Bifurcation Prediction Method for the Emergence and Development Dynamics of Information Conflicts in Cybernetic Space

Oleksii Pysarchuk[1] [0000-0001-5271-0248], Andrii Gizun[1] [0000-0002-2974-6987], Andrii Dudnik[1] [0000-0003-1339-7820], Vladyslav Griga[0000-0002-1408-5805] and Tetiana Domkiv[1] [0000-0002-1625-7754], Sergiy Gnatyuk[1,2,3] [0000-0003-4992-0564]

[1] National Aviation University, Kyiv, Ukraine
[2] State Scientific and Research Institute of Cybersecurity Technologies and Information Protection, Kyiv, Ukraine
[3] Yessenov University, Aktau, Kazakhstan

andriy.gizun@gmail.com, s.gnatyuk@nau.edu.ua

Abstract. The article discusses the solution to the problem of predicting the occurrence and dynamics of the development of information conflicts in cybernetic space. The frequency of occurrence of an analysis unit in the blogosphere was chosen as an indicator reflecting this process. The analysis of information threats is considered as a multifactorial process that reflects all spheres of society's life. The superposition of multifactorial trends obtained by non-linear optimization convolution gives a model that can have bifurcation points. The developed technique is aimed at searching for bifurcation intervals for planning effective methods of counteracting negative information influences.

Keywords: bifurcation forecasting, cybersecurity, information conflicts, cyberspace, information security.

1. Introduction

To date, a significant increase in the role of informational influence to achieve the economic, political, military goals of any power has become apparent. Information influences have been conducted all the time since the existence of mankind and its socio-political structure. At the same time, the active development of information technology in the last decade has led to a qualitatively new understanding of the development and use of information impacts. The consequence of this was the emergence of hybrid confrontations. Asymmetric hybrid actions produce sometimes unexpected results even for the aggressor, as evidenced by recent local wars, conflicts, revolutions, etc. [1-4].

A separate, specific area of distribution of means of informational impact is cybernetic space. Its popularization, globality, efficiency, relatively low controllability, novelty and dynamism of development, a variety of forms, methods and genres of information supply, new social communicative forms and psychological

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consequences generated by it form new challenges for information security along with existing threats.

Effective opposition to information impacts (IW) is possible in the case of the organization of coordinated, creative and dynamic systematic work to implement the tasks of quickly identifying, protecting and countering information threats (IE) that cause information conflicts (IC). Timely and adequate response to identified IU requires accurate data about: their level of danger and priority in neutralization; development trend and dynamics; critical time points and intervals of development dynamics. This makes it possible to rationalize the distribution of forces and means of counteraction against goals, objectives and time, as well as to increase the adequacy of planned and implemented measures to neutralize identified DIs and prevent them from developing into dangerous infrareds. This task is especially relevant in conditions of a high density of occurrence flux, dynamics of development and transformation of IR, which is typical for cyberspace.

In this regard, the urgent task is to develop effective approaches to predicting the emergence and development of information conflict in cybernetic space.

2. Analysis of existing approaches

An analysis of practical approaches to solving the problems of forecasting infrared in cyberspace shows a rather low level of automation, which does not provide high indicators of efficiency, reliability and completeness of measures to neutralize them. At the same time, there is a fairly wide range of publications devoted to the issues of modeling informational influences generated by processes and social phenomena. [5-9]. The well-known approaches have many positive aspects, however, they are based on decomposition analysis and forecasting of each individual information security, which somewhat contradicts the complexity of the reaction of the target to these threats.

The task of forecasting the occurrence and dynamics of the development of information conflicts in cyber space can be classified as a task of statistical analysis. Methods known in this field are based on processing experimental redundancy of temporal or parametric data using recurrent or posterior methods of smoothing (estimating) the parameters of the process under study, but actually the parameters of approximating models [10]. The models thus formed possess prognostic properties of the analysis of the processes under study. Despite the variety of specific smoothing algorithms (polynomial smoothing by recursive procedures, the classical least squares method), nonlinear smoothing by modified forms of least squares, etc.) they are all based on the use of smooth, monotone functions that satisfy the Dirichlet conditions [11]. Practice shows that the processes of occurrence and the dynamics of changes in information conflicts as information and social processes have a mixed, monotonous-peak character with the emergence of qualitatively new reactions (processes), while developing alternatives. This circumstance requires finding ways to build adequate models of the process of the emergence and development of IC in the field of synergetic methods using fractal representations, catastrophe theory and the search for bifurcation phenomena [12,13].

The aim of the article is to develop a bifurcation forecasting technique for the occurrence and dynamics of the development of information conflicts in cyber space.

3. Research methods and key findings

We will implement the solution to the problem of forecasting the occurrence and dynamics of the development of information conflicts in cyber space according to the classical scheme: observation of the process under study and measurement of its characteristics (accumulation of experimental data); synthesis of a mathematical model and determination of its parameters consistent with experimental data; predicting the dynamics of the development of the investigated process in accordance with the adopted model [10]. In this regard, the most important stage is the synthesis (construction, definition) of a mathematical model for predicting the occurrence and dynamics of the development of information conflicts in cyber space, which is characterized by a high degree of adequacy. The article is devoted to the solution of this problem.

To build an adequate model of the process under study, it is necessary, first of all, to study it in detail, formalize and describe with highlighting the features and patterns. As the basic concepts in the field of information security, the article uses the terminology that has a generally accepted interpretation [14,16], that they reflect is illustrated by the diagram in Fig. 1.

