Chapter 29
Fuzzy Cognitive Map Reasoning Mechanism for Handling Uncertainty and Missing Data:
Application in Medical Diagnosis

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ABSTRACT

In this study, the fuzzy causal map inference mechanisms are analyzed for decision making tasks and a comparative analysis is performed to handle with the uncertainty in the problem of pulmonary risk prediction. Fuzzy Cognitive Mapping (FCM) is a causal graphical representation including nodes, determining the most relevant factors of a complex system, and links between these nodes determining the relationships between those factors. It represents knowledge in a symbolic manner and relates states, processes, policies, events, values, and inputs in an analogous manner. In the proposed work, a modified inference mechanism for FCM approach, which handles uncertainty and missing data, is presented and compared with the common fuzzy causal graph reasoning process for a medical diagnosis problem. Through this study, we overcome the problem of missing data and/or incomplete knowledge, especially for the cases where there is no any information about a concept-state or the knowledge of some concepts is insufficient. By this way, the rescaled inference process is proved more reliable, yielding more exact and natural inference results than traditional FCMs. A number of different scenarios for medical diagnosis concentrated on the pulmonary infections are elaborated to demonstrate the functioning of the rescaled FCM inference mechanism.

INTRODUCTION

FCMs are able to capture and imitate human behavior by describing, developing and representing models. Their aim is to mimic the reasoning process of the human. They are graphical representation tools proposed by Kosko to represent the causal relationship between concepts and analyze inference patterns (Kosko, 1986, 1992). FCMs include nodes determining the most relevant factors of a complex system and links between these nodes determining the relationships between

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those factors (Rodriguez-Repiso, 2005). The graph structure of FCMs allows for static analysis, while its execution model allows for dynamic analysis of the modeled system (Froelich et al., 2009). FCMs are convenient to handle issues of knowledge representation and reasoning, which are essential to intelligent systems (Kosko, 1992). This modeling technique comes with a number of desirable properties, such as abstraction, flexibility, adaptability, and fuzzy reasoning (Banerjee, 2008; Wei et al., 2009).

The core task of a decision support system (DSS) is decision analysis. Real-life problems are mostly unstructured in nature, which makes it difficult to apply algorithmic methods based on mathematical models to the process of decision analysis. Decision makers often find it difficult to cope with significant real-world systems. These systems are usually characterized by a number of concepts or facts interrelated in complex ways (Hudson, 2006). They are often dynamic ie, they evolve through a series of interactions among related concepts. Feedback plays a prominent role among them by propagating causal influences in complicated pathways. Formulating a quantitative mathematical model for such a system may be difficult or impossible due to lack of numerical data, its unstructured nature, and dependence on inexact or "fuzzy" verbal expressions.

FCMs are knowledge-based systems which represent knowledge in a symbolic manner. Compared either expert system or neural networks, it has several desirable properties, such as it is relatively easy to use for representing structured knowledge, and the inference can be computed by numeric matrix operation. FCMs are appropriate to explicit the knowledge which has been accumulated for years on the operation of a complex system (Stylios & Georgopoulos, 2008). They provide a qualitative and semi-quantitative tool for representing and analyzing such systems with the goal of aiding decision making.

Basically, the inference mechanism (engine) is a computer program that attempt to infer or derive a deep insights or answers from the knowledge base. Typically, expert systems analyze the knowledge base in the inference mechanism which is designated to simulate human like expertise and reason for problem solving in a certain domain. As such, expert system could explain the reasoning process and handle levels of confidence and uncertainty, which straight algorithms do not do (Sordo et al., 2008). In this study we are modeling our proposed soft computing components as an adaptive inference mechanism for the decision support process. The FCM inference mechanism is an important issue for FCM operation which significantly improves the functionality and effectiveness of the approach.

FCMs are popular for their simplicity and transparency while being successful in a variety of applications (Aguilar 2003). Examples of specific applications include political developments (Taber, 1991), support for strategic problem formulation and decision analysis (Eden & Ackermann, 1993), electrical circuits (Styblinski & Meyer, 1988), knowledge bases construction (Silva, 1995), computing and decision sciences (Craiger et al. 1996; Schneider et al. 1998; Liu and Satur, 1999; Konar & Chakraborty, 2005; Osei-Bryson, 2004; Papageorgiou et al. 2006b; Stach et al. 2007, Yaman and Polat, 2009), urban design support (Xirogiannis & Glykas, 2004), relationship management in airline services (Kang, Lee, & Choi, 2004), web-mining inference amplification (Lee et al., 2002), agriculture and ecological sciences (Mendoza & Prabhu, 2006; Ozesmi & Ozesmi, 2004), engineering analysis (Pelαez & Bowles, 1996; Lee, et al., 2004), and medical diagnosis and decision support (Georgopoulos, Malandraki, & Stylios, 2003; Papageorgiou et al., 2006a, Yue He 2008, Papageorgiou et al., 2003, 2006, Georgopoulos and Stylios 2007, Stylios et al. 2008, Froelich and Wakulicz-Deja, 2009). In medical diagnosis, FCM based decision