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Designing a forecasting system using its parameters

Abstract

The work solves the problem of calculating parameter values and their use in building a system for forecasting external, random events that negatively affect the functioning process implemented by a technical object. To clarify the functioning process, a number of conditions defining the boundaries within which the parameters are studied are proposed. The design of the system is performed in stages, and therefore the investigated parameters are analyzed at each stage separately.

The first stage of the process of designing a forecasting system is the formation of a hypothesis that determines the general purpose of using the system. The work offers an interpretation of the hypothesis that is adapted to the solved problem. A description of the process of preliminary analysis of input data is provided, and the processes related to the requirements for the components of the forecasting system, which expand its functionality, are considered. The peculiarities of the functioning of the component, which predicts a random event, are considered. The statement is proved, which defines the type of functions on the basis of which the prediction is realized. At the second stage, the processes of determining the values of the countermeasures against the impact of a random event on the functioning of the technological process are implemented. As part of these processes, textual descriptions of data interpretation are used to expand their functionality related to the implementation of the corresponding countermeasure. In this regard, the statement about the non-contradiction of the system of algorithms, which is modified based on the use of information from textual descriptions of the interpretation of data used in the forecasting system, is proved.

Keywords: forecasting, parameters, random event, determinism, hypothesis.

Projektowanie systemu prognozowania z wykorzystaniem jego parametrów

Streszczenie

Praca rozwiązuje problem obliczania wartości parametrów i ich wykorzystania przy budowie systemu prognozowania zewnętrznych, losowych zdarzeń, które negatywnie wpływają na proces funkcjonowania realizowany przez obiekt techniczny. Dla sprecyzowania procesu funkcjonowania zaproponowano szereg warunków określających granice, w których badane są parametry. Projektowanie systemu odbywa się etapami, w związku z czym badane parametry są analizowane na każdym etapie z osobna.

Pierwszym etapem procesu projektowania systemu prognozowania jest formułowanie hipotezy, która określa ogólny cel wykorzystania systemu. W pracy zaproponowano interpretację hipotezy dostosowaną do rozwiązywanego problemu. Przedstawiono opis procesu wstępnej analizy danych wejściowych oraz rozpatrzono procesy związane z wymaganiami dla elementów systemu prognozowania rozszerzających jego funkcjonalność. Uwzględniono specyfikę działania komponentu, który przewiduje zdarzenie losowe. Udowodniono stwierdzenie, które określa rodzaj funkcji, na podstawie których realizowana jest predykcja. Na drugim etapie realizacji procesu wyznaczania znaczeń parametrów przeciwdziałania wpływu zdarzenia losowego na funkcjonowanie technologicznego procesu wykorzystywani tekstowe opisy interpretacji danych do rozszerzenia ich możliwości funkcjonalnych związanych z realizacją odpowiedniego przeciwdziałania. W tym zakresie udowodnione jest stwierdzenie o spójności systemu algorytmów, który jest modyfikowany w oparciu o wykorzystanie informacji z tekstowych opisów interpretacji danych wykorzystywanych w systemie prognostycznym.

Słowa kluczowe: prognozowanie, parametry, zdarzenie losowe, determinizm, hipoteza.

1. Introduction

Forecasting, within the $SU(Pr_i)$ technological process control system, is used for the anticipating detection of a random event Vp_i with the aim of activating countermeasures against the influence of Vp_i on the technological process $Pr_i(TO_i)$. Let's assume that forecasting is used to service the technical object TO_i that functions in the environment (Ep_i) and activates the corresponding functionalization process $Pr_i(TO_i)$. We limit ourselves to predicting events that negatively affect $Pr_i(TO_i)$ that occur in Ep_i. To implement forecasting methods, initial data Df_i is formed on the basis of data on test results, input data Di_i is obtained as a result of monitoring Ep_i and operational data Dw_i, which are formed on the basis of using the results of preliminary analysis of input data and are directly used to implement forecasting processes. Let us assume that the data Di_i are closely related to the processes that generate events Vp_i in the environment Ep_i and their determination can be carried out in the following ways. The first method consists in increasing the amount of information about processes $Pr_i(Vp_i)$, which leads to the occurrence of Vp_i in Ep_i. This approach consists in conducting extended studies of the processes occurring in Ep_i. The second way is to use additional data about $Pr_i(TO_i)$, which can be used when predicting the event Vp_i. This approach is more related to $Pr_i(TO_i)$ and is therefore more relevant to the researched problem.

