Fuzzy Logic in Monitoring the Non-Proliferation of Nuclear Technologies, Raw Materials and Weapons

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ABSTRACT

This project is dedicated to the elaboration of a man-machine system for monitoring the non spread of nuclear weapons, technologies, raw materials.

The main purpose of such a system depends on the customer requirements and may be:

– control of non proliferation of nuclear technologies, especially those that can be used to manufacture a nuclear explosive device;

– the appraisal of the possibility of production of nuclear weapons by a certain country on the basis of its intellectual and scientific-technical potential, its raw material resources, its export-import potential and other parameters.

I. Introduction

As the First International Conference on Fuzzy Logic and Intelligent Technology in Nuclear Science FLINS'94 showed, it took place in Mol (Belgium) in September of 1994, it is possible to recognise some ways of use of fuzzy and intelligent technologies in this subject area:

– use of fuzzy models for modelling atoms and various processes on the atom level;

– use of fuzzy logic devices for control of various processes in nuclear piles;

– use of fuzzy models for the development of information support systems for an operator of nuclear power plants;

– use of fuzzy technologies for the development of models of nuclear catastrophes and models to avoid them (or control);

– use of fuzzy models in tasks of appraisals of impacts of nuclear catastrophes;

– use of fuzzy and intelligent technologies in tasks linked with social-and political questions of employment nuclear technologies, raw materials and weapons.

This article belongs to the last item in the list of the area of employment fuzzy and intelligent technologies in nuclear science.

We think that use of fuzzy and intelligent technologies in social-political area has great future. This area is a classical example of "human systems", for modelling and exploring of which theory of fuzzy sets has appeared [1].

The importance of the problem of non proliferation of raw materials, technologies and weapons is quite obvious. To our opinion, this problem is a very important practical task in the framework of IAEA, where applications based on intelligent and fuzzy technologies can have a significant effect. That is why we make efforts on the development of the theory and practical principles of building intelligent systems for monitoring complex problems in the mentioned

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area.

Ⅱ. The task of the non proliferation of nuclear technologies, raw materials and nuclear weapons from the point of view of system engineering of information support

The task of monitoring problem in such area is a complex multidimensional problem. As a result of the conducted research, the information system support for this task can be described as follows.

The purpose of such a system may be the following:

– the supervision of movement of raw materials inside and outside certain countries;

– control of non proliferation of nuclear technologies especially the most dangerous and monitoring the movements of persons who can employ them in dangerous products;

– evaluation of the possibility of production by a particular country of a particular kind of nuclear weapon on the basis of its intelligent, technological potential etc. by using different parameters.

The main elements of such a monitoring system at the top level are, on the one hand, the information space, containing information about the state of the problem, and on the other hand, expert(experts), working with this information and reaching conclusions about the state of the problem and forecasts about its development.

2.1. The information space represents a set of various information elements, which characteristics may be described as follows:

– variety of carriers of the information, i.e. fixing of the information in articles, notes in newspapers, computer files, audio-and videoplots etc.;

– fragmentary information. The information usually relates to a fragment of the problem, and different fragments can be "covered" by various information sources;

– different levels of the information. The information can relate to the problem as a whole, to one of its parts, or to particular elements of the problem;

– various degrees of reliability. The information can contain the particular data of various degrees of reliability, indirect data, results of conclusions on the basis of reliable information or indirect conclusions;

– possible contradictions. The information from different sources can coincide, be slightly different or in contradiction.

– time-varying. The problem is evolving in time, and therefore information at different moments of time about the same element of the problem can and should be distinguished;

– possible bias. The information reflects the definite interests of the source of the information, and can therefore have a biased nature. In that specific case it can be expressly wrong information (for example, for political problems or for problems, connected with competition).

