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The Fuzzified Employability Model for the Perceived Multiple Intelligence of People with Epilepsy

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Abstract

The focus of this paper is on the development of an employability model for People with Epilepsy (PWE). It describes the use of logistic regression to produce a crisp model and then fuzzy procedures are integrated into the crisp model to come up with a fuzzy model to be used to identify the optimal parameters of the eight intelligence skills. Next, the algorithms of the model were coded into C Sharp (C#) programming language to come up with the estimation of optimal combination of eight intelligences that improves the probability of being employed, P(Y=1).

Keywords: Fuzzy model, Multiple Intelligence Theory, People with epilepsy.

1. Introduction

As globalization and information technology are becoming more dominant in today's world, the perception and notion of intelligence and the perceived intellectual characteristics among the Malaysian society changes. The society isno longer focused on one's physical ability and social ranking, but is focusedon academic achievement and excellence. Commoners are on par with the royal elites if their academic achievement is excellent. Changes are inevitable. Previously if one did well in his or her Malaysian Certificate Education and Diploma level, he or she could get a good job, but in the 20th century, the scenario has changed. At present, it has been imbedded in many Malaysian minds that a person with cognitive ability is able to succeed and lead a good life. From preschool to tertiary, Malaysians are very much into academic excellence. This can be seen especially amongst those who have multiple intelligences whereby they are able to score As in various disciplines and skills. These achievers are considered as successful people and have a bright future compared to those who do not get that many As.

Multiple Intelligence Theory was first introduced by Howard Gardner in 1983 in his book, Frames Of Mind (1983), and twenty years later it has become established as a classical model, accepted not only by those in education, but also by people from other fields.Gardner viewed intelligence as the "ability to solve problems, or to create products that are valued within one or more cultural settings"(Gardner, 2004a, 2004b). Initially formulated asa list of seven intelligences in 1983, an eighth intelligence (naturalist or nature smart) was added later in 1997, followed by spiritualist. The present study uses only the first eight intelligences as shown in Table 1, based on a number of justifications, rationales and practicality. Although the MI theory was initially developed to contribute to psychology, it was not fully accepted by the psychology fraternity, but was very well received by many in the field of education instead (Gardner, 1999, 2004b).

Table 1. Gardner's Eight Multiple Intelligences

Intelligence Type	Capability
1. Linguistic	Words and language
2. Logical-mathematical	Logic and numbers
3. Musical	Music, sound, rhythm
4. Bodily-Kinesthetic	Body movement control
5. Spatial-Visual	Images and space
6. Interpersonal	Other people's feelings
7. Intrapersonal	Self-awareness
8. Naturalist	Animal or natural phenomenon

Gardner suggested that every human being possesses a basic set of intelligences, which is a unique blend of intelligences. Therefore, it is up to each individual to take advantage of this uniqueness for constructive or destructive purpose. Gardner further asserted that the eight intelligences rarely operate in isolation, but complement one another as people develop skills or solve problems (Gardner, 2004b).

One of the most challenging problems faced by people living with epilepsy is employment. Regardless of qualification and experience, many PWE feel discriminated in the job market and indeed find it more difficult to get employed than other people. People with epilepsy expect a common understanding about epilepsy from the employers and management. Smeets et al.(2007) concluded in their studies that people with epilepsy face problems getting and keeping their jobs as a result of the stigma, severity of seizure and other psychological deficiencies (e.g., low self-esteem, passive coping style, and low self-efficacy). Studies have shown that the general employment rate and earnings of PWE are slightly lower than those of the general population. For example, people with epilepsy were paid less wages than those without epilepsy in the Netherlands (Lassouw, Leffers, Krom & Troost, 1997) and in India (Varmaa, Sylajaa, Georgea, Sarmaa, & Kurupath Radhakrishnan, 2007).

Ignorance about the illness on the part of the management and colleagues have often been the cause of PWE not being able to keep their jobs, apart from the discrimination arising thereof. Elwes et al. (1991) identified 137 epileptics from a population of 23,837 who were employable in three urban areas of North East England. The survey indicated that the unemployment rate for economically active PWE was 46% against 19% for the control group ($p < 0.01$). Another study conducted by the Department of Neurology, Cleveland, UK revealed that 59% of patients with active epilepsy were unemployed (Elwes et al., 1991).

Thus, it is important to let PWE know about their condition and that employers must provide them with equal employment opportunities. A person with epilepsy has as much a right to employment as does a person without epilepsy.