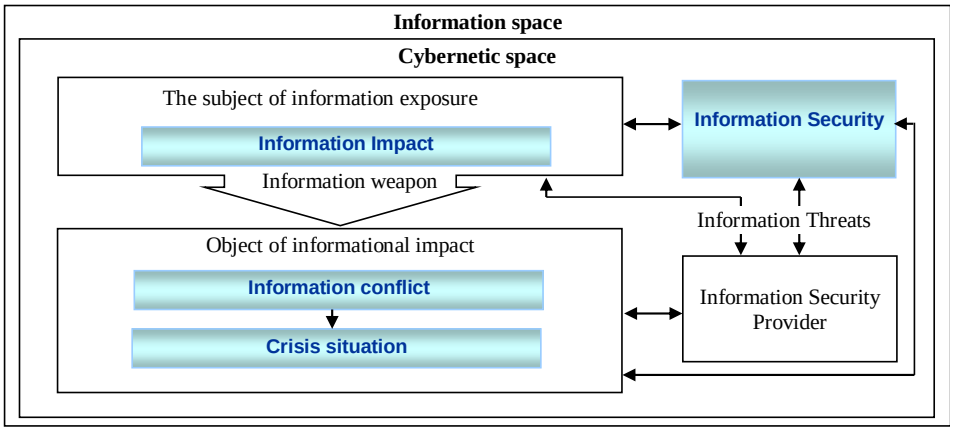

Fig. 1. The relationship of basic concepts in the field of information security

The key category of informational (informational-psychological) influences (IPV) is the individual, i.e. directly the object of IW. In this case, the main goal and result of informational impact is the generation of informational conflict (IW) to change the beliefs, behavior and actions of the target.

The mechanisms of the emergence and development of information conflicts in cyber space.

The procedural description of the emergence and development of information conflict. The information conflict is generated by the information content of the directed content, intended for the transformation of consciousness or modification of the actions of the object of influence. In turn, information content has the property to develop, modify and transform in cyberspace after evaluating (viewing, primary perception) by its object of influence. We will call the development and modification of information generated in the consciousness of the object of influence the required opinion, and the degree of perception of information - the stability of opinion. The development and modification of information content is associated with the psychological aspects of the perception of information by an individual, which include receiving information, understanding it, creating an emotional reaction and transmitting this content, reinforced by one's own emotions, through cyberspace to other individuals. As a result, with the correct management of the information impact, a certain resonance of opinions can be achieved, which is the result of cognitive dissonance (the result is information conflict), which consists in the perception or antipathy of information content by the target, the ability to cause a positive or negative reaction, etc.

Information and information-psychological impact is implemented in a sequence of well-known stages, reflecting a diagram of the change in the frequency of occurrence of information content in the information environment [15]:

1. Information stage – the creation of a relevant or resonant informational occasion;
2. Stage of activation – popularization of an information occasion;
3. Achievement of the goals of IW by bringing the informational occasion to informational conflict – the target stage;
4. The final stage is the consolidation of the goals of IW.

The scale ratio of the duration of the IPV stages is also characterized by the scheme in Fig. 2.

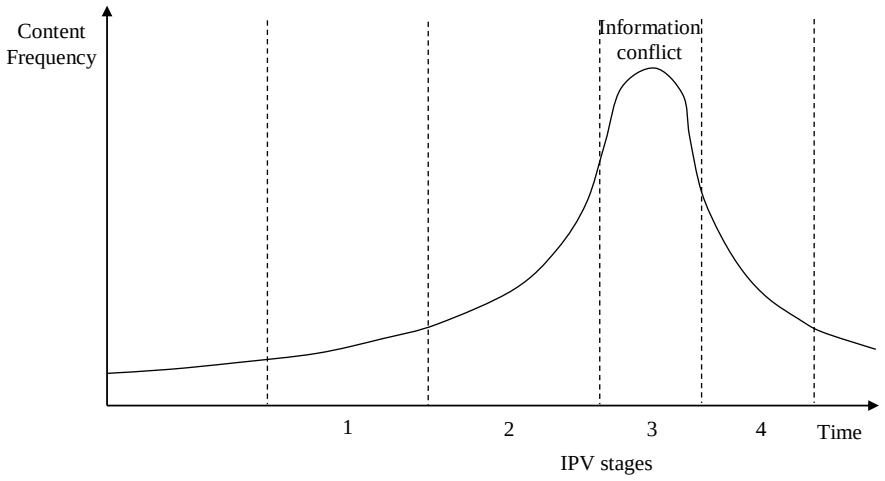

Fig. 2. Scheme of the procedural description of IW

Thus, we have a monotonous trend in the frequency of occurrence of target content in cybernetic space.

Traditional approaches to describing the dynamics of change and predicting the development of information conflicts are based precisely on a similar representation and description of the process of implementing IPV. That is, in the form of a one-dimensional, one-factor, and monotone model [14-17]. In this case, the object of influence is abstracted to the level of the "black box" which is characterized only by a reaction to IPV. The law of reaction change is most often chosen by the simplest one - linear or non-linearly monotonic. This approach greatly simplifies the analysis of IPV processes and is based on the principles of trivial empirical practice, which does not reflects the underlying processes of IPV. This circumstance leads to the planning and implementation of counteraction processes after the fact, i.e. in the form of a reaction to IR. As a result, we have the principle of permanent situational reactions to individual manifestations of IPV with a constant shortage and inefficient use of forces and means to implement counteraction to negative information influences. In the practice of counteracting negative IPV, the time interval for exposure and counteraction is limited to only a few months [14-18]. This circumstance contradicts modern concepts and practices of conducting hybrid aggressive actions, when information exposure is conducted continuously, and the peak manifestations of individual forms of IPV are only stages of escalation to achieve the goals of exposure mainly at the local level [1-4].

Thus, the traditional model representation of IPV does not explain the reasons and does not allow to determine the characteristics of the reaction of society to such an impact. When and how does a change of opinions and the behavior of objects of influence occur. What informational reason is priority in neutralizing, how they are formed into a single plan, and what ultimate goal they pursue. At the same time, there are many well-known approaches of in-depth analysis of processes in complex social and sociotechnical systems, successful examples of using synegetics methods to describe self-organization processes in them, productive multidimensional data mining based on OLAP and Data Mining technologies. In this regard, the article shows the possibility of using system analysis, methods of synergetics, statistical data processing, multi-criteria optimization, data mining, general scientific methods for studying social phenomena for bifurcation forecasting of the occurrence and dynamics of information conflicts in cyber space [3,12,13].

