Medical decision support system using Fuzzy Cognitive Mapping& Fuzzy Inference System.

Abid Hussain M[1],Dr.D.Chitraprasad[2]

[1]*Associate Professor, Dept. of ECE, TKM College of Engg, Kollam, Kerala, India*
[2]*Prof & Head, Dept. of CSE, TKM College of Engg., Kollam, Kerala, India*

Abstract-This paper is on the suitability ofusing Fuzzy Cognitive Mapping technique (FCM) along with Fuzzy inference system(FIS),for the diagnosis of human disease.The diagnosis is based on the symptoms and the biochemical analysis of blood.Health care professionals use symptoms and signs as clues that can help to determine the most likely diagnosis when illness is present..Biochemistry involves in the diagnosis and monitoring of disease by measuring the concentration of chemicals in blood, urine etc. The substances in blood are maintained within defined limits in health but the disease process upsets the normal balance of these chemicals and they then become markers of the disease state. A Fuzzy cognitive map is proposed, which will enable the diagnosis of disease, from various symptoms. Fuzzy inference system in Mamdani is also proposed in conjunction with the FCM for further confirmation of the diagnosis.

Key Words: Medical Decision support systems, Fuzzy logic, Fuzzy inference system, Fuzzy cognitive mapping.

1. INTRODUCTION

Health is the primary concern of every human being. As per World Health Organization (WHO): in the 21st century, health is a shared responsibility, involving equitable access to essential care and collective defense against transnational threats. Developments in the soft computing techniques, has contributed a lot in the management, diagnosis, therapy and maintenance of human health care system. Fuzzy logic is gaining momentum, in its wide areas of application.The natural evolution of various diseases, the obscure nature of medical data and the intrinsic ambiguity of medical problems require a consistent framework that can handle uncertainty by allowing variable and multiple class memberships and facilitating approximate reasoning. This inevitably makes the fuzzy logic (FL) a valuable tool for depicting medical concepts by treating them as fuzzy sets [1].

A Fuzzy Inference System (FIS) is a way of mapping an input space to an output space using fuzzy logic. FIS uses a collection of fuzzy membership functions and rules, to reason about data.Fuzzy inference systems has wide applications in the area of automatic control, data classification, decision analysis, expert systems, computer vision etc. The strength of FIS relies on their twofold identity.On the onehand, they are able to handle linguistic concepts. On the otherhand, they are universal approximators able to perform nonlinearmappings between inputs and outputs.[2]

Fuzzy cognitive maps are fuzzy graph structures for representing causal reasoning. Their fuzziness allows hazy degrees of causality between hazy causal objects. They consist of concepts, that illustrate different aspects in the behavior of the system and these concepts interact with each other showing the dynamics of the system.[3]A fuzzy cognitive map demonstrates the system by a graph showing the cause and effect along with concepts, and it is a simple way to describe the system's behavior in a symbolic manner,by exploiting the accumulated knowledge of the system.

The paper is organized as follows. Section II explains the Fuzzy Cognitive Map, developed for the initial inference of disease based on symptoms. Section III describes the Fuzzy inference system developed for the medical DSS, based on the blood test results. Section IV is the result and discussion and Section V is the conclusion.

1. FUZZY COGNITIVE MAPS

The FCMs were first introduced by Kosko. It was a fuzzy extension of the cognitive maps. The cognitive maps were introduced in byAxelord.FCMs are fuzzy signed directed graphs with feedback. There are many casual feedback loops in FCMs. Feedback prevent the graph-search techniques used in artificial intelligence expert systems.[4].Fuzzy Cognitive Maps have gained a good reputation in the last decade and have been used successfully in different medical fields for decision making, diagnosis and classification [5].

To build a FCM, doctors are not required to quantify the importance of contributing information, they only need an intuitive comprehension of a clinical scenario, and the relevant factors that need to be considered. As shown in different experimental studies, FCM can improve the diagnostic process by incorporating a cognitive balanced decision.

