Method of Informational and Psychological Influence Evaluation in Social Networks Based on Fuzzy Logic

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Abstract. Recent years number of influences on the information environment of the states has been increased by non-military methods, which is due to the high level of development of information technologies and social engineering. Information and psychological influences become extremely widespread, as evidenced by the publications of the advanced countries where information security issues are discussed in the context of information and psychological influences. The main areas that become the goals of such influences are economic, military, political, and the means through which they are implemented, mainly media, social networks. Obviously, for effective counteraction, timely identification and identification of the impact is necessary. However, an equally important task is to clearly and accurately assess possible destructive effects, which leads to informational and psychological interference. There have been described the processes of information confrontation in the aspect of its psychological component. The developed method can be used in information and psychological security, in particular to prevent information and psychological influence on the individual and social group, effective implementation of countermeasures. The method of evaluation of informational and psychological influences and the corresponding structural solution of the system of evaluation of information and psychological influences, which, by processing fuzzy identifying parameters, allows us to assess the destructive effect of informational and psychological influences and create such systems for fuzzy environment.

Keywords: Model, Informational and Psychological Influence, Methods of Informational and Psychological Influence, Evaluation, Fuzzy Logic.

1 Introduction

Information has become an integral part of the activity in the modern environment. Modern external and internal policies are impossible without taking into account and

using effective forms of informational and psychological confrontation. In recent years, the number of influences on the information environment of the states has been increased by non-strain methods, which is due to the high level of development of information technologies and social engineering. Information and psychological influences become extremely widespread, as evidenced by the publications of advanced countries where information security issues are discussed in the context of information and psychological influences. The main areas that become the goals of such influences are economic, military, political, and the means through which they are implemented, mainly media, social networks, global computer networks, rumors, etc. Obviously, for effective counteraction, timely identification and identification of influence is necessary. However, an equally important task is to clearly and accurately assess of the possible destructive effects, which leads to information and psychological intervention. In this regard, the actual task is to develop a system for assessing the destructive actions of information and psychological influences.

2 Modern expert evaluation methods

The role of expert methods assumes special importance during the period of unstable development of informational, social, economic and other processes that directly or indirectly affect the activity of public administration bodies and local governments. Thus, the expert systems are actively implemented in priority tasks [1], risk identification and management [2], various tasks of information systems option [3], for the detection and evaluation of critical situations [4] etc.

The basis of such systems, besides the actual knowledge created by experts, is the so-called heuristic or production rules [3, 5]. Under such circumstances, a high degree of uncertainty in the environmental factors influence is a defining attribute, and therefore an acceptable accuracy of results cannot be provided by any statistical or other formalized methods, no matter how perfect they are [3].

Expert methods are intended to predict qualitative and quantitative characteristics, the development of which is not completely or partially subject to mathematical formalization due to the lack of sufficient and reliable statistics. The core of expert forecasting method is based on qualified specialists assessments on a specific problem (experts or groups of experts), formed according to the certain rules for problems solving or forecasts development, the conclusions are drawn about the development paths of the forecasting object.

Among the expert techniques there are two main groups distinguished: quantitative and qualitative. Quantitative methods of expert technologies are based on the logical-mathematical and statistical methodologies application for generalizing expert opinions, testing statistical significance of the assessment results, confirming the refutation of the assessment quality in general.

Similar expert approaches were set up to create decisive rules relating to the attacker detection in the information-communication networks and systems [6-10] and in the method of criticality level assessment as the emergence result of the information security incidents [11].

3 Method of detection and identification of informational and psychological impact

During the modern warfare, the following classification can be made:
1) methods aimed at people who perceive the information critically:

- change of opinion by persuasion;
- psychological isolation of the object;
- coercion;
- propaganda.

2) methods aimed at people who perceive the information uncritically:

- misinformation;
- propaganda;
- change of sights by suggestion;
- infection;
- manipulation;
- reframing [12].