The implementation of forecasting requires the formulation of a hypothesis Hp_i regarding the events Vp_i, which are planned to be predicted. The hypothesis contains a description of the prediction goal Cp_i. In addition to the target description, Hp_i may contain some input Di_i. The prediction goal is dominant and describes Vp_i and its relationship with $Pr_i(TO_i)$ to a certain extent. The description Cp_i may represent the identifier Vp_i and some information $Iv_i(x_i)$ regarding the event and its relationship with $Pr_i(TO_i)$. The above Hp_i components are supplemented by textual descriptions of their interpretation, which are formed on the basis of data relating to the various stages of the TO_i tests. To build textual descriptions of the interpretation, specialists in the subject area form a semantic dictionary Sc_i, for the components of the forecasting system SPG_i, for anomalies An_i and events Vp_i that appear in Ep_i. Text descriptions related to SPG_i data and components are presented in the form: $j(x_{i,k}), j(y_i)$ and are used to implement the processes of their semantic analysis and transformations (Korostil, Afanasyewa, Korostil, 2021). In the process of conducting tests, modeling of possible Vp_i is used, which allows for establishing the corresponding threats to $Pr_i(TO_i)$. Based on the information obtained during the tests, the initial versions of the input data Df_i are formed. In the process of testing, not only possible attacks on $Pr_i(TO_i)$, but also means of countering the corresponding attacks are investigated.

Let's accept the following conditions.

Condition 1. The event Vp_i occurs in Ep_i, within the set time interval ΔTp_i, which is determined for Ep_i and coordinated with the process $Pr_i(TO_i)$.

Condition 2. The event Vp_i is not one-time and can be repeated within time intervals, the value of which may change during the functioning of $Pr_i(TO_i)$.

Condition 3. If Vp_i of different types occur in Ep_i, it means that Ep_i can be divided into components of the environment Ep_i^k, each of generates the corresponding types Vp_i^k.

The event Vp_i, which can occur as a result of the functioning of processes $Pr_i(Ep_i)$, is characterized by parameters related to the parameters $Pr_i(TO_i)$. The process of occurrence of Vp_i is characterized by the following factors:

– at the moment τ_i of the occurrence of Vp_i within the prediction interval ΔTp_i,
– by the values of the parameters y_i, which characterizes Vp_i and are commensurate with the parameters x_i, which counteract the negative influence of y_i on the technological process control system $SU(Pr_i)$.

Let's assume that Vp_i is determined by the occurrence of anomalies An_i in the Ep_i environment. Anomalies arise as a result of the functioning of processes $Pr_i(An_i)$. Anomalies An_i are characterized by deviations of the values of parameters y_i, which are eliminated during the operation of the control system of the corresponding process $SU(Pr_i)$. If the value of the parameters An_i increases and $SU(Pr_i)$ cannot eliminate An_i, then Vp_i occurs. From the first and second condition, it follows that the event Vp_i in relation to the intervals ΔTp_i, in general, is not random, because Vp_i within the framework of a separate interval ΔTp_i will necessarily occur. The sizes of consecutive forecasting intervals ΔTp_i during the process of functioning $Pr_i(TO_i)$ may be different, which is connected with the probability of occurrence of Vp_i during the established period $\mathfrak{D}(\Delta Tp_i)$, which may represent a separate cycle of functioning $Pr_i(TO_i)$. The need to use the period $\mathfrak{D}(\Delta Tp_i)$ is determined by the fact that establishing the probability of occurrence of Vp_i during $\mathfrak{D}(\Delta Tp_i)$ will allow to selection time intervals in which the occurrence of Vp_i has a sufficiently low probability. Such information can be used to form an optimal strategy for the functioning of $Pr_i(TO_i)$ during $\mathfrak{D}(\Delta Tp_i)$, due to the use of different modes of functioning of $Pr_i(TO_i)$ in these intervals.

2. Implementation of the stages of functioning of the hybrid forecasting system

The first stage of the implementation of the SPG_i forecasting system is the formation of the hypothesis $Hp_i(Vp_i)$, about the possibility of predicting the occurrence of a random event Vp_i, which negatively affects $Pr_i(TO_i)$ and implementing countermeasures against such negative impact (Korostil, Afanasyewa, Korostil, 2022).