2. Sample and Research Instrument

For the study on the intelligence profile of PWE, 147 subjects comprising outpatients at the Neurology Department, Kuala Lumpur General Hospital (HKL) were randomly selected and examined, based on the following selection criteria:

i. 16 to 50 years old

ii. Confirmed epileptic by clinical history

iii. Having experienced at least one seizure according to ILAE definition (Fisher et al., 2005)

iv. Not suffering from any other neurological disorder

v. Capable of being independent, not registered with the Social Welfare Department as mentally challenged, or had not been referred to psychiatrists for having abnormal neurological disorder

vi. Currently employed or are awaiting employment.

Based on Gardner's MI theory, Ability Test of Epilepsy (ATIE) (Awang, 2008) was developed to measure the eight types of multiple intelligences of epilepsy patients. The eight intelligences are musical, bodily/kinaesthetic, math-logic, spatial, linguistic, interpersonal, intrapersonal and naturalist. These were selected based on past studies and discussions with epilepsy experts as well as interviews with the patients and their caretakers. The main objective of the instrument was to gauge the patients' own perceptions about their mental ability or level of intelligence. In the test, it is assumed that the patients are capable of describing their true selves. ATIE© was designed to be capable of comparing the intellectual ability of PWEs with that of other people. This test requires subjects to have the mental ability of at least primary six pupils (Malaysian School System of Education).

The test consists of nine sections. The first section is the profile section that contains the demographic characteristics of the respondents (Items 1-15), followed by section on the respondents' illness (Items 16–18). The next eight sections contain 11 items for musical intelligence and 10 items for seven other intelligences for self-assessment by the subjects. To measure the respective intelligence, a 5-point Likert scale was used, ranging from 1 (not at all like me) to 5 (definitely me). The subjects were asked to choose the score that best described themselves and their thoughts or feelings. The test score was calculated by adding all the scores in each item for each section. The total score for an individual subject was the mean of all the scores for each section, and this reflected his/her intelligence level in a particular section.

3. Methods and Implementation

The process of developing the employability model, from estimating the logistic regression to the mechanism of fuzzification is presented in the following five algorithms. These developed five algorithms arecalled Fuzzy Inverse ATIE (FIA).

Algorithm 1*: *Determination of Crisp Intelligence Parameters

A logistic regression equation on employability is estimated from the intelligence scores and intelligence types and is developed to identify the relevant intelligence parameters (Equation (1)). The estimated logistic regression model for the study is written as:

$$P(Y=1)=\frac{1}{1+e^{-z}} \quad (1)$$

where

$$Z_x\,(x_1,x_2,x_3,\ldots,x_8) = c_0 + c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + c_5x_5 + c_6x_6 + c_7x_7 + c_8x_8 \quad (2)$$

Y is a binary variable (1=employed; 0=not employed); and ***X*** is intelligence:

x_1 = music; x_2 =kinaesthetic; x_3 = math-logic; x_4 = spatial;
x_5 = verbal; x_6: interpersonal; x_7 = intrapersonal; and x_8 = naturalist.

The full model was estimated using the sample of 147 PWE, who were either currently employed or unemployed, but who were potentially employable. As discussed in the introduction, many potentially employable PWE were still jobless, while many of those working were under-paid. Using this model, the study determined the probability of PWE getting jobs that match their present skills.

The estimated logistic regression model obtained for the study can be written as:

$$P(Y=1)=\frac{1}{1+e^{-z}}$$

such that

z = -.879 - .094 music + .497 kinaesthetic + .256 math-logic + .121 spatial - .180 verbal - .086 interpersonal + .308 intrapersonal - .154 naturalist (3)

The significance of the model and the parameter estimates are not important for this analysis. This equation would then be incorporated into a fuzzy model to determine the parameters that produce optimum employment probability in Algorithm 2.

Figure 1 shows the fuzzy modelling process, where initially, the fuzzified eight variables were used as the input to the fuzzy model, and at the end of the process, it would be defuzzified to yield an optimum variable. The variable Z_x is as defined in Equation (2), F_{Z_x} is the fuzzified Z_x, both f^* and Z_x^* are the optimised fuzzy values and I_x^* are the optimised input values after the fuzzification process.

