Employing Artificial Intelligence Techniques in Mental Health Diagnostic Expert System

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***Abstract* – The Mental Health Diagnostic Expert System (MeHDES) is proposed to assist the Malaysian psychology industry in diagnosing and treating their mental patients, and also to allow each mental patient to have several options on selecting a treatment plan that fits their budget without jeopardizing their overall health conditions. MeHDES will be using three artificial intelligence (AI) reasoning techniques: rule-based reasoning, fuzzy logic, and fuzzy-genetic algorithm (fuzzy-GA). The human experts' knowledge in the area of mental health and disorders will be transformed and encoded into a knowledge base using the rule-based reasoning technique; fuzzy logic then allows the severity level of a particular disorder to be measured; and fuzzy-GA will be used to determine and propose the suitable treatment for each of the mental patients based on their budget and their overall health conditions.**

Keywords- rule-based reasoning; fuzzy logic; fuzzy-genetic algorithm; expert system

I. INTRODUCTION

Different mental patients have different overall health conditions, even if they are suffering from the same exact type of mental disorder. Financial matters also come into consideration to each individual mental patient because getting the treatments are very expensive and not everyone can afford them. This is especially true in developing countries like Malaysia because, unlike the developed countries, almost the majority of the people in Malaysia are not covered with insurance. For those who are covered, many of them are not covered when it comes to mental health. Therefore, it is essential to cater for mental patients with a safe and affordable treatment plan. We propose the Mental Health Diagnostic Expert System (MeHDES), an expert system that can help improve the situation. Three artificial intelligence (AI) techniques will be used in implementing the MeHDES: rule-based reasoning, fuzzy logic, and fuzzy-genetic algorithm (fuzzy-GA). A knowledge base will be developed based on the human experts' knowledge in the area of mental health and disorders using the rule-based reasoning technique. This is to assist and train new psychotherapists in making a more accurate diagnosis efficiently, by means of attempting to prevent misdiagnoses from happening. Fuzzy logic then allows the psychotherapists to measure the severity level of a particular disorder. Lastly, fuzzy-GA will be used to determine and propose the suitable treatment for each of the mental patients based on their budget and overall health conditions, allowing each mental patient to have several options on selecting a treatment plan that fits the patient's budget and without jeopardizing the patient's overall health conditions.

II. LITERATURE REVIEW

Currently, when a potential mental patient walks in to a psychological center, the first procedure is to carry out the Mental Status Examination (MSE). The MSE is a "structured assessment of the patient's behavioral and cognitive functioning", which includes taking notes on the patient's appearance, general behavior, level of consciousness, motor and speech activity, mood, thoughts, perceptions, attitude, and insight [1]. The MSE helps in determining whether the patient may or may not be suffering from a mental disorder. If the patient is suffering from a mental disorder, then a diagnosis will be conducted, determining the type of specific mental disorder, along with the severity of the disorder. Then, the treatment plan will be given to the mental patient.

Taking the same concept as to current way, the procedures (MSE, diagnoses for specific disorders and severity level, and treatment) and the order in which the procedures are currently set are to be implemented into the proposed expert system (ES). An ES consists of valuable information and searches for patterns in the information it holds by applying rules to the facts in order to reach a conclusion; replicating the way a human expert analyzes a particular situation. Thus, implementing AI techniques is crucial to the ES as AI is considered to be a field of scientific inquiry, instead on an end product [2].

The rule-based reasoning technique is taking place at the diagnoses in figuring out the specific disorders [3]. As mentioned previously, the human experts' knowledge in the area of mental health and disorders will be implemented using the rule-based reasoning. The knowledge expression is naturally formatted through the use of rules, thus suitable to apply such technique [4].

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The fuzzy logic will be used in determining the severity level of the mental disorder, which has already been determined through the diagnosis [3]. The severity of a condition is not a finite measurement, as it follows the probability theory, and therefore suitable to apply the fuzzy logic.

The fuzzy-GA is used in determining the treatment plan [5]. Genetic algorithm is a search algorithm based on the mechanics of biological evolution which provide efficient and effective techniques for optimization [6]. With the combination of fuzzy logic, this technique will enable the system to determine and proposed the best options of a treatment plan for the individual mental patient.

III. RULE-BASED REASONING

Rule-based reasoning is a reasoning technique consisting of "rules containing 'if-then-else' conditional statements or cases containing various fact patterns" [7], which is implemented into the knowledge base. With rule-based reasoning technique, the rules applied to solve the problem can be traced, which is useful because the logic behind the solution can easily be understood [8].

