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Application of Fuzzy logic to determine the retentive causes of pulse body by the pulse parameters in Iranian Traditional Medicine

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***Abstract*— There are ten (10) parameters in Iranian Traditional Medicine (ITM) to describe and classify each pulse. The Degree of The Supply Ability State, vascular wall consistency and The Demand State of the body were determined using complex rules of pulse in traditional medicine and is of paramount importance. Ten (10) parameters were used and the Degree of retentive causes of pulse body were categorized as very low, low, medium, high and very high, and fuzzy logic was used to inference the rules of pulse. These rules have ten (10) input parameters and three (3) output parameters. Therefore, the Degree of retentive causes of pulse was determined using twenty-five (25) rules of pulse in ITM, by fuzzy logic in MATLAB.**

***Keywords*— Iranian Traditional Medicine; pulse; Fuzzy logic.**

I. INTRODUCTION

A. *Pulse parameters in ITM*

Three causes were named by Avicenna to be the "Asbaab-e-Masek-e-Nabz" meaning "The retentive causes of pulse", because they retain pulse beating and are mentioned below:

1. The state of the heart, as well as its health and power today, are known as "The Supply Ability State".

2. The state of the vascular wall such as consistency and elasticity, depends on the body's wetness and is somehow related to vascular sclerosis.

3. The state of the body's heat depends on the body's metabolic rate, which is known as "The Demand State" [1].

Avicenna and other great physicians of Persian medicine used ten parameters to describe and classify each pulse [2]. More details of these parameters are listed below:

1. The extent of expansion of a vessel in each of the three dimensions namely length, width and height during the passage of a pulse, in regard to the four examining fingers placed with a defined pressure on the radial artery.

2. The "pulse strength" was assessed by the impact of the pulse-beat on the examining fingers,

3. The "pulse velocity" relates to the duration of its movements,

4. The "pulse frequency" relates to the duration of the rest period intervals,

5. The "vascular wall consistency" relates to the elasticity and rigidity of the vessels,

6. The "artery's temperature" in comparison with the surrounding tissue and also the normal population,

7. The degree of fullness of the vessels,

8. The "resemblance" or "diversity" of pulses,

9. The "regularity" or "irregularity" of the diverse pulse, and

10. The "harmony or proportion" within different segments of a pulse wave or in between similar segments of two pulse waves named "the weight" or "vazn" of a pulse [3].

Each of the above mentioned parameter guides the traditional physician to at least one of the retentive causes of pulse, if not all three. To make it clearer, the "Supply State" was assessed by the extensibility of the artery in length, pulse strength, rhythm, regularity and also the weight of the pulse [4].

B. *Fuzzy Logic*

Dr. Lotfi Zadeh, a professor of mathematics from U.C. Berkeley, proposed the fuzzy theory [5]. He also reported the concept of linguistic variables. Fuzzy logic is based on the theory of fuzzy sets, where an object's membership of a set is gradual rather than just being a member or not a member.

It includes different processes in itself such as fuzzification, defuzzification, membership functions, domain, linguistic variables and rules.

Domain determines the range of values in which membership of fuzzy is performed. The basic part of fuzzy sets is the membership function. The relationship between domain value and degree of membership was determined by a membership function. Fuzzy logic exhibits many similarities and differences with Boolean logic. Fuzzy logic operates Boolean logic results, when all the fuzzy membership functions are restricted from 0 to 1. So there are infinite values between 0 and 1 in fuzzy logic. Fuzzy logic uses natural language techniques and variables which are based on the degree of truth and is easier for human beings to understand. The application of fuzzy logic in medicine and bioinformatics has received much appreciation [6, 7, 8, 9, 13, 14].

In this research, a fuzzy inference system (FIS) was developed for teaching staff erformance appraisal using MATLAB [10]. The model can be viewed as an alternative to the use of addition, in aggregating the scores from all categories, to produce a final score [11, 12]. The factors used for evaluating the performance are considered as input parameters for fuzzification. The study utilized FIS to deal with the problem associated with rule explosion. The proposed FIS was implemented using the Mamdani-type inference. To defuzzify the resulting fuzzy set, the center of gravity defuzzification method was selected.

II. DESIGN OF FUZZY LOGIC BASED PULSE PARAMETERS

Each of the above mentioned parameter guides the traditional physician to at least one of the retentive causes of pulse, if not all three. To make it clearer, the "Supply State" was assessed by the extensibility of the artery in length, pulse strength, rhythm, regularity and also the weight of the pulse. The "Demand State" is assessed by the degree of arterial wall expansion in height and length, the velocity, the frequency and the weight of the pulse and also the temperature of the artery.

