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The Main Provisions of the Cognitive-Dynamic Approach to Forecasting the Military-Political Situation in the Region

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Abstract. The relevance of the study is due to the need to assess and forecast the military-political situation in order to respond in a timely manner to its possible changes.

The article reveals the main provisions of the cognitive-dynamic approach to forecasting the military-political situation in the region. It is based on the complex application of cognitive modeling, system dynamics, experiment design theory, the method of group consideration of arguments and methods of time series analysis. It implements a new approach to cognitive modeling of complex military-political processes, which makes it possible to build hierarchical models with functional connections instead of sign-weight ones. The proposed approach makes it possible to take into account during modeling the maximum number of significant relationships between indicators (factors), as well as connections between spheres (slices) that describe the functioning of the elements of the system under study, while for the first time the procedure for determining the influence of indicators (factors) on each other is proposed, which takes into account the entire possible range of such influences, including indirect and auto-influences, as well as the possible time of delay in the implementation of the counteraction strategy. which more accurately reflects the real processes when the system's reaction to excitation cannot be instantaneous.

The basis of the approach is the complex use of the theory of experimental design and the method of group consideration of arguments for the construction of functions that describe a priori unknown dependencies between the values of the parameters of the constructed cognitive model of the system of military-political relations and the results of its functioning, as well as systems of differential equations, which are built using graph theory and system dynamics.

With the help of the cognitive-dynamic approach, complexes of forecasts can be developed: exploratory express and hierarchical, as well as normative forecast with subsequent calculation and analysis of the characteristics of the dynamics of the obtained time series for the development of measures to ensure the required level of military security of the state.

Keywords: cognitive-dynamic approach, military-political situation, forecasting, time series.

Introduction

The last years of the 20th century and the beginning of the 21st century are characterized by sharp changes in the political life of both the entire planet as a whole and its individual regions. In the course of modern interstate relations, many political, economic and other contradictions are revealed.

Today, no state is able to defend itself using only military-technical means. Ensuring security is increasingly becoming a complex task that includes political, economic, informational and other measures. It is possible to successfully accomplish this task thanks to the widespread use of economic, diplomatic and other non-force means, as well as information technology. To organize a successful counteraction, it is necessary to understand the geopolitical and military-political processes taking place around and with the participation of Ukraine.

In this regard, the issue of the military-political situation (MPS) in the region around Ukraine, the range of dangers and threats of a military nature, their scale and dynamics of changes over time is relevant. However, to date, the issues of developing a methodological apparatus for assessing, monitoring and forecasting the military-political situation, as well as decision-making to ensure national security, have not been sufficiently studied.

A lot of works are devoted to the issues of MPS assessment both in Ukraine and in other countries. Thus, V. Bogdanovich (2019) offers a general approach to assessing the complex impact of military and non-military means on the state of military security and the military-political situation. Semenyuk Y. (2020) defines the main components of the socio-political situation and their impact on the military security of the state. Stychynska, A. (2022) emphasizes the importance of military-political forecasting to increase the thoroughness of political decision-making. The monographs (Romanchenko, 2023) and (Romanchenko, 2021) explore various aspects of national and military security, offer methodological approaches to their analysis and forecasting. In his works, Bocharnikov V. (2019) identifies the main trends that determine the state of the future global security environment and its projection on security in the region around Ukraine, as well as make a forecast of the development of the military-political situation.

However, these works are mostly of a general theoretical nature and do not provide an answer on how exactly it is possible to predict a possible aggravation of MPS, which may lead to an armed conflict, and provide a basis for the development of recommendations for its stabilization. A significant drawback in this regard is the lack of a perfect approach that would guarantee the identification of dangers and threats at the early stages of their occurrence, assessment and forecasting of the dynamics of their level, taking into account the specifics of the region, the conflict of geopolitical, economic, military and other interests of both the member states of the region and the leading states of the world, whose interests are projected on this region, in order to adapt the system of ensuring the national (military) security of Ukraine to the identified ones in advance progressive threats of a military nature, which determines the relevance of the article.

Methodological Framework

Traditional approaches to the assessment of MPSs usually operate with a relatively small number of factors and are aimed at forming a qualitative description of MPSs, while it is difficult to give a clear assessment of how much MPSs have become more acute, in which area the greatest threats are and where to direct resources to prevent conflict. Therefore, in order to eliminate these shortcomings, a cognitive-dynamic approach to predicting MPS is proposed, which is based on cognitive modeling and system dynamics, as well as the theory of experimental design and the method of group consideration of arguments.