Let's consider a possible version of the definition of the hypothesis.

Definition 1. We will call the hypothesis Hp_i a relationship in which, based on the use of information about the input data and on the basis of possible hypothetical transformations, the possibility of predicting the occurrence of Vp_i and the possibility of counteracting the negative influence of Vp_i on the corresponding $Pr_i(TO_i)$ are asserted.

Using the notion of An_i occurring in Ep_i and the possibility of occurrence of An_i event Vp_i, it is possible to directly associate An_i with Vp_i, which is written in the form: $An_i \rightarrow Vp_i$. In accordance with modeling concepts, the object model SPG_i in general, consists of components using the following elements (Zarubin, 2006):

– input data Di_i used for calculations and transformations,
– which is implemented by the forecasting system model $MO_i(SPG_i)$,
– algorithms of calculations and transformations $Al_i(SPG_i)$ reflecting the processes that occur in the system SPG_i,
– output data Dv_i or events $\mathcal{F}(\wp)$ characterizing the results of functioning $MO_i(SPG_i)$.

The $MO_i(SPG_i)$ model can describe the processes in the modeled object with varying degrees of approximation of the reproduction of the corresponding processes in relation to the processes that may take place in the case of the functioning of the real object. Therefore, it is appropriate to talk about the degree of closeness *(χ)* of the $MO_i(SPG_i)$ model to the real processes being modeled, which is formally described by the ratio: $NMO_i = \chi(MO_i)$, where NMO_i approximate model. The degree of closeness of an arbitrary model can also be determined by the degree of correspondence of the obtained modeling results to the real results of the functioning of the modeled objects. Based on definition (1), it can be assumed that the hypothesis Hp_i is an approximate model of $MO_i(SPG_i)$. The degree of its closeness to the model is minimal or $\chi[MO_i(SPG_i)] = min$, since it does not use, but only declares possible algorithms for transformations of Al_i input data Di_i. Thanks to this approach to the interpretation of the hypothesis Hp_i, it can be described in the form of $NMO_i(SPG_i)$, which significantly distinguishes Hp_i from the ideas about hypotheses used in probability theory (Billigslej, 2021; Gajek, Kałuszka, 2000). Based on the above, definition (1) can be presented in a form that corresponds to the ideas about NMO_i.

Definition 2. The hypothesis Hp_i represents the model MO_i of the system SPG_i, for which the relation $\chi[MO_i(SPG_i)] = min$ is fulfilled.

The given definition allows for a more constructive approach to the formation of the hypothesis Hp_i, which constitutes the first stage of the construction of SPG_i.

The next stage of implementation of the SPG_i system is the *SE* stage, or the stage of stipulation the event Vp_i. As part of this stage, processes are implemented, thanks to which the reliability of predicting the occurrence of Vp_i can increase to a certain extent. This is facilitated by preliminary analysis and transformations of input data Di_i into operational data Dw_i. The degree of reliability of the prediction process can be determined by the degree of correspondence of the prediction result in relation to the real occurrence in the current time interval ΔTp_i of the event Vp_i. Preliminary analysis methods can use different algorithms, depending on the overall assessment of the nature of the data and the chosen prediction algorithms. An example of preliminary analysis can be the process of filtering input data Di_i. An example of the prediction process is the use of the prediction function extrapolation method. Such a function describes the change in the increment value of the parameter $P_j(Vp_i)$ characterizing Vp_i per unit of time δt_i. The unit of time δt_i calculated based on data on the speed of the technological process $Pr_i(TO_i)$, which determines the real-time mode of operation of $Pr_i(TO_i)$. As part of this stage, the threshold value of $P_j(Vp_i)$ is also determined, within which the control system $SU_i(Pr_i)$ can counteract the negative influence of Vp_i on the process $Pr_i(TO_i)$. The $SU_i(Pr_i)$ system eliminates the unacceptable influence of the value of the parameter An_i, which has a negative effect on $Pr_i(TO_i)$, if the value of $P_j(An_i)$ does not exceed the set threshold. Data on the amount of change $\Delta P_j(Vp_i)$ can be used to construct the development process function of the corresponding An_i. This function describes the variation of $P_j(Vp_i)$ and is synchronized with the time intervals allocated to the extrapolation function used by the prediction process.