The "Vascular Wall Elasticity or Consistency" is also assessed by the degree of arterial wall expansion in width and the degree of its softness or firmness, under the examining fingers.

Degree of The Supply Ability State, vascular wall consistency and The Demand State of body were determined using complex rules of pulse in traditional medicine and is of paramount importance, but it is difficult to determine the above.

On the other hand, given the ten parameters and the Degree of The Supply Ability State, vascular wall consistency and The Demand State of body were categorized as very high, high, medium, low, and very low; therefore, fuzzy logic was used to inference the rules of pulse.

In this paper, according to the ITM and by using fuzzy logic, a fuzzy expert system was designed that works as a doctor of ITM.

A. Input and Output Parameters

The first step in using fuzzy logic within this model is to identify the parameters that will be fuzzified and to determine their respective range of values. The final result of this interaction is the value for each performance parameter. MATLAB was used for the development of FIS.

The input and output parameters were created in the FIS editor as shown in Figure 1. Ten (10) input and three (3) output parameters were applied to the FIS.

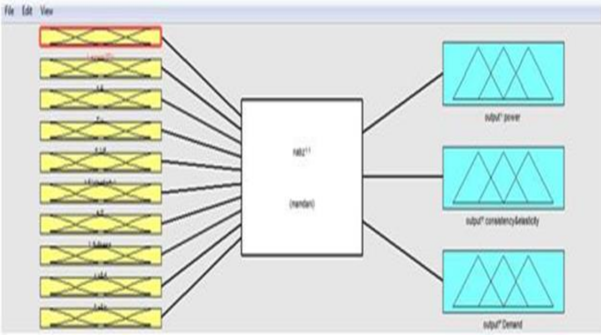

Fig. 1. *Input and output parameters.*

For the design process, the extent of the expansion in three dimensions Strength, velocity, frequency, vascular wall consistency, artery's temperature, fullness, resemblance, regularity and harmony were used as input parameters and The Supply Ability State, vascular wall consistency and The Demand State of the body were obtained as output. For fuzzification of these parameters, the linguistic variables Very High, High, Medium, low and Very low were used.

For the inference mechanism, the Mamdani max-min inference was applied. The rating scale of input and output parameters were classified into different categories, as given in Tables 1 and 2.

TABLE I. RATING SCALES OF INPUT PARAMETERS

Linguistic	***Very High***	***High***	***Medium***	***Low***	***Very Low***
Input Name	The extent of the expansion in three dimensions				
	Strength				
	Velocity				
	Frequency				
	vascular wall consistency				
	artery's temperature				
	Fullness				
	Resemblance				
	regularity				
	Harmony				

TABLE II. RATING SCALES OUTPUT PARAMETERS

Linguistic	***Very High***	***High***	***Medium***	***Low***	***Very Low***
Output Name	Supply Ability State				
	Vascular Wall Consistency				
	Demand State				

B. Membership Functions

Fuzzification comprises the process of transforming crisp value into grade of membership [15]. The membership function is used to associate a grade to each linguistic term. The membership function editor is used to define the properties of the membership function for the system variables. Figure 2 shows fuzzification of input parameters for the first fuzzy module with membership function as explained in Table 1, the membership function overlap with each other for achieving better results.

Figure 3 shows the fuzzification of output parameter performance with membership function as explained in Table 2, the membership functions touch each other for achieving better results.