As we can see, there is a certain imbalance among the methods, which are directed at people who perceive information uncritically in most cases. This situation is due to the fact that it is much easier to achieve a result, to carry out an attack, if the attacker's actions are aimed at non-critical thinking, since they will bypass a certain "psychological shield" of a person.
Propaganda is attributed to both groups, because of the variety of means, it is evident that its use is equally effective for all people [13].
Concepts and classifications regarding information psychological impact analysis has shown that today there is no single classification that would cover all aspects and characteristics of its implementation during the information warfare [13].
In the course of the research, the following evaluation parameters of the informational and psychological influences were identified: CSA – «Completeness and strength of argument», CGN – «Consistency with the norms of general public opinion», PR – «Public reaction», GAF – «Growth of the anxiety factor», VD – «Velocity of distribution», NAT – «Number of affected targets».
The standard values were constructed in accordance with [10-12].
For the CSA parameter, the following linguistic estimates are: {low (L), medium (M), high (H)}. Intervals for defining reference values = {[0-20], [21-40], [41-60]} intervals of time.
After the operations we will form the following terms of the linguistic variables for this parameter:
L = {0/0,33; 1/0,33, 0,63/0,75; 0,43/1; 0/1},
M = {0/0,33; 0,22/0,33; 1/0,75; 0,57/1; 0/1},
H= {0/0,33; 0,33/0,33; 0,75/0,75; 1/1; 0/1}.

For the CGN parameter, the following linguistic estimates are typical: {unmatched (U), medium agreed (M), agreed (A)}. Intervals for determining reference values = {[0-33], [34-66], [67-100]} percent.
After the operations we will form the following terms of the linguistic variables for this parameter:
U = {0/0,33; 1/0,33; 0,92/0,66; 0,4/1; 0/1},
M= {0/0,33; 0,35/0,33; 1/0,66; 0,07/1; 0/1},
A = {0/0,33; 0,1/0,33; 0,44/0,66; 1/1; 0/1}.
For the PR parameter, the following linguistic estimates are: {small (S), medium (M), high (H)}. Intervals for determining reference values = {[0-33], [34-66], [67-100]}.
After the operations we will form the following terms of the linguistic variables for this parameter:
S = {0/0,33; 1/0,33; 0,89/0,66; 0,36/1; 0/1},
M = {0/0,33; 0,7/0,33; 1/0,66; 0,27/1; 0/1},
H = {0/0,33; 0,3/0,33, 0,56/0,66; 1/1; 0/1}.
For the GAF parameter, the following linguistic estimates are: {slow (S), medium(M), high (H)}. Intervals for determining reference values = {[0-33], [34-66], [67-100]} percent.
After the operations we will form the following terms of the linguistic variables for this parameter:
S = {0/0,33; 1/0,33, 0,78/0,66; 0,6/1; 0/1},
M = {0/0,33; 0,27/0,33; 1/0,66; 0,5/1; 0/1},
H = {0/0,33; 0,18/0,33; 0,44/0,67; 1/1, 0/1}.
For the VD parameter, the following linguistic estimates are: {slow (S), medium (M), high (H)}. Intervals for determining reference values = {[0-33], [34-66], [67-100]} percent.
After the operations we will form the following terms of the linguistic variables for this parameter:
S = {0/0,33; 1/0,33, 0,91/0,66; 0,75/1; 0/1},
M = {0/0,33; 0,54/0,33; 1/0,66; 0,33/1; 0/1},
H = {0/0,33; 0,23/0,33; 0,73/0,67; 1/1, 0/1}.
For NAT characteristic parameter such linguistic assessment {low (L), medium (M), high (H)}. Intervals for determining reference values = {[0-33], [34-66], [67-100]}.
After the operations we will form the following terms of the linguistic variables for this parameter:
L = {0/0,33; 1/0,33, 0,57/0,66; 0,33/1; 0/1},
M = {0/0,33; 0,5/0,33; 1/0,66; 0,56/1; 0/1},
H = {0/0,33; 0,17/0,33; 0,36/0,66; 1/1, 0/1}.
For the DR parameter, the following linguistic estimates are: {short-term (S), medium-term (M), long-term (L)}. Intervals for determining reference values = {[0-33], [34-66], [67-100]}.
After the operations we will form the following terms of the linguistic variables for this parameter:
S = {0/0,33; 1/0,33, 0,95/0,66; 0,78/1; 0/1},
M = {0/0,33; 0,42/0,33; 1/0,66; 0,39/1; 0/1},