Patterns of development of information conflicts as a reaction of the object of influence on IPV. The forecasting process of the emergence and development of information conflicts in cyberspace, in fact, is the reaction of an individual, group or society to information in general and to IPV in particular. Therefore, for the formation of an adequate model of this process and the choice of its class, a detailed analysis of what is happening in society after an informational stuffing is necessary.

Informational impact belongs to the sphere of "soft" influences and is procedurally more consistent with chaos theory as applied to social phenomena [1-3,19,20]. In this perspective, society is seen as a complex system to which the methods and categories of system analysis and synergetics are applicable. In addition, taking into account the specifics of the process of informational impact, modern society can be considered as a complex sociotechnical system. Then, the development of society and the social phenomena occurring in it should be considered as a process

of self-organization with respect to the attractor system (national idea, value orientations of society and an individual individual, moral laws, traditions, etc.) [21]. The dynamics of this development is described by phase trajectories. In the simplest cases, the level of reachability and approaching the attractor, its essence, value and relevance determine the stable and critical sections of the development of society. Stable conditions of society are characterized by monotonous, well-predicted dynamics. Critical sections in the development of society can be characterized by complex nonlinear dynamics, have bifurcation points (sections) that generate phase transitions, jumps and stratifications of phase trajectories - chaos in a sociosystem. Sustainable sectors are characterized by a consistent smooth evolution of society, and critical, various qualitative transitions, including revolution. The presence of areas and points of bifurcation in the development of society is a natural process, without which the phenomena of stagnation and degradation are possible. The presence of bifurcations means an alternative to development after the stage of asymptotic saturation - a qualitative transition in evolution. It can be positive or negative up to a change in the attractor system. Near the points of bifurcation transitions (bifurcation regions), the sociosystem is in an extremely unstable state. At the same time, ultralow impacts on society, under certain conditions, can give rise to catastrophic reactions and fluctuations – to chaos [21]. Subsequently, the system, under the influence of internal or external control mechanisms, or according to the laws of self-organization, follows the old one or acquires a new phase trajectory tending to a system of attractors. The specifics of the phase trajectory is determined by the nature and tasks of control, self-organization, and the attractor system (see Fig. 3).

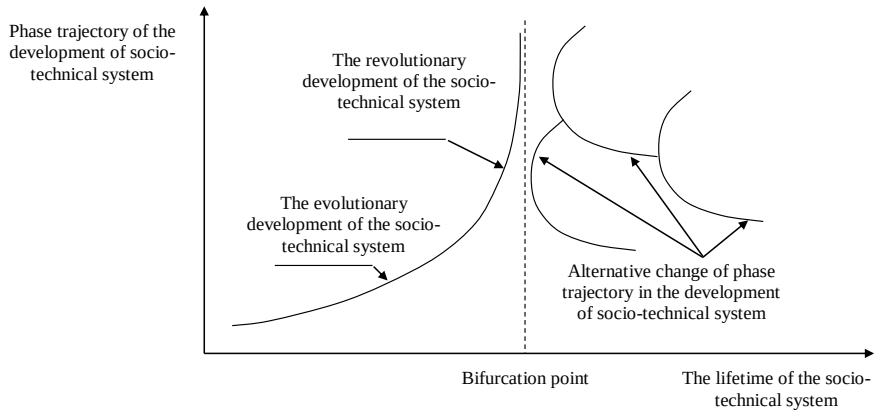

Fig. 3. Bifurcation transition of the phase trajectory of the socio-technical system

In the presence of mechanisms of internal or external influence, we have the phenomena of controlled chaos. Similar processes exhibit analogies in many phenomena of the animate and inanimate nature of the macro and micro worlds and are described by the fundamental mathematical methods of synergetics [12,13]. The applicability of synergetic methods is possible only for systems that provide conditions for self-organization and self-development [13]. The sociotechnical system certainly satisfies these conditions.

It can be reasonably assumed that the IW process, in the formalization used, has for the purpose of bringing the sociotechnical system (or its individual elements - the individual, their groups, etc.) to the area of bifurcation, intercepting internal control and bringing society to the required attractors by given phase trajectory. Thus, bringing society to instability - chaos and its management is the essence of the IW process and the achievement of its goals. Such formalization of the IW process certainly entails its abstract description and moves away from practical terminology, but provides the possibility of a mathematical description with the subsequent automation of the stages of neutralizing negative IW. In the future, this will make it possible to obtain adequate, operational, accurate and optimal solutions to the mathematical problems of identification, forecasting, resource allocation, planning and evaluation, which are the basis for the steps to counteract the negative information impact

Advanced research devoted to the study of the modern IPV paradigm is based on the representation of the object of influence (modern society) as a complex social or sociotechnical system [21,22]. From the perspective of IPV, society can be represented as a complex hierarchical structure with feedback, with memory and self-regulation. The system can be in stable and unstable states, which can give asymmetric IPV results depending on the state of the system. Minor impacts can cause avalanche-like processes if the system is unstable. The latter circumstance is exacerbated by the emergence and development of cyberspace in the last decade, which, in fact, forms a sociotechnical system in which huge flows of publicly available information circulate. It is cyberspace, today, that is the prevailing field of realizing IW.

The above allows us to make an important assumption, which are essential for predicting the emergence and dynamics of the development of information conflicts in cyber space. The presence of mechanisms of self-regulation and self-organization of society as a reaction to IPV leads to the need to consider not bifurcation points, as applied to the description of phenomena in a complex social or sociotechnical system, but about *bifurcation sites (or intervals)* [21].

The root cause in the field of ensuring information security, the emergence of social biffurcation processes are information threats. In turn, information threats can cover critical areas of the individual, individual groups, society - the state as a whole (see Fig. 4): political; economic; social; spiritual; legal; personal; national security and defense [23,24]. This is one of the options where information threats are realized, no less important is the consideration of threats to the value orientations of society and the national interests of the state.