MPSs are understood as a historically specific set of conditions and factors related to the deployment of military-political forces, the nature of their actions and the state of relations between them, the use of military force for political purposes (Picha, 2020).

Usually, MPSs are assessed in qualitative terms – *ordinary*, *exacerbated*, *crisis*, *armed conflict*, or *cooperative* or *confrontational* (Bohdanovych, 2019). With this approach, it is difficult to give an answer about the trends in the development of MPS and the moment of transition from one state to another.

Therefore, it is proposed to use the concept of *MPS status*, which is the numerical equivalent of the relevant qualitative indicator and characterizes the totality of the circumstances of the existence of MPS (Solomytskyi, 2020). Such an indicator will formalize the assessment of MPSs and forecast trends in their development.

Results and Discussions

It is expedient to assess and forecast the military-political situation within the geopolitical region, which includes the state itself and its environment, taking into account the influence of extra-regional centers of power, organization and non-state actors.

The general scheme of the proposed approach is shown in Fig. 1.

At the first stage, a cognitive model of military-political relations in the region under study is being built (Solomytskyi, 2020).

The process of building cognitive art consists of the following stages:

1. Identification of factors that characterize the problem situation.

1.1. Identification of basic factors (concepts) that describe the essence of the problem. Separation from the set of basic target factors, the state of which is desirable to change.

1.2. Determination of influencing factors, which in the model will be potential levers of influence on the situation (control parameters).

1.3. Determination of indicators (parameters) of factors and processes that reflect and explain the dynamics of the development of the problem situation. Grouping into separate blocks of factors that characterize a certain area of the problem (geopolitical, macro- and microeconomic, social, environmental, demographic, sectoral, regional, etc.).

2. Grouping factors into blocks.

2.1. Allocation for each block of partial indicators that characterize in detail the trends and processes under study.

2.2. Construction of a group of integral indicators for each block, which can be used to judge the general trends in a particular area.

2.3. Determination of measurement scales for constructed indicators.

3. Determination of relationships between factors.

3.1. Determination of the direction of influences and mutual influence between factors.

3.2. Determination of the nature of the impact (positive, negative).

3.3. Determination of the strength of influence and mutual influence of factors (in particular, in terms of linguistic variables).

3.4. Determination of relationships between factors of different blocks.

When choosing the factors under study, it is advisable to choose only those that have a significant impact on the system as a whole.

At the same time, in contrast to existing approaches to building cognitive models:

– to describe the structure of military-political relations, we will use hierarchical cognitive maps (the number of hierarchical levels can be determined by the required level of detail during research), as a result of which we will obtain a complex multi-level directed graph;

– to describe the connections in the model, we will use a cognitive model of the "vector functional graph" type, where each of the connections (arcs) of the resulting graph is described by a function;

– to reflect the dynamics of the system functioning under the influence of factors, time is introduced into the model.