2.2. Experts are active elements of the monitoring system and, in observing and studying the elements of information spaces, judge about the condition of the problem and the prospects of its development in view of the listed properties of the information space. Usually experts form some structure (marketing department firm, consulting service, agency, ministry etc.). Then each expert "of bottom level" deals with some part of the problem and works with the elements of the information space, experts of higher level deal with larger fragments of the problem or the problem as a whole, and work also with conclusions of previous experts. Thus they can be acquainted with conclusions of lower level up to the elements of the information space.

Ⅲ. Technology for the monitoring of the information

For the development of computer systems oriented on solving the task of monitoring and processing such

information, we analysed the known information processing technology (technology of data bases, technology of knowledge bases or expert systems, gipertext of information processing technology). They do not satisfy completely the functional requirements of the systems. Therefore the necessity of development of some special technology, supporting the creation of such systems has arisen. This technology is based on the use of a series of elements, enabling to process similar sort the information.

In particular:

– for the realisation of opportunity of processing the information from diverse sources, the documents are not stored in the data base of the system. Only their references, with evaluation of the information contained in them given by experts, are stored;

– for the processing of fragmentary information the tree model is used;

– the processing of different levels information is reached by allowing the user the opportunity to relate the evaluation of any particular information material to different tops of the tree-model;

– the processing of information of various degrees of reliability, which can be probably contradictory or tendentious, is made possible by using linguistic evaluations [2, 3] of the information given by experts;

– time-variation is taken into account by making it one of elements of description of the objects of the system.

The scheme of this technology is shown in fig. 1.

Thus, systems constructed on the basis of our technology permit to have a model of the problem developing in time, supported by references for all information materials, coming from experts, with common and private evaluations of state of the problem or its aspects, received on the basis of fuzzy logic. The use of time as a parameter of the system permits to conduct analyses and to build forecasts of development of the problem (to answer questions "What would happen, if...?"). In this case the opportunity of allocation "of critical ways" arises, i.e. such elements of the model, small change of which can cause significant changes in the conditions of the problem. Knowing such elements has a large practical significance and permits the discovery of "critical locations" in the state of the problem at certain moment, to develop measures on blocking of undesired situations or to make desirable, i.e. to manage the development of the problem for the purpose of the interested organisation.

Ⅳ. Technical aspects of building such a system

To build applications based on this technology we have chosen GURU. GURU is an Expert System Development Environment especially suitable for fuzzy logic solutions. It is an interference engine with rule based processing, fuzzy reasoning and certainty. We can use it as a tool for forward, backward and mixed chaining to develop intelligent applications. To secure and protect our database we can have 55535 different Security Code Combinations and we of course can encrypt our database by means of GURU. With GURU we have not only an expert system shell but integration of complete development environment for Fuzzy logic solutions. Fuzzy variables with GURU are multi valued variables. They can be manipulated the same as discrete variable. In programming with GURU we can make combinations of fuzzy variable and certainty factor algebra concepts. We also can combine rule based programming with fuzziness and certainty so that the determination of a premise can be based both upon fuzzy and uncertain variables. It gives us an outstanding opportunity to build adequate and effective models in the subject area.

Since a user will normally have the competence to evaluate and input information only in specific areas of the subject area, we think that a network based multi-user version of the system would be the most useful.