L = {0/0,33; 0,13/0,33; 0,4/0,66; 1/1, 0/1}.

Let's represent the calculated reference values in the form of graphs (see **Помилка! Джерело посилання не знайдено.**) [13].

In the further, we calculate the for each estimation parameter. At this stage, an assessment is made of the criticality of the impact of each valuation parameter and their respective ranking. We apply for this method a quantitative pair comparison with the definition of the square root, which is a kind of method of quantitative pair comparison.

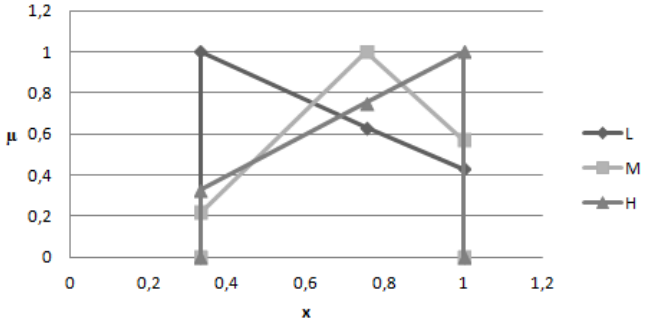

Fig. 1. Graphic representation of fuzzy values. Completeness and strength of argumentation

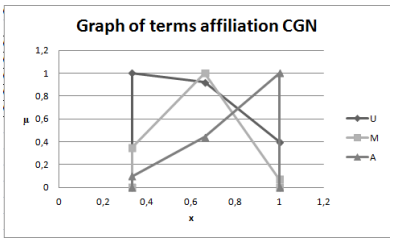

Fig.2. Graphic representation of fuzzy values. Consistency with public opinion standards

