

DOI:10.5604/20830157.1109369

## INFORMATION SYSTEM FOR A FUZZY COGNITIVE ANALYSIS AND MODELING

**Alexander Gozhyi, Irina Kalinina**

Petro Mohyla Black Sea State University, Department of Information Technologies and Program Systems

**Abstract.** *The paper presents the information system for the cognitive analysis and modeling based on fuzzy cognitive map. The system allows to analyze the information of the experts to model complex systems and processes. Describes the structure of the system and the features of the functioning and implementation.*

**Keywords:** fuzzy cognitive map, the cognitive analysis, the concept

### SYSTEM INFORMACJI DO ANALIZY I MODELOWANIA POZNAWCZEGO

**Streszczenie.** *Przedstawiono system informacji do analizy i modelowania poznawczego opartego na rozmytej mapie poznawczej. System pozwala na analizę informacji ekspertów w celu modelowania złożonych systemów i procesów. Opisano strukturę systemu oraz cechy funkcjonowania i realizacji.*

**Słowa kluczowe:** rozmyta mapa poznawcza, analiza poznawcza, pomysł

### Introduction

Development of methods of cognitive analysis and modeling is substantially caused by need of research of semistructured problems, systems and situations which include a set of elements of the various nature, and dependences between which elements carry both quantitative, and qualitative character. Cognitive approach to research of poorly structured situations was offered by R. Axelrod and F. Roberts [1, 9] because of limitation of applicability of exact models for creation of models of semistructured systems and research of behavior of studied system, preparation and adoption of administrative decisions on permission of semistructured problems and the situations, arising during the functioning and development of such systems.[4, 6, 7]. At such approach at the heart of creation of models of semistructured system or a situation the subjective understanding and idea of the subject of management of parameters of operated system and communications between them lies. The cognitive map as an image of internal representations of the subject serves as the tool for formation and specification of a hypothesis of functioning of studied object which is considered as difficult system. To understand and analyse behavior of difficult system, it is expedient to construct the block diagram cause – follow relationship. The cognitive map is especially useful to the analysis of action of the hardly formalizable factors which measurement often is very complex problem in the analysis of difficult systems. Analyzing personal and others' cognitive maps, the researcher can quickly deepen understanding of a problem, improve quality and validity of made decisions.

### 1. Exposition

Now some types of the cognitive analysis on the basis of cognitive maps which differ with ways a problem of cognitive maps and methods of their analysis [2, 3, 4, 8] are known.

The most widespread types of cognitive maps:

- Sign cognitive maps;
- Kosko's fuzzy cognitive maps;
- Kosko's modified fuzzy cognitive maps;
- fuzzy relational cognitive maps;
- fuzzy productional cognitive maps;
- Silov's fuzzy cognitive maps.

All types of cognitive maps are given in the form of a directed graph and represent the modeled system as a set of concepts that reflect the system variables are related by cause - follow relationship of exposure. These relationships can be positive, negative or neutral concepts characterizing the corresponding impact on each other. Thus it is possible to analyze the entire system, and changing the input parameters to solve and understand how and what kind of concept will be most affected by the system and other concepts.

The goal of this work is to develop a modeling system implements all types of fuzzy cognitive maps. As a result of the analysis of algorithms and techniques to support strategic decision-making based on fuzzy cognitive map has been designed and developed a software framework for analysis and modeling of complex processes or systems based on a variety of fuzzy cognitive map. The main problem is solved by the system is to support the construction of fuzzy cognitive map correctly describing a given subject area or situation, carrying out statistical modeling based on the obtained fuzzy cognitive map, the generation of alternatives (scenarios, plans) based on static analysis and modeling.

Figure 1 shows the structure of the software framework.

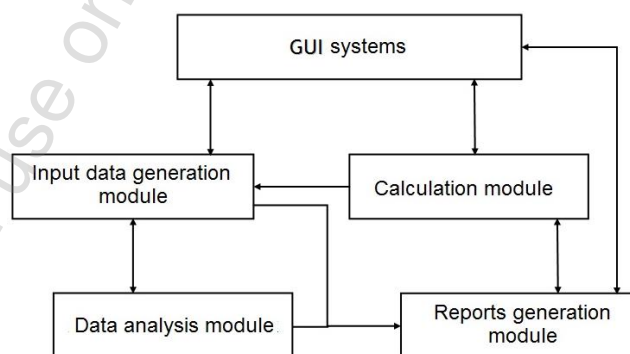


Fig. 1. The structure of the software framework

The software framework consists of four main modules:

- Input data generation module;
- Data analysis module;
- Calculation module;
- Reports generations module.