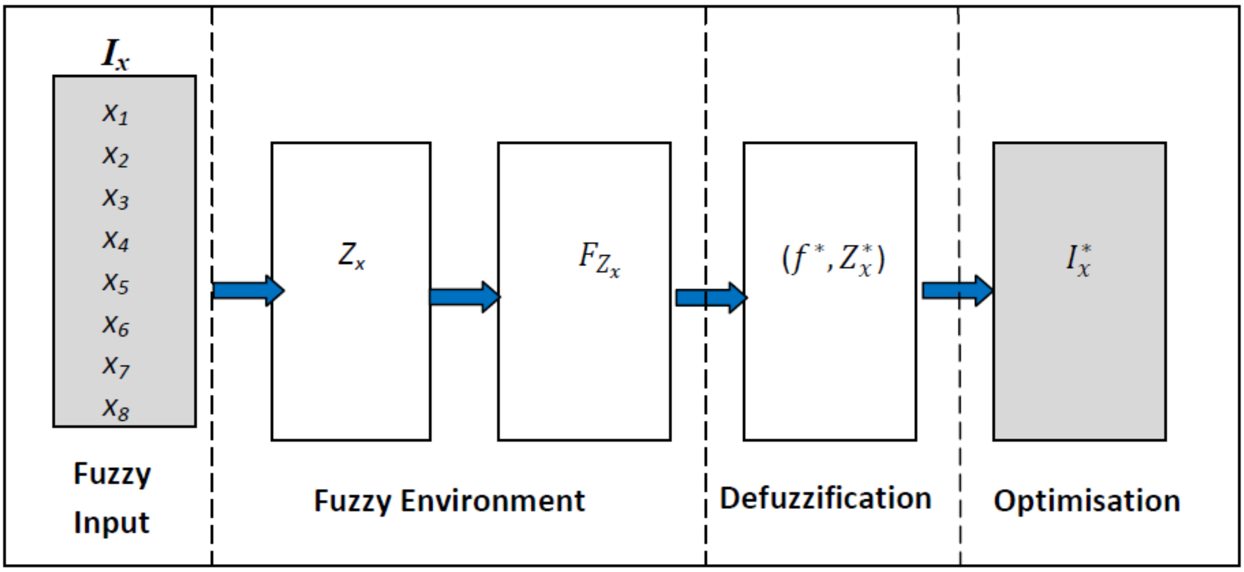


Figure 1. The Fuzzy Modelling Process

Algorithm 2: Fuzzification Process

This second algorithm contains the process of obtaining the input parameters and the α-cut values. From the values, the combinations of the input parameters with respect to each α-cut value will be determined. At the end of this process, minimum and maximum values are calculated.

The triangular fuzzy number is used to assign these input parameters containing the lowest, highest and suggested values. The three values of the domain are based on the lowest score (1), the highest score (5) and the suggested value representing the mean score of each particular skill as illustrated in Figure 2.

