(14)

On the basis expression (12) we will find \( \lambda(y_0) \):

\[
\lambda(y_0) = \lim_{N \to \infty} \lim_{\delta \to 0} \frac{1}{N} \ln \left| f^N(y_0) - f^N(y_0 + \delta) \right|
\]  

(15)
Sum $L$ is a positive indicator of Lyapunov, i.e.

$$L = \sum_{k=1}^{p} \lambda_k^+ \geq 0, k = 1, p,$$

(16)

and inverse value $T = \frac{1}{L}$ is the average time for which the volume phase space will stretch in $e$ time. In phase space $R^n$ for one observed phase coordinates, $y(t)$ we will consider a vector

$$y(t) = (y(t), y(t+\tau), \ldots, y(t+(m-1)\tau)). \quad \tau > 0.$$  

(17)

Applying an asymptotic formula (12) we will receive

$$C_m(\delta) = \delta^d \cdot e^{-\tau L \cdot m}, \delta \rightarrow 0, \ m \rightarrow \infty,$$

(18)

where $C_m(\delta)$ the generalized correlation integral[12].

Considering expression

$$\frac{C_{m+1}}{C_m} = e^{\tau L},$$

(19)

we will receive

$$L = \frac{1}{\tau} \ln \frac{C_{m+1}}{C_m}.$$  

(20)

Sequence $(Q_i)_{i=0}^\infty$ we will define based on the sequence experimental values a variable $T(t)$. We will carry out this process as follows.

3. Practical part. Obtaining experimental values by determination quantity portions of the trained information

Taking into account the created processes preliminary testing, formation the predicted parameters students and also management process with the predicted number control checks, the training determining duration provided that portions training and time intervals identical among themselves, the structure information process training with the predicted quantity portions the trained information is developed.

The following modules enter a basis a program complex:

1. Database.
2. Statistics about training process.
3. Access rights users.
4. Initial testing trainees.
5. The predicted information.
6. Analysis process training.

Process training is carried out according to the following scheme.

1. Training happens both on occupations to the teacher, and during independent work.
2. Training session duration identical to all trainees, i.e. $t_k = const, k = 1, 2, \ldots, N$.
3. Time between sessions training isn't set.
4. On each session training control is exercised.

Control was exercised as follows. On each session of training testing till portions information was held. At positive testing the next portion of information was given, otherwise the same portion information was represented for training. Process training came to an end if on all portions
information, the condition the trainee got to the target area. Results experimental group are given in tables 1 and 2.

**Table 1**: Results training in experimental group (Voronezh state pedagogical university)

| Number trainee | $Q_0$ | $Q^*$ | Quantity passed occupations $L_0$ | Thespenttime, min. | Average time passing one portions information, min. |
|----------------|-------|-------|----------------------------------|--------------------|-----------------------------------------------|
| 2              | 0,7   | 0,33  | 0                                | 150                | 25                                            |
| 4              | -     | 0,26  | 2                                | 180                | 30                                            |
| 5              | 0,4   | 0,22  | 4                                | 225                | 37,5                                          |
| 7              | -     | 0,2   | 1                                | 200                | 33,3                                          |
| 8              | 0,6   | 0,53  | 0                                | 180                | 30                                            |
| 10             | 0,4   | 0,37  | 1                                | 225                | 37,5                                          |
| 11             | 0,5   | 0,25  | 1                                | 180                | 30                                            |
| 13             | -     | 0,4   | 0                                | 150                | 25                                            |
| 17             | -     | 0,51  | 0                                | 225                | 37,5                                          |
| 20             | 0,5   | 0,35  | 2                                | 200                | 33,3                                          |

**Table 2**: Results training in experimental group (Lipetsk state pedagogical university)

| Number trainee | $Q_0$ | $Q^*$ | Quantity passed occupations $L_0$ | Thespenttime, min. | Average time passing one portions information, min. |
|----------------|-------|-------|----------------------------------|--------------------|-----------------------------------------------|
| 2              | -     | 0,3   | 1                                | 200                | 33,3                                          |
| 4              | 0,2   | 0,16  | 0                                | 150                | 25                                            |
| 5              | 0,3   | 0,22  | 4                                | 200                | 33,3                                          |
| 7              | -     | 0,2   | 2                                | 225                | 37,5                                          |
| 8              | 0,4   | 0,33  | 0                                | 180                | 30                                            |
| 10             | 0,7   | 0,2   | 0                                | 200                | 33,3                                          |
| 11             | -     | 0,4   | 1                                | 180                | 30                                            |
| 13             | 0,6   | 0,61  | 0                                | 225                | 37,5                                          |
| 20             | 0,5   | 0,25  | 1                                | 150                | 25                                            |

