Cognitive Computer Graphics Based on n-m Multiterminal Networks for Pattern Recognition in Applied Intelligent Systems

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Abstract

Authors introduce original approach to design of cognitive computer graphics for applied intelligent systems (IS). Concept of “n-m multiterminal network” (N-MMN) is applied in novel way to knowledge structuring and cognitive representation.

Keywords: *cognitive computer graphics, intelligent systems, pattern recognition, n-m multiterminal networks.*

1. INTRODUCTION

Use of cognitive computer graphics (CCG) for intelligent systems (IS) is one of the key tools for object localization and recognition. For our purposes we accept definition of CCG as method to visualize data and represent knowledge that allows generating new decision or finding a way (prompting) to the new one [Зенкин]. CCG image is a tool that gives understanding of task or situation (image-decision), representation of IS-generated decision (decision-image), visualization of objects that helps to set task (image-task) [1]. CCG considered as crucial component for representation of knowledge as well as operation of it in IS, including decision-making justification. In this paper authors present CCG development for current work in progress Intelligent Instrumental Software (IIS) IMSLOG [2], which is later development of CCG for IS described in [3] and belongs to tradition of pattern recognition research (pattern recognition is a set of principals and rules for designing systems able to determine if given object belongs to the one of pre-defined classes). In particular, we address very complex problem of IS based medical diagnostic, where, for example, symptoms of decease would be an object and diagnosis would be a class.

This particular article is inspired by Global Risk Report 2009 prepared and published for World Economic Forum [4]. In this document experts use cognitive graphics as an instrument for analysis and representation of complex knowledge. They identified 36 six global risks under five categories – economic, geopolitical, environmental, societal, technological. All risks are interconnected and resulting image gives representation of global risks as interconnected network (see Figure 1). This model gives sense of structure, complexity, visual coherence, conceptual approach (network dynamic interconnection), concentration on content, easy focusing on key elements, generalized and unified complex data, analytical convenience and usability. However, for computer based IS we need adequate principles of structuring and multivariate analysis of cognitive maps similar to one presented at Figure 1.

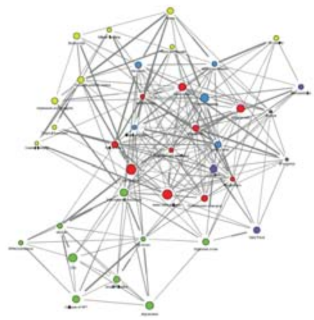

Figure 1: *Risk Interconnection Map (RIM) 2009 (Source: World Economic Forum).*

We propose original approach based on N-M multiterminal networks (N-MMN).

2. N-M MULTITERMINAL NETWORKS

“N-m multiterminal networks” (N-MMT) concept comes from radiotechnics and logic devices design. It means element of electric chain with several connections with other chains. As a general principal it is conveniently described as N-inputs and M-outputs for the object given as “black box”. Any type of objects can be represented as n-m multiterminal network and analyzed with multivariate combinations of inputs and outputs. In our current project IIS IMSLOG we approach to use N-MMT for designing typical structural templates of applied IS (scenario, typical decision based on different algorithms) that appears for user as a separate object presented as N-MMT (Figure 2).

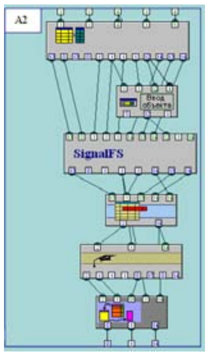

Figure 2: *Cognitive visualization of structural template (typical decision for algorithm of signal features revealing) as N_MMT for IIS IMSLOG.*

Our research and graphic modeling shows that we can easily find N-MMN equivalent representation for different typical decisions, such as sequential recoding of features, signal features revealing algorithm, implication matrix construction etc. Decision-making is based on original logic-combinatorial and logical-combinatorial-probabilistic test methods of pattern recognition [5]. In case of medical diagnostic, inputs are symptoms and syndromes; output are syndrome or diagnosis (if output of N-MMN is not an input for another one). CCG for diagnostic decision-making will be looking like following (Figure 3).

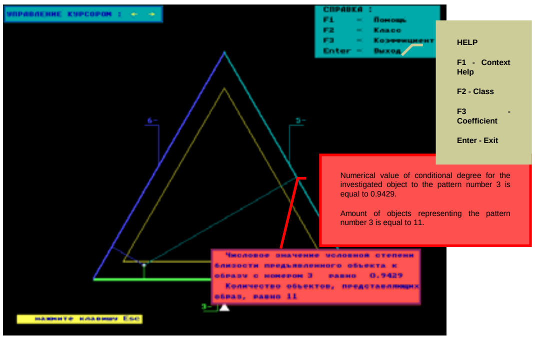

Figure 3: *CCG for medical diagnostic decision-making (ISS IMSLOG).*

Illustration reflects dimensional arrangement of object (patient own diagnosis) with respect to any 3 patterns (differential diagnosis). Side of triangle is one of the patterns. Position of white point (patient diagnosis) informs about diagnosis nearness to distinct disease (side) and error of decision made (distance to internal triangle). Thus, CCG for N-MMN provides us with knowledge representation for decision-making process itself, and triangle model gives us a structure of final decision. If one of the inputs (symptom or syndrome) changes, then general N-MMN structure changes too and final decision could be different. Again, CCG - both for N-MMN and triangle - immediately shows us all dynamic changes. Thus, cognitive graphics becomes an instrument for operations with IS knowledge base. It gives us unique opportunity to use knowledge and its cognitive representation for recognition of complex situations (patterns) with localized objects, influences and multiple variables. In the Global Risk model (Figure 1) it will let us to see what happens in the model if some variables of the risks are rapidly changing or some interconnection of risks become weaker/stronger. What kind of interconnections and influences are activated? What variables for different objects (risks) are to get changed? How can we localize the most dangerous impacts?

CCG tools in the N-MMN model allow us to apply this approach to recognition of different types of objects and situations: economic structure of the city or region, marketplace dynamics, scientific theoretical framework, military logistics and battlefield operation, governmental structures and processes, structure of course program and curriculum in educational etc. Do we face market stagnation or growth? What are the reasons of that? How effective governmental agency's operation is? Answers for the questions are to be given via elements of the network localized by means of CCG. For the purpose of the recognition of situation with high level of uncertainty, CCG for applied N-MMN based IS should be functional in the following ways: 1) represent objects by categories with key variables and interconnections, 2) activate any object of the network and any interconnection, 3) localize influences and vectors, including complex "chains" of influences, 4) localize segment of the network by assigned criteria.

3. CONCLUSION

CCG for applied knowledge based IS can be integrated with knowledge structure and used as means for pattern recognition through N-MMN. This approach gives high level of knowledge representation and dynamic recognition of complex situations. N-MMN based CCG tools can be applied for analysis, modeling, forecasting and decision making in different practical areas: decision making support in business and government, medicine, education, science and culture.

At the current stage of our work we consider following tasks of further development: 1) design complete set of CCG tools for IIS IMSLOG able to effectively operate with N-MMN based complex networks; 2) user friendly IS Interface design that gives full functional opportunities to operate with N-MMN graphic models and clear defined recognition and object localization; 3) adaptation of IS logical and mathematical apparatus to N-MMN based operation, including learning samples and validation.

4. ACKNOWLEDGMENTS

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