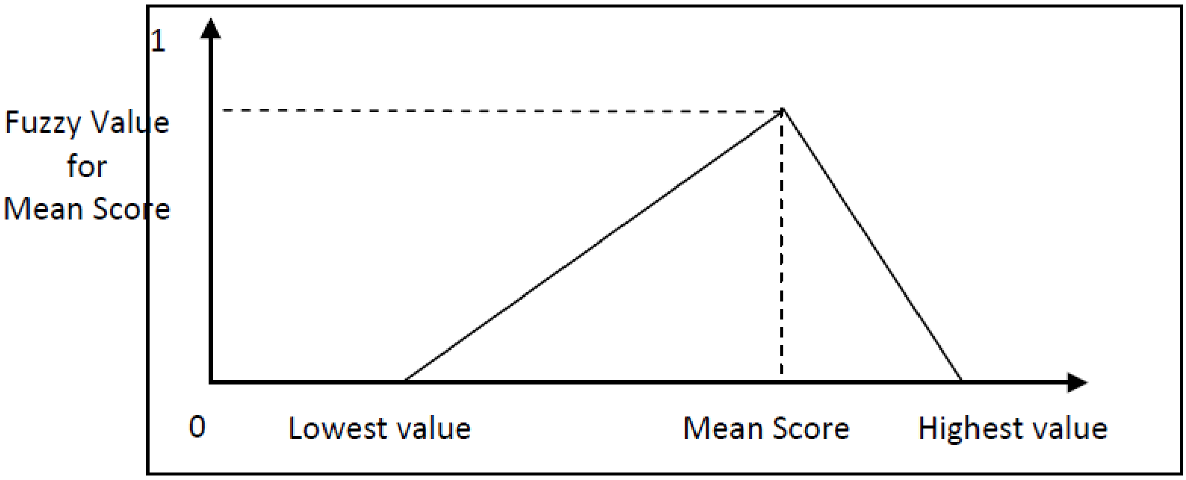


Figure 2. Triangular Fuzzy Number

The domain has two limits, namely, the lowest and highest fuzzy values as shown in Table 2. For example, in Figure 3, 1 is the lowest and 5 the highest fuzzy value for the musical skill. The value which is shown in Figure 3 represent the mean (suggested values) of 3.55 for music skillbased on the actual mean scores. The mean score value is designated as the highest fuzzy value.

Table 2. Input parameters for Patient A

Parameters	Domain	Suggested (Mean Score)
Music	1 - 5	3.55
Kinaesthetic	1 - 5	4.20
Math-logic	1 - 5	3.70
Spatial	1 - 5	3.10
Verbal	1 - 5	3.90
Interpersonal	1 - 5	4.80
Intrapersonal	1 - 5	3.70
Naturalist	1 - 5	3.60

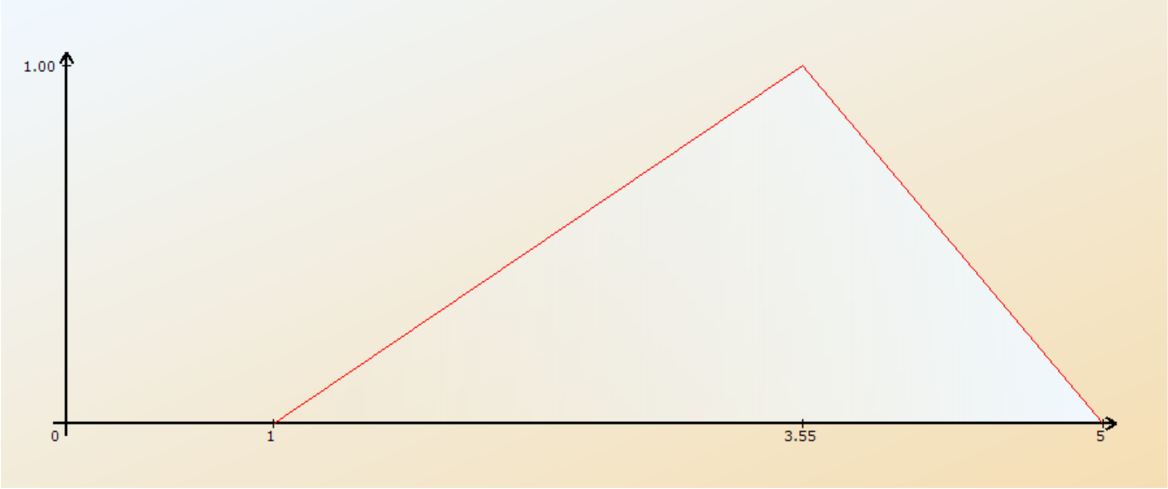


Figure 3. Input parameters Patient A (music - x_1)

In this study, the value of the α-cut starts from 0, increasing by intervals of 0.1, and ends with 1.0, giving a total of eleven α-cuts for each intelligence skill. This will generate $11(2^n)$ combinations of α-cut values in total per subject, eventually producing a total of 2,816 ($11*2^8$) combinations. The α-cut values for Patient A are presented in Table 3.

