Original Research Article

ANALYSIS OF FORECASTING METHODS AS A TOOL FOR INFORMATION STRUCTURING IN SCIENCE RESEARCH

ABSTRACT

Aims: To study forecasting methods so as to identify a general approach to information structuring and to choose the most efficient and approximated to natural intelligence method.
Study design: logical experiment that reveals the advantages and disadvantages of the forecasting methods.
Place and Duration of Study: Department of Information Systems and programming of the Kuban State Technological University.
Methodology: Logical experiment: mental simulation of the forecasting methods, of information structuring, knowledge and initial data representation, and the choice process in the studied methods followed by a written statement; inductive and deductive methods: comparing individual intuition methods and collective expert estimations to natural intelligence (NI), presenting the findings in Tables.
Results: The data collected as a result of logical experiment:
1.The more formalized a method is, the farther it is from NI and the readier for implementation by modern methods and means of computing equipment.
2. Eliminating any shortcomings of a forecasting method requires the approximation of its information structuring and choice making to those of NI.
3. Developing efficient DSSs for method searching requires the knowledge structuring similar to that of NI.
Conclusion: The existing forecasting methods are not suitable for intellectual DSSs. This paper suggests that science research should use new intelligence enhancement methods (IEM) when structuring information and formulating problems to be solved.

Keywords: forecasting methods analysis, intelligence enhancement, information structuring, natural intelligence, science research

1. INTRODUCTION

Planning and forecasting for various kinds of managerial activity [1-5] are known to be the most popular areas for practical implementation of modern decision support systems (DSS). Therefore, the presentation manner of knowledge base (KB), i.e. information structuring [6-10], will largely depend on the proposed problem solution method in a particular DSS. Thus, a common trend in approaching solution and its implementation in modern DSS is determined.

Some modern problems, such as [11] - the choice of one of two alternatives depends on presence of other alternatives; the notion of preference is meaningless; the choice out of many alternatives; the rules of choosing «typical», «average», «the most extraordinary» and so on, are still being solved manually, or fail to be solved accurately and effectively [11-13]. Only some stages of these problems (the literary and patent review, collection of experimental data, data processing, decision application tasks, registration of research results and their publication) are being solved with the use of information technology. To such problems can be referred search researches, connected with the search for solution method for a certain problem from a certain area of study. Its stages are not regulated, implemented in different ways which, in turn, depends on the researcher's personal skills and knowledge of computing equipment. For other tasks, that are automated and use various planning and forecasting methods, a great variety of intellectual information systems and application packages have been elaborated. For science researching, modern DSSs of such level have not been designed yet [11-13].

All depends, or 'gets stuck', on the process of choosing the 'best' option of many possible ways of structuring knowledge, data, where information is not numerical [14]. The efficiency of such information system at choosing the best option should not be worse than the efficiency of NI making a decision on its own.

In order to develop a method of getting KB for any specified area of study, all known forecasting methods have been studied. This will allow explore all the modern approaches to the structuring of the information, which are used in modern intellectual DSSs. Conducting of such research allows a common approach to information structuring has been identified.

That's why a logical experiment was applied for explore all the modern approaches to the structuring of the information. Mental simulation of the forecasting methods, such as individual intuition methods and collective expert estimations methods, revealed a general approach to information structuring and helped to choose the most efficient and approximated to natural intelligence the method of information structuring. New properties of the methods have been identified, their advantages and disadvantages have been compared by means of inductive and deductive methods. The data collected as a result of the logical experiment have been presented consecutively in Fig. 1-3. Such proposed by us method of data representation in Fig. 1-3 revealed the fact that the more formalized a method is, the farther it is from natural intelligence and the better for using in modern methods and means of computing equipment. Thus, it was detected, that the existing methods (which were researched in this article) are not suitable for intellectual DSSs using for science research. Therefore, we suggest that new intelligence enhancement methods (IEM) [11] should be applied for structuring information [15-17] to solve a problem of science research [13].

The empirical data of the logical experiment have been obtained in ten stages, demonstrating a gradual alienation (becoming more distant) of artificial intelligence (AI) from natural intelligence (NI). Such data presentation reveals how certain technical decisions lead to specific drawbacks. These data can be employed for upgrading the indicated methods by the suggested techniques.

