Usage of Decision Support Systems in Information Operations Recognition

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Abstract. In this paper, usage of decision support systems in information operations recognition is described. Based on information of experts, the knowledge engineer constructs a knowledge base of subject domain, using decision support system tools. The knowledge base provides the basis for specification of queries for analysis of dynamics of respective informational scenarios using text analytics means. Based on the analysis and the knowledge base structure, decision support system tools calculate the achievement degree of the main goal of the information operation as a complex system, consisting of specific informational activities. Using the results of these calculations, decision makers can develop strategic and tactical steps to counter-act the information operation, evaluate the operation's efficiency, as well as efficiencies of its separate components. Also, decision support system tools are used for decomposition of information operation topics and evaluation of efficiency rating of these topics in dynamics.

Keywords: Information operation · Decision support system · Expert estimate
Content-monitoring system

1 Introduction

Given the present level of development of information technologies, it is hard to overestimate their impact on human life. Information media, which involve every man, any social group or population, form their worldview, affect their behavior and decision making [1, 2]. Therefore, the problems related to formation and modification of these information media are extremely important nowadays.

Under information operation (IO) [3], we assume the complex of information activities (news articles in the Internet and the papers, news on TV, comments in social networks, forums, etc.) aimed at changing public opinion about a definite object (person, organization, institute, country, etc.). For example, spreading the rumors about problems in a bank can provoke its clients to take back their deposits, which in turn can cause its bankruptcy. Mainly, this activity has a disinformation character. The information operation belongs to so called ill-defined subject domains [4, 5], because it possesses several such characteristic: uniqueness, inability to formalize the objective of its function and, as a consequence, inability to construct the analytical model,

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dynamics, incompleteness of description, presence of human factor, absence of standards. These domains are treated using expert decision support systems (DSS) [6].

In [3], techniques of IO identification are presented, which are based on analysis of time series built on the basis of thematic information stream monitoring. The following problematic situations, which can appear in IO identification due to drawbacks of current methods and techniques, can be noted:

1. Given a sufficiently large number of publications about the IO object, the number of publications (information stove-piping) about its definite component can be very small and, as a consequence, respective system distortions of typical dynamics of information plots will not be revealed (such as, for example, "Mexican Hat" and Morlet wavelets [7] discovered on the respective wavelet scalogram). Some IOs may be complex and respective information stove-pipings may be staged, related to different components of the IO object in different time periods. If their number is blurred at the background of the total number of publications about the IO object ("information noise"), and the respective information attacks are not identified, then the beginning of the information campaign on the object discredit can be missed, and some information damage to its image will not be taken into account.
2. Content-monitoring tools control queries consisting of keywords to search for respective publications. Keywords are formed based on the IO object title. But the complex IO object can have a great number of components with respective titles, which are not accounted for in queries and, as a consequence, not all the publications on the issue will be found.
3. Queries related to IO object have different degrees of importance according to IO components, to which they are related. Absence of information about values of these importance degrees (i.e. their equivalence) leads to reduction of the IO model relevance.

To overcome the above-mentioned drawbacks, we suggest using the following techniques for application of decision support systems in IO recognition.

2 Methodology for Usage of Decision Support Systems in Information Operations Recognition

The core of the methodology for usage of expert decision-making support tools in information operations recognition [3, 8] proceedings along the following lines:

1. Preliminary investigation of the IO object is carried out, and its target parameters (indexes) are being selected. Then it is suggested that formerly, in retrospective, IOs against the object were taking place, and, thus, its condition (respective target indices) has been deteriorated.
2. The group expertise is conducted to determine and decompose information operation purposes and to estimate its degree of influence. Thus, the IO object is being decomposed as a complex weakly structured system. For this purpose, means of the system for distributed collection and processing of expert information (SDCPEI) are

used. For obtaining expert information in a full range and without distortions, the expert estimation system is used.