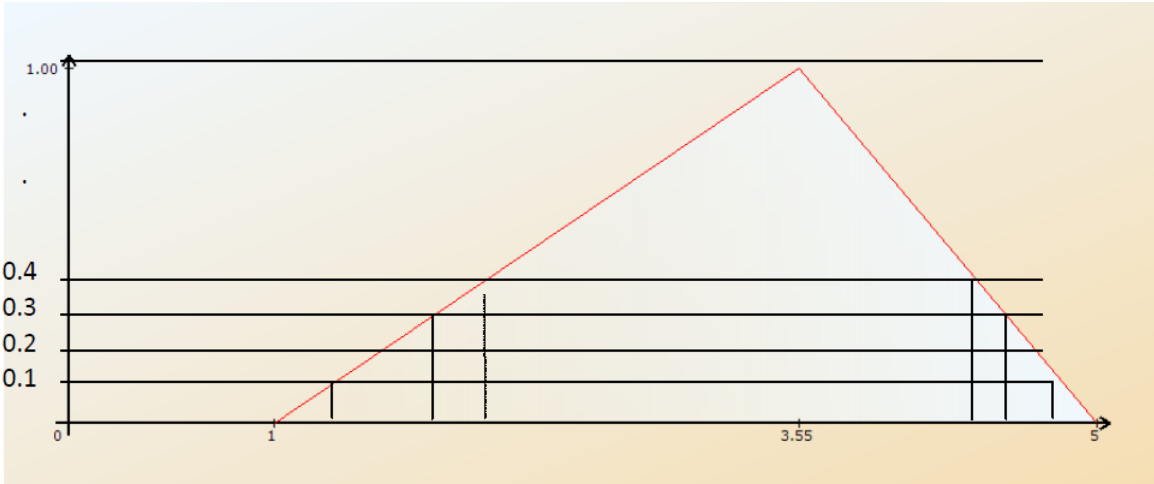


Figure 4. Alpha cuts for Patient A

Using the values in Table 3, the minimum and the maximum values of the intelligence parameters were obtained by substituting these values and the fuzzy values into Equation (3), which then produced the normal and convex fuzzy intelligence parameters of induced graph. The results obtained were then used for the next step.

Table 3. The α-cut values for Patient A

α_i-cut	Input Parameters							
	Music	Kinaesthetic	Math-logic	Spatial	Verbal	Interpersonal	Intrapersonal	Naturalist
0.0	[1.00, 5.00]	[1.00, 5.00]	[1.00, 5.00]	[1.00, 5.00]	[1.00, 5.00]	[1.00, 5.00]	[1.00, 5.00]	[1.00, 5.00]
0.1	[1.26, 4.86]	[1.32, 4.92]	[1.27, 4.87]	[1.21, 4.81]	[1.29, 4.89]	[1.38, 4.98]	[1.27, 4.87]	[1.26, 4.86]

0.2	[1.51, 4.71]	[1.64, 4.84]	[1.54, 4.74]	[1.42, 4.62]	[1.58, 4.78]	[1.76, 4.96]	[1.54, 4.74]	[1.52, 4.72]
0.3	[1.77, 4.57]	[1.96, 4.76]	[1.81, 4.61]	[1.63, 4.43]	[1.87, 4.67]	[2.14, 4.94]	[1.81, 4.61]	[1.78, 4.58]
0.4	[2.02, 4.42]	[2.28, 4.68]	[2.08, 4.48]	[1.84, 4.24]	[2.16, 4.56]	[2.52, 4.92]	[2.08, 4.48]	[2.04, 4.44]
0.5	[2.28, 4.28]	[2.60, 4.60]	[2.35, 4.35]	[2.05, 4.05]	[2.45, 4.45]	[2.90, 4.90]	[2.35, 4.35]	[2.30, 4.30]
0.6	[2.53, 4.13]	[2.92, 4.52]	[2.62, 4.22]	[2.26, 3.86]	[2.74, 4.34]	[3.28, 4.88]	[2.62, 4.22]	[2.56 4.16]
0.7	[2.79, 3.99]	[3.24, 4.44]	[2.89, 4.09]	[2.47, 3.67]	[3.03, 4.23]	[3.66, 4.86]	[2.89, 4.09]	[2.82, 4.02]
0.8	[3.04, 3.84]	[3.56, 4.36]	[3.16, 3.96]	[2.68, 3.48]	[3.32, 4.12]	[4.04, 4.84]	[3.16, 3.96]	[3.08, 3.88]
0.9	[3.30, 2.70]	[3.88, 4.28]	[3.43, 3.83]	[2.89, 3.29]	[3.61, 4.01]	[4.42, 4.82]	[3.43, 3.83]	[3.34, 3.74]
1.0	[3.55, 3.55]	[4.20, 4.20]	[3.70, 3.70]	[3.10, 3.10]	[3.90, 3.90]	[4.80, 4.80]	[3.70, 3.70]	[3.60, 3.60]

In order to get all the best combinations from the α-cuts, a simulation is performed using the specifically developed C# computer programme based on the flowchart shown in Figure 5.