2. MATERIAL AND METHODS

"Mental experiment in its logics is a hypothetical-didactical structure, as along with the essential assumptions, whose veracity has been established theoretically and experimentally, hypothetical assumptions are introduced in the course of the research. The latter find their reaffirming in the process of all transformations of the source material, whereby sensory-visual components, evaluation components and suchlike are involved. Unlike ordinary deductive argumentation, this creativity act does not produce the isolation of implicit information, but new knowledge, which the assumptions for the mental experiment did not contain. It is exactly this hypothetical-didactical structure, i.e. the introducing of new hypothetical assumptions to fill in 'blind spots', which stimulates discovering new qualities, aspects and relations of the researched objects" [18].

For this study, authors reviewed a number of research papers [19-24], containing theoretical material on forecasting methods. Among forecasting methods the best known and frequently used methods have been selected. These methods are cutting-edge in the selected groups, therefore, they have been chosen for our research. These methods are cutting-edge in the selected groups, therefore, they have been chosen for our research. The definitions of these forecasting methods, as well as their main advantages and disadvantages (see section 3 of this article in the discussion of each of the selected forecasting methods), obtained experimentally and published, have been taken from the mentioned papers.

The given experiment is not aimed at revealing implicit information hidden in the text or contained implicitly in the very well-known empirical data obtained for these methods. The novelty of our research is in carrying out a mental experiment which made it possible to compare the functioning of these methods (structuring of information, algorithmic sequence of actions, presentation of initial data, and so on) with the functioning of NI (presentation of initial data, structuring knowledge, among which it will be get necessary solution, and so on). Introducing hypothetical assumptions (they are given in Fig. 1 - 3), the authors managed to determine a number of new properties of these methods and their shortcomings. Authors also happened to define a number of ways to approximation these methods to the NI.

As a result, new knowledge has been obtained and presented in tables in the underlined bold italicized type, such as - the choice of alternatives in AI is performed by algorithms which differ from the rules of memorizing (structuring) information in NI, but similar to the algorithms of finding alternatives used for mathematical methods, for instance, optimization, statistics and so on (misrepresentation № 4, stage 8 in Fig. 2).This knowledge is not contained in the method definition and in the theoretical data taken from other papers. It is completely new knowledge, obtained as a result of the mental experiment. Thus, the obtained knowledge given in the tables can be considered empirical data. This method of presenting empirical data has been designed by the authors of this article and is new. It helped to take a look at these methods from another side. Such approach made it possible to obtain the new knowledge: the more formalized a method is, the farther it is from natural intelligence. Therefore, the authors suggest apply in DSSs, which are using for science research, approximated to NI the methods of information structuring and methods of processing.

3. RESULTS AND DISCUSSION

To identify a general approach to information structuring, the methods used for forecasting most frequently have been studied. The analysis of individual intuition methods and collective expert estimation methods revealed the following advantages and disadvantages (stages 1-10 in Fig.1 - 3).

3.1 Individual intuition methods

Method of interview is known to provide feedback to the questions stated according to the objective of the study by means of an interview between an interviewer and a respondent [19]. Its advantage is the ability to withdraw and utilize information (or knowledge) already past the cognition stage at the respondent's natural intelligence. The disadvantages here are: small scope of knowledge, information is not structured.

So interview methodcan be used for copying structured information from natural intelligence of the subject into artificial intelligence as similar to the original as possible. It is also necessary to find out the methods of information structuring utilized by the subject to find a solution method (stages 1 and 2 in Fig. 1)

THE DEGREE OF FORECASTING METHOD APPROXIMATION TO NATURAL INTELLIGENCE (NI) DEPENDING ON FORMALIZATION

The more formalized the method is, the farther it is from NI and closer to implementing by methods and means of computing equipment