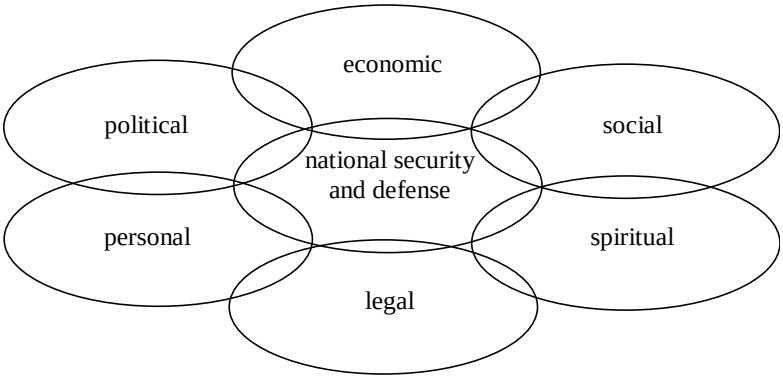

Fig. 4. Critical areas of society

Each of these areas may have a hierarchical structure in the form of areas and sub-areas, for example, the field of national security and defense may include: environmental security; energy independence; information security (information protection, information-psychological, cybernetic), etc. In turn, each of the critical areas of activity is characterized by the specifics of the object of influence: an individual (ordinary citizen, middle management, decision-maker at the level of organization, state institution, society as a whole); a group of people (by social (cultural, spiritual) interests, corporate structure, organization); the state as a whole; interstate entities, unions, etc. For these hierarchical structures, it is possible to formulate a list of indicators (signs) of information threats on the basis of which key phrases of units for analyzing the content of cyberspace information messages are generated. Thus, we have the hierarchy of Table 1, which is a methodological basis for constructing relevant classifiers of information threats, for example, in the form of implementations considered in publications [23,24].

Table 1. Hierarchy of relevant classifiers of information threats

Critical Areas			**Object of Impact**	**Threat indicator (sign)**	**Unit of analysis**
Sphere	**Region**	**Subregion**			
Threat class	**Threat group**		**Type of threat**	**Threat signs**	
political			individual		
economic			mid-level management		
social			organizational decision maker		
spiritual			government decision maker		
legal			state decision maker		
personal			group of people on social cultural, spiritual interests		
national	environmental		corporate		

security and defense	Safety		structure, organization		
	energy independence		society		
	Information Security	protection of information	interstate entities, unions		
		psychological information			
		cybernetic			

Considering the classification structure of information threats of Table 1 in the time domain, we obtain the problem of bifurcation prediction of the occurrence and dynamics of the development of information conflicts in cybernetic space from the mathematical point of view as the task of multidimensional, multivariate statistical analysis of a large amount of time-varying information. To do this, it is proposed to use general scientific methods of system analysis, synergetics, statistical data processing, multi-criteria optimization, data mining with OLAP and Data Mining technologies [25]. A multidimensional display of the dynamics of the development of IC allows us to assess the level of threats, for example, according to a three-level classification, indicated schematically in Fig. 5.

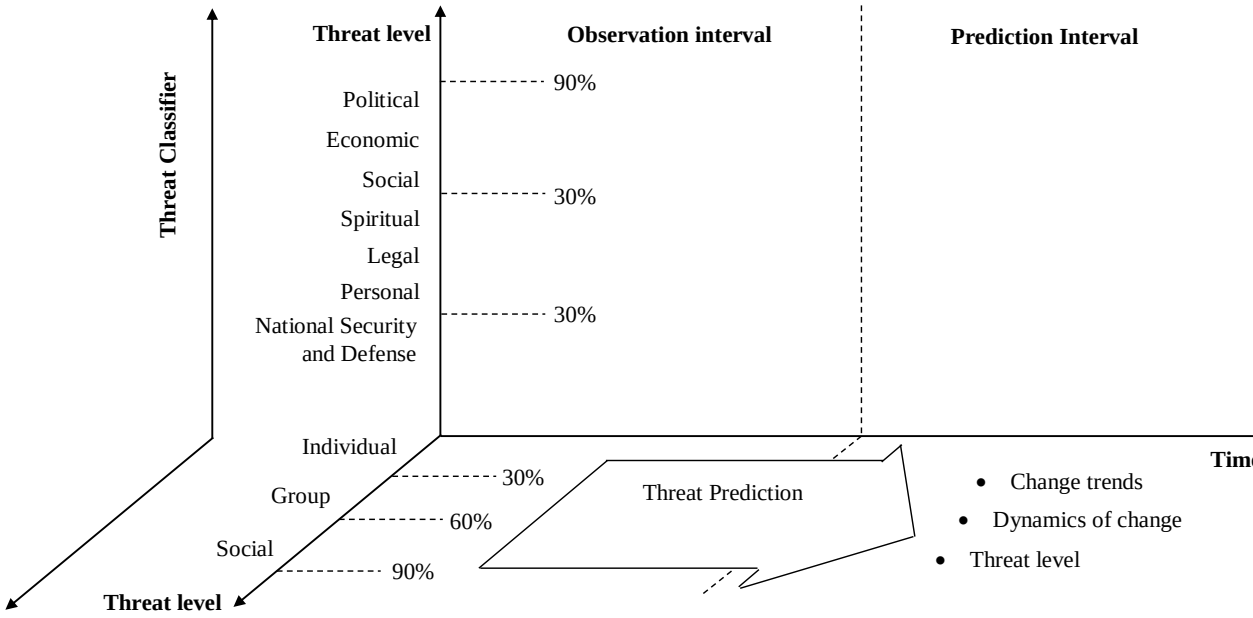

Fig. 5. The multidimensional and multifactorial nature of information threats

Formalizing the problem of predicting the occurrence and dynamics of the development of information conflicts in cyber space.

Prediction is the process of reaction (response) of society to the information impacts exerted on it, distributed in cyberspace. The essence of formalization is to describe the processes occurring in the social environment, generated by informational impact, by mathematical categories. To this end, it is proposed that the real subject area of social phenomena be displayed by methods of the theory of complex synergetic systems with the subsequent formation of statistical mathematical models that describe the dynamics of IC. Such a process has an analogy with operator methods for solving complex nonlinear modeling problems in combination with abstraction techniques and reduction-induction mechanisms for using simulation results [11].