Fig 1 shows the structure of an FCM. C1,C2, C3 etc makes the node of FCM. Each node represents a concept. Edges (eij) is formed between nodes Ci and Cj (i≠j). The directed edge eij from causal concept Ci to concept Cj measures how much Ci causes Cj. The time varying concept function Ci(t) measures the non negative occurrence of some fuzzy event, perhaps the strength of a political sentiment, historical trend or military objective.

The edge can be signed as follows: if increase (or decrease) in concept Ci direct to increase (or decrease) in concept Cj then causality between two concepts is positive. If there is no relation between two concepts then there exists no causality. If increase (or decrease) in concept Ci direct to decrease (or increase) in concepts Cj then causality between two concepts is negative. FCMs with edge weights or causalities from the set {-1, 0, 1} are called simple FCMs. In simple FCMs, edges can be signed as follows:

Positive causality is signed by eij = +1.

Negative causality is signed by eij = -1.

Non-causality is shown by eij = 0.

We combine arbitrary FCM connection matrices F1, F2, ..., FK by adding augmented FCM matrices. F1,..., FK. Each augmented matrix Fi has n-rows and n-columns n equals the total number of distinct concepts used by the experts. We permute the rows and columns of the augmented matrices to bring them into mutual coincidence. Then we add the Fi point wise to yield the combined FCM matrix F.

$F = \sum_i Fi$

We can then use F to construct the combined FCM directed graph.
Even if each expert gives trivalent description in {-1, 0, 1}, the combined (and normalized) FCM entry fij tends to be in {-1, 1}. The strong law of large numbers ensures that fij provides a rational approximation to the underlying unknown

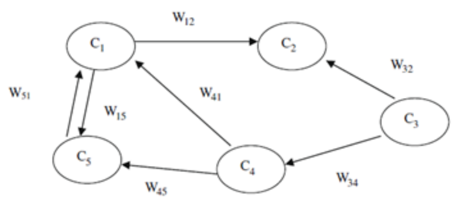

Fig 1. A typical FCM

population opinion of how much Ci affects Cj. We can normalize fij by the number K of experts. Experts tend to give trivalent evaluations more readily and more accurately than they give weighted evaluations. When transcribing interviews or documents, a knowledge engineer can more reliably determine an edge's sign than its magnitude.

In our proposal, we have made an FCM for the symptoms. These symptoms are corresponding to 12 diseases. Some of these symptoms are unique for a particular disease, while certain diseases share many symptoms.
Shown is the list of symptoms associated with the diseases.[8-15]

1. Muscle weakness and fatigue
2. Weight loss and decreased appetite
3. Darkening of skin (hyperpigmentation)
4. Low blood pressure, even fainting
5. Salt craving
6. Low blood sugar (hypoglycemia)
7. Muscle or joint pains
8. Irritability
9. Depression
10. Body hair loss or sexual dysfunction in women
11. Excessive fat on top of back
12. Increased libido
13. Loss of scalp hair
14. Increased body hair
15. Increased facial hair
16. Anxiety or jumpiness
17. Shakiness or trembling
18. Sweating
19. Nausea and vomiting
20. Insomnia
21. Headache
22. Yellowing of the skin
23. Loss of appetite.
24. Itching.
25. Difficulty in breathing
26. Wheezing
27. Edema
28. Dizziness
29. Rapid or irregular heartbeats
30. Weight gain, obesity.
31. Fatty deposits, especially in the face.
32. Stretch marks on the breasts, arms, abdomen, and thighs.
33. Thinning skin that bruises easily.
34. Increased thirst
35. Increased Hunger
36. Frequent urination
37. Blurred vision
38. Extreme tiredness
39. Genital itching
40. Nausea and vomiting
41. Slow healing of wounds
42. Unexplained weight loss
43. Abdominal pain.
44. Cramping.
45. Bloating.
46. Dehydration.
47. Fever.
48. Bloody stools.
49. Frequent urge to evacuate the bowels.
50. Loss of appetite.
51. Mild fever.
52. Increased sensitivity to cold
53. Constipation
54. Dry skin
55. Unexplained weight gain
56. Puffy face
57. Hoarseness
58. Elevated blood cholesterol level
59. Muscle aches, tenderness and stiffness
60. Pain, stiffness or swelling in your joints

61. Heavier than normal or irregular menstrual periods
62. Thinning hair
63. Slowed heart rate
64. Impaired memory
65. Skin and eyes that appear yellowish (jaundice)
66. Swelling in the legs and ankles.
67. Hay skin.
68. Dark urine color.
69. Pale stool color, or bloody or tar-colored stool.
70. Itching (pruritus) and dry skin.
71. Weight loss without trying to lose weight.