NI ==========▶ AI

1 2 3 4	5 6 7	8 9	10 11
Individual intuition:	*Collective expert estimations:*	*Methods of projected extrapolation:*	*Modeling methods:*
- Interview; - Scenario modeling; - Psycho-intellectual idea generation.	- Method of panel counseling; - Method of collective generation; - "Delphi" method; - Matrix method.	- OLS; - Exponential smoothing; - Moving averages; - Adaptive antialiasing; - Autoregressive transformation; - Harmonic balance.	- Structural; - Web-based; - Matrix; - Immitating.
Really close to NI, but it is impossible to verify the path of result attainment		***The choice of options by means of well-known mathematical methods which can be mapped to other known methods and means of computing equipment.***	

Individual intuition method of interview	**Misrepresentation №1**	**Problems:**	**Misrepresentation №2**
Structuring information on solution methods and comprehension are performed by NI, but the retrieval of knowledge to use in AI systems	***Information*** is ***not structured yet*** and is in arbitrary form.	- how to present, process and use this information(knowledge) in the best way ; - how to improve information collection accuracy, its sufficiency (completeness). **Solution:** - to introduce specific definitions for the knowledge and information required to be used in AI which will allow to use other methods; - ***to apply methods of collective expert estimations***	***The knowledge*** used in ***AI*** is now ***different from that of in NI*** in presentation structure and basic definitions.
1	2	3	4

Fig. 1.Forecasting methods becoming more distant from NI depending on their formalization degree – stages from 1 to 4 (formalization degree and number stage are directly proportional)

The employment of intuition method (stage 1 in Fig. 1) brought about misrepresentation № 1 (stage 2 in Fig. 1) of all the processes taking place at NI. After that, some problems with understanding a number of informational processes arose, which led to the following misrepresentation № 2 (stages 3 and 4 in Fig. 1).

Problems:	Misrepresentation №3	Problems:	Misrepresentation №4
- the results obtained by AI have to be trusted without further explanation of how, what and why; - human element influencing opinions of experts at collective expert estimations. **Solution:** - to change the approach to a forecasting problem solution (solving by NI on paper) which will make use of mathematical methods, for instance, in optimization or statistics; - ***to apply method of*** **scenario modeling**.	***AI structures information on a situation***, process and so on which are under study. Methods known to AI are further selected to solve the problem of study. However, in ***NI*** the opposite takes place – ***knowledge of solution methods is specifically structured***, and, depending on the situation, a suitable ***method is chosen following special memorizing (structuring) rules***.	- in adequacy at solution method choosing; - small number of options; - information representation does not allow to use more complex algorithms, structures and methods to solve forecasting problems (choice of alternative). **Solution:** - application of methods of psycho-intellectual idea generation, as well as collective expert estimations; - ***application*** **of neural network and formalized methods** of forecasting problem solution.	***The choice of alternatives in AI is performed by algorithms which differ from the rules of memorizing*** (structuring) ***information in NI, but similar to the algorithms of finding alternatives used for mathematical methods***, for instance, optimization, statistics and so on.
5	6	7	8

Problems (Ten "hot spots" in the AI studies (Pospelov, D.A. (1996). Intellektualnye sistemy [Intelligent Systems]. Moscow: MSU.)):
- transition to reasoning ;
- problem of justification;
- generation of explanations;
- search for relevant knowledge;
- text comprehension;
- text synthesis;
- cognitive graphics;
- multi-agent systems;
- network models;
- meta-knowledge.

Solution:
- to approximate AI to NI by providing information on the studied situation, object, process, etc., in the form of neural network, resembling the neural network system performance;
- elimination of drawbacks by perfecting formalized methods, combination of well-known methods and information representation models and implementation in AI.

9

Fig. 2.Forecasting methods becoming more distant from NI depending on their formalization degree – stages from 5 to 9

Misrepresentation № 2 gave birth to a number of problems (see stage 5 in Fig. 2) that were to be solved in order to boost the efficiency of the discussed methods for addressing more challenges. As is seen from Fig. 2 stage 5, due to this reason a method of scenario modeling was introduced.

Method of scenario [20] modeling allows for describing logically a consecutive process, event, etc, on the basis of the current situation. The scenario in such method - is a picture, which reflecting a consecutive detailed task solution, helps to detect serious drawbacks and to make a preliminary decision about possible ceasing or completion of work on the projected object. To be precise, the scenario is an accumulator of the initial information on the basis of which all work on the projected object is to be carried out.