Below is an example of rules for an eating disorder, *Anorexia Nervosa*. The symptoms are categorized as represented in Fig. 1, and the conclusion is derived based on the categorization.

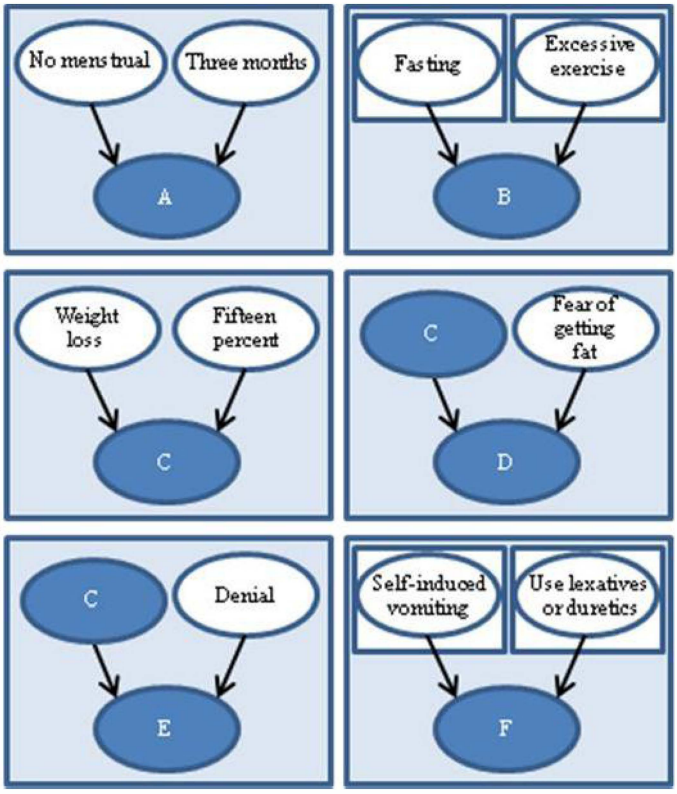

Figure 1. Grouping of symptoms.

Based on the representation in Fig. 1, the rules can be driven as such shown in Fig. 2.

IF *No menstrual* and *Three months*
THEN **A**

IF *Fasting* or *Excessive exercise*
THEN **B**

IF *Weigh loss* and *Fifteen percent*
THEN **C**

IF *C* and *Fear of getting fat*
THEN **D**

IF *C* and *Denial*
THEN **E**

IF *Self-induced vomiting* or *Use lexatives and duretics*
THEN **F**

IF *A* and *B* and *C* and *D* and *E*
THEN **ANOREXIA NERVOSA, NON- PURGING TYPE**

IF *A* and *B* and *C* and *D* and *E* and *F*
THEN **ANOREXIA NERVOSA, PURGING TYPE**

Figure 2. Example of rules

IV. FUZZY LOGIC

The control of performance in solving real life problems is limited when using a linear approximation technique due to the ambiguous terms commonly found in natural language. Therefore, fuzzy logic is used as it provides methods to represent and to reason with the ambiguous terms [9].

The use of fuzzy logic focuses in diagnosing the criteria as well as the severity of a particular episode or disorder. A set of questions will be given based on the specific condition which is being diagnosed, and specific points are assigned to each possible answer for each question. Assume that a set of questions is worth a maximum of 11 points. Table I illustrates how the total points are divided into four categories.

TABLE I. OUTPUT CATEGORIES

OUTPUT	TOTAL: 12 POINTS
Normal	0 – 2
Mild	3 – 5
Moderate	6 – 8
Severe	9 – 11

Fuzzy logic, as shown in Fig. 3, takes place between the border between normal and mild, mild and moderate, and moderate and severe.

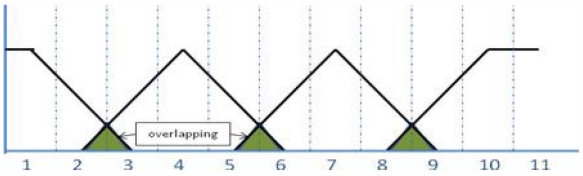

Figure 3. Representation of fuzziness.

For example, if the patient has a score of 5 points, it does not automatically calculate that the patient is suffering from a specific episode or disorder with a mild severity level; because 5 is on the border between mild and moderate, which give a slight possibility that the condition could be round up to 6, with a moderate severity level. Therefore, a randomization is used to presume which of the two sides of the border the severity level lays.

