

## INTRODUCTION

There is a lot discussion nowadays regarding the decision making problem. Making decisions and creating computational models using the tools of Fuzzy Cognitive Maps and Neural Systems is a complicated task. The reason is that the contributing factors are several and complicated themselves. In medicine, factors such as age, symptoms, clinical tests all play their role and have their own importance when it comes to examine a patient, or to decide a medical action. Heart disease is the leading cause of death in developed nations despite known ways to prevent and treat heart problems. One common type of heart disease is called Coronary Heart Disease, sometimes referred to as coronary artery disease (CAD) [1]

## THE FCM MODEL (1)

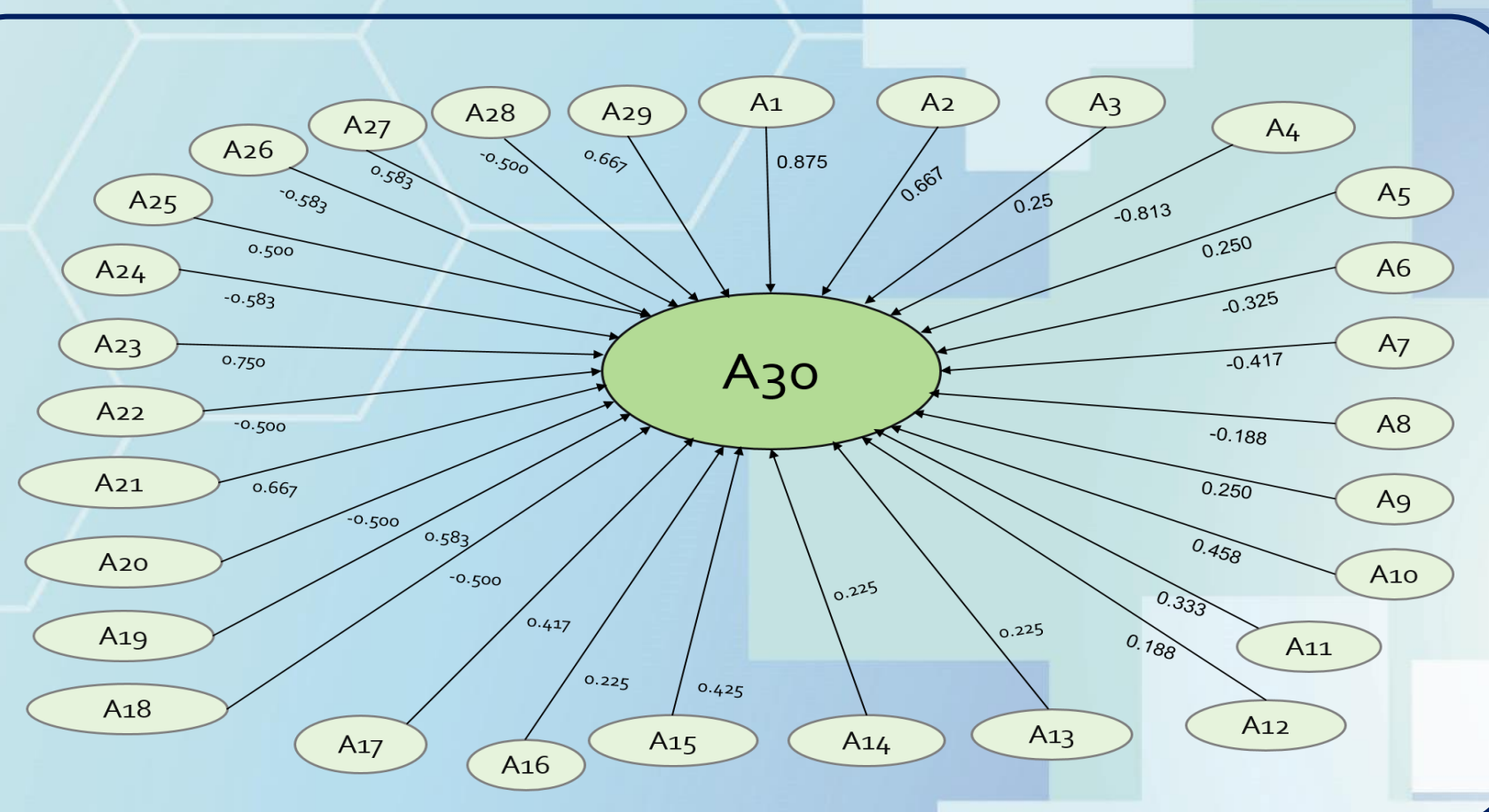
After the cooperation with the experts, we developed the FCM model. It is consisted of 29 inputs and one output. The experts have defined the weights between the concepts. The 29 input concepts are: Typical Angina, Atypical Angina, Nonanginal chest pain, Asymptomatic, Gender – Male, Gender – Female ,Age below 40, Age [40 50], Age [50 60], Age above 60, Smoking, Arterial Hypertension, Dyslipidemia, Obesity, Family history of coronary artery disease Diabetes Mellitus, Renal Insufficiency, Baseline ECG (Electrocardiogram) normal, Baseline ECG (Electrocardiogram) abnormal, Cardiac Ultrasound Normal, Cardiac Ultrasound Abnormal, Treadmill Exercise Test Normal, Treadmill Exercise Test Abnormal, Dobutamin Stress Cardiac Ultrasound Normal, Dobutamin Stress Cardiac Ultrasound Abnormal, Myocardial Perfusion Imaging Normal, Myocardial Perfusion Imaging Abnormal, Computerized Tomography Coronary, Angiography Normal, Computerized Tomography and Coronary Angiography Abnormal.