Fuzzy cognitive machine designed here will check the symptoms which are positive or negative concepts (here symptoms) for a particular disease and reach an initial conclusion. This is the initial part of diagnosis and the diagnosis is further confirmed by the blood results.

I. FUZZY INFERENCE SYSTEM

Fuzzy logic (FL),which is based on fuzzy sets theory, provides a natural way for constructing fuzzy IF-THEN rules that are closer to the human decision making process by using linguistic interpretations in a mathematical framework.[14]

Fuzzy inference systems (FIS), also referred to as fuzzy models, are nonlinear black-box models that describe the relation between the inputs and the output of a real system using a set of fuzzy IF–THEN rules. The internal operation of FIS requires the application of the inference rules of fuzzy logic, which can be defined as the "basis to what might be called approximate reasoning, that is, a mode of reasoning in which the truth values and the rules of inference are fuzzy rather than precise" (Zadeh 1975). FIS provide flexible solutions, because their model structure and inference mechanisms can be adapted to the modelling problem.

The steps of fuzzy reasoning (inference operations upon fuzzy IF–THEN rules)
performed by FISs are:
1. Compare the input variables with the membership functions on the antecedent
part to obtain the membership values of each linguistic label. (this step is often
calledfuzzification.)
2. Combine (usually multiplication or min) the membership values on the premise
part to get firing strength (deree of fullfillment) of each rule.
3. Generate the qualified consequents (either fuzzy or crisp) or each rule depending
on the firing strength.
4. Aggregate the qualified consequents to produce a crisp output. (This step is called
defuzzification.)

There are two main types of Fuzzy Inference Systems (FIS): the Mamdani-type and the Sugeno type. In terms of use, the Mamdani FIS is more widely used, mostly because it provides reasonableresults with a relatively simple structure, and also due to the intuitive and interpretable nature ofthe rule base.

The Mamdani method has several advantages

- Mamdani method is widely accepted for capturing expert knowledge.
- It allows us to describe the expertise in more intuitive, more human-like manner.
- Mamdani-type FIS uses the technique of defuzzification of a fuzzy output
- Due to the interpretable and intuitive nature of the rule base, Mamdani-type FIS is widely used in particular for decision support application.
- Mamdani FIS has output membership functions.

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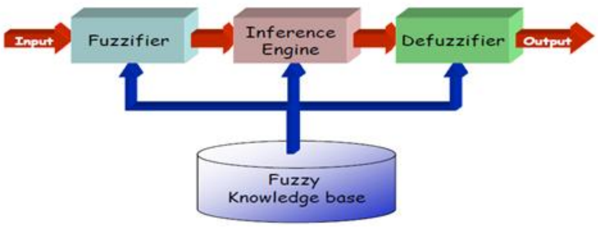

Fig2 Fuzzy Inference System

Demerits of this method are:

- Mamdani FIS is less flexible in system design
- Mamdani-type FIS entails a substantial computational burden

In the proposed system we have made a Mamdani FIS, with 13 rule bases. 17 chemical analytes available in the blood were computed in the FIS. Each analytes value were classified as low, Normal and High using triangular membership functions. Disease manifestations are done by the system, as per the rule bases available. All the diseases, that were diagnosed by the proposed system has two or more analytes in the abnormal range. This makes the system more accurate than reaching a final diagnosis from the values of one or two alone.

IV **RESULT AND DISCUSSION**

Fuzzy cognitive map is realized using the modelling tool mental modeler. Mental Modeler is comprised of three main user interfaces: (a) the concept mapping interface that provides a space for model building and parameterizes model construction in the format required for FCM analysis; (b) the matrix interface that allows the structural properties of the cognitive map (i.e. a representation of a mental model) to become clear by examining pairwise relationships; and (c) the scenario interface which allows stakeholders to run and compare change within the system under different potential scenarios and revisit and revise their models in the concept mapping interface in light of this new information.