The experiment was made in two VSPU and LSPU groups: experimental and in group in which classes were given in a usual technique. The selection of groups was carried out on the condition that the average score in them is the same. Training in groups was provided at the same time and according to the same tests. For each trainee in groups the initial level ignorance ($Q_0$) on the basis expression was defined (12). Further the average level ignorance ($Q^*$) at the end an experiment was defined. Results of an experiment are reduced in tables 3 and 4 coinciding on structure with tables 1 and 2.
Table 3: Results training in control group (Voronezh state pedagogical university)

| Number trainee | $Q_0$ | $Q^*$ | Quantity The skipped classes, $L_0$ | Spent time, min. |
|----------------|------|------|-------------------------------------|-----------------|
| 1              | -    | 0.45 | 1                                   | 225             |
| 3              | 0.1  | 0.25 | 0                                   | 225             |
| 6              | 0.3  | 0.3  | 2                                   | 225             |
| 9              | -    | 0.15 | 1                                   | 225             |
| 12             | 0.4  | 0.25 | 3                                   | 225             |
| 14             | 0.5  | 0.7  | 0                                   | 225             |
| 15             | 0.7  | 0.81 | 2                                   | 225             |
| 16             | 0.4  | 0.67 | 0                                   | 225             |
| 18             | -    | 0.61 | 2                                   | 225             |
| 19             | 0.6  | 0.65 | 0                                   | 225             |

Table 4: Results training in control group (Lipetsk state pedagogical university)

| Number trainee | $Q_0$ | $Q^*$ | Quantity The skipped classes, $L_0$ | Spent time, min. |
|----------------|------|------|-------------------------------------|-----------------|
| 1              | 0.4  | 0.45 | 0                                   | 225             |
| 3              | 0.3  | 0.25 | 2                                   | 225             |
| 6              | -    | 0.3  | 2                                   | 225             |
| 9              | -    | 0.15 | 0                                   | 225             |
| 12             | 0.6  | 0.25 | 3                                   | 225             |
| 14             | 0.1  | 0.7  | 2                                   | 225             |
| 15             | 0.5  | 0.81 | 0                                   | 225             |
| 16             | 0.7  | 0.67 | 0                                   | 225             |
| 18             | -    | 0.61 | 2                                   | 225             |
| 19             | 0.5  | 0.65 | 1                                   | 225             |

The analysis results an experiment has shown reduction influence admissions occupations (an external factor) by training process. For an illustration of this statement the dependence between the received level of ignorance and the number the skipped classes provided on fig. 3 and 4 is constructed.

On these experimental groups I was determined correlation forces between admissions of occupations and level of ignorance by expression:

$$\eta = \frac{\sigma_{xy}}{\sigma_x \sigma_y}$$  \hspace{1cm} (21)
As a result of the carried-out calculations have defined VSPU: $\eta_{ecs} = 0.38$, $\eta_{contr} = 0.61$. LSPU: $\eta_{ecs} = 0.39$, $\eta_{contr} = 0.63$.

There is a communication between the level ignorance reached by the end training and the number of the skipped classes. But this dependence isn't so essential to experimental groups.

**Figure 1**: The schedule dependence between the average level ignorance and the number the skipped classes "VSPU" where: 1 values experimental group; 2 - values control group

**Figure 2**: The schedule dependence between the average level ignorance and the number the skipped classes "LSPU" where: 1 values experimental group; 2 - values control group

At the end training in each member of the group in the form test practical task which was estimated on four points was given:

3 – the test task is solved correctly;
2 – the test task is solved with small inaccuracies;
1 – the test task is solved partially;
0 – the test task isn't solved.

Level dependence was defined on the basis correlation coefficient between level $Q^*$ knowledge theoretical material and level practical knowledge $c \in \{0, 1, 2, 3\}$.