The advantages of method of scenario seem to be the following. It makes possible detailed presentation of initial information on the projected object and the plan of work with it. Thus, the information on the researched object is fairly well structured, which enables better understanding the situation and selecting a suitable research method. When solving forecasting problems by natural intelligence (NI), the given method may be similar to drawing up schematic charts on paper in order to structure information on the researched situation. For instance, a schematic chart of a driver's behavior in different circumstances when following appropriate traffic rules which makes it possible for a driver or a pedestrian to understand how to behave in a certain situation. So, the method of scenario modeling enables one fairly accurately to automate the process of information structuring about the researched object by NI.

Its disadvantages are also obvious. The choice of solution method is subjective as it is based on individual or group experience and does not cover all possible solution options currently known. This method may contain the information on solution methods though, which is typical for NI when solving such forecasting problems, yet it is incomplete as it is based only on the hands-on experience. There are much more the effective theoretical developments for such problems, which might be unknown yet for the researcher.

Scenario modeling method is the most efficient for structuring information on the projected object (the closest to NI in terms of the research process or method of study). The structured in this way information can be successfully used for further choosing a solution method from all specially structured knowledge about all solution methods (the closest to NI way of representing information on all solution methods and choice of "the most suitable" of them). It also makes it possible to structure the obtained personal expertise (results, ways of building scenarios, the scenarios themselves and so on) after the use of this method for its further application which will increase the efficiency of AI.

Method of psycho-intellectual idea generation [21] is a method of individualized expert estimation at which the latter is performed by means of program management which includes access to human memory or mass storage device of PC.

The analysis of method of psycho-intellectual idea generation reveals the following advantages. When addressing human memory psycho-intellectual methods are used, which evoke such associations which help individual obtain from their NI necessary information on solution methods in various areas of specifically structured knowledge. For this, special techniques are used to enhance intelligence. Thus, ideas are generated. This method tends to be more effective when the individual uses special techniques for memorizing information (i.e. information structuring) based on the associations, in other words, on the associative memory. It is obvious that the application of methods structuring information to remember and the techniques improving memorizing makes it possible not only to obtain high quality test data for artificial intelligence (AI), but improve immensely your own NI and become an outstanding expert in a particular area.

In addition, the given method helps to identify an important tool of NI in search of necessary option or, when selecting the necessary alternative out of all currently available alternatives. As is known, any scientific problem is gradually specified in the course of its solving and the most suitable solution is selected in the end. Thus, the search for problem solution among the knowledge structured at NI in a specific way occurs simultaneously with specifying the knowledge about the object of study. It is important to bear in mind that in NI the very knowledge about solution methods, which is specially structured, sets the direction for problem solution. Indeed, if a method for solving such problems exists, then it is sure to be found among other known methods where it occupies its own place in the structured memory of NI. NI recognizes the needed method by means of associations used for memorizing. Then, if the direct solution is missing, NI shall offer options for adaptation of the initial information on the researched object to the required kind which will make it possible to apply "the most suitable" method. And if the "most suitable" method is missing, the information on existing techniques of designing a new (unknown beforehand) method of solution is to be used.

Thus, the given method is in fact a simulator of natural solution search mechanism at NI. With the application of the given method all search functions remain with the NI respondent, and along with the implementation of psycho-intellectual techniques which help the respondent work with their NI and propose different ideas, various tools of computing equipment are used. They are also used for assessing the ideas and working with the obtained empirical data.

Disadvantages of this method have become obvious too. The mentioned techniques are still used for retrieving successful ideas from NI. Techniques of information (knowledge) structuring for problem solution methods have neither been developed, nor used in AI yet. NI functional capabilities and performance peculiarities have not been yet implemented in AI either. They were designated indirectly in discussing this method:

- the search for problem solution among the knowledge structured at NI in a specific way occurs simultaneously with specifying the knowledge about the object of study;
- in NI the very knowledge about solution methods, which is specially structured, sets the direction for the problem solution;
- NI recognizes the needed method by the associations used for memorizing;
- if the direct solution is missing, NI shall offer options for adaptation of the initial information on the researched object to the required kind which will make it possible to apply "the most suitable" method;

- if the “most suitable” method is missing, the information on existing techniques of designing a new (unknown beforehand) method of solution is to be used.