3. The respective knowledge base (KB) is constructed using DSS tools, based on the results of the group expertise performed by means of SDCPEI and using available objective information.
4. Analysis of dynamics of the thematic information stream by means of content-monitoring system (CMS) is carried out. KB of DSS is complemented.
5. Recommendations are calculated by means of DSS based on the constructed KB. For this, the IO target achievement degrees are calculated in retrospective and are compared with the respective changes of the IO object condition. The mean value of IO target achievement degrees is calculated, at which degrees the deterioration of the IO object target indices occurs. Thus, monitoring of the IO object condition for the current period of time allows to predict the deterioration of the IO object target values based on the comparison of the calculated value of IO target achievement degree with the above mentioned mean value. In the case of availability of statistically sufficient sample size, and given sufficient correlation between values of IO target achievement degrees and deterioration of IO object target index values, one can even predict the quantitative value of the IO object target index for the current period.

Advantages of the suggested methodology are as follows:

1. Great specification of the model. At the background of numerous publications about IO object in general, the change in publication number dynamics due to the stove-piping about one of IO components will be insignificant and, therefore, will not be revealed.
2. The number of found thematic publications will increase, because of a larger number of queries and keywords.
3. Weighing of IO components allows to avoid the situation when all components are of equal importance. The IO model constructed in such a way will be more relevant.
4. The constructed KB can be used again later during a long period without the necessity to carry out a new expertise.
5. Application of SDCPEI tools makes it possible for experts to work through the global network, thus saving time and resources.

Drawbacks of the suggested methodology are as follows:

1. Application of expert techniques requires time and financial efforts for implementation of the group expertise. Besides, the timely actualization of KB should be done for its second use in the future.
2. Complexity and sometimes ambiguity of the presentation of some sufficiently complex statements of IO components in the form of queries in the content-monitoring system.

Let us show in details the suggested methodology at the example of information operation against National Academy of Sciences (NAS) of Ukraine. It is known that presently NAS of Ukraine is going through hard times. In recent years, the funding of NAS is getting worse. The total funding of NAS of Ukraine decreases, and the share of the budget of NAS of Ukraine in the total budget of Ukraine decreases as well. This is well seen from the information about distribution of expenses for the State Budget of Ukraine for 2014–2016 [9–11]. Suppose that this cut of funding is the result of information operation against NAS of Ukraine.

As SDCPEI for group expert decomposition, we use Consensus-2 system [12] aimed at performing estimations by territorially distributed expert groups.

Based on interpretation of the knowledge base generated after operation of Consensus-2 SDCPEI, Solon-3 DSS [13] generates the respective KB. In Solon-3 DSS, a novel method is used based on decomposition of main objective of the program, construction of knowledge base (hierarchy of targets), and dynamic target estimation of alternatives [6]. Expert's pair comparisons were performed in the Level system [14].

Let's consider some aspects of the above mentioned method. The KB has a structure of goal hierarchy graph. Nodes (vertices) of the graph represent goals or KB objects. Edges reflect the impact of one set of goals on achievement of other goals: they connect sub-goals to their immediate "ancestors" in the graph (super-goals).

To build the goal hierarchy, the method of hierarchic target-oriented evaluation of alternatives is used [6]. A hierarchy of goals is built, after which respective partial impact coefficients (PIC) are set, and the relative efficiency of projects is calculated. First, the main goal of the problem solution is formulated, as well as potential options of its achievement (projects) that are to be estimated at further steps. After that, a two-phase procedure of goal hierarchy graph construction takes place: "top-to-bottom" and "bottom-to-top" [6]. "Top-to-bottom" phase envisions step-by-step decomposition of every goal into sub-goals or projects, that influence the achievement of the given goal. The main goal is to decompose into more specific components, sub-goals that influence it. Then these lower-level goals are further decomposed into even more specific sub-components that are, in their own turn, decomposed as well. When a goal is decomposed, the list of its sub-goals may include (beside the just formulated ones) goals (already present in the hierarchy) that were formulated in the process of decomposition of other goals. Decomposition process stops when the sets of sub-goals that influence higher-level goals include already decomposed goals and decision variants being evaluated. Thus, when decomposition process is finished, there are no goals left unclear. "Bottom-to-top" phase envisions definition of all upper-level goals (super-goals, "ancestors") for each sub-goal or project (i.e., the goals this project influences).