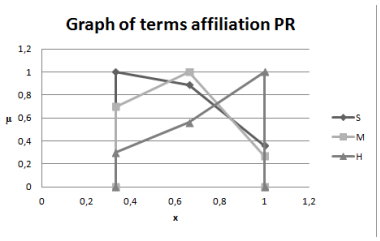

Fig.3. Graphic representation of fuzzy values. Public response

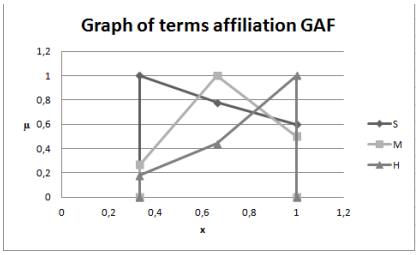

Fig.4. Graphic representation of fuzzy values. Anxiety rising

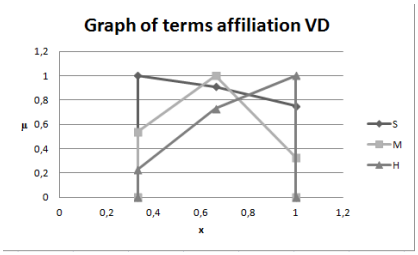

Fig.5. Graphic representation of fuzzy values. Spread rate

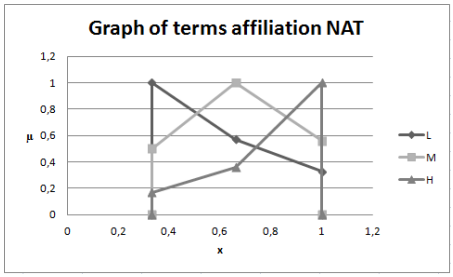

Fig.6. Graphic representation of fuzzy values. Number of affected targets

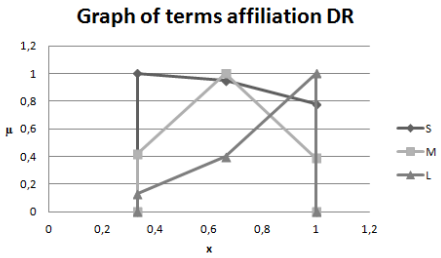

Fig.7. Graphic representation of fuzzy values. Duration

Pair comparison is the procedure for setting preferences options by comparing all possible pairs and further streamline object on the basis of comparison [18]. The paired comparison method is one of the most widely used expert procedures for determining the relative weights of objects.

The basis is the comparison of each of the table parameters and the formation of the matrix of the pair comparison $A = \left\| a_{ij} \right\|$, where a_{ij} selected according to experts on a scale of relative importance: 1 - alternatives are equally important, 3 - moderate advantage of one parameter over another, 5 - significant advantage of one parameter over another, 7 - significant advantage (convincing evidence available), 9 - obvious advantage of one of the parameters; 2, 4, 6, 8 - intermediate solutions.

The expert fills the locations of the comparison table of the factor with itself gives a unit. In the first location of the first line, the expert writes a unit, in the second - the result of a comparison of the first factor with the second, in the third - the result of a comparison of the first factor with the third, etc. Moving to the second line, the expert writes in the first location the result of the comparison of the second factor with the first, in the second - the unit, in the third - the result of comparison of the second factor with the third, etc. [19].

Next, we calculate the weight coefficients according to the expression $\omega_i = \sqrt[n]{\prod_{i=1}^{I} a_{ij}}$, where $i = \overline{1, I}$, I is number of evaluation parameters, in this case 7.

After that the valuation of the obtained coefficients is carried out according to the formula: $\sigma_i = \omega_i / (\sum_{i=1}^{I} \omega_i$, so that $\sum_{i=1}^{I} \sigma_i = 1$.

Consider an example of determining the importance coefficients for the predetermined valuation parameters (Table 1). The expert evaluates the importance of each of them in comparison with the other and puts the information in the table. The coefficients of importance are calculated and their rationing is carried out. The result of a pair wise comparison of the estimated parameters of informational and psychological influences *Pi*

Table 1. The result of a pair wise comparison of the estimated parameters of the IPI *Pi*

i\i'	*P*1	*P*2	*P*3	*P*4	*P*5	*P*6	*P*7	*P*8	ω_i	Ω_i
*P*1	1	5	2	1/5	1/7	3	4	6	1,45	0,15
*P*2	1/5	1	¼	5	5	¼	1/3	1/2	0,69	0,07
*P*3	5	1/5	7	1	1/5	4	5	2	1,65	0,17
*P*4	7	1/5	5	5	1	5	6	3	2,73	0,29
*P*5	1/3	4	¼	¼	1/5	1	¼	5	0,61	0,06
*P*6	¼	3	2	1/5	1/6	4	1	7	1,04	0,11
*P*7	1/6	2	3	½	1/3	1/5	1/7	1	0,5	0,05
									8,48	0,92

The next step is to conduct a ranking of the estimated parameters on the calculated and normalized factors of importance. As a result of calculations, the parameter «Growth the factor of anxiety» gets the highest score, and therefore, according to the expert, is the most priority among the other parameters (Table 2).