Considering that $c \in \{0, 1, 2, 3\}$ has 4 values, then the coefficient rank correlation accepting values on an interval $[0, 1]$, we will spread out to four parts and we will appropriate to each them the rank $q$:

$$q = \begin{cases} 
1, & \text{if } 0.8 < Q \leq 1 \\
2, & \text{if } 0.5 < Q \leq 0.8 \\
3, & \text{if } 0.2 < Q \leq 0.5 \\
4, & \text{if } 0 < Q \leq 0.2
\end{cases} \quad (22)$$
According to expression (22) tables (1)-(4) we will transform to tables (3) and (4).

**Table 5:** VSPU. Number the points having ranks \([q, c]\)

| \(q\) | \(0\) | \(1\) | \(2\) | \(3\) |
|-------|-------|-------|-------|-------|
| 1     | 0     | 1     | 0     | 0     |
| 2     | 1     | 4     | 1     | 0     |
| 3     | 1     | 2     | 5     | 1     |
| 4     | 0     | 0     | 3     | 2     |

**Table 6:** LSPU. Number the points having ranks \([q, c]\)

| \(q\) | \(0\) | \(1\) | \(2\) | \(3\) |
|-------|-------|-------|-------|-------|
| 1     | 1     | 0     | 1     | 0     |
| 2     | 2     | 3     | 0     | 1     |
| 3     | 2     | 2     | 2     | 1     |
| 4     | 0     | 4     | 5     | 0     |

On the basis of these tables 3 and 4 communication between knowledge theoretical material and the level practical knowledge should be defined through coefficient rank correlation of Spirmen and to construct dependence between two these sizes. Considering what is considered, results we average the connected ranks with use coefficient of Spirmen (expression 22) on the following expression:

\[
\rho_s = 1 - \frac{6\sum d_i^2}{n^3 - n},
\]

where: \(n\) – sample size, \(d_i = x_i - y_i\).

In our case the coefficient rank correlation of Spirmen, is equal \(\rho_s = 0.6\). Confidence interval \(\rho\) equal \(\beta = 0.95\) with confidential borders \((0.413; 0.805)\).

It has been calculated \(T_\alpha = 0.54\) (with \(n = 20\) and significance value \(\alpha = 0.01\)) we receive that coefficient rank correlation we mean with probability 0.95 (as \(\rho = 0.6 > T_\alpha\)). These results confirm interrelation between knowledge theoretical material and level practical knowledge.

On the end an experiment in two groups the examination has been held. Tests which were given to trainees during training have been the basis for content an examination. The examination consisted five identical tasks on complexity. Duration an examination was two class periods. Check an examination was made by two teachers who didn't know from what group to them provided trainees for check. Assessment results an examination was made on three-point system:

- 1 – the test task is solved correctly (knowledge);
- 0,5 – the test task isn't completely solved (semi-knowledge);
- 0 – the test task will be able truly (ignorance).

Results check an examination are given in tables 7 and 8.

**Table 7:** Results an examination(Voronezh state pedagogical university)

| Number "pupil" | Number the teacher | Experimental group | Check group |
|----------------|--------------------|--------------------|-------------|
| 1              | 1                  | Number a task      | Number a task |
| 1              | 2                  | 1                  | 2           |
| 0              | 1                  | 1                  | 3           |
| 4              | 5                  | 5                  | 4           |
| 1              | 0                  | 0,5                | 0,5         |
| 1              | 1                  | 0,5                | 0,5         |
| 1              | 0                  | 0,5                | 0,5         |
| 0              | 5                  | 0,5                | 0,5         |
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| Number "pupil" | Number the teacher | Experimental group | Checkgroup |
|----------------|--------------------|--------------------|------------|
|                |                    | Number a task      | Number a task |
|                |                    | 1 2 3 4 5 1 2 3 4 5 |
| 1              | 1                   | 1 1 1 1 0,5 1 0,5 1 0,5 1 0,5 1 0,5 1 |
| 2              | 1                   | 1 0 0 0,5 1 1 1 0 0,5 1 0,5 1 0,5 1 |
| 3              | 1                   | 0,5 1 0 1 0,5 0,5 1 0,5 0,5 1 0,5 0 |
| 4              | 1                   | 0 0,5 0,5 0 0,5 0 1 0,5 1 0,5 1 0,5 1 |
| 5              | 1                   | 0,5 1 0,5 0,5 1 0,5 0,5 1 0,5 1 0,5 1 |
| 6              | 2                   | 0,5 0,5 0,5 0,5 1 0,5 1 0,5 0,5 1 0,5 1 |
| 7              | 2                   | 1 0 0,5 1 0,5 1 0 0,5 1 0,5 1 0,5 1 |
| 8              | 2                   | 0,5 1 0,5 1 0,5 0,5 1 1 1 0,5 1 0,5 0 |
| 9              | 2                   | 1 0 0,5 1 0,5 1 1 1 1 0,5 1 0,5 0 |
| 10             | 2                   | 1 0,5 1 1 0,5 1 0 0 1 0 0,5 1 |