The *CE* event conditioning stage is intended to specify the requirements for the following functionality of the SPG_i system:

– prediction procedures;
– possibilities of counteracting the influence of Vp_i on $Pr_i(TO_i)$;
– a number of aspects characterizing the process of functioning of SPG_i;
– which relate to various components that can be part of the system.

The CE stage concerns most of the components involved in the functioning of the SPG_i system. Since the forecasting process is directly related to the components of SPG_i, the goal of forecasting $Cp_i \subset Hp_i(SPG_i)$ must determine certain requirements for the functioning of these components. Such requirements should extend the functionality of algorithms $Al_i(SPG_i)$. The use of NMO_i provides an opportunity to more constructively implement changes aimed at expanding the protection capabilities of $Pr_i(TO_i)$, from Vp_i. During the functioning of SPG_i, individual components of SPG_i may be modified. The requirements for such a modification can have a direct form in relation to the corresponding component, or it can take an indirect form due to the fact that the components of SPG_i are connected to each other by the corresponding structure.

The $SU_i(Pr_i)$ system implements the interaction management processes between individual components of the SPG_i systems. Such interaction can be foreseen in the algorithms of the corresponding components, which can also lead to the implementation of the modification of the goal, the description of which is placed in Hp_i. An important function of the $SU_i(Pr_i)$ system is solving the problems of modifying individual components of the SPG_i systems, which allows adapting the forecasting system to changes that may be caused by the environment in which the SPG_i functions. Fulfillment of such requirements leads to an increase in the degree of approximation of NMO_i to SPG_i. The SPG_i system provides the following possibilities for the implementation of $SU_i(Pr_i)$ protection processes:

– biased opposition to the possible negative influence of Vp_i on $SU_i(Pr_i)$;
– countering the negative influence of Vp_i on $SU_i(Pr_i)$ in the real-time mode of the functioning of $Pr_i(TO_i)$;
– formation of recommendations to avoid the negative influence of Vp_i on $SU_i(Pr_i)$ by changing the operating modes of $SU_i(Pr_i)$.

3. Functioning components of the prediction system prognostication

The EF stage is implemented by the prediction system SPR_i of the event Vp_i. The main processes of this stage include the following:

– determining the probability and intensity of the occurrence of Vp_i;
– implementation of prediction function extrapolation;
– definition of the prediction interval ΔTp_i.

To determine the probability $Pb_i(Vp_i)$ and the intensity $It_i(Vp_i)$ of the occurrence of the event Vp_i, at the initial stage of the operation of the process $Pr_i(TO_i)$, data obtained in the process are used conducting $Pr_i(TO_i)$ tests (Bidiuk, Romanenko, Tymoszczyk, 2013; Dittmann, 2008). During the operation of $Pr_i(TO_i)$, events Vp_i are monitored, data from which are used to modify the current value of the parameters $Pb_i(Vp_i)$ and $It_i(Vp_i)$ which characterize the occurrence of event Vp_i. The values of these parameters may change during the operation of $Pr_i(TO_i)$. Consider the following statement.

Statement 1. Random processes $Pr_i(An_i)$ in the environment Ep_i, which lead to the occurrence of anomalies An_i and the rise of random events Vp_i based on them, are described by exponential functions.