Table 2. Ranking of valuation parameters by factors of importance

Estimated parameter, Pi	Coefficient of Importance
Growth the factor of anxiety	0,29
Public reaction	0,18
Completeness and strength of argument	0,16
Number of affected targets	0,11
Associations that cause the source of information	0,08

The problem of assessing the level of criticality of informational and psychological influence as one of the processes of providing informational and psychological influence is determined by the fact that its occurrence and development are difficult to predict (and often not even predictable), that is, we are dealing with an event in an unclearly formalized space. In addition, there are no generally accepted criteria for assessing the level of criticality, most of them have different nature (including clear and unclear) and mathematical properties, which makes it impossible to use most of the currently known estimation methods to the general set of these criteria. Therefore, the formation of parameters and the development of methods for assessing the level of criticality of informational and psychological influence and the methods for its identification is an relevant task. The method uses the following methods of fuzzy logic as a method of linguistic terms using statistical data (MLTS) - for constructing reference values of parameters and evaluation standards, linear approximation by local maxima (LALM), generalized Heming's distance (DH) - for processing fuzzy data and conducting operations of fuzzy logic. In addition, expert methods of evaluation and ranking are used: the method of average grades (AG).

The next step is to calculate the overall assessment of the criticality of the situation. Initially, taking into account the specific methods of information and psychological impact, the low frequency is formed:

$$LSC_i = \sum_{e=1}^{E} (\sigma_e \bullet L_e) \quad (1)$$

The current low frequency is compared with the reference standard by one of the known methods of comparison of the low frequency. For these purposes, we use the method of forming the α-- level nominalization of the low frequency [16] and the method for identifying the terms [14]. The procedure is to calculate nominalized (transformed) standards and levels. The definition of the generalized Heming's distance is carried out then. The criterion for LCS compliance with one of the terms of the benchmark is the smallest Heming distance.

At the final stage, visualization of the results takes place. In addition, in order to better reflect the criticality of the IPCC, it is proposed to display the criticality parameters using the critical indicator. To do this, the appropriate L_e parameters should be pre-defused. The most expedient in this case is the application of the method of the center of gravity, by which the LF is converted into a clear by the formula:

$$L = 100 \bullet (\sum_{i=1}^{q} X_{Lq} \bullet \mu(x_{Lq}) / \sum_{i=1}^{q} \mu(x_{Lq})) \quad (2)$$

where q is number of LOAs. A case where the values of individual parameters are calculated directly without the use of expert methods is possible. In this case, they are displayed on the indicator by histogram. The development of the method reflects a new approach to solving the problem of assessing information and psychological influence. The method is based on fuzzy logic. During its implementation there are several stages, which are aimed at determining the reference and current values of a certain information space for the detection of information and psychological influence. A special feature is the provision of the information and psychological influence evaluation process, which will be useful in improving the effectiveness of the development and implementation of countermeasures.

4 Experimental study of the proposed method

We use the example of the political anti-advertising campaign of the election company P. Poroshenko - the video "50 shades of Poroshenko", which was shown on the 1 + 1 channel before the first round of presidential elections in Ukraine [21]. The video tells about corruption schemes headed by Petro Poroshenko, but not a single concrete fact was given, which indicates this. The video and individual cuts from it, the information was actively disseminated to the official page of the TV channel 1 + 1, affiliated with it pages, hostile to the presidential candidate by public groups, as well as networks of bots on the social network Facebook. Previously, the following method of information and psychological influence was identified and identified as "Manipulation". Identifying parameters of this method are CSA "Completeness and Strength

of Argumentation", CGN "Consistency with Common Public Opinion Standards", GAF "Anxiety Rise".
By expert comparison, coefficients of importance for the estimation parameters "Manipulation" were established. Thus, the following coefficients were obtained for the importance of fuzzy estimation parameters: $\Omega_1 = 0{,}115$; $\Omega_2 = 0.333$; $\Omega_3 = 0.552$.
The measured and analytical data are entered in the table and after the phasation process the value of the estimating parameters is determined and the index of the level of criticality in the fuzzy form is calculated, which then translates into a clear form after the dephasing, and the results are displayed on the indicator of the criticality of the situation. In Table 3 the results of critical assessment of "Manipulation" in the social network Facebook about the video "50 shades of Poroshenko" are given.