#### **Input data generation module**

The module provides the possibility of building a fuzzy cognitive models. To ensure the efficiency of the process of creating and editing the FCM (fuzzy cognitive map) and to reduce the degree of subjectivity of experts implement methods of indirect jobs weight of the connections in the FCM and provides the ability to direct the task of weight with the help of the adjacency matrix or a visual representation of the FCM in the form of a graph.

#### **Data analysis module**

This module implements algorithms for static and dynamic analysis FCM. This module incorporates a full function of the static modeling based on FCM using fuzzy causal algebra. To present the results of modeling an analyst uses the mode with the maximum information content, as well as a visual mode.

**Calculation module**

The module performs the calculation and visualization of concepts (the construction of the graph), monitoring the values of concepts, charting the interaction of concepts, calculation of the values of consonance and dissonance.

**Reports generation module**

The module performs all the calculations and reporting on the results of analysis and simulation.

The program was written in the Java, using the core of JUNG, to use a large built-in Java API, as well as other existing third-party Java libraries. There was created a separate library, which provides the general and extensible means for modeling, analysis and visualization of data that can be represented as a graph or network. Architecture library of visual representations of graphs is designed to support a variety of representations of entities and their relations, such as directed and undirected graphs, multi-modal graphs and hypergraphs. This facilitates the creation of analytic tools for complex data sets that can examine the relationship between the objects and the metadata attached to each object and their relationships. The JUNG library and the kernel includes a number of algorithms for graph theory, data mining and analysis, such as clustering algorithms, decomposition, optimization, the generation of random graphs, statistical analysis

and calculation of distances in the network, streaming algorithms. JUNG kernel makes it easy to create tools for the interactive exploration of different graph models.

Figure 2 shows the diagram classes of the software framework.

For example, consider the simple of the cognitive model the impact of industrial emissions on the population of the city. Identification of concepts:

- BK - harmful substances;
- CM - direction of the wind;
- SS - industrial facility;
- MK - state treatment facilities;
- SV - the city's population;
- MZ - modernization of treatment facilities;
- CP – the public health.

Cognitive map is presented in figure 3. Figure 3 shows an example of constructing fuzzy cognitive map for the problem of ecological forecasting. Figure 4 shows a fuzzy cognitive map in the form of a graph (Data analysis module).

Figure 4 shows the transitive closed cognitive matrix for the representation of fuzzy cognitive map (Calculation module).

Figure 5 shows the results of calculations (system indicators).