As mentioned, experts build a hierarchy of goals represented by an oriented network-type graph. Its nodes are marked by goal formulations. Presence of an edge connecting one node (goal) to another indicates impact of one goal upon achievement of the other one. As a result of the above-mentioned process of goal hierarchy construction, we get a graph that is unilaterally connected, because from each node, there is a way to the node marking the main goal. Each goal is assigned an indicator from 0 to 1 of achievement level. This indicator equals 0 if there is absolutely no progress in achievement of the goal, whereas if the goal is completely achieved, it equals 1. Impact of one goal upon the other can be positive or negative. Its degree is reflected by the respective value, i.e. a PIC. In the method of target-oriented dynamic evaluation of alternatives, the delay of impact is also taken into consideration [6]. In case of projects, their implementation time is taken into account as well. PIC are defined by experts, and, in order to improve credibility of expert estimation process, pairwise comparison based methods are used.

In the result of the group expertise, 15 expert statements were obtained presenting the components of IO against NAS of Ukraine, namely, “Bureaucracy in NAS of Ukraine,” “Inefficient personnel policy of NASU,” “Corruption in NAS of Ukraine,” “Underestimation of the level of scientific results of NAS of Ukraine,” “Lack of introduction of scientific developments into manufacture,” “Underestimation of the level of international collaboration,” “Misuse and inefficient use of the realty of NASU,” “Misuse and inefficient use of land resources of NASU,” “Discredit of President of NAS of Ukraine,” “Discredit of Executive secretary of NAS of Ukraine,” “Discredit of other well-known persons of NAS of Ukraine,” “Juxtaposition of scientific results of Ministry of Education and Science (MES) and NAS,” “Juxtaposition of scientific results of other academic organizations to NAS,” “Juxtaposition of developments of Ukrainian companies to NAS of Ukraine,” “Juxtaposition of scientific results of foreign organizations to NAS.”

By means of InfoStream CMS [15], analysis of thematic information stream dynamics was made. For this, in accordance with each of the above listed IO component, queries were formulated in a special language, using which the above mentioned process (analysis of publication dynamics on target issues) takes place.

Figure 1 presented results of the express analysis [3] of thematic information stream corresponding to the IO object, i.e. NAS of Ukraine. In the result of the analysis by means of InfoStream CMS, the respective information stream from the Ukrainian Internet segment was obtained. To reveal information stove-piping, publication dynamics was analyzed on the target issue using available analytical tools. In Fig. 1, one characteristic fragment of the dynamics is shown (for the period from July 1, 2015 to December 31, 2015).

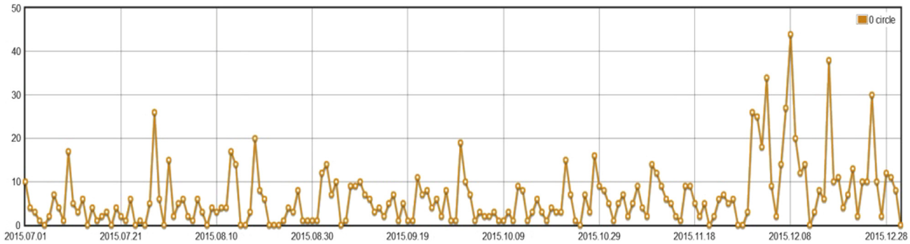

Fig. 1. Publication dynamics on target issue

To reveal the degree of similarity of fragments of respective time series to IO diagram in different scales, one can use wavelet analysis [3, 16]. A wavelet is a function which is well localized in time. In practice, we often use the Mexican Hat wavelet):

$$\psi(t) = C(1 - t^2)\exp\left\{-\frac{t^2}{2}\right\}, \tag{1}$$

and the Morlet wavelet:

$$\psi(t) = \exp\left\{ikt - \frac{t^2}{2}\right\}. \tag{2}$$

The essence of the wavelet transform is to identify regions of time series, which are similar to the wavelet. To explore different parts of the original signal with various degrees of detail, the wavelet is transformed by stretching/squeezing and moving along the time axis. Therefore, the continuous wavelet-transform has the location parameter (l) and the scale parameter (s). The continuous wavelet transform of function $x \in L^2(R)$ is determined as follows:

$$W(l,s) = \frac{1}{\sqrt{s}} \int_{-\infty}^{\infty} x(t)\psi^*\left(\frac{t-l}{s}\right)dt, \tag{3}$$

where l, $s \in R$, $s > 0$, ψ^* is complex conjugate of ψ, values $\{W(s,l)\}$ are called coefficients of wavelet transform, or wavelet-coefficients. The wavelet-coefficients are visualized in the plot with a location axis and a scale axis.

The reason to use the Mexican hat wavelet and the Morlet wavelet is a possibility to detect spikes in time series. Wavelet coefficients show, to which extent the behavior of the process in a definite point is similar to the wavelet in a definite scale. In the respective wavelet spectrogram (Fig. 2), all the characteristic features of the initial series can be seen: scale and intensity of periodic variations, direction and value of trends, presence, position, and duration of local features.

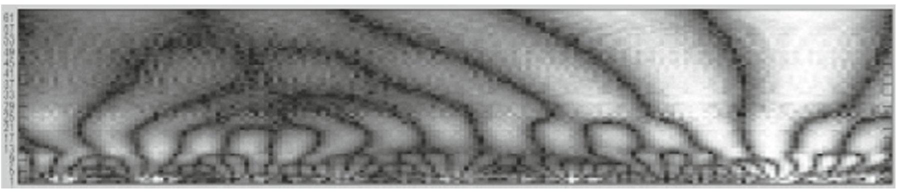

Fig. 2. Wavelet spectrogram (Morlet wavelet) of the information stream

IO dynamics is represented by most exactly the "Mexican Hat" and Morlet wavelets [3, 7, 16]. Therefore, the time series according to each of 15 IO components are analyzed during four periods (January 1, 2013–December 31, 2013; January 1, 2014–December 31, 2014; January 1, 2015–December 31, 2015; and January 1, 2016–December 15, 2016), and the presence of the above-mentioned wavelets is identified.

Based on revealed mentioned above information stove-pipings and their parameters (position, duration and intensity), the knowledge engineer complements KB of Solon-3

DMSS. In particular, the stove-piping was identified on the IO component "Underestimation of the scientific results of NAS of Ukraine" situated at November 30, 2015 with the duration of 14 days. Correspondingly, as a characteristic of the project "Underestimation of the scientific results of NAS of Ukraine," the parameter of duration of the project execution of 14 days is introduced, and as a characteristic of the project "Underestimation of the scientific results of NAS of Ukraine" influence on the objective "Discredit of scientific results of NAS of Ukraine," the parameter of delay in influence distribution for 10 months term is introduced. For other revealed information stove-pipings, characteristics of projects and influences are introduced in a similar fashion.