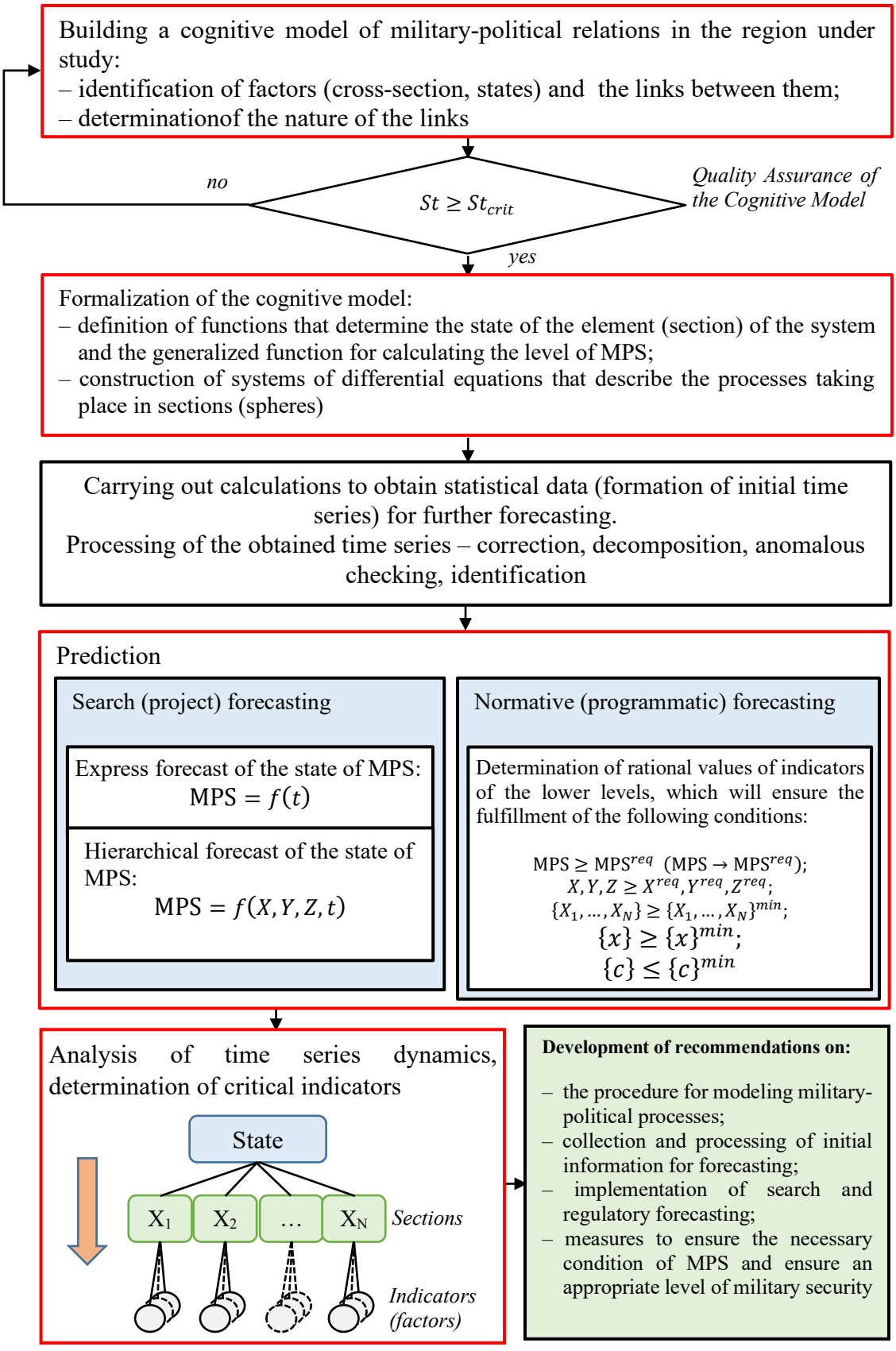


Figure 1. General Scheme of the Cognitive-Dynamic Method of Forecasting IDPs in the Region

– to determine the weighting coefficients, an extended analysis of the relationships between the vertices is carried out (three types of influences are possible, for which the corresponding weighting coefficients are determined: auto-influence (the influence of a factor (slice, sphere) on itself), characterizes the efforts of the national government aimed at maintaining (developing) this factor; the influence of a factor on itself through the influence on another factor, characterizes possible changes in a factor due to an attempt to influence another factor; the influence of a factor on another factor, according to the classical approach, characterizes the influence of one factor on another);

– when describing the connections, we will foresee a possible time delay in the reaction of one party to the actions of the other – the time of *implementation of counteraction strategies*. Taking into account this time will allow us to more accurately describe the real processes taking place and explain why, even with the availability of the necessary forces, means and resources, one side of military-political relations is not able to adequately respond to the actions of the other state;

– when constructing a hierarchical cognitive map, we will take into account not only the connections within one slice (sphere), but also the impact between sections both within the same state and between different sections (of the same and different names) of different states (Shebanin, 2022) and (Forrester, 1961).

In contrast to existing approaches to constructing cognitive maps, a new approach to determining the weighting coefficients ω_{ij} is proposed.

It consists in an extended analysis of the relationships between vertices, in which not only the direct influence of one factor on another is evaluated, but also the inverse influence of the first factor on itself as a result. That is, each of the links will be characterized by two weighting coefficients. At the same time, these coefficients can change over time discretely or according to a certain law.

However, military-political processes are multidimensional, so it is proposed, if necessary, to build a tree of goals for each of the elements. That is, the value of each of the defined elements can be a function of a certain set of lower-level indicators.