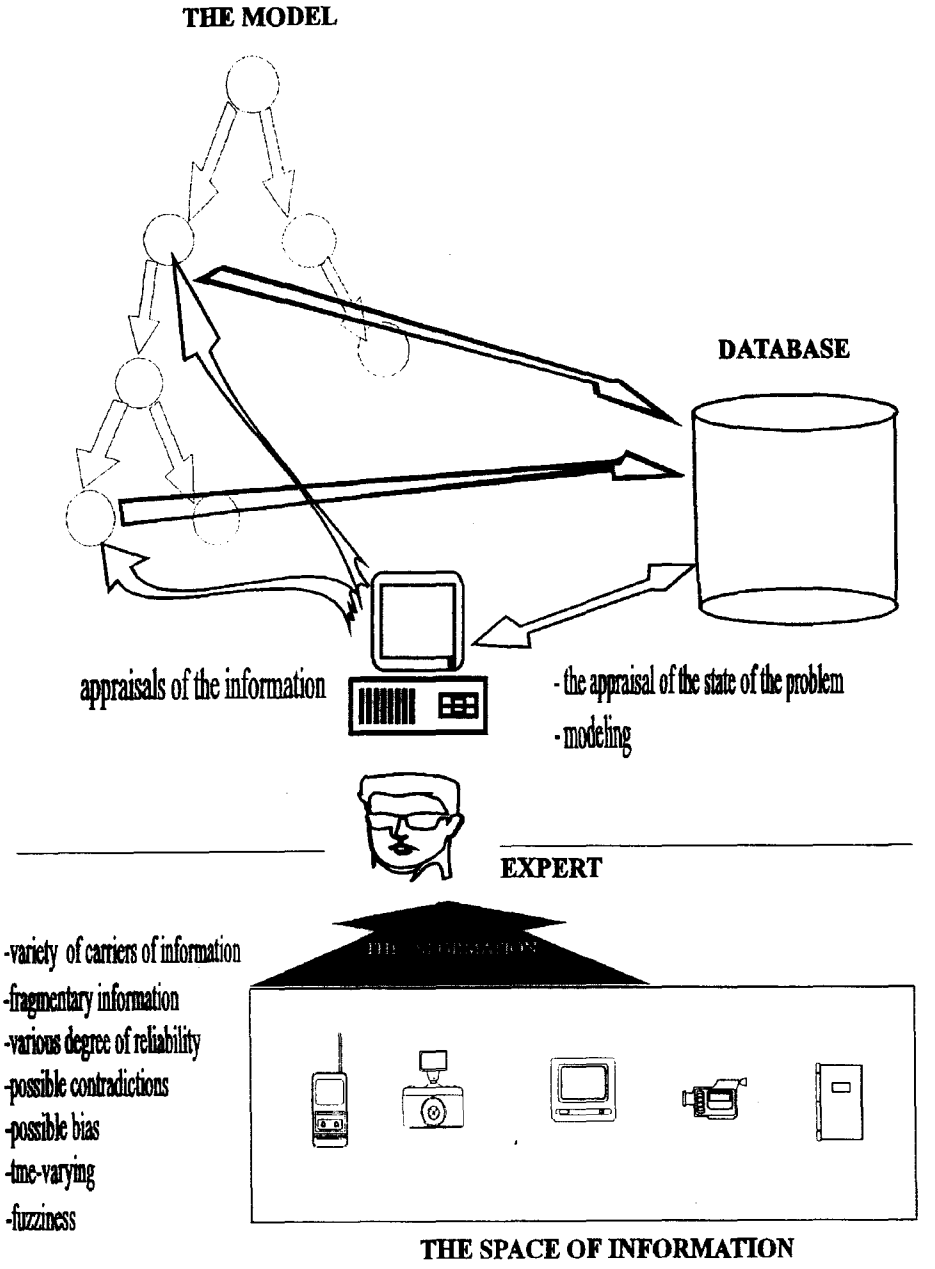
THE MODEL
DATABASE
appraisals of the information
- the appraisal of the state of the problem
- modeling
EXPERT
-variety of carriers of information
-fragmentary information
-various degree of reliability
-possible contradictions
-possible bias
-time-varying
-fuzziness
THE SPACE OF INFORMATION

Fig. 1

The main idea is to cut the information tree into different layers, and to use the described technology in such a way that local tasks are possible. The top output of a bottom level of the system will be used as input for the higher levels.

This gives us an opportunity to optimally use distributed knowledge in monitoring the task.

V. Description of the system

The information monitoring system realised with use of stated above principles, in our opinion, should consist of several main subsystems:

- subsystem of input of the information;
- subsystem of forecasting;
- subsystem of modelling;
- subsystem of the reports;
- subsystem of the analysis of the entered information;
- subsystem of the manager.

Each of listed subsystems plays the important role and cannot be excluded without considerable reduction of qualitythe whole system.