This statement is based on the ideas about the events of An_i and Vp_i. The speeds of the processes $Pr_i(TO_i)$, $Pr_i(An_i)$ and $Pr_i(Vp_i)$ are compared based on the determination of the change in the values of the co-dimensional parameters of the processes $Pr_i(TO_i)$ and $Pr_i(Vp_i)$. Such changes in the value of the parameters that characterize them can be considered the speeds of the corresponding processes, which will be denoted by $Sp_i(TO_i)$ and $Sp_i(Vp_i)$. Since it is assumed that the event Vp_i is random and negatively affects $Pr_i(TO_i)$ during its operation, it means that $Sp_i(Vp_i) \gg Sp_i(TO_i)$. Let's choose some conditional interval of the functioning of processes $Pr_i(TO_i)$ and $Pr_i(Vp_i)$, which we will denote by $\Delta t_i(TO_i)$and $\Delta\tau_i(Vp_i)$. Since the relation $Sp_i(Vp_i) \gg Sp_i(TO_i)$ holds, it can be assumed that the interval $\Delta t_i(TO_i)$ is described by a linear function, for example: $Pr_i(TO_i) = k + \gamma t$, where *k* and *γ* are coefficients and *t* is an independent time variable of the functioning process. In order for the condition $Sp_i(Vp_i) \gg Sp_i(TO_i)$ to be fulfilled, it is necessary that the projection of the interval $\Delta\tau_i(Vp_i)$ on $\Delta t_i(TO_i)$, while ensuring the necessary increase in $Pj_i(Vp_i)$ was shorter than the interval $\Delta t_i(TO_i)$. Otherwise, the necessary requirements for the relevant processes will not be fulfilled. To prevent this from happening, it is necessary that the trajectory of $Pr_i(Vp_i)$ in relation to the trajectory of $Pr_i(TO_i)$ at the selected time interval is described by an exponential type function, for example: $\varphi e = \alpha e^{\beta t}$, where α and β are coefficients. The coefficients are selected when forming the description of the interpretation of the processes $Pr_i(TO_i)$ and $Pr_i(Vp_i)$, *t* is an independent variable of the exponential function that determines the time of the functioning process. The independent variable t_i changes in accordance with the operation time of the corresponding process and cannot take negative values. The coefficients $\alpha \geq 0$ and $\beta \geq 1$ of the function $Pr_i(Vp_i)$ varies from 0 to ∞, which corresponds to the assumption that the event Vp_i within the selected interal $\Delta t_i(TO_i)$ is necessarily will come. The exponential function, in accordance with the given conditions, takes exclusively positive values, which corresponds to the semantics of the occurrence of Vp_i and condition (1). This proves the statement that to predict the occurrence of Vp_i by the method of extrapolation, you have to choose an exponential function.

The definition of the prediction interval ΔTp_i is based on the analysis of its components, which include subintervals.

1. The subinterval determined by the time of development of the next anomaly $\Delta\tau_i(An_i)$, which can turn into Vp_i.
2. The subinterval of direct prediction described by the extrapolation function $\varphi e(t) = \alpha e^{\beta t}$.

When designing any $Pr_i(TO_i)$, the technical requirements for the corresponding object are determined (Bidiuk, 2004; Dechter, 2003). For a certain type of $Pr_i(TO_i)$, in addition to the requirements for the reliability of the functioning of $Pr_i(TO_i)$, requirements for stability in relation to the selected Vp_i are formed. Such requirements provide initial data on the values of the probability of occurrence of Vp_i and the possibility of their influence on $Pr_i(TO_i)$, which should be countered by the SZO_i, protection system. They are formed based on the use of information obtained in the conditions of simulation of the impact on TO_i of possible Vp_i. Such data are the probability of occurrence $Pb(Vp_i)$ and their intensity $It(Vp_i)$. Using $Pb(Vp_i)$, it is possible to determine the time intervals during which the occurrence of Vp_i has certain probabilities. Such intervals in the theory of probability are called confidence intervals, the definition of which requires the distribution function $Pb(Vp_i)$. The value of the corresponding confidence interval is determined as a percentage in relation to the interval on which the distribution function $Pb(Vp_i)$ is determined and based on the data obtained during the $Pr_i(TO_i)$ and SPG_i tests. Data on the intensity of occurrence of events Vp_i, are used to determine the starting points of the forecast intervals, (Chung, AitSahlia, 2003).

The interval of direct prediction of the event Vp_i is determined by the time interval $\Delta\tau(\varphi e)$, during which this process is described by a function φe. For convenience, let's assume that the function φe is active during the time interval $\Delta\tau_i$ *(φe).* The operation process φe is synchronized with the moments of time, which corresponds to the initial moment of the prediction interval ΔTp_i. Such synchronization is necessary because anomalies An_i develops on the interval $\Delta\tau_i(An_i)$, which can lead to the occurrence of Vp_i. The time interval $\Delta\tau_i(An_i)$ begins at the moment when the activity of An_i increases. Such activity is determined by the value of the current value of the key parameter An_i and is confirmed by the increase in the growth rate of the value of this parameter. The moment of transition from $\Delta\tau_i(An_i)$ to $\Delta\tau_i(\varphi e)$ is determined by the change in the value of the threshold $Pj(An_i)$, after which $SU_i(Pr_i)$ cannot eliminate the corresponding anomaly An_i. The ratio for determining ΔTp_i can be written in the form: $\Delta Tp_i = \Delta\tau_i(An_i)+ \Delta\tau_i(\varphi e)$.