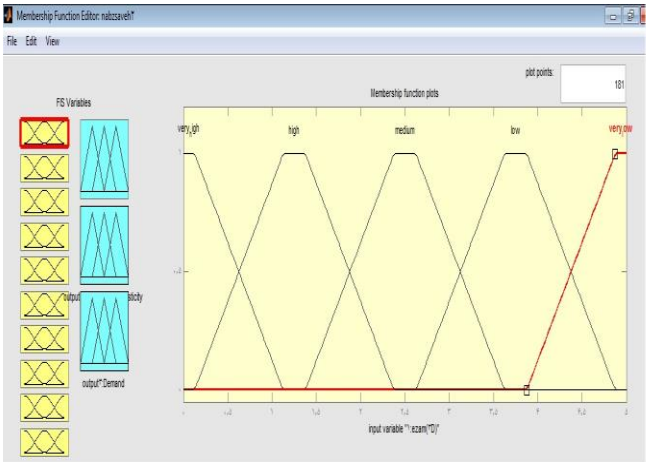

Fig. 2. *Membership function for input pulse in ITM.*

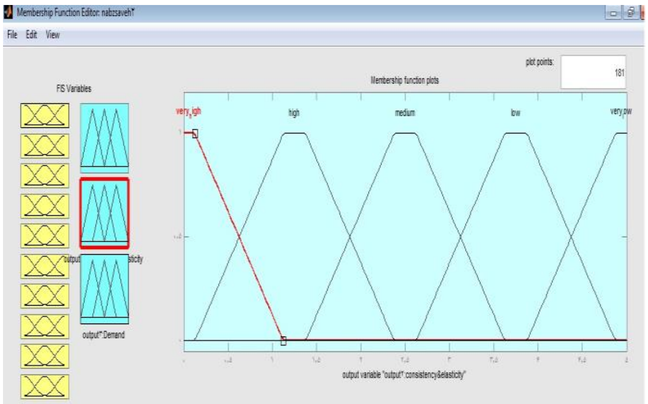

Fig. 3. *Membership function for output "vascular wall consisty".*

C. Rule Base

A fuzzy rule base is a collection of knowledge in the If-Then format from experts. It describes the relationship between fuzzy input parameters and output. It is used to display how an output is dependent on any one or two of the inputs. The rule editor enables the user to define and edit the rules that describe the behavior of the system. As per the fuzzified input and output parameters, rule base is generated by applying pulse parameters in Iranian Traditional Medicine to determine the retentive causes of pulse body. A total of 25 rules were generated. The following are the sample rules collected from the rule base which determine the retentive causes of pulse body:

If (extent of the expansion in three dimensions is medium) and (strength is very high) and (velocity is medium) and (frequency is very high) and (vascular wall consistency is medium) and (artery's temperature is medium) and (fullness is medium) and (resemblance is medium) and (regularity is medium) and (harmony is medium) then (supply ability state is very high) and (vascular wall consistency is medium) and (demand state is very high).

For the inference mechanism, the Mamdani max-min inference was applied.

III. RESULTS AND DISCUSSION

The proposed method was applied to determine the retentive causes of pulse body. Sample data were examined and randomly selected for the present study. This is an example of the activation of rules relative to retentive causes of pulse body in ITM, for the initial FIS. Figures 4 and 5 show snapshots of results of work done in MATLAB. The rule viewer is a read only tool that displays the whole fuzzy inference diagram. The surface viewer is also a read only tool.