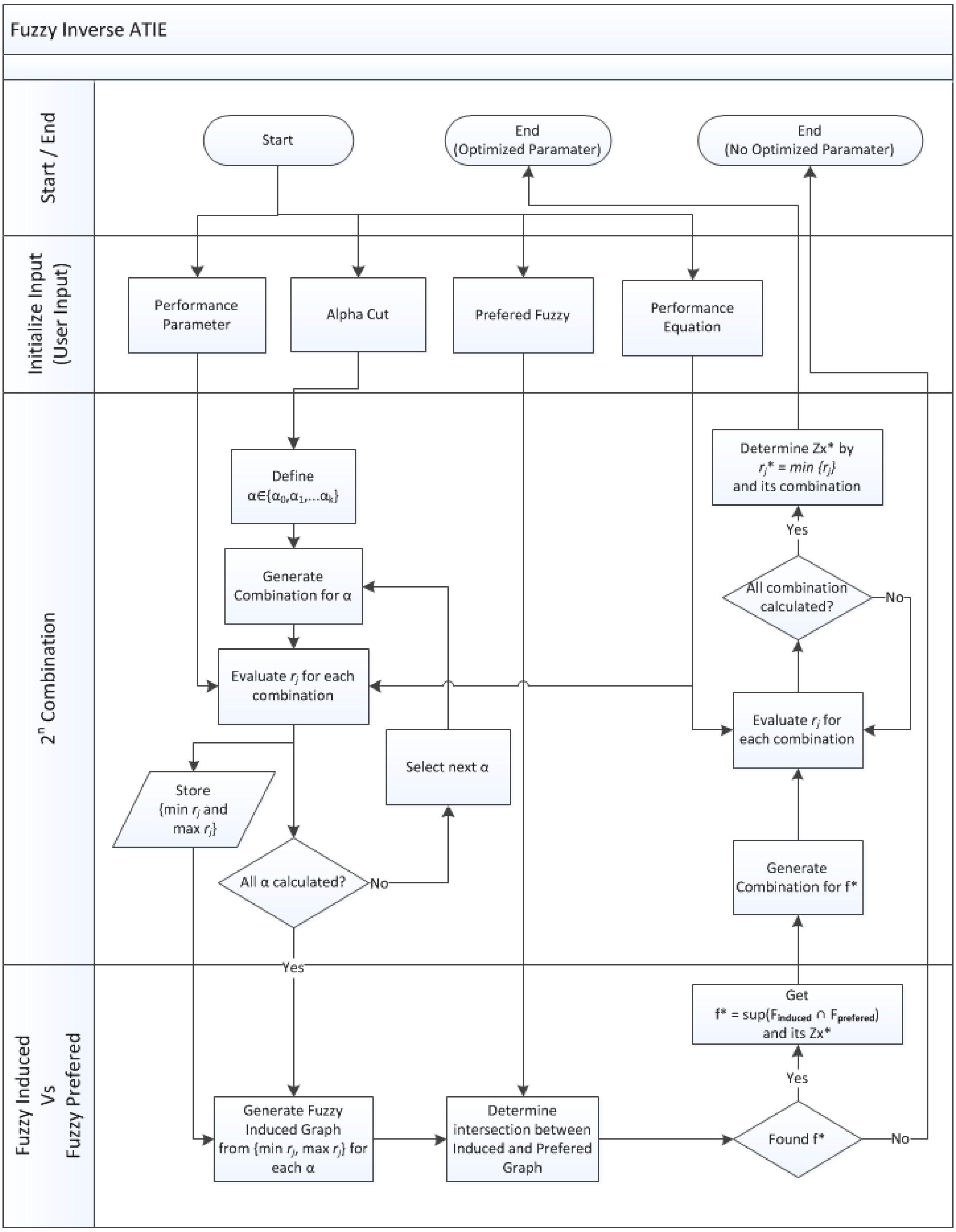


Figure 5. Flow Chart of Fuzzy Inverse ATIE C# Program

Algorithm 3: Determination of Optimized Fuzzy value f^*

The process of defuzzification starts with the determination of f^* and Z_x^*, the intersection of preferred and induced graphs, obtained as the result of the Algorithm II. f^* is the fuzzy induced value obtained from the intersection. The results derived from this process were then analysed to obtain the ideal parameters for each intelligence skill.

The mean score of 4 (ATIE score = 80%) is the score that is needed as a person with such a score is deemed to have that particular skill (Shearer, 2007). Figure 6 illustrates the process for Patient A. In this figure, the blue triangle on the right represents the preferred graph and the black triangle on the left represents the induced graph. From the intersection, the f^* value is 0.6012. Different patients may have different f^* values. These values were used to determine the optimum values in the next defuzzified algorithm.