To formalize the task of predicting the occurrence and dynamics of the development of information conflicts in the cybernetic space, three strata are used to sequentially map the real social stratum and the processes occurring in it into abstract categories - system and model strata (see Fig. 6).

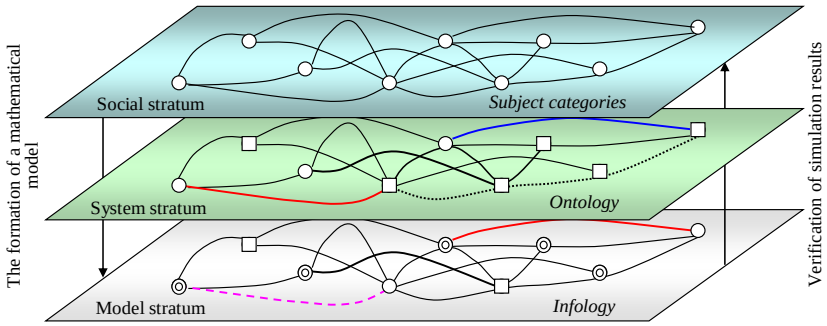

Fig. 6. Decomposition of the IR simulation problem

A social (real) stratum has the properties of a natural adequate display of the process of informational impact, while the forecasting of the generated phenomena is possible only by subjective empirical or heuristic approaches. The accuracy and efficiency of such a prognostic approach is quite low and is determined by subjective competence and experience. The popularity of using such a forecast can be explained by poor knowledge of the real subject area or by the difficulty of formalizing the forecasting problem and creating mathematical models of the processes under study.

The system (intermediate) stratum leads to the introduction of abstractions of the first level, but in compliance with the adequacy of the display of the real social stratum. The emergence of abstractions of the first level is due to the transformation of real social processes into subjective knowledge about them, the capabilities of system analysis methods. This stratum is necessary to describe the systemic synergetic properties of society and the processes occurring in it - the whole is greater than the sum of the parts. The conditionality of using the theory of complex systems and synergetic methods for a system stratum is confirmed by the results of studies by many authors studying complex processes in social and economic fields, in technical systems, objects of animate and inanimate nature [12, 13, 21, 22].

At the level of the system stratum, we will consider society with its hierarchical state structure, which is in interaction with cyberspace as a complex sociotechnical system. The processes of state (intrasystem) management implemented in such a

system give it the properties of a cybernetic system. Then the information impact on the socio-technical system should be considered as an interfering effect or external, in relation to public administration (see Fig. 7).

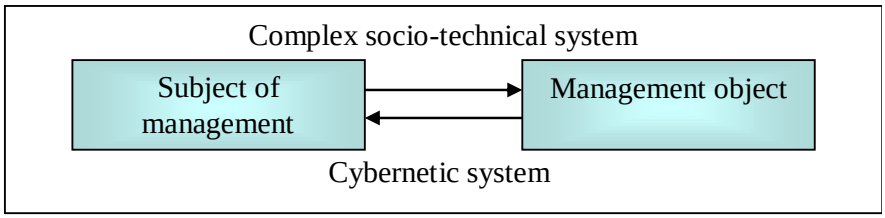

Fig. 7. Socium as a sociotechnical system

Elements of the socio-technical system are individuals and their associations (groups). Between the elements of the socio-technical system there are complex concentric informal (family, online communities, labor collective, network structures, interest clubs, non-traditional religious communities, foundations, etc.) and hierarchical state, formal (state institutions, official parties, traditional religion, etc.) communication. Then the processes occurring in such sociotechnical systems are described and explained by the categories and laws of synergetics.

The development of the system is characterized by a phase trajectory. The direction of development is determined by the system of attractors. The processes of evolutionary development of a sociotechnical system along a predetermined phase trajectory relative to a given attractor system are the result of internal control actions and self-organization processes. The revolutionary processes of the development of the sociotechnical system, accompanied by bifurcation processes, catastrophes with a change or stratification of phase trajectories, a change in the system of attractors can be generated by external control processes with possible resonance of internal processes of self-organization. As the latter, in this paper, we consider the information impact.

The model stratum has the properties of a rigorous mathematical description of the process of predicting the occurrence and dynamics of the development of information conflicts in the form of statistical mathematical models generated using the bifurcation phenomena of synergetics. This stratum gives rise to second-level abstractions due to the limitations and simplifications of the generated mathematical models. However, the accuracy and operational characteristics of forecasting results will be higher than the results obtained in the social stratum. The subjectivity of model results is determined only at the level of formation of the system and model strata and can be estimated and reduced a priori. This circumstance is the advantage of using modeling methods to predict the occurrence and dynamics of the development of information conflicts in the cybernetic space under conditions of a high density of occurrence flux, the dynamics of the development and transformation of IR.

The used analogies of the categories of sociology, complex technical systems, and the provisions of the theory of synergetics summarized in Table 2 are conditional and proven in numerous well-known publications [12,13,21,22].

Table 2. The categories of sociology, complex technical systems, and the provisions of the theory of synergetics

Categories		
Sociology	**Synergetics**	**Complex systems**
Individual, group	System element	System element
Social	System	System
Communicative mechanisms	Element relationship	Element relationship
Community development	Phase trajectory	Functional dependencies
Values, goals	Attractor	Extremum
Revolutionary processes	Bifurcation	Critical points
	Catastrophe	Asymptotic behavior
Social device	System properties	System properties

Thus, the process of the emergence and development of information threats and conflicts that grow into CS, generated by the target information impact, which is realized in the global cyber space of the Internet network and undergoes a change in the mood, judgment and behavior of the affected objects - the individual, individual social groups or population, is subjected to modeling generally. As a controlled indicator (measure) of the simulated process, the number of publications (messages) containing a key phrase (analysis unit) from the list of information threats on sites of various classes was selected.

*As a parameter that numerically characterizes the dynamics of the development of the K*C, the number of information messages K_j^{ik} on global Internet sites containing an information unit ik at a time j will be used. By an information unit we mean a word or phrase whose content (content) reflects a topic, concept or event that generates a CS [23,24].