Table 8: Results of an examination (Lipetsk state pedagogical university)

On each teacher each group have been counted the total amount of points on five to a ball scale. Ordered estimates on each group for all teachers, the total amount of points, GPA, dispersion and a standard deviation are given in table 9 and 10.
Table 9: Statistical estimates an examination (Voronezh state pedagogical university)

| Group 1 (experimental) | Group 2 (control) |
|------------------------|-------------------|
| $X_{ij}^{(1)}$ | $X_{2j}^{(1)}$ | $X_{ij}^{(2)}$ | $X_{2j}^{(2)}$ |
| 4 | 3.5 | 2 | 1.5 |
| 2.5 | 4 | 3.5 | 1.5 |
| 3.5 | 2.5 | 4.5 | 3 |
| 3 | 4 | 4 | 4.5 |
| 4 | 3 | 3 | 2 |
| 2.5 | 2.5 | 1.5 | 2 |
| 3 | 3 | 3 | 3.5 |
| 3 | 3.5 | 3.5 | 3.5 |
| 4 | 3 | 2.5 | 4 |
| 2 | 4 | 3.5 | 2 |

GPA | 3.4 | 3.4 | 3.2 | 3.2 |

$ar{X}$ | 3.15 | 3.2 | 3.1 | 2.75 |

$s_{X^2}$ | 0.86 | 0.92 | 0.788 | 0.71 |

$s_x$ | 0.93 | 0.959 | 0.89 | 0.84 |

Table 10: Statistical estimates an examination (Lipetsk state pedagogical university)

| Group 1 (experimental) | Группа 2 (contr) |
|------------------------|------------------|
| $X_{ij}^{(1)}$ | $X_{2j}^{(1)}$ | $X_{ij}^{(2)}$ | $X_{2j}^{(2)}$ |
| 4.5 | 2.5 | 3.5 | 3.5 |
| 3 | 1.5 | 2.5 | 3 |
| 2 | 2 | 3 | 2.5 |
| 3 | 3 | 3 | 3.5 |
| 3 | 2.5 | 1.5 | 1.5 |
| 2.5 | 3 | 2.5 | 2 |
| 3 | 3.5 | 2.5 | 3 |
| 2.5 | 4 | 2.5 | 3.5 |
| 3.5 | 3.5 | 2 | 4.5 |
| 3.5 | 4 | 4 | 4 |

GPA | 3.2 | 3.2 | 3.15 | 3.15 |

$ar{X}$ | 3.05 | 2.95 | 2.7 | 3.1 |

$s_{X^2}$ | 0.89 | 0.87 | 0.7 | 0.92 |

$s_x$ | 0.94 | 0.93 | 0.837 | 0.959 |

In the table following designations are used:

$\bar{X}_{ij}^{(k)} = \frac{1}{n[i]} \sum_{j=1}^{n[i]} X_{ij}^{(k)}$ – GPA in $i$ group on $k$ teacher; $n^{(i)}$ – number trainees in $i$ group; $X_{ij}^{(k)}$ – point $j$ the trainee from $iv$ groups, this $k$ teacher; $i = 1, 2; n^{(1)} = n^{(2)} = 10; j = 1, 2; S_{X_{ij}^{(k)}}$ – not displaced dispersion assessment $I$ groups on $k$ teacher.
With use standard methods [7, 14] the uniformity the received empirical material was checked. On the basis the made experiment it has been proved that two selections one group are selections the same population i.e. in each group the corresponding selections can be united in one selection bigger volume and to compare two sets – experimental and control. Check a statistical hypothesis has shown that both sets are selections different populations. It is necessary to emphasize the fact that averages these selections differ from each other in experimental group

\[
X = 4,31 \quad \text{and} \quad X = 0,5,31
\]

in control

\[
X = 1,32 \quad \text{and} \quad X = 9,22
\]

i.e. the value an average in experimental group is more than in control [1, 7, 12].