4. Parameters for counteracting the negative impact of random events

The main parameters characterizing the effectiveness of using the hybrid forecasting system for the protection of $Pr_i(TO_i)$ include:

- parameter of the degree of determinism of the processes (λ) implemented in the system SPG_i;
- parameter μ, measures of the influence of countermeasures against threats, for $Pr_i(TO_i)$, conditioned by the occurrence of Vp_i;
- parameter of the prediction performance measure (π) provided by SPG_i.

The degree of determinism λ of the SPG_i system depends on a number of factors that are determined to one degree or another by various components of the forecasting system. Therefore, let's divide such factors into the following groups:

- the first group of factors represents numerical data, the interpretation of which is to some extent adequate for the system;
- the second group of factors is usage results data of algorithms used in SPG_i;
- the third group of factors refers to textual descriptions of numerical data and algorithms of the SPG_i system.

Initial data obtained from known sources do not require expansion of semantic components due to the fact that they are used only once when activating the process of system functioning.

The determinism measure parameter λ, in most cases, depends on the factors of the third group, the elements of which are textual descriptions of data interpretation and system components.

The transformation of data Dj_i at the stage of input analysis is carried out within the framework of their mathematical interpretation, which can determine the clarification of data with the aim of possibly increasing the efficiency of their use. In this case, the efficiency of data use leads to an increase in the degree of determinism. All other types of numerical data used in the system correspond to the description of the interpretation, the elements of which are presented in the semantic dictionary Sc_i. Let's assume that the expansion of their semantics can be determined by the situation when, as a result of transformations, additional data appear, which determines the need to expand their semantics.

The textual descriptions of the interpretation of the algorithms used within SPG_i can also be modified during their analysis and transformations.

Modification and expansion of textual descriptions of the interpretation of system components is the main factor in changing the value of the semantic parameters of the elements to which they refer (Hobson, Cole, Hannes, 2022; Thomas, 2020). Such changes may occur as a result of their formal transformations and expansions by elements existing in the dictionary Sc_i. Each element Sc_i has its own semantic significance $\sigma^Z(x_i)$. Text descriptions of interpretation TOI_i consist of informational elements $In_i(x_i)$ that describe data and elements that describe algorithmic means $Al_i(x_i)$. Fragments of the text description of the elements of the algorithmic tools are used to describe the processes of implementation of the functioning of SPG_i. Thus, the text descriptions of SPG_i interpretation not only describe the numerical data of the system, but also describe the algorithmic capabilities of SPG_i functioning processes.

The expediency of using TOI_i in technical systems is determined by the fact that such descriptions have wide possibilities in displaying the processes occurring in the system and the data it uses. The range of such possibilities is determined by the requirements for methods of normalization of texts representing TOI_i. For ease of use of TOI_i, let's assume that the text description $Al_i(x_i)$ represents the text model $TMO_i(Al_i)$ of the corresponding $Al_i(x_i)$. Any TO_i and corresponding processes $Pr_i(TO_i)$ can be described with varying degrees of completeness. The completeness of the description in TMO_i of the process $Pr_i(TO_i)$ is determined by a more or less detailed description of the functionality of individual components in TO_i, which may consist of individual elements. Such elements $\mathscr{k}_{ij}[Pr_i(TO_i)]$ can be replaced, eliminated, or added.

We will show that the transition from TOI_i to TOI_i^*, which is determined by the result of the analysis and transformations of text descriptions in TMO_i if the corresponding logical model $L(Al_i)$, will not lead to the emergence of a contradiction in the logical model $L_i^*(Al_i^*)$ and, as a result, in the system of means implementing the process of functioning of the SPG_i system.

Consider the following statement.

Statement 2. The extension $L(Al_i) \rightarrow L_i^*(Al_i^*)$ as a consequence of the modification $TMO_i(Al_i) \rightarrow TMO_i^*(Al_i^*)$, will not lead to a contradiction within the model $L_i^*(Al_i^*)$.