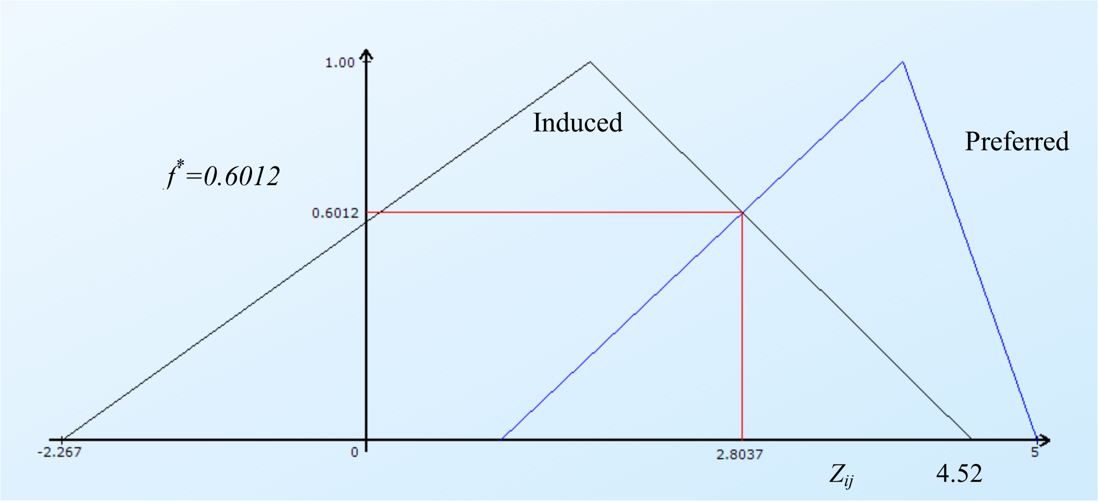
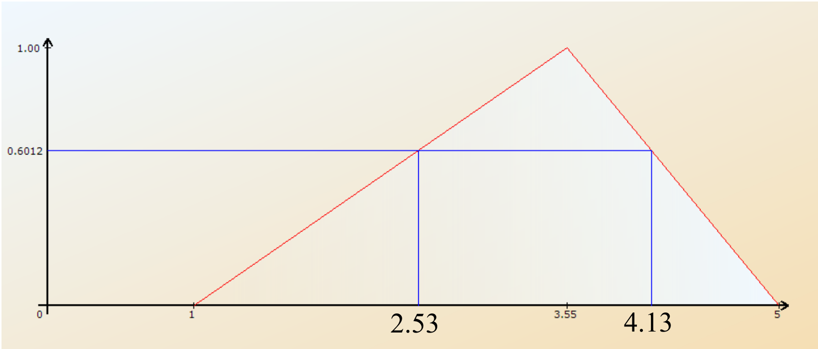


Figure 6. Intersection of Induced and Preferred Graphs (f^*) for Patient A

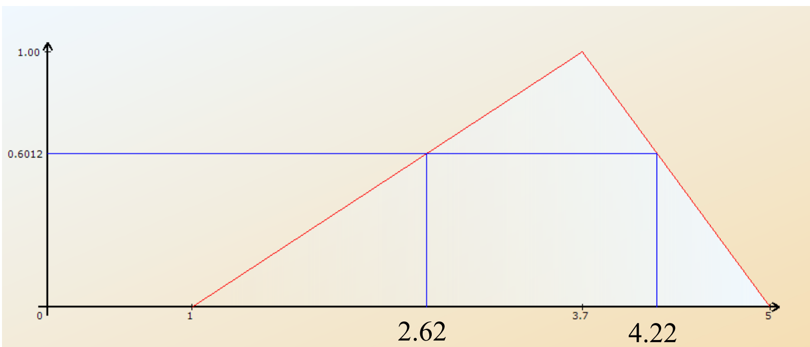
Algorithm 4: Defuzzification

Once the value of f^* is obtained, it is used as the new α-cut value to determine the optimised input parameters of every intelligence parameter as illustrated in Figure 7 for Patient A using $f^* = 0.6012$.