Modeling of CS is carried out unitarily for each CS and their classes with their subsequent aggregation. The behavior of aggregated CSs is supposed to be built according to the biffurcation model, which after the bifurcation point can reflect (stratification, positive or negative dynamics of development) the result of IPV - a change in moods, judgments, behavior in the object of influence, which can generate a new active topic (themes) and CS, respectively.

The generated model should provide a high degree of accuracy in predicting the development of CS for the formation of decisions about: the most dangerous CS and information content at the current and given point in time, the dynamics of changes in CS in time; the current and forecasted state of a specific and (or) all emerging CS; quantitative characteristics of the COP and their changes for a given time interval; time of the bifurcation points of the CS This information is used for the purpose of: rational allocation of resources for monitoring the COP by topic and information source; planning effective measures to neutralize the negative information impact; warning (decreasing) the level of bifurcation processes in the moods, judgments and behavior of the object of influence. Accordingly, the accuracy of estimating and predicting the CS affects the effectiveness of these measures, which, in turn, is

determined by the adequacy of the selected mathematical model and the accuracy of determining its parameters.

Thus, the bifurcation forecasting technique for the occurrence and dynamics of the development of information conflicts in cyber space should contain a set of stages.

1. Monitoring cyberspace.

1.1. Definition of the list of sources of IW in cyberspace for monitoring information threats (list of information sites and (or) social services).

1.2. Setting key phrases - units of analysis for each field of activity of the IW object in accordance with the classifier of information threats (see table. 00).

1.3. Accumulation of an array of "raw" data — the frequency (frequency growth dynamics) of the appearance of analysis units with discreteness during a given period of monitoring information threats.

2. Initial processing of monitoring results - OLAP analysis.

2.1. According to the monitoring results, for each unit of analysis, the Hirsch index is calculated. In the future, units of analysis with positive values of the Hirsch index — active threats with an upward trend — are subject to monitoring and storage.

2.2. If there is a sample of monitoring results in 10 measurements or more (at least 3 days with recording of the monitoring results three times a day), its statistical analysis is carried out (determination of the statistical characteristics of the sample of measurements). The stage is realized by sequentially enumerating polynomial models up to $m \geq 2n$ and including (m,n - the order of the polynomial model and the number of measurements in the sample, respectively).

2.3. If there are monitoring results for 7 days, a weighted average estimate of the frequency of occurrence of analysis units per day is calculated and the raw data array is replaced with weighted average estimates to reduce the amount of stored information.

3. Secondary processing of monitoring results - Data Mining analysis.

3.1. Polynomial-nonlinear smoothing and prediction of each unit of analysis.

3.2. Formation of a convolution model using a nonlinear compromise scheme.

3.3. Prediction of convolution, identification of bifurcation processes, intervals, points.

3.4. The study of convolution into critical units of analysis (critical threats) in the appearance of bifurcation processes, intervals, points.

4. Formation of recommendations to neutralize threats

4.1. Formation of recommendations on the list of critical units of analysis (critical threats) necessary for operational neutralization.

4.2. Determining the type of information threat by the time interval of their implementation (action, operation, war).

4.3. Repeat paragraphs 1,2,3 to clarify all calculation results with an increase in the forecast time interval and growth of the experimental sample for analysis.

4.4. Presentation of the results of using the methodology: results of forecasting units of analysis; convolution bifurcation prediction; time characteristics of intervals and bifurcation points; critical threats necessary to neutralize.

The mathematical basis of the existing methodology covers the methods of pattern recognition, the theory of statistical analysis, mathematical modeling and multi-criteria optimization, as well as synergetic methods of self-organization and catastrophe theory [25]. Their implementation for the specific tasks of detection and

bifurcation forecasting of the development of information threats is described in [27-29].

The specificity of the proposed methodology is a multivariate analysis of trends in the development of individual threats with their aggregation into a single functional. It is precisely this approach that characterizes the identification of intervals leading to bifurcation processes.

To formulate a generalized optimality criterion for the convolution model (Section 3.2 of the methodology), a nonlinear compromise scheme will be used in accordance with the convolution of Professor A. Voronin [26]. Compared with other optimization schemes [6], convolution has the following advantages: optimization problems are solved if there are restrictions within which the unimodality of the function of the generalized criterion is guaranteed; relatively small computational complexity of the solution search algorithm.

To form a convolution model (Section 3.2 of the methodology), a non-linear scheme of trade-offs by Professor A. Voronin is used. [26]. Then the threat indicator - the frequency of the appearance of the analysis unit in cyberspace is a factor, and their multitude in accordance with the classifier - generates multifactor. From the threat indicator, you can go to the criterion is minimized. That is, the repetition rate of the unit of analysis should approach to a minimum, which ensures the prevention of occurrence or reduction of the level of information conflict. This reflects the desired scenario for the development of information impacts in the face of opposition to it. So, the non-linear scheme of compromises reflects the process of information counteraction in the form of multivariate analysis.

Convolution for discretely defined particular criteria looks [26]

$$Y(y_0) = \sum_{l=1}^{b} \gamma_{0l} (1 - y_{0l})^{-1} \Rightarrow \min, \quad (1)$$

where $l = 1...b$ – is the number of partial criteria for optimality of the system included in the convolution;

γ_{0l} – is normalized weight coefficient; y_{0l} – is normative particular optimality criterion.

Rationing of particular criteria is carried out to build a single scale for considering each criterion and to avoid their dominance and absorption.

The multifactor model (1) in its dynamics of development over time can be considered as a phase trajectory of the development of society (see Table 2) under the action of a vector of informational influences in various industries (see Table 1, Fig. 5). And, therefore, the nature of the change in the phase trajectory can have a model of the type shown in Fig. 2 at a low level of information threats and the form of Fig. 3 at a high level of them. An example of the application of the proposed methodology is aimed at confirming the formulated hypothesis.

An example of using the proposed methodology

For a calculated example, the monitoring of changes in three current threats from various areas of society has been carried out. Monitoring of their changes has been implemented for twenty days. Based on the results of processing samples of discrete data, polynomial models are obtained with the dynamics of change shown in Figs. 8, 10.