5.1 Subsystem of input of the information

This subsystem plays the important role in information maintenance of information monitoring system. We shall remind, that the model of subject area is submitted as a tree of aspects, the structure of each of which is also submitted as a tree. The expert receives the document as the text and evaluates it. If the expert considers, that the document is important he enters it in the system. For this purpose it is necessary to the expert to choose in structure of model of a problem necessary aspect (aspects) and its attribute (attributes). The information from the chosen document can confirm or to change significances of the attributes. If the expert experiences difficulties at acceptance of the decision concerning significance of evaluation of an attribute he can overlook the information connected with this attribute from the database in the order beginning from the present moment. After the expert has accepted the decision he enters the evaluation of an attribute in the system and the given evaluation becomes current evaluation, which then is taken into account by work of other subsystems.

We developed a group of algorithms on sequencing of a state of the model at defect of the information to some attributes of the aspect or at input of the evaluations in the top units of the tree.

5.2 Subsystem of forecasting

Given subsystem allows to evaluate development of a problem hereafter. The valuation of the state of the problem hereafter is built proceeding of the analysis of the information entered into system earlier. The user sets a temporary interval on which it would be necessary to look dynamic changes of the development of the whole problem or its separate aspect and receives the answer as the graph or agreed set of evaluations of each attribute. At designing and construction of this subsystem we use algorithms allowing to give, on our opinion, the authentic forecasts at a limited set of initial data.

5.3 Subsystem of modelling

This subsystem serves for imitation of various variants of change of a state of the model of the subject area and allows to answer questions "What would be if...?". By entering in this subsystem the user receives an opportunity by change of significances of evaluations of the attributes look on and to evaluate the state of the model. In this subsystem search of so-called "critical" ways is possible. Under a "critical" way we understand such a combination of significances of interconnected attributes small changes of significances located below attributes cause large changes located above attributes.

5.4 Subsystem of the reports

The subsystem of the reports serves for granting

maximum convenience to the users of system at drawing up of the various information and reports. With the help of the given subsystem it is possible to receive samples of the current information on current significance of an attribute, aspect or problem as a whole with allowance for of various parameters. Retrospective sample of the information on an analysed problem is possible too.

5.5 Subsystem of the analysis of the entered information

The subsystem of the analysis of the entered information allows to conduct retrieval of the information from a database of the system to various attributes. It allows quickly to receive data on changes made in system for a determined interval of time, changes introduced by the particular user, changes made on the basis of the particular document and other.

5.6 Subsystem of the manager

In many systems there are the requests of division of access to the information. This division is necessary in many cases and serves in interests of organisation of using the system. This subsystem serves for registration, exception of the users, change of a level of their authorities.

Ⅵ. Discussions of results and conclusions

The monitoring of the spread of nuclear technologies, raw materials and nuclear weapons is a very urgent problem especially nowadays, which requires for its solution the application of fuzzy and artificial intelligence technology. It is therefore suited as one of the important practical problems in the framework of IAEA.

Ⅶ. Acknowledgement

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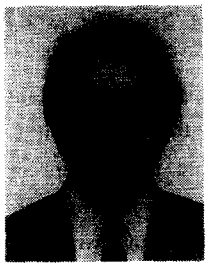

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Alexander Pavlovich Ryjov was born in Karanovo (Rybinsk), Russia on April 18, 1960. He currently lives in Moscow, Russia. He is married, and the father of three sons.

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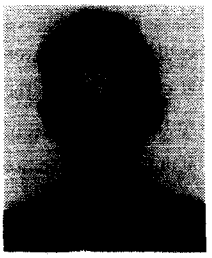

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He received the M.Sc. degree in Computer Science from Moscow Institute of Radiotechnic, Electronic and Automatic in 1983.

He together with Dr. Alexander Ryjov from Lomonosov' Moscow State University have been developing technology of information monitoring of complex problems since 1992, when he became a head of the Software Department of Association of CD-ROM Users and Producers. The first publication on this topic was in 1994 in the FLINS'94 Proceedings.