

Knowledge Acquisition Based on the Global Concept of Fuzzy Cognitive Maps*

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Abstract. Combination of prior knowledge and implicit knowledge hidden in the data of system can enhance the quality of information services in Knowledge Grid. Fuzzy Cognitive Maps (FCMs) are constructed by experts using prior knowledge and do not acquire the implicit knowledge from the data of systems directly, which may distort the dynamical behaviour of information services systems in which knowledge representation and reasoning are based on FCMs. We propose a global concept of FCMs method to acquire implicit knowledge and modify the false knowledge maybe done by experts from the data of system. Experiments show that this method can acquire the implicit knowledge from the data of system and modify the false knowledge hidden in FCMs, which makes the learned FCMs that acquire knowledge from the data of system more natural than the FCMs constructed by experts to emulate intelligent information services behaviors in Knowledge Grid.

1 Introduction

The Knowledge Grid is an intelligent, sustainable Internet application environment that enables people or virtual roles to effectively capture, publish, share, and manage explicit knowledge resources [1]. So, how to capture knowledge is an essential question in Knowledge Grid. To enhance the quality of information services in Knowledge Grid, we need combination of the prior knowledge of systems, objects or virtual roles, and the implicit knowledge hidden in the data of system. Fuzzy Cognitive Maps (FCMs) are aimed to mimic human causal knowledge reasoning and store the prior knowledge of experts [2]. FCMs have been widely used in economy, fault analysis, information system [3], tacit knowledge management [4], industry control [5] and virtual world [6] and so on.

Usually FCMs are constructed by experts and do not acquire the implicit knowledge from the data of system, which may distort the behaviour of system whose knowledge representation and reasoning are based on FCMs. In the other hand, implicit knowledge of systems hidden in the data of systems; the implicit knowledge is hard to

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be acquired using the weight between two concepts. The implicit knowledge in the data is about system instead of two concepts. We can acquire the weight between two concepts by hebb rule [6], but how to acquire the weights among multi-concepts. (Weight reflects the knowledge and its relations' degree between two concepts.) In FCMs, using hebb rule to acquire weight between two concepts can be regard as the local view, and the process of weights acquiring among multi-concepts needs a global concept to control.

In the reasoning process of FCMs, the enabled concepts are synchronously and equally. There is no global concept in FCMs, which leads FCMs lack the capability of weights acquiring from the data of systems. It is necessary to find a method using global view to control the weights acquiring process among multi-concepts of FCMs.

2 Knowledge Acquisition Based on Global Concept of FCMs

The dynamical behaviors of FCMs are composed by the set of concepts \vec{C} , the state values set \vec{V}_C , the set of relations \vec{R} and the weights set \vec{W} . The influences on FCMs of the state values of causal concepts, the weights between concepts, the effect concepts at time t and $t+1$ can be synthetically reflected by the set of \vec{V}_C . All the state values and the weights of FCMs interaction produce the simulation of the real world or systems. In the following, we define the error of the concept's state value.

Definition 1. (The error of the concept C_j 's state value, δ_j)

$$\delta_j = |T(V_{C_j}(t)) - O(V_{C_j}(t))|,$$

where $O(V_{C_j}(t))$ is the output of C_j ; $T(V_{C_j}(t))$ is the plan output of C_j . δ_j can be regard as a measure degree between C_j and information system.

We acquire the weights of FCMs according to the principle of Linsker's maximal information holding. Concretely, we should hold the minimal sum of the adjusted values of weights. So we define the adjusted value of weight as follows:

Definition 2. (The adjusted value of weights, Δw_{ij})

$$\Delta w_{ij} = \eta w_{ij} \delta_j + \delta_j \varepsilon,$$

where η is a constant; ε is a stochastic number.

After the definitions of δ_j and Δw_{ij} , we definite a global concept of fuzzy cognitive maps as follows:

Definition 3. (The global concept of fuzzy cognitive maps, h)

$$h = \eta \sum \sum \delta_j^2 \Delta w_{ij} + \sum \sum \delta_j \Delta w_{ij} \varepsilon_{ij},$$

where η is a constant; ε_{ij} is the stochastic number.

The global concept h is a measure degree between FCM and the real world, which accord with the principle of Linsker's maximal information holding. The smaller h shows that the distance between the reasoning values of FCMs and the real values of system is more close, the adjusting process of the weights needs more fine, and vice versa. The global concept h of FCM can control the weights acquiring process of FCMs from the data of system.