Method of psycho-intellectual idea generation demonstrates a successful application of psycho-intellectual techniques to get ideas for scientific problems solution, proves availability and efficiency of certain memorizing techniques (information structuring) in NI, as well as dependent on them information retrieval methods. Special training on memorizing improvement is necessary to become a highly qualified specialist. It also proves it why the level of the expert directly depends on training quality, ability and will to learn information. Such training may produce an expert with most efficiently structured knowledge in his/her NI. So, to obtain the best AI, most approximated to NI in operating, it is necessary to use in it structured knowledge about solution methods along with suitable methods of choice from this structure.

This method visualizes the way the NI searches for the solution from the specifically structured knowledge, simultaneously specifying the information on the object of study, which proves the importance of its being employed by AI as it is in NI.

As is seen from the descriptions of the methods (their advantages and disadvantages), as well as from Fig. 2, with each method being introduced, more challenges arise that are to be solved with the help of computing power. These solutions further alienate information structuring ways, choice techniques, the representations of the studied situations from the NI ways (see stage 6 and 7 in Fig. 2).

The further boost of efficiency has become possible through developing collective expert estimations methods. The methods below can be employed for addressing more challenging tasks.

3.2 Collective expert estimations

The given methods enhance the efficiency of NI of one respondent by increasing the number of participants there.

The first one to mention here is the method of panel counseling [22].Experts are invited to open discussions in order to develop a coordinated decision on the issue of consideration. The following advantages have been revealed here. It seems to be quite efficient as the expertise of participants is increasingly building up on condition that they regularly attend those discussions. A positive atmosphere of such panel meetings facilitates a better engagement of the experts’ potential. Yet, there are disadvantages too. The personal confidence in their rightness, infallibility prevents experts from arriving at a solely correct decision.

Unless panel counseling method is used for psychological idea stimulation and generation, it appears to be ideal for problem solving, where some knowledge is added to another resulting in a problem solution (“two heads are better than one”). In this case one can speak about natural intelligence enhancement.

The method of collective generation (“brainstorming” technique) [21] uses the following algorithm. A problem is stated, participants in order of their ranks speak out any possible ideas (even absurd), the leader takes them down, and the panel selects the most interesting. The ideas undergo changes in the process of discussion. The obvious advantages of this method are in the following. Expertise from different areas of knowledge is combined here which makes it possible to find new, more interesting solutions. A favourable atmosphere facilitates finding options. On the other hand, the method has its own drawbacks: the structured knowledge is still located at NI of the participants; these data are not yet structured in AI and are not implemented by means of PC. The human factor is present – ambitions, fear of bosses at discussion.

Collective generation method saves time spent on research, as it had been carried out by different people at different times by different methods and has its own parameters of information structuring in NI. The structured information is retrieved, sieved and utilized in a specific form for finding a solution. It is obvious that the NI should first structure information on the issue of consideration, collective structuring being more efficient. It is also obvious that the result of the collective information

structuring by NI is an efficient tool for problem solving, a relevant result which can be used in the database of intelligent information system.

Delphi method [23] represents a combination of surveys, interviews, brainstorming meetings. It is used in strategic planning. It allows arriving at the maximum consensus in making a decision. The results are further processed by statistical methods. It is devoid of negative group influence through engaging independent experts. The method appears to be effective on condition that individual estimations of qualified experts are correctly generalized and processed, enabling to achieve a collective opinion with high degree of accuracy and reliability. Nevertheless, it is not devoid of its own shortcomings. Too much time is spent on the analysis. The result is also influenced by interpersonal and individual factors.

Delphi method makes it possible to retrieve structured knowledge by NI in a more comprehensive way, and the results are more reliable. In other words, a combination of methods fights their individual drawbacks, but does not preserve the knowledge retrieved from NI in their structured form.

The method of forecasting based on matrices with vertex values of the projected object graph-model is known as matrix method [24]. The matrices undergo further transformation and operating. Its efficiency is best proved at panel forecasting of large systems, where a large data massif is to be processed to research on the issue of consideration. Yet, there is a need for coordination in separate elements forecasts, identifying and forecasting the main relations between them. It is necessary to detect the cross-influence of the system events which complicates the studies and the algorithm.