Thus, for the time period from January 1 2015 to December 31, 2015, KB is complemented and has the structure shown in Fig. 3. Correspondingly, the list of numbers and statements of all targets and projects of KB is as follows: 0 — "Information operation against National Academy of sciences of Ukraine", 1 — "Discredit of scientific results of NAS of Ukraine," 2 — "Discredit of the structure of NAS of Ukraine," 3 — "Discredit of well-known persons of NAS of Ukraine," 4 — "Overestimation of scientific results of competing with NASU organizations," 5 — "Lack of introductions of scientific developments into production," 6 — "Underestimation of the level of international collaboration," 7 — "Discredit of the organization structure of NASU," 8 — "Juxtaposition of scientific results of MES and NAS," 9 — "Discredit of President of NAS of Ukraine," 10 — "Discredit of other well-known persons of NAS of Ukraine," 11 — "Juxtaposition of scientific results of other academic organizations to NAS of Ukraine," 12 — "Juxtaposition of scientific results of foreign organizations to NAS of Ukraine," 13 — "Juxtaposition of developments of Ukrainian companies to NAS of Ukraine," 14 — "Underestimation of the level of scientific results of NAS of Ukraine," 15 — "Corruption in NAS of Ukraine 2," 16 — "Bureaucracy in NAS of Ukraine 2," 17 — "Inefficient personnel policy of NASU 2," 18 — "Misuse and inefficient use of the realty of NASU 1," 19 — "Misuse and inefficient use of the realty of NASU 2," 20 — "Misuse and inefficient use of land resources of NASU 1," 21 — "Misuse and inefficient use of land resources of NASU 2," 22 — "Discredit of the actions of the Case Management department of NASU," 23 — "Discredit of Executive secretary of NAS of Ukraine," 24 — "Corruption in NAS of Ukraine 1," 25 — "Bureaucracy in NAS of Ukraine 1," 26 — "Inefficient personnel policy of NASU 1."

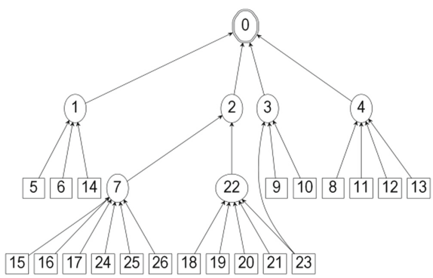

Fig. 3. Structure of goal hierarchy of knowledge base for information operation against National Academy of Sciences of Ukraine

It should be noted that for some IO components, namely, “Corruption in NAS of Ukraine,” “Bureaucracy in NAS of Ukraine,” “Inefficient personnel policy of NASU,” “Misuse and inefficient use of land resources of NASU,” and “Misuse and inefficient use of the realty of NASU,” stove-pipings were revealed twice during 2015, therefore, respective projects were entered into KB twice. For example, for the IO component “Bureaucracy in NAS of Ukraine,” projects “Bureaucracy in NAS of Ukraine 1” and “Bureaucracy in NAS of Ukraine 2,” but each of them has different characteristics of the execution duration (9 and 15 days) and respective influences have different characteristics of delay in distribution (9 and 11 months).

Then, in the Solon-3 DSS, degrees of project implementation are introduced. If for some IO components no stove-piping was found, as, in particular, for “Juxtaposition of developments of Ukrainian companies to NAS of Ukraine” and “Discredit of the actions of the Case Management department of NASU,” then for respective projects, implementation degrees are set equal to 0%. For all other projects they equal 100%.

Next, the results are obtained of the calculation of recommendations, namely, the degree of achievement of the main IO target and of project efficiency (relative contribution into achievement of the main target).

For the periods January 1, 2013–December 31, 2013; January 1, 2014–December 31, 2014; January 1, 2015–December 31, 2015; and January 1, 2016–December 15, 2016, the degrees of achievements of the main target have the following values: 0.380492, 0.404188, 0.570779 and 0.438703, respectively.

In the retrospective, the mean value of the degree of achievements of the main target is equal: to $(0.380492 + 0.404188 + 0.570779)/3.0 \approx 0.45182$.

Thus, since the mean retrospective and current value of the degree of achievements of the IO main target are sufficiently close (differ less than by 3%), then the conclusion can be drawn that IO during the current period can provoke the deterioration of the target indexes of the object with high probability.

3 Methodology for Constructing Knowledge Bases of Decision Support Systems in Information Operations Recognition

Application of the approach and the methodology described in the previous section calls for availability of a group of experts. Labor of experts is rather costly and requires considerable time. Also, for small expert groups, it is necessary to take into account competence of experts [17], which entails the need for additional information and time for its collection and processing. So, reduction of expert information usage during construction of DSS KB during IO detection represents a relevant issue.