To take this into account, it is proposed to move to a hierarchical (multi-level) cognitive map. That is, for each of the elements, a list of indicators is determined, on which its value depends. This procedure can be repeated until the desired level of detail is achieved.

An important element of checking the performance of the constructed cognitive map is its static analysis, which generally consists of the following stages:

1. Determination of the final (cumulative) mutual influence of factors on each other, taking into account both direct and indirect influence, when one factor affects another through a chain of intermediate factors. On this basis, a matrix of mutual influence is built.

2. Calculation of the system indicators of the cognitive map according to the constructed matrix of the final interaction, such as the influence of the factor on the system and the influence of the system on the factor.

3. Analysis of the interaction of factors on each other.

The constructed cognitive model should be tested for structural stability and excitation resistance (Grzesik, 2020). That is, it is proposed to consider two aspects of the concept of "stability": the stability of the system under the influence of external perturbations with a fixed structure of the system (this is a situation when only the external environment changes), and the stability of the system's behavior under changes in the structure of the system – structural stability (this is when small changes in the structure of the system cause small changes in its dynamics). If it meets the quality requirements, then the model can be considered as an initial one for further research, formalization and calculations.

The next step is to formalize the constructed cognitive model and determine the type of functional relationships between elements and functions that describe the state of each of the elements. To do this, an approach is proposed, described in detail in (Solomytskyi, 2020), which consists in determining the a priori unknown relationship between input and output variables based

on the integrated application of the theory of experimental design, expert survey and the method of group consideration of arguments (MGCA) (Ivakhnenko, 1982).

For further assessment of the military-political processes that take place in the studied system in time, it is proposed to build an appropriate system of differential equations. For this purpose, we will use the provisions of the theory of differential equations on graphs (Kopas, 2018) and (Kurbatova, 2020).

Given that we already have a directed graph, we can relate the properties of the solution of the system of equations to the geometric properties of the graph. According to Kopas, 2018, important properties of solutions are determined only by the geometry of the graph and do not depend on the form of functions that describe the state of its vertices. The task of studying military-political processes according to the above approach is close to the typical formulation of the problem of constructing systems of differential equations on networks, related to the study of hydrogrids, in the scalar formulation.

To directly construct differential equations that will describe the behavior of graph elements in time, we will use a formal rule to write a system of differential equations (Kopas, 2018). In this case, the state of the vertex (element) of the system will be considered directly as the probabilities of the states, and the degree of influence of the vertices of one on the other will be considered as the intensity of the transition. That is, in the left part there will be the derivative of the element, and in the right part – the sum of the products of the states from which the connections in this element are derived, by the degrees of influence of the corresponding connections, minus the total degree of influence of all the connections that come from this element multiplied by the value of this state.

The cognitive model formalized in this way allows to calculate the values of the relevant indicators that characterize the state of the elements of the system and the system as a whole, which makes it possible to obtain initial statistical data for a certain period of time – time series. They are subjected to standard processing (adjustment, decomposition, checking for anomalousness and non-stationarity) and bringing them to a single form (Yurchenko, 2018).

The obtained time series are the initial data directly for building a forecast. However, for forecasting, it is necessary to determine its fundamental possibility, that is, to determine the presence of a certain trend. For such a pre-forecast analysis, it is advisable to use Hearst's statistics – the "normalized range", which allows you to establish the fact of the presence of a trend in the time series.

In contrast to existing approaches, it is proposed to develop two types of forecast at once, which differ in terms of the problem-target criterion (the purpose of developing a forecast):

– search (research) – determination of possible states of the system (phenomenon) in the future;

– normative – determination of ways and terms of achieving possible states of the system (phenomenon) accepted as a goal.

The development of the search forecast is carried out with the help of MGCA. However, it should be noted that within the framework of this forecasting, several subtypes of search forecasts can be developed: operational (express); hierarchical (for the appropriate number of levels).

For operational forecasting, a forecast of the time series of MPS levels obtained using a previously created model is built. It usually has low accuracy, but it allows you to make a preliminary analysis of trends in the development of MPSs and prepare appropriate recommendations.