V. Fuzzy Genetic Algorithm

Fuzzy-genetic algorithm (fuzzy-GA) is used to determine and propose the suitable treatment for each individual mental patient based on their budget and overall health conditions. This gives each mental patient to have several options on choosing a treatment plan that fits the patient's budget without jeopardizing the patient's overall health conditions [5].

Inspired by Darwin's theory of evolution, genetic algorithm is based on the biological metaphor, where every single living organism consists of cells, and in each cell is a set of chromosomes. Each chromosome is represented by a set of solutions, called population, where the population is used to create a new set of population with better solutions [10].

There are many different sets of treatments for a specific mental disorder, and the price variation between the sets of treatments can sometimes even reach hundreds. Each set of mental treatments, which specifically involved medications, comes with risk (i.e. side effects). The probability of the risk to take effect depends on the patient's current condition. Hence, to calculate the risk probability of possible suitable sets of treatments, fuzzy-GA is applied, resulting in more optimized options of solutions [5]. Fig. 4 (next page) shows the flowchart of the fuzzy-GA taking place within the proposed system.

To ensure that the medicines are suitable for each patient, each medicine has to be evaluated to determine whether the patient has met any contraindications and special precautions. An elimination of a medicine will occur if a patient's condition meets any contraindication of a medicine. The special precautions contribute to the risk probability.

A medicine carries a risk to a patient's condition if any special precautions of the medicine are met with the patient's condition. The probability of risk for each medicine is calculated by dividing the number of risks a patient has met based on the patient's condition and the medicine's special precautions, by the total number of special precautions of the medicine. The risk possibility increases as more special precautions of the medicine are met with the patient's condition [5].

The establishment of the population is made out of numerous sets of combined medications as the chromosomes. The length or the number of genes available in a chromosome depends on the assigned values which represent the combination of medicines. But as the chromosomes are formed in a group or a population, each chromosome will have the same length, taking the longest length of a chromosome within the population.

To determine the fitness of each chromosome, the first half of the genes on a chromosome are compared with the last half. The greater value of the two corresponding genes is taken as the calculated value, as shown in Fig. 5 (next page). The calculated value is then compared to the patient's overall condition, using the similar technique when eliminating the unsuitable medicines. The risk for the chromosome is then taken into account. The lower the risk, the fitter the chromosome is.

Fuzzy logic also plays a role in determining the placement of a risk. Table II illustrates the certainty factor of risk probability.

Two chromosomes, based on the fitness, are selected for a crossover to recreate a new generation of chromosomes. The better the fitness of a chromosome is, the higher the chance for it to be selected for the crossover. The fitness of the offspring will be evaluated in the same way as their parents.

TABLE II. Fuzzy Certainty Factor

Value of Parameter	Fuzzy Term	Fit/Unfit
0.0	Definitely not	Unfit
0.1	Almost certainly not	
0.2	Probably not	
0.3	Maybe not	
0.4	Unknown	Depends on results of mutation
0.5	Unknown	
0.6	Unknown	
0.7	Maybe	Fit
0.8	Probably	
0.9	Almost certainly	
1.0	Definitely	

