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The Recognition of Migraine Headache by Designation of Fuzzy Expert System and Usage of LFE Learning Algorithm

Monire khayamnia[1] MohammadrezaYazdchi[2] Ali Vahidiankamyad[3] Mohsen Foroughipour[4]

1 Ph.D. candidate of Applied Mathematics, Tehran Payame Noor University, Tehran, Iran

2 Assistant Professor, Department of Biomedical Engineering , Faculty of Engineering , University of Isfahan, Isfahan, Iran

3 Full Professors, Faculty of Mathematics, Ferdowsi University of Mashhad, Mashhad, Iran

4 Associate Professor, Neurology school of medicine, Mashhad University of Medical Sciences, Mashhad, Iran

Abstract— **The migraine headache is a kind of most populated headache which its rate of population is so high. The first step for starting of treatment is the recognition stage. Also the fuzzy logic has good power for describing of enigmatic and imprecise aspects and due to this reason this tool could be used for the system modeling. The aim of this research is the migraine recognition by the usage of fuzzy logic and systems. A fuzzy expert system for diagnosis of migraine by LFE algorithm is presented, that Mamdani model was used in fuzzy inference engine using MAX-MIN as OR-AND operators and Centroid method was used as defuzzification technique. By the usage of 148 patients, the migraine diagnostic system has been trained by LFE algorithm and in average 80 pieces of IF-THEN rules have been produced for fuzzy system and accuracy, precision, sensitivity, specificity of the system were 97%, 80%, 70%, 94%. By attention to this point that the linguistic rules may be incomplete when human expert to express their knowledge and according to importance of early diagnosis and favorable results, the LFE training algorithm rather than human experts system, will be more effective for recognition of migraine headache.**

Keywords— **headache; fuzzy Expert system; LFE algorithm; recognition**

I. INTRODUCTION

Migraine is a kind of headache which is accompanied by beating and pulsating pains. This sort of headache would be commenced by enigmatic pains which could be transformed to knocking and beating pains. The recognition of migraine would be possible through its signs and symptoms but, due to having similar symptoms to cluster and tension and other sorts of headaches, it could be caused some mistakes for recognition process of low-experienced medicines or doctors. In addition to pain specification checking, most of doctors would proceed clinical palpation, which is comprised of blood pleasure and pulse checking, complete central nerve system checking and ophthalmoscopy. In addition to mentioned actions, sometimes, it's necessary to proceed some specific recognition approaches, such as (CT-Scan, MRI), Electroencephalography (EEG registration), Visibility scrutinizing, blood testing for recognizing of pain reasons. These sorts of experiments would be prescribed for putting away the other reasons of the pain. For diagnosing of disease, fuzzy system could play valuable role [1, 3, 4, 6 and 7]. Sanchez could introduce the existing fuzzy relationship between the disease and symptoms, and Adlassing could address to this issue with accuracy [1, 2]. Ahn, Mun, Kim and Oh could propound one special approach through interview table and exiting relationship between disease and symptoms [12]. The fuzzy inference system is included of four main levels which are comprised of fuzzification, fuzzy inference engine, data base and defuzzification. For attaining to fuzzy IF-THEN rules, two possible approaches are in access. The first one is receiving from human expert and the second one is fuzzy system production by automatic learning approaches. It could be possible which the received IF-THEN rules from human expert were not complete or this human experiences could not cover whole the items, and due to this reason, the systems which were based according to human expert experience are assumed in low level of validity. In this sort of situation, the approaches which could train the system by existing and limited data could become so valuable. In recent years, for producing of fuzzy IF-THEN regulation, many approaches have been offered from training data [13, 14 and 15]. One of the existing approaches is the LFE algorithm. Inside this text, it has been attempted to introduce a system which is able to model the knowledge and experience of genius persons, then through the LFE algorithm and without the usage of genius person's knowledge, the system would be remodeled and next the reached results would be compared.

II. FUZZY EXPERT SYSTEM

Through the theory of fuzzy system the modeling of enigmatic and imprecise concepts would be possible. Ambiguity and uncertainty in medicine knowledge is explicit and clear, which is related to modeling of medicine knowledge. The figure in below is a general schema from the adaptive-diagnostic model of recognition by the usage of fuzzy system.