To prove the statement, consider the transformation of the model $TMO_i^*(Al_i^*)$, into the corresponding logical model $L_i^*(Al_i^*)$ (Korostil, 2012). Let us show that $L_i^*(Al_i^*)$ is not contradictory. The transformation $TMO_i(al_i) \rightarrow TMO_i^*(al_i^*)$, is implemented based on the use of methods of analysis of the corresponding text descriptions of individual elements $al_i \in Al_i$ and their groups. In this analysis, the semantic parameters of the textual description characterizing individual elements $TOI_i(al_{ij}) = j(al_i)$ are used. The unary type semantic parameter is the semantic significance parameter σ^Z for $j(al_i)$. The values of unary semantic parameters are determined on the basis of data on the subject area in which $Pr_i(TO_i)$ functions, and are recorded in Sc_i. The structure of text descriptions consists of descriptions of elements $j(al_i)$ that correspond to the syntactic rules of the grammar of the selected language $\Gamma(Sy)$, which provide the types of text structure accepted in it. To ensure the necessary semantics of the texts, in the grammar of type Г(Sy) binary semantic parameters are used, for example, the parameters of semantic consistency σ^U, semantic contradiction σ^S and others. Therefore, the textual description of the interpretation $TMO_i(Al_i)$ corresponds to the syntactically permissible structures Г(Sy) of the selected grammar and provides an appropriate way of forming the text structure adopted in it. The use of semantic parameters to form $TMO^*_{i\ i}(Al^*_i)$ allows to ensure the semantic consistency of the description of the interpretation Al_i. The textual description of the logic interpretation Al_i corresponds to the algorithms that represent the model $TMO_i(Al_i)$, which describes the corresponding processes $Pr_i(TO_i)$. Thus, the transformation $TMO_i(Al_i) \rightarrow TMO^*_{i\ i}(Al^*_i)$ does not lead to contradictions in $TMO^*_{i\ i}(Al^*_i)$, since the expansion of the text description of the interpretation meets the semantic requirements of their interpretation and the syntactic requirements of Г(Sy). In addition, the extension elements are semantically consistent within the framework of $TMO^*_{i\ i}(Al^*_i)$ due to the use of the corresponding semantic parameters σ^P and do not go beyond the scope of their interpretation. Since $TMO^*_i(Al^*_i)$ is not contradictory, when transforming $TMO^*_i(Al^*_i) \rightarrow L^*_i(Al^*_i)$ we get the model $L^*_i(Al^*_i)$, which is non-contradictory, since it represents a non-contradictory model $TMO^*_i(Al_i)$, presented in a shortened form, which uses semantically consistent element notations, which proves the statement.

The use of the μ parameter, which characterizes the degree of counteraction to the negative influence of Vp_i on $Pr_i(TO_i)$ is aimed at determining the practical degree of implementation of counteraction to the influence of Vp_i on $Pr_i(TO_i)$. The use of this type of parameter in TO_i control systems is mandatory, because within the framework of the SPG_i system it can be considered an analogue of feedback parameters, which in deductive control systems enable the system to adapt to changes occurring in $Pr_i(TO_i)$. The μ parameter also allows for the analysis of the level of security of the $Pr_i(TO_i)$ functioning process in case of external threats. The parameter μ is dimensionless and takes values in the range [0,1]. When $\mu \rightarrow 1$ it means that for all threats from Vp_i the protection system SZO_i provides the necessary protection. If $\mu = 0$, it means that in relation to threats from Vp_i, the system SZO_i does not provide protection for $Pr_i(TO_i)$. In this case, the corresponding $Pr_i(TO_i)$ may go into a catastrophic state. If in the process of functioning of $Pr_i(TO_i)$, the value of μ decreases, it means that new Vp_i arise, the detection and countermeasures of which require the expansion of the capabilities of protection means, or the use of additional protection means.

