

Modeling and Experimentation Framework for Fuzzy Cognitive Maps

Maikel Leon Espinosa

Department of Business Technology, University of Miami, USA
mleon@bus.miami.edu

Gonzalo Napoles Ruiz

Faculty of Business Economics, Hasselt University, Belgium
napoles.gonzalo@gmail.com

Abstract

Many papers describe the use of Fuzzy Cognitive Maps as a modeling/representation technique for real-life scenarios' simulation or prediction. However, not many real software implementations are described neither found. In this proposal the authors describe a modeling and experimentation framework where realistic problems can be recreated using Fuzzy Cognitive Maps as a knowledge representation form. Design elements, and descriptions of the algorithms that have been incorporated into the software, and hybridized with Fuzzy Cognitive Maps, are presented in this paper. Case studies were conducted and are illustrated with the intention of demonstrating the success and practical value of the general approach together with the implementation tool.

Introduction

Fuzzy Cognitive Maps (FCMs) were presented by B. Kosko as a knowledge-based methodology for modeling and simulating dynamic systems [1]. FCMs can be seen as combination of fuzzy logic and cognitive mapping, it's a way to represent knowledge of systems which are characterized of uncertainty and complex processes, also causality. From a structural point of view, a FCM may be represented as a fuzzy directed graph that allow feedback, consisting on neurons and signed weighted relations. Using this methodology, a system could be modeled in terms of concepts (e.g. variables, objects, entities or states which are mapped as neurons in connectionist approaches) and the causal relations among such mentioned concepts. FCMs provide a flexible and natural mechanism for knowledge representation and reasoning, which are essential to intelligent systems. For example, interaction strengths are used to denote either the experts' opinion, semi-quantitative or quantitative data on the relative degree to which one variable influences another concept in a map. Recently the

FCMs theory has gained a lot of attention among researchers worldwide where both practical and theoretical results have been introduced. Some fields where the FCMs-based modeling has been successfully applied include [2]: decision making, risk analysis, system control, engineering, transport management, protein modeling, etc.

Modeling & Experimentation Framework

The proposal consist of more than 20.000 source code lines (completely written in Java language) which are distributed in 115 Java source files. These archives are organized in 4 global packages (Map, Algorithms, Interface and Resources) and numerous sub-packages (e.g. Causality, Topology, Stability, Dataset, Handlers, and Graphics). Figure 1 displays the tree of packages for the FCM TOOL including primary packages and sub-packages.

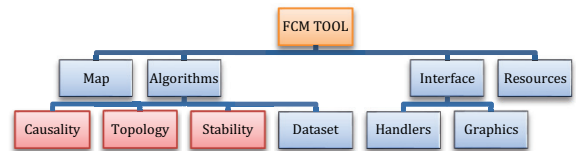


Fig. 1. Tree of packages for FCM TOOL architecture.

FCM TOOL (see Figure 2) provides a set of functionalities and not all of them can be detailed in this short demo paper. As a rough picture, the proposed software involves three groups of functionalities that are distributed in six menus (File, Edit, Build, Run, Reset and Help). The first group is oriented to the design of new FCM-based systems, where an expert in a given domain could completely develop and simulate a system without having previous strong knowledge in mathematics or computer science. The second group involves learning algorithms for adjusting the introduced parameters (e.g. the direction and intensity of causal relations).

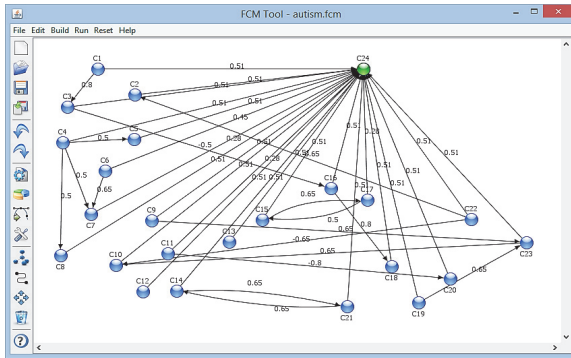


Fig. 2. Main window of the proposed FCM TOOL.