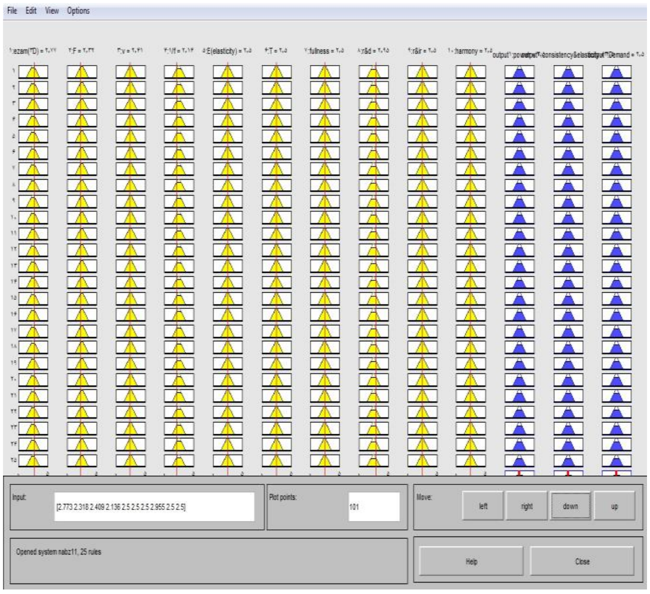

Fig. 4. *Rule viewer view of input, output parameters*

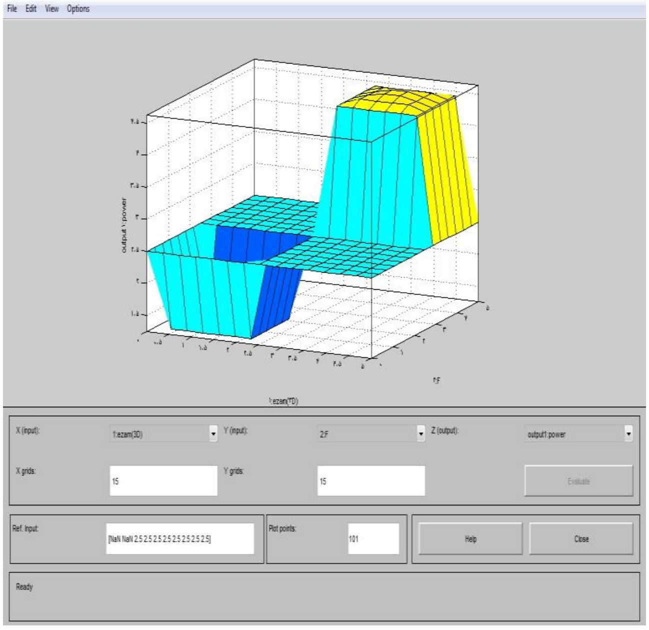

Fig. 5. *Surface viewer view of input, output parameters*

According to the Iranian Traditional Medicine and by using fuzzy logic, a fuzzy expert system was designed that works as a doctor of ITM. Therefore, 25 rules of pulse in ITM by fuzzy logic in MATLAB were reviewed, respectively.

These rules have ten input parameters as the extent of expansion in three dimensions, strength,velocity, frequency, vascular wall consistency, artery's temperature, fullness, resemblance, regularity and harmony. As well, these rules have three output parameters namely The Supply Ability State, vascular wall consistency and The Demand State of body. The linguistic variables for these parameters namely Very High, High, Medium, low and Very low were used.

Finally, based on input parameters, a reasonable estimate of the Degree of The Supply Ability State, vascular wall consistency and The Demand State of body were obtained using fuzzy logic. Therefore, doctors can use it to better assess patients.

References

[1] Ibn Sina AAH. Medicine. In: al-Din IS, editor. Al-Qanun fi al-Tibb [The Canon of Medicine] (Arabic). Lebanon: Alamy Le-Al- Matbooat Institute, 2005. p. 28.

[2] Zarshenas MM, Abolhassanzadeh Z,Faridi P,Mohagheghzadeh A. Ibn Sina's treaties on pulsology. Cardiol 2010, ijcard.2010.

[3] Azam Khan M (2004). Aksir Azam (Persian), the Institute for Medical History-Islamic and Complementary Medicine, Tehran University of Medical Sciences; Tehran, pp: 770-4.

[4] M. Alizadeh ,M. Keshavarz, M. Ebadiani,E. Nazem, M.Isfahani,Complexity and rationality of Avicenna's pulsology, doi:10.1016/j.ijcard.2012.03.168.

[5] L. A. Zadeh “Fuzzy Sets and Applications”, Selected papers, ed R.R Yarger, John Wiley, 1987.

[6] Li-Xin Wang, A course in fuzzy systems and control, 1996.

[7] Faran Baig. Muhammad Waseem Ashraf, Fuzzy Logic based Fuel Consumption System, Bahria University Journal of Information & Communication Technology Vol. 5, Issue1, december 2012.

[8] Torres A. and Nieto J.J, Journal of Biomedicine and Biotechnology, 2005.

[9] Lathak.C., Madhub. Ayesha S. Ramya R., Visualization of risk in breast cancer using fuzzy logic in MATLAB, International Journal of Computational Intelligence Techniques, 2013.

[10] Fuzzy Logic Toolbox for use with Matlab – Users Guide.

[11] G.A.Bhosale. R. S. Kamath, Fuzzy Inference System for Teaching Staff Performance Appraisal, International Journal of Computer and Information Technology (ISSN: 2279 – 0764)

Volume 02– Issue 03, May 2013.

[12] J. Pouramini and A. Saeedi, “Fuzzy model identification for intelligent control of a vehicle speed limit,” Journal of Mathematics and Computer Science, Vol. 2, pp. 337-347, 2011.

[13] C. C. Lee, Fuzzy logic controller-part 1, IEEE Transactions on Systems, Man and Cybernetics, Vol. 20, No. 2, 1990.

[14] Valarmathi S., Harathi P.B., Prashanthi Devi M., Guhan P. and Balasubramanian S. Geoinformation Technology for Better Health, pp.141-144, 2008.

[15] Shikha Rao, Lini Mathew, Rahul Gupta, Performance Comparison of Fuzzy Logic Controller with Different Types of Membership Function using Matlab Tools, IRNet Transactions on Electrical and Electronics Engineering.