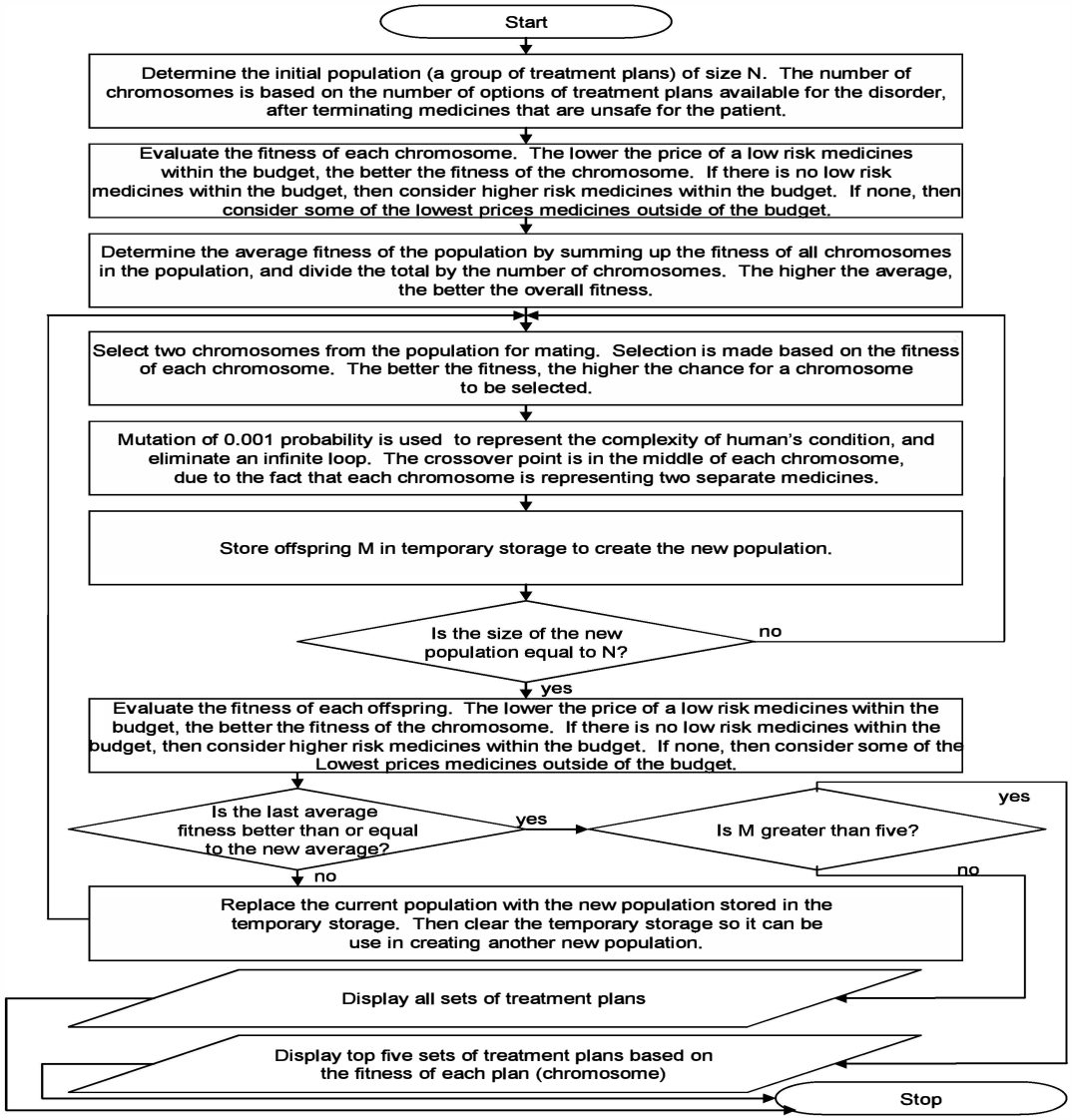

Figure 4. Flowchart of fuzzy-GA design.

Drugs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Priadel	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	1	1	-1
Luvox	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1
CALCULATED VALUES	-1	1	-1	-1	-1	-1	-1	0	-1	-1	-1	0	0	1	1	-1

17	18	19	10	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
-1	0	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1
0	0	-1	0	-1	0	-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1	-1	-1

36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
-1	-1	-1	-1	-1	-1	-1	-1	0	-1	1	-1	-1	1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1	0
-1	-1	-1	-1	-1	-1	-1	-1	0	0	1	-1	-1	1	-1	-1	0

Figure 5. Determining the calculated value.

The mutation, which normally takes place after the crossover, with the rate of 0.001, is needed to represent the complexity and complication of human's condition as risks are being dealt with [5]. It also eliminates the possibility of infinite loops.

The fuzzy-GA terminates the loop either when the prices of the parents are not within the range of the patient's budget, or when the average fitness of the new population is smaller than the average fitness of the previous population. The price comparison is done based on the patient's budget and the minimum approximation of the price of medications [5].

VI. CONCLUSION

The use of rule-based reasoning, fuzzy logic, and fuzzy-genetic algorithm (fuzzy-GA) in the Mental Health Diagnostic Expert System (MeHDES) is appropriate and useful in facilitating the main functions of the system. The

rule-based reasoning allows MeHDES to imitate an expert's reasoning in diagnosing and coming up with the conclusion; while the fuzzy logic allows MeHDES to enhance the conclusion to be more precise when dealing with the indefinite terms such as the severity level of a mental condition. And the technique of fuzzy-GA allows MeHDES to determine several options of suitable sets of treatment for a specific patient based on the patient's health condition and budget. With that, not only MeHDES is contributing to the psychotherapists in Malaysia, but it also contributes to the Malaysian public economically.

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