The determinism parameter λ of the $\mathcal{K}_i$ component of the SPG_i system determines the extent to which the distribution range of the initial numerical data decreases in relation to the distribution value of the input numerical data, which can be interpreted as the values of their mathematical expectations $M_i(D_v)$ and $M_i(D_w)$. But such distribution, in this approach, is expanded and determined by two components of the information element $In_i(x^k_i)$. The first component is the value by which the mathematical expectation $M(D^{\mathcal{K}}_{w,v})$ of the numerical data obtained at the output of the components $\mathcal{K}_i$ is refined. The second component is the amount of increase in the semantic significance of the text model $RTM_i(\sum_j^r TOI_j)$, where TOI_j is a textual description of the elements of the source data $D^{\mathcal{K}}_v$, or other transformation results implemented by the component $\mathcal{K}_i$. This component represents the amount of change in the sum of parameters of semantic significance $\sigma^Z[j(x_i)]$ of all elements $TOI_i \in Sc_i$, which make up the text model of the transformation result. Such a change is carried out by the $\mathcal{K}_i$ component in relation to the values of the input data values, which leads to a semantic expansion of the interpretation of these data. Changing the value of the sum of parameters $\sigma^Z[j(x_i)]$ can be done by replacing elements in TOI_i, for example, from $\sigma_i^Z[j(x_i)]$ to $\sigma_k^Z[j(x_k)]$, for which $\sigma_k^Z > \sigma_i^Z$, and by adding new elements from Sc_i to TOI_i , which agree semantically with the elements in TOI_j within its syntactic structure. For the next steps of analysis and transformations implemented in the $\mathcal{K}_i$ component, not only the numbers Dv_j, but also descriptions of modifications or changes in interpretations that occurred with the data Dv_j are transmitted. Models of such textual descriptions $TMO_j(Al_k)$, allow modification of data transformation in $\mathcal{K}_i$ components with the aim of increasing their degree of determinism.

If $\lambda(\mathcal{K}_i) = 0$, then the component $\mathcal{K}_i$ does not implement determinism changes in the component $\mathcal{K}_j$. If $\lambda(\mathcal{K}_i) > 0$, then transformation $\mathcal{K}_i$ increases the amount of determinism due to refinement of Dv_j, or replacement or addition of elements $k_{ij}(Pr_i)$ in accordance with the following ratio:

$$\lambda(\mathcal{K}_i) = \sum_q^m \sigma^{Z*}[j(x_i)] + \Delta MO_i(D_v).$$

The quantity $\lambda(\mathcal{K}_i)$ is a dimensionless numerical quantity, $\sigma^Z[j(x_i)]$ and $\Delta MO_i(D_v)$ are dimensionless quantities. The component $\Delta MO_i(D_v)$ describes the change in the number of text elements in $MO_i^*(D_v)$, if the text description is expanded.

The efficiency measure π is an integral parameter that combines all the factors taken into account in each individual case of system design SPG_i. For example, the proportionality parameter η, which characterizes the possibility of interaction between parameters of negative influence and parameters of counteraction to this influence, can be taken into account only at the testing stage. Then the determination of the value of the parameter π can be limited only to the values of the parameters $\lambda(\mathcal{K}_i)$ and μ, which can be written in the form: $\pi(SPG_i) = \sum_{i=1}^m \lambda(\mathcal{K}_i) + \sum_{j=1}^k \mu(y_j, x_j)$, where $\mathcal{K}_i$ is the component that realizes the change of determinism in the process of functioning of SPG_i, x_j – is a parameter that characterizes the process of counteracting the corresponding parameter y_j, which characterizes Vp_i and exerts a negative influence on SPG_i.

5. Conclusions

In the work, in accordance with the stages of designing a forecasting system, an analysis of parameters and methods of their determination is carried out. At the first stage of design, a hypothesis is formed about the possibility of predicting the occurrence of a random event that negatively affects the process of managing a technical object. The proposed and described interpretation of the hypothesis provides the possibility of its more effective use. Such an interpretation defines a hypothesis as a description of a forecasting model characterized by a minimal degree of its closeness to the modeled system.

At the stage of stipulation, the occurrence of a random event, the processes of preliminary data analysis are implemented, which allows to increase the efficiency of their use. At this stage, it is possible to determine the magnitudes of the covariance values of the random event parameters with the parameters that characterize the resistance of the technical object to their negative impact. At the stage of condition, the methods of specifying the goal of forecasting are considered, which allows taking into account the features of countermeasures against the negative impact of a random event on a technical object.

At the stage of predicting the occurrence of a random event, the method of implementing this process is investigated. In this regard, the statement about the need to use extrapolation methods, which are implemented on the basis of the use of exponential functions, is proved.

The paper analyzes the method of using parameters related to counteracting the negative impact of random events on the process of functioning of a technical object. One of the key parameters characterizing the degree of, which is the description of its textual interpretation. Changes in the text description make it possible to modify the algorithms of data transformations, which are implemented in the corresponding component. The paper proves the statement that the modification of text descriptions within the framework of the described system does not lead to contradictions in the modified algorithms used in the forecasting system.

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