The arithmetic of knowledge acquisition with the global concept of FCMs as follows:

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Initialization;
while (step<200)&(h>10e-8)
     $V(t+1) = V(t) \cdot W(t)$ ; According to  $V(t+1)$ , calculate  $\delta_j(t+1)$ ;
For  $i=1$  to  $n$ 
    Calculate  $\Delta w_{ij}(i)$  and  $h(i)$ ;
End
Find the minimal  $h(i)$ ; Modify the adjacency matrix  $W(t+1) = W(t) + \Delta W$ ;
End

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3 Experiments

We construct a fuzzy cognitive map (denoted as FCM1) shown in Figure 1 according to the file of the leader group of the science and technology of Anhui province [WanKe.NO. (1999) 01]. FCM1 reflects which factors influence on the progress of the science and technology, which has 43 concepts and there are complex relations among these concepts shown in Figure 1. In this paper, we use global concept h to acquire the implicit knowledge and modify the false knowledge hidden in FCM1.

Figure 2 to Figure 4 are the knowledge acquisition results of FCM1 from the data of the HeFei's progress of science and technology in 1998. From Figure 2, we know there are conspicuous differences between the real values of 1998 and the first step reasoning values of FCM1 because the constructed FCM1 only consider the experts' knowledge. We know from Figure 3, there is little difference between the learned FCM1 and the real values of 1998 because the implicit knowledge is partially acquired by FCM1 from the data of system. Figure 4 shows the final results between the learned FCM1 and the real values of 1998. From this figure, we know there is inconspicuous difference between FCM1 and the real values of 1998 because the implicit knowledge and the false knowledge are been acquired and modified from the data of 1998 by the method of global concept of FCMs.

FCM1 can acquire the knowledge from the data of the HeFei's progress of science and technology in 1998 using the global concept of FCMs. So, the learned FCM1 that acquires knowledge from the data of system should have more knowledge about the progress of the science and technology. Here, we use the data of 1997 to verify the learned FCM1 that has more correct knowledge than the constructed FCM1 by experts.