We will compare results testing on three to a ball scale (0, 1 and 0,5) in two groups. In total estimates it has been exposed \( S = 50 \). That selections can be united, we will determine the average number points by different teachers in both groups with definition \( W_j \) relative. Results are given in table 9 and 10. We will carry out assessment change quality knowledge [8, 12] with use of the coefficient characterizing quantitatively various techniques training:

\[
K = \frac{K_0 + K_1}{2},
\]

where:

\[
K_0 = \frac{W^{(2)}_0}{W^{(1)}_0} \quad \text{the indicator characterizing ignorance reduction},
\]

\[
K_1 = \frac{W^{(1)}_1}{W^{(2)}_1} \quad \text{the indicator characterizing increase in knowledge}.
\]

**Table 11**: The number points 1, 0.5 and 0 in experimental and control groups

| Group | Teacher | Point |
|-------|---------|-------|
|       |         | 0     | 0.5   | 1     |
| 1     | 1       | 12    | 13    | 25    |
|       | 2       | 9     | 18    | 23    |
| 2     | 1       | 10    | 16    | 24    |
|       | 2       | 12    | 21    | 17    |
|       | Average of points | 10,5 | 15,5 | 24 |
| 1     | Relative number of points | 0,21 | 0,31 | 0,48 |
| 2     | Average of points | 11    | 17,5 | 20,5 |
|       | Relative number of points | 0,22 | 0,35 | 0,41 |

**Table 12**: The number points 1, 0.5 and 0 in experimental and control groups

| Group | Teacher | Point |
|-------|---------|-------|
|       |         | 0     | 0.5   | 1     |
| 1     | 1       | 9     | 19    | 22    |
|       | 2       | 9     | 22    | 19    |
| 2     | 1       | 11    | 24    | 15    |
|       | 2       | 11    | 16    | 23    |
|       | Average of points | 9    | 20,5  | 20,5 |
| 1     | Relative number of points | 0,18 | 0,41 | 0,41 |
| 2     | Average of points | 11    | 20    | 19    |
Relative number of points | 0.22 | 0.4 | 0.38
---|---|---|---

As a result calculations have received for VSPU:

\[ K_0 = \frac{0.22}{0.21} = 1.05; \quad K_1 = \frac{0.48}{0.41} = 1.17 \]  \hspace{1cm} (25)

Level residual knowledge accepts value \( K = 1.11 \).

For LSPU:

\[ K_0 = \frac{0.22}{0.18} = 1.22; \quad K_1 = \frac{0.41}{0.38} = 1.08 \]  \hspace{1cm} (26)

Level residual knowledge accepts value \( K = 1.15 \).

4. Conclusion

In this paper, the structure of the information process described in the form of a discrete information flow is considered. To determine portions of the information flow information for the formation of a control action, these flows are identified and structured based on determining the dimension of the attractors of dynamical systems in finite-dimensional spaces. Based on time series of observations, the predictability interval of certain parameters on an attractor is determined. A measure of predictability is the sum of Lyapunov’s positive indicators, which are a quantitative measure of the rate of run-up of the system. The obtained results can characterize the embedding spaces of attractors. In addition, for each attachment, it is possible to determine the correlation dimension of the attractor. For small or finite dimensions of a strange attractor, the quality function has a finite number of variables corresponding to the dimension of the phase space. In practical terms, the discrete information process of assessing the quality of training described in the form of a discrete information flow based on the experimental values obtained was shown that the quality of instruction was increased 1.11 times in the VSPU and 1.15 times in the LSPU. As a result of the experiment it was revealed that the number of excellent estimates increases with the use of the proposed method, and the number of unsatisfactory ones decreases.

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