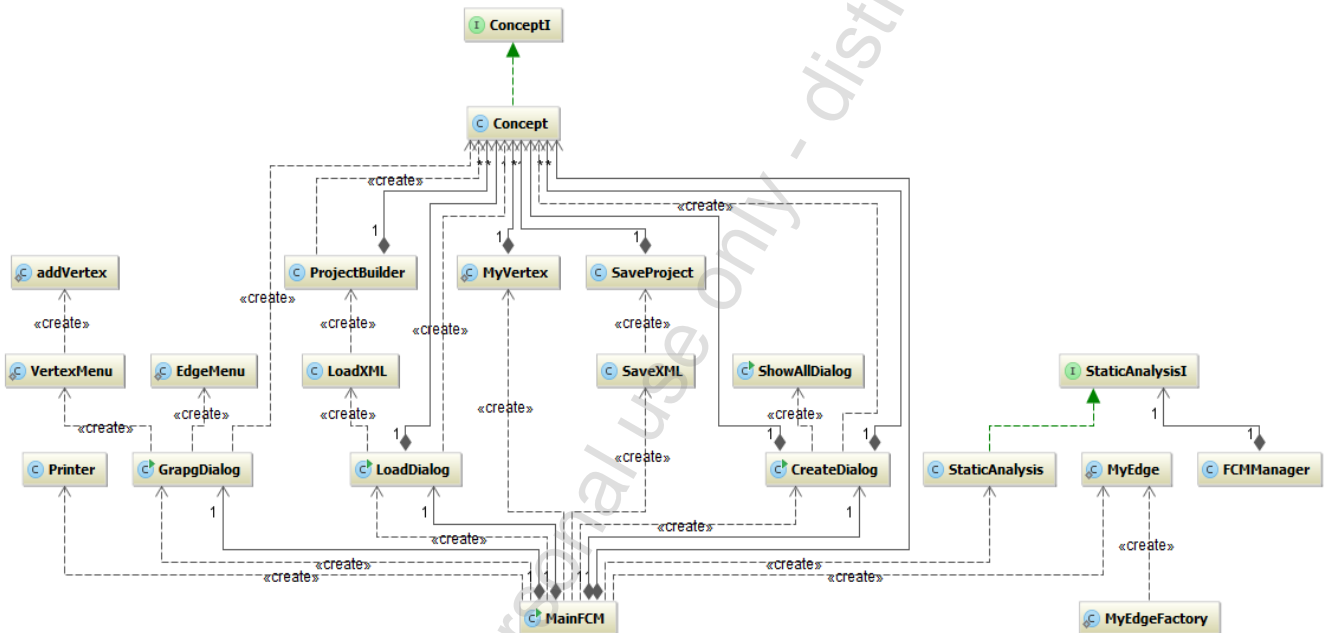


Fig. 2. The diagram classes of the software framework

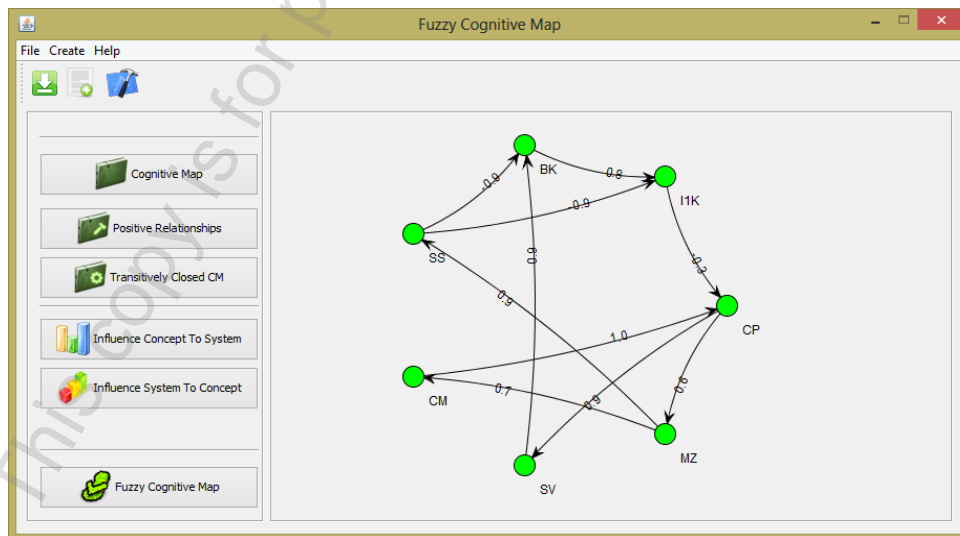


Fig. 3. The fuzzy cognitive map

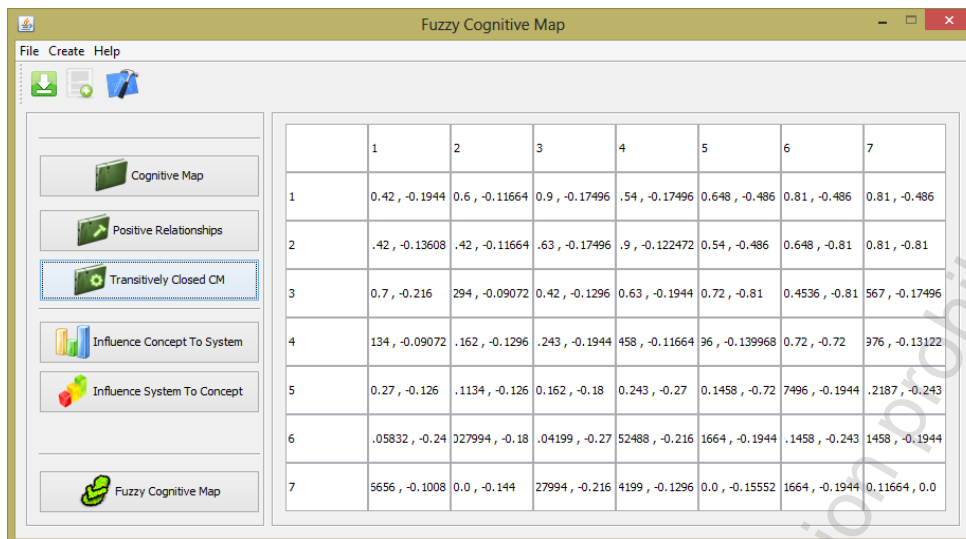


Fig. 4. The transitive closed cognitive matrix

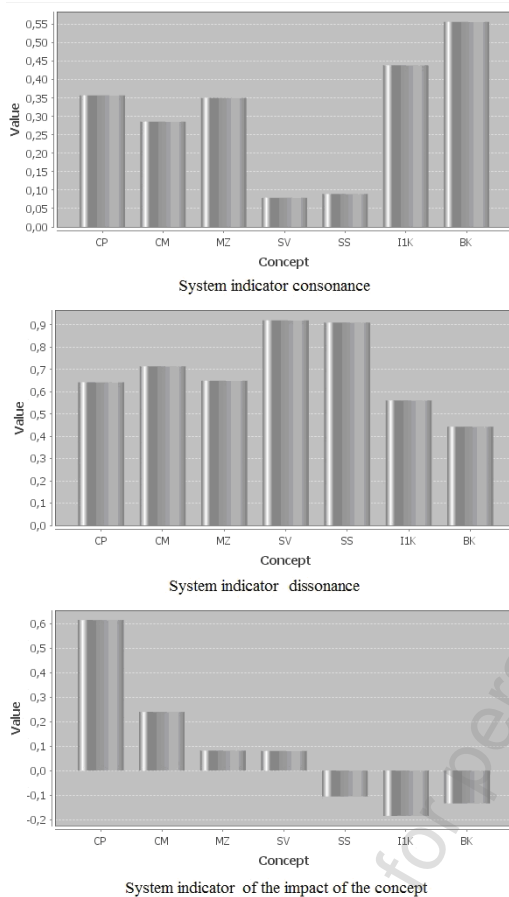


Fig. 5. The results of calculations (system indicators)

Figure 5 shows the results of calculations of system performance that set key indicators problem to be solved.

## Conclusion

The developed program can be used by experts and analysts in all subject areas. Their main task is, on the basis of domain knowledge to identify the main factors influencing the behavior of the system, and establish a connection between them. The task of analysts is to provide advice to decision-making. They work directly with the system, and their requirements are taken into account by analysts in the dynamic modeling. The program is used to solve the problems of dynamic planning and decision-making in the field of ecology and industry.

## References

- [1] Axelrod, R.: The Structure of Decision: Cognitive Maps of Political Elites, Princeton University Press, 1976.
- [2] Carlsson C., Fuller R.: Adaptive fuzzy cognitive maps for hyperknowledge representation in strategy formation process, Budapest, 1996
- [3] Kosko B.: Fuzzy Cognitive Maps, International Journal of Man- Machine Studies, Vol. 1, 1986, p. 65-75.
- [4] Kosko B.: Fuzzy systems as universal approximators, IEEE Transactions on Computers. Vol. 43. No. 11, 1994, p. 1329-1333.