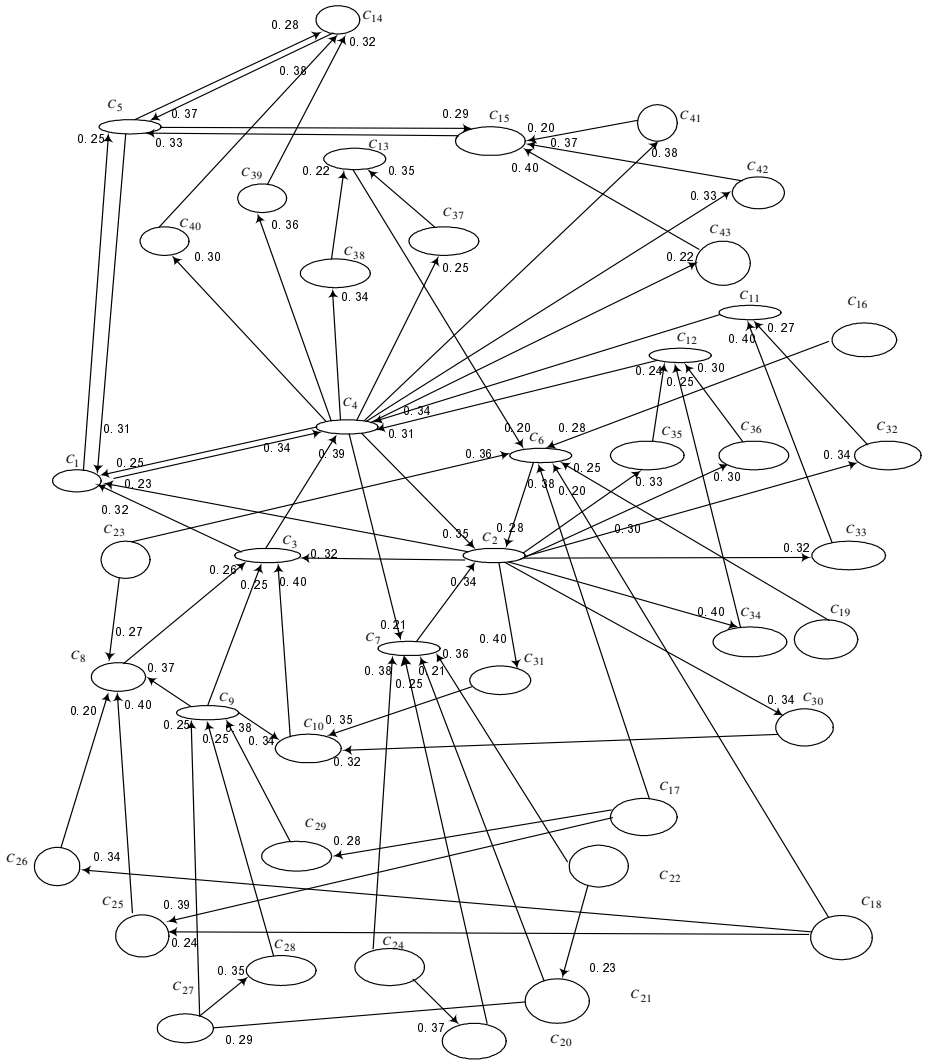


Fig.1. The fuzzy cognitive map is constructed according to the file of the science and technology leader group of AnHui province [WanKe. NO. (1999) 01]

Figure 2 shows the difference between the first step reasoning values of FCM1 constructed by experts and the real values of 1998. Figure 5 shows the difference between the first step reasoning values of the learned FCM1 and the real values of HeFei’s progress of science and technology in 1997. Figure 5 compared with Figure 2, we know that there is more correct knowledge hidden in the learned FCM1 than the FCM1 constructed by experts. The global concept can acquire and learn knowledge from the data of system effectively.

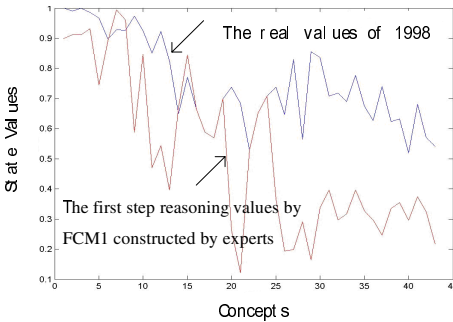


Fig. 2. The difference between the first step reasoning values of FCM1 and the real values of 1998

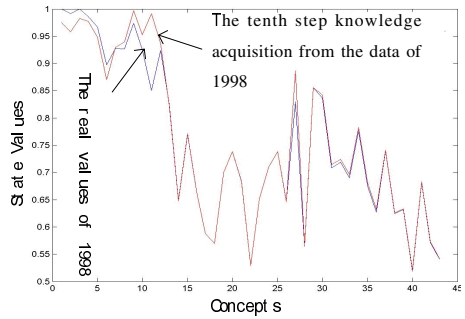


Fig. 3. The difference between the tenth step knowledge acquisition from the data and the real values of 1998

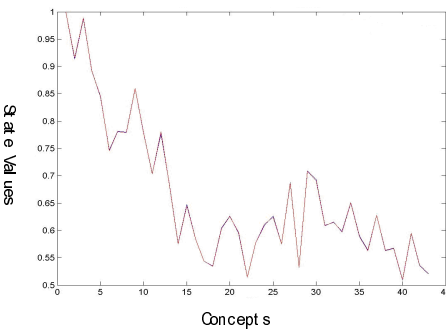


Fig. 4. The final results of the learned FCM1 and the real values of 1998

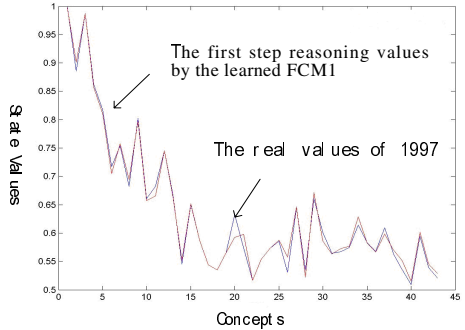


Fig. 5. The results between the first step reasoning values of the learned FCM1 and the real values of 1997

4 Conclusions

FCMs have no global concept; they are hard to acquire the implicit knowledge from the data of information systems. A global concept is proposed to acquire and learn the implicit knowledge and modify FCM's false knowledge that maybe done by experts. Compared with the reasoning results of the FCM1 constructed by experts, we know that the learned FCM1 has the capability of acquiring implicit knowledge and modifying the false knowledge of FCM from the data of systems effectively.

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