Fig2 shows the concept interface, which has the disease symptoms as concepts. After concepts in the model have been determined, relationships between concepts areadded by using directional arrows which indicate theamount of influence one component can have onanother, called edge relationships. Concepts includedin

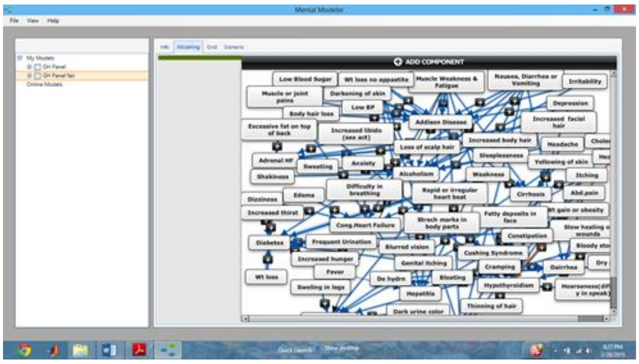

Fig3 Concept interface of mental modeler

the model can have positive (high, medium, orlow), negative (high, medium, or low) or no (norelationship defined) edge relationships.

Fig 4 shows the grid interface of the proposed system. Mental Modeler also includes a Matrix interface that converts the concept map built in the Concept Mapping interface into a structural matrix. The matrix interface lists all concepts included in the model on the i and j axes and translates the amount and direction of edge relationships. This interface is a different representation of the conceptual model, putting in the form required for matrix algebra calculation needed for the Scenario interface.

The screen shot of scenario interface is given in fig 5. The scenario interface indicates the amount of relative change in the components included in the model based on the edge relationships defined in the Concept Mapping interface for the chosen scenario. In the proposed system, as per the concept strength (diseases symptoms here) relative change is evaluated. The disease diagnosis correspond to the maximum relative change.

From the scenario, we could get an initial diagnosis only. The final diagnosis can be achieved only after blood test, whose values are analysed using the fuzzy inference system (FIS).