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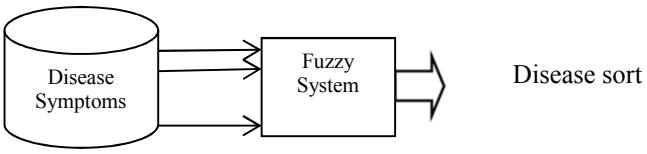

Figure 1: The fuzzy system quality of operation

The proposed system in this text has been designed through the FIS tools in MATLAB Software in which the input/output variables and then their membership functions would be explained. Finally fuzzification and defuzzification would be elaborated too.

According to our primary studying, it was estimated that the system could have the diagnostic ability of 76% for a sample by 30 pieces members in other words; the estimated "p" factor is 0.76. Then sample society volume has been calculated by the usage of Cochran formulation (due to unknown society volume) and finally $n = 148$ got reached.
The Cochran formulation (on the time which the society volume is unknown) is $n = \frac{z^2_{\alpha/2}\, p(1-p)}{d^2}$, in which the $z^2_{\alpha/2}$ is depended to the current distance of certainty and the error of (α). Whenever the error level is considered 0.05, the certainty level would be 0.95 and consequently the $z^2_{\alpha/2} = 1.96$ and $d = 0.05$ could be gained.

III. Fuzzy System Input/Output Parameters

In this fuzzy system for diagnosing of migraine headache, there are nine input parameters, but the one output parameter is considered the recognition of migraine headache. The diagnostic and linguistic parameters are issued in Table 1. For example, one of diagnostic parameters is the severity of headache. The linguistic parameters for the severity of headache are considered as low to moderate, sever to high severe. In fuzzy system low to moderate headache is introduced as the function of $trapmf\,(0, 0, 2.5, 7)$ which is a trapezoidal function and the fuzzy complex for severe and high severe headache is a function of $trapmf\,(2.5, 7, 10, 10)$ which is considered as trapezoidal function. The membership function of severity of headache has been shown in Figure 2.

$$\mu_{low\ and\ moderate}(x) = \begin{cases} 1 & , \ x \le \frac{5}{2} \\ \frac{-2}{9}(x-7) & , \ \frac{5}{2} \le x \le 7 \\ 0 & , \ x \ge 7 \end{cases}$$

$$\mu_{sever\ and\ high\ sever}(x) = \begin{cases} 0 & , x \le \frac{5}{2} \\ \frac{2}{9}\left(x - \frac{5}{2}\right) & , \frac{5}{2} \le x \le 7 \\ 1 & , x \ge 7 \end{cases}$$

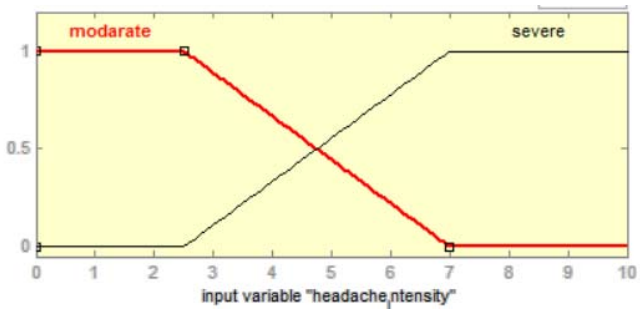

Figure 2: Membership function of severity of headache

Table 1: Used diagnostic and linguistic parameters in regulations

Diagnosis parameter	Linguistic parameter
x_1 =Vomiting	Yes/No
x_2 =Aura	Yes/No
x_3 =Severing by special smell	Yes/No
x_4 =Improving with inhalation	Yes/No
x_5 =Headache site	one-sided, both sides, entire head
x_6 =Headache quality	throbbing , not throbbing
x_7 =Headache intensity	low and moderate , severe and high severe
x_8 =Headache duration	fewer than 4 hours, from 4 hours to 72 hours, from 72 hours to 4 weeks, from 4 weeks to months
x_9 =Headache history	some days, some weeks, some month, some years

IV. The Base of Fuzzy If-Then Rules Through Human Expert

This section is included of issued fuzzy rules for the system. These regulations are reached by the consulting of human expert which is comprised of 40 regulation of IF-THEN and it could be shown according to below formulas:

$$if\ x_1 \text{ is } A_1^l \text{ , } x_2 \text{ is } A_2^l \text{ , ……, } x_n \text{ is } A_n^l\ then\ \text{y=}B^l$$

After translation of each imprecise aspect and by usage of fuzzy reasoning, the logical value of each fuzzy rule would be determined [13, 14]. In fuzzy reasoning and by the usage of combined AND, OR operators along with fuzzy supplementation, it would be attempted to provide special results from fuzzy rules and recognized realities.