It should be highlighted that such algorithms comprise a large advantage over other software tool related to FCMs since they are oriented to pattern classification problems, where understanding the behavior of the system under investigation is well appreciated. The third group includes procedures for evaluating the system behavior which generally requires more expertise. The user could also modify graphical aspects when designing a new map such as the concepts' color or labels' position. Even it is possible to simulate the map in a mode where the size of each concept is proportional to its activation value. Undo and redo stacks were also implemented. The following Figure 3 illustrates, as an example, the learning progress for the drug IDV [3] where experts can inspect relevant statistics (e.g. problem features, accuracy, convergence, number of decision classes). They are updated step-by-step, which allow visualizing the algorithm progress in real-time. Moreover, we included a panel for plotting the best evaluation computed at each step, therefore the experts can check whether the learning algorithm shows non-progress (i.e. stagnation or premature convergence) states or not.

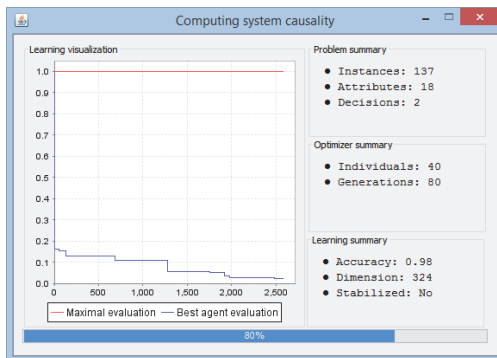


Fig. 3. Window summarizing relevant statistics related to the algorithm progress, when computing the causal weight matrix.

Figure 4 shows the window where the output pattern and the stability features of all map neurons are provided. The reader can observe that the last position of the output vector includes the decision class, which is automatically computed from the activation value of the decision neuron and the corresponding threshold.

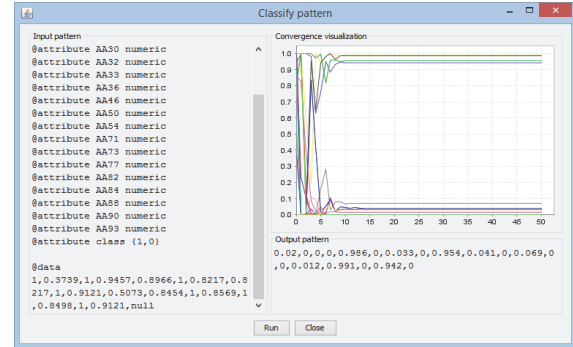


Fig. 4. Windows for classifying new patterns.

We focused on the tool options rather than the mathematical formulation, algorithms or computed results since the reader could find such details in other papers (e.g. the estimation of causal relations [4]) where we focused more on the model, and not in the software tool.

Conclusions

FCM TOOL is a Java object-oriented implementation with a simple to use and manage interface, organized in packages, including algorithms for computing causal relations, optimizing the network topology and improving the system convergence. It should be stated that these algorithms are mainly oriented to systems with prediction capability, although other scenarios could be modeled as well. FCM TOOL becomes a platform-independent software tool where the expert could mine the system knowledge, mainly for decision-making activities.

References

[1] B. Kosko, "Fuzzy Cognitive Maps" Int. J. of Man-Machine Studies, vol. 24, pp. 65–75, 1986.

[2] M. Leon Espinosa et al., "Learning and Clustering of Fuzzy Cognitive Maps for Travel Behaviour Analysis". Knowledge and Information Systems. ISSN: 0219-1377. Springer-Verlag, 2014.

[3] I. Grau Garcia et al., "Predicting HIV-1 Protease and Reverse Transcriptase Drug Resistance using Fuzzy Cognitive Maps," LNCS, vol. 8259, pp. 190–197, 2013.

[4] G. Napoles Ruiz et al., "Learning of Fuzzy Cognitive Maps for simulation and knowledge discovery," Studies on Knowledge Discovery, Knowledge Management and Decision Making. Atlantis Press, Paris, pp. 27–36, 2013.