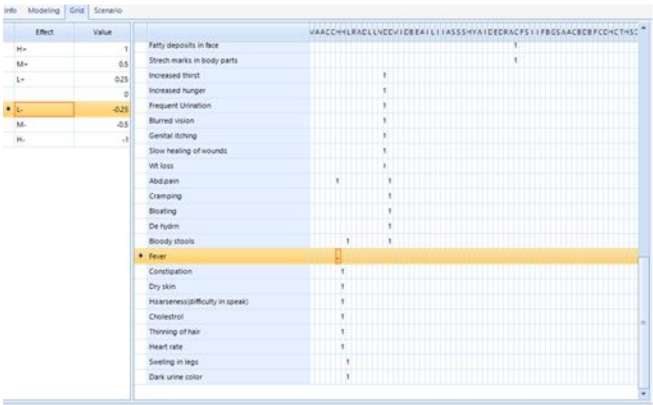

Fig 4 Grid interface

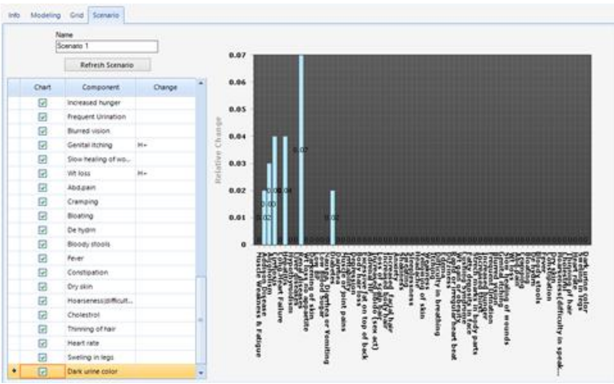

Fig 5 Scenario interface

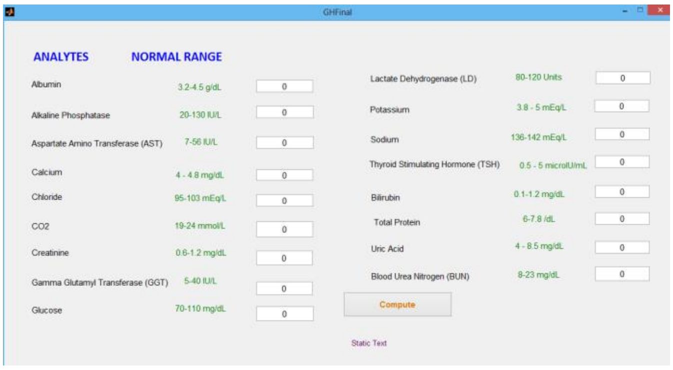

Fig 6 Fuzzy inference Initial Screen

Fuzzy inference system, is realized using MATLAB. A GUI is built, which enables the user interface. The initial screen displays the normal values of analytes, which are predominant in the General Health panel. The Physician has to input the lab result of these analytes, and the system will do the inference as per the rule bases in fuzzy. The inference used here is Mamdani and there are 13 rules in the rule base. Triangular membership functions are used.The analytes values are classified as low, normal and high. The system will reach in a conclusion from the rule bases.

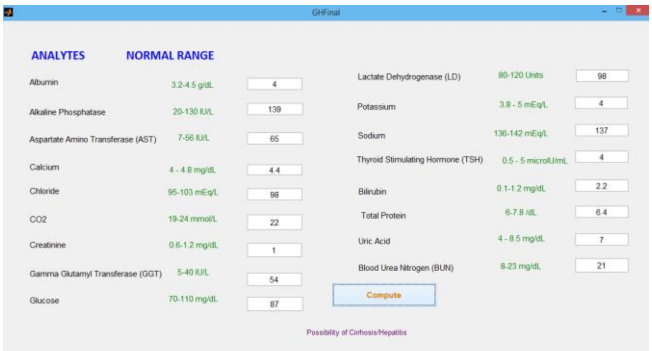

Fig 7 Fuzzy inference final Screen

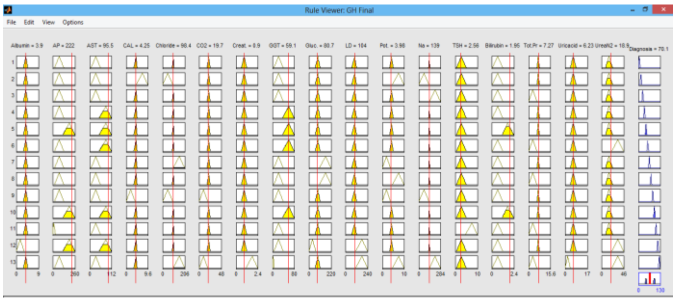

Fig 8 Fuzzy inference system rule viewer

V CONCLUSION

Medical decision support system is presented here. It works in two phases. The first phase deal with the physiological symptoms, which is linguistic in nature. Fuzzy cognitive map is well suited for modelling and decision. A Fuzzy cognitive map is realized using mental modeler tool. Once the FCM gives initial diagnosis as per the available symptoms, further diagnosis is carried out with the blood analysis. Since the blood analysis gives numerical data, a fuzzy inference system with the use of membership functions will provide proper inference.

Hence it can be noticed that, a combination of various tools in soft computing yield more reliable results in applications like medical diagnosis.

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BIOGRAPHIES

Prof. **ABID HUSSAINM** is currently Associate Professor at TKM College of Engineering, Kollam, Kerala in the department of ECE. He received his Bachelors and Masters degree from College of Engineering, Trivandrum. He had worked in Higher College of Technology, Muscat for six years. He is currently pursuing research in the field of soft computing in biomedical applications.

Dr. CHITHRAPRASAD D is the Professor and Head of department of CSE at TKM College of Engineering, Kollam, Kerala. He has received his Masters from IIT Delhi and PhD from IIT Kharagpur. Being a senior Professor with vast experience, he has produced multiple PhDs. His area of interest includes Algorithm Design, Computational Geometry, Computer Graphics, Data mining and Social Network Analysis.