- [5] Papageorgiou E.I., Markinos, Ath. Gemtos, Th.: Application of fuzzy cognitivemaps for cotton yield management in precision far-ming, Expert Systems with Applications, vol. 36, no.10, 2009, pp. 12399-12413.
- [6] Papageorgiou E.I., Stylios C.D.: Fuzzy Cognitive Maps, in book: Handbook of Granular Computing, editors: Witold Pedrycz, Andrzej Skowron and Vladik Kreinovich, Chapter 34, John Wiley & Sons, Ltd, 2008, pp. 755-775.
- [7] Pedrych W.: Relevancy of fuzzy models. Information Sciences. V. 52. 1990, p. 285-302.
- [8] Rajaram T., A. Das.: Modeling of interactions among sustainability components of an agro-ecosystem using local know-ledge through cognitive mapping and fuzzy inference system, Expert Systems with Applications, vol. 37, no. 2, 2009, pp. 1734-1744.
- [9] Roberts F.: Dyscretne matematicheskie modeli s prilozheniyami k socialnym biologicheskim i ekologicheskim zadacham. Nauka, 1986.

**Ph.D. Alexander Gozhyi**  
e-mail: mailto:alex\_daos@mail.ru

Associate professor, Ph.D., in 1994 defended Ph.D. thesis "Application of mathematical methods in scientific research." Dean of Faculty of Computer Science at Petro Mohyla Black Sea State University. Currently his research interests include multicriteria optimization, functional programming, fundamentals of Artificial Intelligence systems, theory of dynamical planning



**Ph.D. Irina Kalinina**  
e-mail: kiol1612@mail.ru

Associate professor, Ph.D., in 1997 defended Ph.D. thesis "Geometric modeling flow turbomachinery parts" Currently his research interests include gtimetric modeling, fundamentals of Artificial Intelligence systems, theory of decision making.