The hierarchical forecast is built in accordance with the hierarchy of the developed model sequentially from the lower levels, when changes in each of the indicators are predicted, and on the basis of the data obtained, the indicators of higher levels are calculated, that is, the chain "indicator-group of indicators-cross-section-state- MPS " is sequentially calculated:

$$MPS = f(X, Y, Z, t),$$

where X, Y, Z are indicators that characterize the state of the state (its contribution to the state

of MPS) and, in general, are functions of lower-level indicators, for example: – dependence of the state of $X = f(\{X\}, \{Y\}, \{Z\}, t)X$ on the states of cuts and time;$\{X\}, \{Y\}, \{Z\}$, t –time.

Such a forecast has a higher accuracy than an express forecast and allows you to identify critical indicators and develop more reasonable recommendations to counter possible threats.

Normative forecasting, as mentioned above, should determine what values the relevant indicators should acquire from those that affect the status of IDPs in order for the status of IDPs in the region to reach the required value. That is:$VPO^{\text{потр}}$

$$MPS = f(X, Y, Z, t) \geq VPO^{req},$$

provided that the indicators of the lower levels are not less than and at the minimum allowable, and the amount of resources either does not exceed the allocated or minimal.

For the task under consideration as a search engine optimization algorithm, it is proposed to use the QUEST search procedure (OptQuest, 2023).

It does not necessarily guarantee the achievement of an exact optimum, but it finds solutions that are close to optimal and at the same time provides fast search convergence of the algorithm. This procedure uses search results for "self-learning," allowing you to intelligently search for the next set of alternatives. If an alternative in its search space does not meet user-defined constraints, it is automatically excluded and other options that are more likely to meet the requirements are explored. The optimization procedure uses the input of the behavior model to evaluate the input of the model. The optimization procedure performs a special "non-monotonic search" where the resulting sequentially generated inputs are different estimates, not all of which are upward, but which subsequently provide a highly efficient path to the best solutions.

The results of the optimization serve as the basis for making a decision on taking measures to ensure the desired condition of They determine what indicators and at what level it is advisable to have to ensure the achievement of the set goal. In order to develop recommendations to ensure the necessary condition of MPS, it is necessary to analyze the dynamics of the relevant military-political processes, the values of which were predicted. That is, the absolute levels of instantaneous or interval time series, as well as the levels of average values, must be converted into relative values (Yurchenko, 2018). It is proposed to carry out a similar analysis according to the following characteristics of the dynamics of the time series: absolute growth; growth rate; growth rate; growth rate;

In addition, it is proposed to determine a set of critical indicators by comparing the numerical values of indicators at each of the levels under study with the limit values of these characteristics. It is advisable to leave the choice of specific limit values of indicators to experts or a decision-maker, based on the goals set for them for the future development of the country, and the system of criteria that they are guided by.

That is:

$$g_h \leq g_h^{gr} \begin{cases} yes, g_h \in G^{crit}; \\ no, g_h \notin G^{crit}, \end{cases}$$

where is the value of any indicator;g_h

g_h^{gr} – the accepted limit value of the h-th indicator;

G^{crit} – a set of critical indicators.

Based on the results of the search and regulatory forecasting of MPS in the region, groups of countries, internal situations in individual countries, as well as the analysis of the characteristics of the dynamics of the time series, decisions are made on the necessary measures to ensure the military security of the state.

Conclusions

The proposed cognitive-dynamic approach allows solving the problem of assessing and

forecasting the military-political situation.

The novelty of the approach lies in:

– the use of a new approach to cognitive modeling of complex military-political processes, which allows building hierarchical models where functional connections are used instead of sign-weight ones;

– in the first proposed approach to determining the influence of indicators (factors) on each other, which takes into account the entire possible range of such influences;

– complex use of the theory of experimental design and MGUA for the construction of functions that describe a priori unknown dependencies between the values of the parameters of the system and the results of its functioning;

– complex application of systems of differential equations, which are built using graph theory and system dynamics, and functionals to describe the course of military-political processes in time;

– development of a set of forecasts: exploratory express forecast, exploratory hierarchical forecast and normative forecast, followed by analysis of the characteristics of the dynamics of the obtained time series and determination of critical indicators.

The direction of further research can be the development, on the basis of the data obtained, of recommendations on the procedure for modeling military-political processes.

Recommendations

The materials of the article can be used in the preparation of proposals for the formation and implementation of Ukraine's military policy. The article can also be useful for specialists of information and analytical services, scientists and analysts who are involved in the development and justification of state decisions in the military-political sphere, for the teaching staff and students of higher military educational institutions.

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