Matrix method is able to process a huge massif of information on the problem (which is impossible for the NI), but the processing method is different from the NI information structuring method. This makes it possible to identify formalized ways of problem solution and refer to computing equipment (CE). If NI could process as large data massifs, as CE can, then such NI would be more efficient at solving problems of that kind, than the computing machine with the matrix method and incapable of information structuring, the way it can be done by NI.

Problem solving (stage 7 in Fig. 2) by the methods in para. 3.2 led to misrepresentation № 4 (stage 8 in Fig. 2). This highlighted a number of problems which are also called ten hot spots of AI (stage 9 in Fig. 2). The modern solution of these problems is in formalizing a large number of processes and the use of computing power, but not in effective ways of information structuring at NI. Henceforth, another misrepresentation № 5 arose (stage 10 in Fig. 3), which contains the same unsolved problems from the previous misrepresentations.

Misrepresentation №5	Problems:
The information of the studied system, process and so on is stored in AI as the neural network system, approximated in the form to NI. *However, the NI information of the same level is the structured information, saved on the physiological level, on solution methods to different problems, which is used depending on the rules of structuring (memorizing).* Thus, such information representation in AI allows achieving accuracy in mathematical calculations, yet one does not succeed in eliminating the above problems and misrepresentations. *Misrepresentations 3 and 4 occur on the level of information structuring.*	- *information on solution methods is not structured*, but in arbitrary form; - *the knowledge* used in *AI differs from that of NI* in representation structure and basic definitions; - *AI structures information on a situation*, process and so on which are under study, and then methods known to AI are further selected to solve the problem of study. However, in *NI* the opposite takes place – *knowledge of solution methods is specifically structured*, and, depending on the situation, a suitable *method is chosen following special memorizing (structuring) rules*; - *the choice of alternatives in AI* is performed *by algorithms which differ from the rules of memorizing* (structuring) *information in NI, but similar to the algorithms of finding alternatives used for mathematical methods*, for instance, optimization, statistics and so on.; - *the information of the studied system, process and so on is stored in AI as the neural network system,* approximated in the form to NI. *However, the NI information of the same level is the structured information, saved on the physiological level, on solution methods to different problems, which is used depending on the rules of structuring (memorizing).* **Solution:** From the arbitrary form of knowledge of solution methods to be used in AI, *to go on to structuring information* which is most approximated to the process in NI.
10	11

Fig. 3.Forecasting methods becoming more distant from NI depending on their formalization degree – stages from 10 to 11

Thus, we have determined the main problems of the indicated solution methods which alienate the AI from the NI and prevent their being used in the intellectual decision support systems of modern science research. They are enumerated in para. 3 of this paper and briefly outlined in item 11 of Fig. 3. In addition, in this item of Fig. 3 we offer the solution to those problems [11-17, 25]. The authors

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4. CONCLUSION

Having analyzed the above methods, we have obtained the following results which were summarized in stages offigures 1, 2 and 3.

The results make it obvious that the more formalized method is, the farther it is from NI and closer to implementing by modern computing methods. Thus, modern ways of NI implementation incur the following problems (specified in the Figures) in this particular area of science. Therefore, we have chosen the following line of research in the development of modern AI – "challenges related to approximation of specialized AI systems to human possibilities and their integration through human effort in this area (i.e. Intelligence Enhancement (IE) application)" [10].

It is only natural to expect such intellectual Decision Support System (IDSS) to become "an expert" able to prompt the right direction, thereby saving the researcher's time. The researcher's manual effort – his personal pursuit of quality – should not excel that of IDSS. So, the approach to information structuring in IDSS must be similar to that performed by NI.

Having compared a number of typical forecasting methods, we have found out that they are unsuitable for IDSS of such kind. Therefore, we propose to use Intelligence Enhancement Method (IEM).This development of ours, method that structures information on the area of studies and the problems to be solved thereby in a special way, was publicized in a number of papers and is characterized by a fairly high degree of novelty [25].

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