V. FUZZIFFICATION AND DEFUZZIFICATION

In this section for determining the features of fuzzy deduction, different sort of models have been studied. Since the fuzzy model would be able to present mankind experiences and this model could be finalized by the features of MAX-MIN as OR-AND operators and Centroid approach for defuzzification.

VI. LFE ALGORITHM

In this part, the information 148 persons, who are suffering the headache and are cared in Ghaem Hospital, is considered to our current existing data. 80% of this data is assumed as our training data and 20% of this data is considered as testing data. By training data, the system could be taught and then the IF-THEN rules could be produced. By training data the ability of extension to fuzzy deduction would be evaluated.

It would be assumed that the A complex is included of below members:

$$A = \{a_1, a_2, \dots\dots, a_m\}$$

Inside this complex, each a_i member is showing 9 input parameters and one output parameter same as below:

$$a_i = ((x_{i1}, x_{i2}, \dots\dots, x_{i9}), y_i)$$

In this section, at first the degree of each parameter $x_{i1}, x_{i2}, \dots\dots, x_{i9}, y_i$ in the fuzzy different groups should be calculated and then the system would dedicate a group by the maximum degree to each parameter and by this approach one rule for each pair of input-output data would be achieved. For the next stage, for each rule one degree would be considered according to below formulations:

$$D\big(rule(i)\big) = \mu(x_{i1}).\mu(x_{i2}) \dots\dots \mu(x_{i9}).\mu(y_i)$$

If there is more than one rule, which its assumption part is the same but they're different at their results, the rule which has the higher degree would be considered and then a compressed group of rules would be reached. In this research, the system was tested by 80% of training data for ten times accidentally and in average 81 rules of fuzzy IF-THEN were attained for the system.

VII. THE RESULTS

The designed headache diagnostic system, which was based on the genius person's knowledge, got evaluated for 148 patient persons. For checking the scale of system result adoption to the realities, the validity of the system was evaluated, and the amount of system validity achieved to the rate of 81%.

For showing the system power or efficiency, the characteristic of accuracy, sensitivity and the specification has been used in this system. For the accuracy, sensitivity and specification, the amounts of 88%, 82%, 79% have been reached sequently. The validity of migraine diagnostic system has been shown in table 2.

Table 2: The validity of migraine diagnostic system which is based of genius person knowledge

System / Reality	Not migraine	Migraine	
Not migraine	41	11	52
Migraine	17	79	96
	58	90	148

The designed system by LFE algorithm has been studied and evaluated on 20% of data. In each evaluation level, the features of validity, accuracy, sensitivity and specifications have been calculated. By performing of ten times of system training, the validity average amount was resulted to 97% , and also the average of accuracy, sensitivity and system specification were resulted to 80%, 70% and 90% sequently.

VIII. CONCLUSION

Migraine is one of most populated headaches. There are several reasons for the headache disease. First headache is not a disease and it's a spectrum of disease. There are different sorts of disease which can produce headache. Actually the headache could be the symptoms of many illnesses and it could be lonely assumed an illness and due to these reasons the headaches could be so varied and populated. Due to the similar primary symptoms of migraine with other sorts of headache, can cause some faults and mistakes for low-experienced doctors, because of these faults and mistakes in recognition system, the system which are using the current knowledge and can support the doctors duties, would be so important and valuable [1, 3, 4, 6]. The recommended system in the current research are able to use the fuzzy logic to describe the enigmatic and imprecise aspects and by the usage of genius people experience and LFE algorithm, some models were designed which were resulted to migraine recognition. According to this reality that the linguistic rules which were gained from genius people might become incomplete, and by noticing to the importance of on time recognition and gaining pleasant results, the results of genius people knowledge based system are compared with LFE algorithm and it was proved

that LFE algorithm could be so useful for recognition of migraine headache and then the validity of diagnostic system will be improved. By the way, the evaluation of this system by more varied data will be possible in the future and the diagnostic domain of this system for other usual sorts of headache will be possible for any developments.

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