Table 3. Evaluation results "Manipulation"

Parameter	Importance factor	Fuzzy number characterizing parameter value	Declassified value
CSA	0,115	{0/0,33; 0,75/0,75; 1/1}	89
CGN	0,333	{0/0,33; 1/0,66; 1/1}	83
GAF	0,552	{0/0,33; 0,44/0,66; 1/1}	90

To reflect the level of criticality of the situation in a linguistic form, the procedure for determining the Heming distance between the terms of the estimated benchmark and the level of LCS is carried out. Having carried out necessary calculations of Heming distance, with the help of SOKS received that the current level of criticality situation "High". In addition, the assessment was carried out at various stages of information and psychological impact, which enabled to show the dynamics of the situation and assess the adequacy of the countermeasures involved. Figure 1 shows an indicator of the criticality of the situation in the development of the IPV for "Manipulation. The overall criticality level is 88.

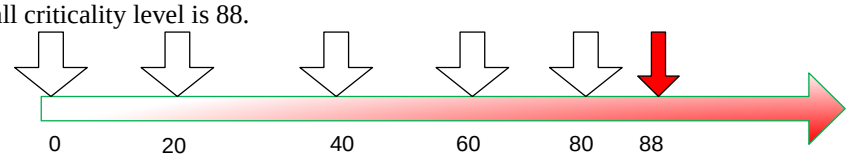

Fig.8. A figure caption is always placed below the illustration. Short captions are centered, while long ones are justified. The macro button chooses the correct format automatically.

5 Conclusions

The system of evaluating destructive actions of informational and psychological influence was developed in the work to solve the problem of destructive effects of informational and psychological influence, which can be used in a weakly formalized environment close to real conditions. To achieve the goal were performed the following tasks:

There was made the analysis of the concept of informational and psychological influence, its place in the modern information environment was determined, the main methods and methods of implementation of informational and psychological influence were investigated and the existing methods of estimating informational and psychological influence were analyzed. This has made it possible to find that there is no generalized and sufficiently universal of informational and psychological influence of evaluation system, and, on the basis of existing highly specialized systems, identify the shortcomings that most need to be finalized.

The method of carrying out an evaluation of informational and psychological influence destructive actions is developed. All the deficiencies of existing evaluation systems identified because of the analysis are taken into account. The most universal estimation parameters are determined. This method is based on quantitative methods of expert evaluation, which gives advantages in the absence of the need to collect large amounts of statistical data and clear formalization of the current situation.

The structure of evaluation of destructive of informational and psychological influence actions is developed, which allows estimating the level of destructive informational and psychological influence actions in a fuzzy environment close to real conditions. The scheme of the architecture of the system is presented, which allows more detailed presentation of the modules and processes with which they interact, input and output data to each of the blocks and modules.

References

1. Gambo, Ishaya P., Abimbola H. Soriyan, Rhoda N. Ikono: A Proposed Process Model for Requirements Engineering using Delphi Techniques for Prioritisation. IJ Information Technology, and Computer Science 1: 73-80 (2015).
2. Danik Yu., Hryschuk R., Gnatyuk S.: Synergistic effects of information and cybernetic interaction in civil aviation, Aviation, vol. 20, №3, pp. 137-144 (2016).
3. Zaied, Abdel Nasser H., Samah Ibrahim Abdel Aal, and Mohamed Monir Hassan. Rule-based expert systems for selecting information systems development methodologies." International Journal of Intelligent Systems and Applications 5.9: 19 (2013).
4. Gizun, A., Gnatyuk, V., Balyk, N., Falat, P.. Approaches to improve the activity of computer incident response teams. In Proceedings of the 2015 IEEE 8th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, Warsaw, Poland, September 24-26, 2015: vol. 1, pp. 478-483 (2015).
5. Trach, O., Peleshchyshyn, A.: Development of directions tasks indicators of virtual community life cycle organization. In Proceedings of 2017 12th International Scientific and Technical Conference on Computer Sciences and Information Technologies (2017).
6. Gizun, A., Gnatyuk, V., Suprun, O.: Formalized model for building heuristic rules for detecting incidents, Bulletin of Engineering Academy of Ukraine, №1, pp. 110-115 (2015).
7. Korobiichuk, I., Fedushko, S., Juś, A., Syerov, Y.: Methods of Determining Information Support of Web Community User Personal Data Verification System. In: Szewczyk R., Zieliński C., Kaliczyńska M. (eds). Automation 2017. ICA 2017. Advances in Intelligent Systems and Computing. Volume 550. pp 144-150. Springer (2017). DOI: 10.1007/978-3-319-54042-9_13