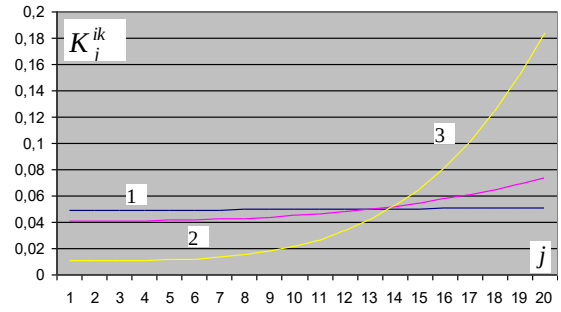

Fig. 8. Source curves

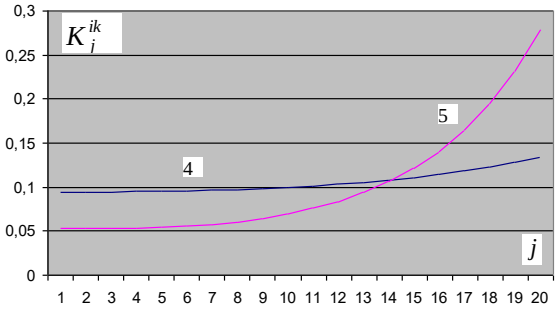

Fig. 9. Aggregated Data

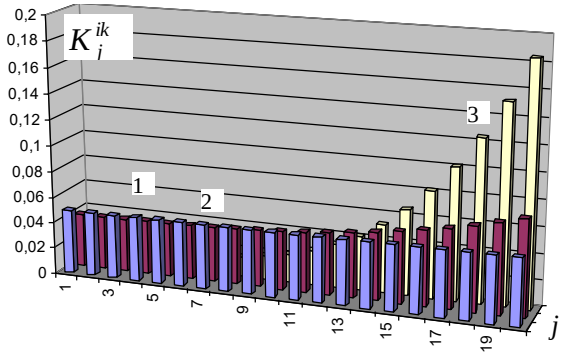

Fig. 10. Source curves

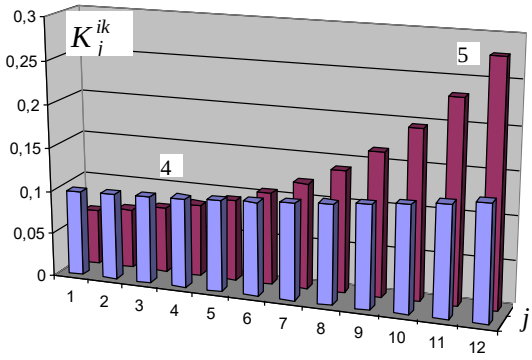

Fig. 11. Aggregated data

At the same time, the dynamics of the change in the frequency of occurrence of the analysis unit with numbers 1,2 (the corresponding curves in Fig. 8,10) had a gentle monotonically increasing character, and with number 3 - a pronounced asymptote. The use of convolution (1) for the aggregation of these curves 1, 2, and 1, 2, 3 is shown in Fig. 9,11. Curves 4 of Fig. 9,11 represent a convolution of monotonic factors of 1.2. Curves 5 - reflect the convolution of monotonic and asymptotic factors. Figure 8-11 shows the normalized data. This simplified example gives the obvious result of displaying a multifactorial aggregated curve of monotone and asymptotic threats. A reverse analysis of the reasons leading to the asymptotic nature of the aggregated curve allows us to identify threats that must be neutralized first. Thus, the hypothesis put forward on the possibility of bifurcation prediction of the occurrence and dynamics of the development of information conflicts in cyber space through the use of aggregate nonlinear convolution is confirmed. The proposed approach is especially productive in conditions of significant flux density and dynamics of changes in information threats. A subsequent analysis of the dynamic properties of the aggregated curves for a sufficient amount of experimental data will provide high accuracy, efficiency and completeness in preventing critical situations.

4. Conclusions

The article proposes a methodology for bifurcation forecasting of the occurrence and dynamics of the development of information conflicts in cybernetic space. In this case, the process of informational impact is considered as a reaction of a complex system to an external impact described by synergetic approaches. The search for bifurcation intervals is based on the analysis of the phase trajectory of a change in the state of the system as an aggregated value of the frequency of occurrence of an analysis unit, an indicator of information threats in various areas of society. Unlike the known ones, the proposed approach allows us to comprehensively predict and analyze both factors and the consequences of informational impact. The considered calculation example confirms the effectiveness of the proposed solutions.