The value of each concept is influenced by the values of the connected concepts with the corresponding causal weights and by its previous value. So the value for each concept  $C_j$  is calculated by the following rule:

$$C_i^t = f\left(\sum_{j \neq i}^N C_j^{t-1} \cdot W_{ij} + C_i^{t-1}\right)$$

This equation indicates that a FCM is free to interact; at every step of interaction every concept has a new value.

## THE FCM MODEL (2)



## RESULTS

After construction of the FCM tool, a number of scenarios have been introduced and the decision making capabilities of the technique will be presented by simulating these scenarios and finding the predicted outcomes according to the available data. The constructed FCM-MDSS model was tested into several real examples.

## EXAMPLE

We consider a patient with atypical angina ( $A_2 = 1$ ), male ( $A_5 = 5$ ) at the age of 70 ( $A_{10} = 1$ ), with dyslipidemia ( $A_{13} = 1$ ) and obesity ( $A_{14} = 1$ ). This patient has been proceeded to Treadmill Exercise Test the results of which can be described as ambiguous ( $A_{23} = 0.25$ ). Thus the initial concept vector is:  $A(0 \ 1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0)$ . After FCM inference, the system converges as in the following state vector named final concept vector:  $A_f(0 \ 0.667 \ 0 \ 0 \ 0.25 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0.458 \ 0 \ 0 \ 0.225 \ 0.225 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0.1875 \ 0 \ 0 \ 0 \ 0 \ 0)$ . The calculated value of decision concept ( $A_{30}$ ) is  $A_{30_f} = 0.8985$ . The result after inserting that value to function (3) suggests that there is a possibility of 79.7% of severity, which corresponds after the fuzzification to the linguistic value of “very strong” possibility.

## MATERIALS AND METHODS

In this work, we illustrate the development of a Medical Decision Support System (MDSS) using Fuzzy Cognitive Maps (FCM). FCM is a soft computing technique capable of dealing with situations including uncertain descriptions using similar procedure such as human reasoning does [2]. FCM was chosen because of the nature of the application problem. The prediction of diseases like CAD is a complex process with sufficient interacting parameters and FCMs have been proved suitable for this kind of problems. Similar MDSS have been suggested for the prediction of diseases like pulmonary infection [3]. Three physicians-experts were pooled to define the number and type of parameters-factors affecting the possibility of been affected by CAD. For this application, concept values take either two, three, four or five possible discrete or fuzzy values. These variables contain information about the patient (ex Age, Gender), the heaviness of the main symptom, some Comorbidities and predisposing factors for CAD, as well as diagnose tests that the patient has been submitted to. The Decision Concept represents the severity of CAD and takes four fuzzy values (low possibility, medium possibility, high possibility, very high possibility). The thirty identified concepts keep relations with each other, in order to characterize the process of assessing infectious diseases and to provide a first front-end decision about the prediction of CAD. After the determination of fuzzy sets, each expert was asked to define the degree of influence among the concepts and describe their interrelationship using if-then rules.

## CONCLUSIONS

After several simulations we summarize some weaknesses that could be a field of future research, as to how those weaknesses could be overpassed. One main weakness is that all the factors, from the special characteristics of the patients to the test results are been described as similar type values, though they aren't.

In this work it was demonstrated that FCMs can be a useful tool for capturing the physicians' understanding of the system and their perceptions on the medical requirements of the infectious diseases management. Future work will be directed towards the insertion of other possible input values and bringing the model to a whole new level, perhaps with the use of learning algorithms.

## REFERENCES

1. Janet M. Torpy, MD; Alison E. Burke, MA; Richard M. Glass, MD, 2009, “Coronary Heart Disease Risk Factors” JAMA Patient Page.
2. Kosko B., 1986, “Fuzzy Cognitive Maps”, International Journal of Man-Machine Studies, 24(1):65–7.
3. Elpiniki I. Papageorgiou, Nikolaos I. Papandrianos, Georgia Karagianni, George C. Kyriazopoulos and Dimitrios Sfyra, “A Fuzzy Cognitive Map based tool for prediction of infectious Diseases” FUZZ-IEE 2009, Korea, August 20-24, 2009.