Augmentative Fuzzy Cognitive Maps with Case Based Reasoning for Advanced Medical Diagnosis

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Abstract

This research work proposes the combination and integration of Fuzzy Cognitive Maps (FCMs) with Case Based Reasoning (CBR) Method to develop an Augmentative modeling method for Medical Decision Support Systems (MDSS). They are two complementary methods that are applied synergistically to support each other, when the FCM part of the MDSS cannot reach a decision, the CBR component heads the decision process. In this scenario the CBR leads to reconstruction of the FCM so that the Medical Decision Support System to easily reach a decision. This integration can successfully used for differential diagnosis in the speech pathology area for the diagnosis of language impairments.

Keywords: Fuzzy Cognitive Maps, Case Based Reasoning, Medical Decision Support System.

1. Introduction

Fuzzy Cognitive Maps (FCMs) and Case Based Reasoning (CBR) are two well known methods that have been applied successfully for developing knowledge-based systems in many different application domains. They are based on utilizing and exploiting existing knowledge and experience to handle and solve new problems. Human knowledge and experience on reasoning and decision making and diagnosis is reflected in the development method so that the infrastructure of FCMs emulates and models the human reasoning process. The complementary method of CBR utilizes a database approach to store the most important significant cases that are used as examples and comparisons are made to find a solution using the assumption that similar problems usually have similar solutions.

FCMs rely on specific human knowledge and system behavior making associations along generalized relationships between domain descriptors, concepts and conclusions. On the other hand, CBR is an expert approach to problem solving and learning, which instead of relying solely on general knowledge of a problem domain, utilizes the specific knowledge of previously experienced concrete problem situations and implicit solutions. Here a hybrid method consisting of the synergic combination of FCMs and CBR is proposed such that when the MDSS based on the FCM module is unable to infer a solution, the CBR module is called to modify the FCM module and finally the MDSS concludes to a decision.

The CBR method is based on identifying the current problem, finding a past case similar to new one, and using that case to suggest a solution to the current problem [1][2][3].

Fuzzy Cognitive Maps are an illustrative causative representation for the description and modeling of complex systems. FCMs model the behavior of a system as a collection of concepts and causal relations between concepts based on the experience and knowledge of experts. An FCM draws a causal graphical representation, which reflects the general operation and behavior of a complex system. The core mechanism behind FCM is the interrelation among concepts that actually determine the FCM model. FCMs are fuzzy signed directed graphs permitting feedback, where the weighted edge from causal concept C_i to affected concept C_j describes how much the first concept influences the latter. The human experience and knowledge on the operation of the system is embedded in the structure of FCM and the FCM developing methodology, i.e., by using human experts who have observed and know the operation of system and its behavior under different circumstances [4].

Fuzzy Cognitive Maps have been successfully used to develop a Decision Support Systems (FCM-DSS) for differential diagnosis [5], to determine the success of the radiation therapy process estimating the final dose delivered to the target volume [6] and many other applications. Particularly in the medical diagnosis and decision field, the main characteristics are complex involving inexact, uncertain, imprecise and ambiguous information [7]. Frequently for these kinds of problems, the available information and input may be inadequate and the FCM module of the MDSS cannot discriminate and reach a decision; this surfaces the need of a mechanism to supplement the FCM-DSS. This is the case where FCM-DSS based on