References

1. Gorbulin V.P. Searching for asymmetric answers: cyberspace in a hybrid war // Mirror of the week. - No. 1031, February 20 - February 27 - 2015. - Access mode: [https://zn.ua/internal/v-poiskah-asimmetrichnyh-otvetov-kiberprostranstvo-v-gibridnoy-voyne-_.html].
2. Gorbulin V.P. Hybrid war: everything is just beginning ... // Mirror of the week. - No. 1086, March 25 - April 1. - 2016. - Access mode: [https://zn.ua/internal/gibridnaya-voyna-vse-tolko-nachinaetsya-_.html].
3. Gorbulin V.P. Bifurcation Point // Mirror of the Week. - No. 1116, November 5 - November 11. - 2016. - Access mode: [https://zn.ua/internal/tochka-bifurkacii-_.html].
4. Gorbulin V.P. “Values of society” and “hybrid world”: crisis of the protection model // Mirror of the week. - No. 1149, June 24 - June 30. - 2017. - Access mode: [https://zn.ua/internal/cennosti-obschestva-i-gibridnyy-mir-krizis-modeli-zaschity-252420_.html].
5. Gorbulin V.P. Information operation and security of suspension: threaten, protidia, model: monograph / V.P. Gorbulin, O.G. Dodonov, D.V. Lande. - K .: Intertekhnologiya, 2009 .-- 164 p.
6. Lande D.V., Snarsky A.A., Bezsudnov I.V. Internet: Navigation in complex networks: models and algorithms. M .: Book House "LIBROCOM", 2009. - 264 p.
7. Gubanov D.A., Novikov D.A., Chkhartishvili A.G. Social Networks: Models of Information Influence, Management and Confrontation / Ed. Corr. RAS D.A. Novikov. - M.: Publishing house of physical and mathematical literature, 2010. - 228 p.
8. Rastorguev S.P. Information war. - M.: Radio and Communications, 1999.- 416 p.
9. Petukhov Yu.A. Modeling of social and political processes: a training manual. - Nizhny Novgorod, 2015- 141 p.
10. Bobalo Yu. Ya. Monitoring of objects in the minds of April unapproachability of information technology / Bobalo Yu. Ya., Danik Yu. G., Pisarchuk O.O., Komarova L.O. and thatshi. - Monograph. - Lviv: Kolo, 2015 - 360 c.
11. Pisarchuk O.O. Non-linear and bug-testing model of process in ceruvann systems with ruhom / Pisarchuk O.O., Kharchenko V.P. - Monograph. - K.: Institut obdarovano ï ditini, 2015. - 248 p.
12. Haken G. Synergetics / G. Haken; trans. from English under the editorship of Yu.L. Klimantovich, S. M. Osovets. - M.: Mir, 1980 - 404 p.
13. Ivakhnenko A. G. Decision-making on the basis of self-organization / A. G. Ivakhnenko, Yu. P. Zaichenko, V. D. Dmitriev. - M.: Sov. Radio, 1979.- 280 s.
14. Zharkov Y.M. Informational and psychological warfare (evolucy and priority): Monograph. / Ya.M. Zharkov, V.M. Petrik, M.M. Prisyazhnyuk ta in .. - K .: ПАТ "Віполь", 2013. - 248 p.
15. Petrik V.M. Suggestive technologies of manpulative infusion: man. pos_b. / V.M. Petrik, M.M. Prisyazhnyuk, L.F. Kompantseva, Є.D. Skulish, O.D. Boyko, V.V. Ostroukhov, for ag.red Є.D. Skulisha. - 2nd view. - K .: ZAT "VIPOL", 2011. - 248 p.
16. Bychenok N.N. Information security of the state in the military sphere: scientific method. Edition / H.H. Bychenok, T.M. Dziuba, A.A. Ros, V.V. Vitkovsky, V.V. Vishchun - K .: NUOU, 2012.264 p.

17. Petrik M.V. Sutnist i special features and special operations informatsiynyh operations and aktsii informatsiynogo infusion / M.V. Petrik // Advanced information technology in the field of security and defense. - No. 3 (6), 2009. - S. 71-75.
18. Markov A.A. The concept and characteristic of information risks, dangers and threats in modern post-industrial society / A.A. Markov // Vestn. Volgogr. state un-that. Ser. 7, Philos. 2010. No. 1 (11) - S. 123-129.
19. Lepsky V.E. Technologies of controlled chaos - weapons of destruction of the subjectivity of development // Access mode [http://spkurdyumov.ru/what/texnologii-upravlyaemogo-haosa].
20. Mamlie K. Points of bifurcation. controlled chaos, as the source of postmodern Access mode [http://communitarian.ru/publikacii/novyy_mirovoy_poryadok_metody/tochki_ bifurkatsii_1968_upravlyaemyy_khaos_kak_istok_postmoderna_ /].
21. Polyarush O.O. The paradigm of informational and psychological influences on social systems. / O.O. Polyarush / Інформаційна bezpeka people, suspensions, powers. - No. 1 (1), 2009. - S. 21-26.
22. Malakhov V.M. Environmental Engineering: a monograph in three volumes. Volume 1 / V.M. Malakhov, A.G. Gritsenko, S.V. Druzhinin: Novosibirsk. SSGA - 2012 .-- 271 p.
23. Logunov A.B. The updated classifier of information threats, taking into account the opinions of experts of the scientific and technical sphere in the field of information security / A.B. Logunov, E.A. Marishev, N.A. Mironov // Innovation and Expertise. 2015. Issue 2 (15), pp. 132 - 140.
24. Threats to information security in crises and conflicts of the XXI century / Ed. - A.V. Zagorsky, N.P. Romashkina. - M.: IMEMO RAS, 2015 .-- 151 p.
25. Pisarchuk O.O. Bagatrix criteria mathematical models of situational management and self-organization in folding information systems / Pisarchuk O.O., Danik Yu.G., Shestakov V.I., Sokolov K.O., that inshi. - Monograph. - Zhytomyr: PP "Ruta", 2016. - 232 p.
26. Voronin A. N. Multicriteria solutions: models and methods: monograph / A. N. Voronin, Yu. K. Ziatdinov, M. V. Kuklinsky. - K.: NAU, 2011 .-- 348 p.
27. Gnatyuk S., Akhmetova J., Sydorenko V., Polishchuk Yu., Petryk V. Quantitative Evaluation Method for Mass Media Manipulative Influence on Public Opinion, CEUR Workshop Proceedings, Vol. 2362, pp. 71-83, 2019.
28. A. Peleschyshyn, T. Klynina, S. Gnatyuk, Legal Mechanism of Counteracting Information Aggression in Social Networks: from Theory to Practice, CEUR Workshop Proceedings, 2019, Vol. 2392, pp. 111-121.
29. Fedushko S., Syerov Yu., Tesak O., Onyshchuk O., Melnykova N. (2020) Advisory and Accounting Tool for Safe and Economically Optimal Choice of Online Self-Education Services. Proceedings of the International Workshop on Conflict Management in Global Information Networks (CMiGIN 2019), Lviv, Ukraine, November 29, 2019. CEUR-WS.org, Vol-2588. pp. 290-300. http://ceur-ws.org/Vol-2588/paper24.pdf
30. S. Gnatyuk, M. Aleksander, P. Vorona, Yu. Polishchuk, J. Akhmetova, Network-centric Approach to Destructive Manipulative Influence Evaluation

in Social Media, CEUR Workshop Proceedings, Vol. 2392, pp. 273-285, 2019.