The essence of the methodology of DSS KB building during IO detection [3, 16] is as follows:

1. Group expert estimation is conducted in order to define and decompose the goals of the information operation. Thus, the IO is decomposed as a weakly structured system. For this purpose, the means of SDCPEI are used.

2. Using DSS, the respective KB is constructed based on the results of expert examinations conducted by SDCPEI as well as using available objective information.
3. Analysis of dynamics of thematic information flow is performed by means of CMS. KB of DSS is supplemented.
4. Recommendations of the decision-maker are calculated by means of DSS, based on the KB already built.
5. As part of the "goal hierarchy graph" model, a hierarchy of goals, or KB, represented in the form of an oriented network-type graph (an example for Brexit is shown in Fig. 4), is built by experts.

The methodology is illustrated by the example of Brexit. Currently, Brexit is a topical issue that is widely researched by the scientific community [18].

The Consensus-2 system [12], intended for evaluation of alternatives by a group of territorially distributed experts, was used as SDEICP for group decomposition. Based on interpretation of the data base, formed in the Consensus-2 SDCPEI, the knowledge engineer created the respective KB of the Solon-3 DSS" [13]. The structure of goal hierarchy of this KB is provided in Fig. 4.

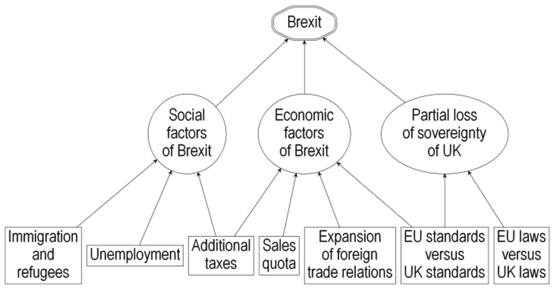

Fig. 4. Structure of goals hierarchy of knowledge base for Brexit

After constructing the goal hierarchy, analysis of dynamics of thematic information flow was conducted by means of InfoStream CMS [15]. For this purpose, in accordance with each component of the IO, queries were formulated in the specialized language. Based on these queries, dynamics analysis of publications on the target topic was performed. During formulation of queries in accordance to the goal hierarchy structure (Fig. 4), the following rules were used:

1. When moving from top to bottom, respective queries of lower-level components of the IO were supplemented by queries of higher-level components (using '&' symbol), for clarification.
2. In cases of abstract, non-specific character of IO components, movement from bottom to top took place, whereas respective queries were supplemented by queries of lower-level components (using '|' symbol).
3. In cases of specific IO components, the query was made unique.

Based on results of fulfillment of queries to the InfoStream system, particularly, on the number of documents retrieved, respective PICs were calculated for each of them. PICs were calculated under assumption that the degree of impact of IO component was proportional to the quantity of the respective documents retrieved. Obtained PIC values were input into the KB. Thus, we managed to refrain from addressing the experts for evaluation of impact degrees of IO components.

Recommendations (in the form of dynamic efficiency ratings of information operation topics) produced in the way describe above are used to evaluate the damage caused by the information operation, as well as to form the information counteractions [19] with information sources impact [20] taken into consideration. Based on the KB for Brexit, the Solon-3 DSS provided the following recommendations (rating of information impact of the publications topics): "Immigration and refugees" (0.364), "EU standards versus UK standards" (0.177), "EU laws versus UK laws" (0.143), "Expansion of foreign trade relations" (0.109), "Additional taxes" (0.084), "Sales quota" (0.08), "Unemployment" (0.043).

4 Conclusions

In the paper, feasibility of application of decision support systems is demonstrated in the process of recognition of information operations. The methodology was suggested for usage of decision support systems in information operations recognition, which allows to predict changes in values of target indices of the object for the current period based on the analysis of retrospective data. Also, the methodology was suggested for constructing knowledge bases of decision support systems in information operations recognition, which allows to provide the decomposition of the topics of the information operations and assess rating of the effectiveness of these topics.

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