8. Fedushko, S.: Development of a software for computer-linguistic verification of socio-demographic profile of web-community member. Webology, Volume 11, Number 2, Article 126 (2014). http://www.webology.org/2014/v11n2/a126.pdf
9. Fedushko, S., Syerov, Yu., Korzh, R.: Validation of the user accounts personal data of online academic community. In: XIIIth International Conference "Modern Problems of Radio Engineering, Telecommunications and Computer Science" (TCSET'2016). pp. 863-866. Lviv-Slavske (2016). DOI: 10.1109/TCSET.2016.7452207
10. Trach O., Vus V., Tymovchak-Maksymets O.: Typical algorithm of stage completion when creating a virtual community of a HEI. In: XIIIth International Conference "Modern Problems of Radio Engineering, Telecommunications and Computer Science" (TCSET'2016). pp. 849-851. Lviv-Slavske (2016).
11. Gnatyuk, S., Sydorenko, V., Aleksander, M.: Unified data model for defining state critical information infrastructure in civil aviation, In Proceedings of the 2018 IEEE 9th International Conference on Dependable Systems, Services and Technologies, Kyiv, Ukraine, May 24-27, pp. 37-42 (2018).
12. Griga, V., Gizun, A., Lanovyi, I. Formation of identifying parameters reference values of information and psychological impact, Litteris et Artibus, 2017, Pp. 404-409 (2017).
13. Hriha, V., Gizun, A., Shchudlyck, I. Information psychological impact detection and identification system, Project interdyscyplinarny projektem XXI wieku, Tom 2, Bielsko-biala, p. 131-149 (2017).
14. Tikhomirov, A., Kinash, N., Gnatyuk, S., Trufanov, A. et al: Network Society: Aggregate Topological Models, Communications in Computer and Information Science. Verlag: Springer International Publ, vol. 487, pp. 415-421 (2014).
15. Korchenko, A.: The formation method of linguistic standards created for the intrusion detection system. Ukrainian Information Security Research Journal, Vol.16, №1, p. 5-12 (2014).
16. Gizun, A., Volyanska, V., Gnatyuk, V.: Etalon models of linguistic variables for information security intruders detection and identification. Ukrainian Scientific Journal of Information Security, vol. 19, issue 1, p. 13-21 (2013).
17. Hriha, V., Gizun, A., Bystrova, B., Kadanova, V., Blidar, A., Roshchuk, M.: Method of evaluation of informational and psychological influence. Project interdyscyplinarny projektem XXI wieku, Tom 2, Bielsko-Biala, pp. 91-104 (2018).
18. Gornitskaya, D., Volyanska, V., Korchenko, A.: Determination of importance factors for expert assessment in the field of information security. Ukrainian Information Security Research Journal, vol. 14, issue 1 (2012).
19. Gizun, A.: Computer complex for detection and evaluation of crisis situations in information sphere. Ukrainian Information Security Research Journal, vol. 18, №. 1, pp. 66-73 (2016).
20. Korchenko, A.: The method of α-level nominalization of fuzzy numbers for intrusion detection systems. Ukrainian Information Security Research Journal, vol. 16, issue 4, pp. 304-311 (2014).
21. Ukrainian sensations. 50 shades of Poroshenko, https://1plus1.ua/1plus1video/ukr-sensacii/10-sezon/8-vypusk-ukrayinski-sensaciyi-50-vidtinkiv-poroshenka, last accessed 2019/03/25.