(a) Music (x_1)

(b) Kinaesthetic (x_2)



(c) Math-logic (x_3)

Figure 7. Fuzzified Input Parameters for f^* =.6012 by Examples of Three Intelligences

The complete results for Patient A for all eight intelligences are summarised in Table 4. Once these values were obtained, they were substituted into Equation (1) as in Algorithm 2. There would be 2^8 combinations for the simulation to determine the best value that is nearest to the Z_{ij} value.

Table 4. Minimum and maximum values of eight intelligence for Patient A for $f^* = 0.6012$

Intelligence	***a***	***b***
1. Music	2.53	4.13
2. Kinaesthetic	2.92	4.52
3. Math-logic	2.62	4.22
4. Spatial	2.26	3.86
5. Verbal	2.74	4.34
6. Interpersonal	3.28	4.88
7. Intrapersonal	2.62	4.22
8. Naturalist	2.56	4.16

For example, the best combination of the eight intelligences obtained from the simulation is $\{x_1a, x_2b, x_3b, x_4b, x_5a, x_6a, x_7b, x_8a\}$ and using Equation (3),

$$z = -0.879 - 0.094\,music + 0.497\,kinaesthetic + 0.256\,math\text{-}logic + 0.121\,spatial - 0.180\,verbal - 0.086\,interpersonal + 0.308\,intrapersonal - 0.154\,naturalist$$

$$= -0.879 - 0.094\,(2.53) + 0.497\,(4.52) + 0.256\,(4.22) + 0.121\,(3.86) - 0.180\,(2.74) - 0.086\,(3.28) + 0.308\,(4.22) - 0.154\,(2.56)$$

$$= \mathbf{2.804}$$

Algorithm 5: Recalculate the Logistic Regression Performance Parameters

The last algorithm is to recalculate the logistic regression parameters, $P_i\,(Y=1)$. Table 5 shows the actual and optimized scores for the intelligence parameters.

For Patient A the ideal combination of intelligence levels to ensure high probability of employment is: *{music = 2.53, kinaesthetic = 4.52, math-logic = 4.22, spatial = 3.86, verbal = 2.74, interpersonal= 3.28, intrapersonal= 4.22, naturalist = 2.56}*.

In order to find the probability of employment, the logit values (z) must be calculated and substituted into Equation (3) as follows.

$$z_{actual} = -.879 - .094\,music + .497\,kinaesthetic + .256\,math\text{-}logic + .121\,spatial - .180\,verbal - .086\,interpersonal + .308\,intrapersonal - .154\,naturalist$$

$$= -.879 - .094\,(3.55) + .497\,(4.20) + .256\,(3.70) + .121\,(3.10) - .180\,(3.90)$$

- .086 (4.80) + .308 (3.70) - .154 (3.60)

= ***1.667***

$z_{optimized}$ = *-0.879 - 0.094 music + 0.497 kinaesthetic + 0.256 math-logic +0.121 spatial - 0.180 verbal - 0.086 interpersonal + 0.308 intrapersonal - 0.154 naturalist*

= -0.879 - 0.094 (2.53) + 0.497 (4.52) + 0.256 (4.22) + 0.121 (3.86) - 0.180 (2.74) - 0.086 (3.28) + 0.308 (4.22) - 0.154 (2.56)

= ***2.804***

$$P\,(Actual = 1) = \frac{1}{1+e^{-1.67}}$$

= 0.841

For the fuzzy optimized value,

$$P\,(Optimized = 1) = \frac{1}{1+e^{-2.80}} = \mathbf{0.943}$$

Table 5. Actual and Optimized Value: Patient A

Parameters	Actual Mean Score	Optimized Value
1. Music	3.55	2.53
2. Kinaesthetic	4.20	4.52
3. Math-Logic	3.70	4.22
4. Spatial	3.10	3.86
5. Verbal	3.90	2.74
6. Interpersonal	4.80	3.28
7. Intrapersonal	3.70	4.22
8. Naturalist	3.60	2.56

Thus, it can be concluded that through this combination, Patient A is capable of increasing the employment probability from 0.841 to 0.943. According to Gardner's MI theory, Patient A can improve the probability of employment by improving her kinaesthetic, math-logic, spatial and also intrapersonal skills (Gardner 2004a, 2004b).

For further illustrations, Table 6 presents five more examples of patients with different employability status, fuzzified values, employment probability and skills that need improvement. The results are sorted by the value of the original probability in ascending order. Four subjects (ID: 02, 69, and 99) needed to improve their kinaesthetic, math-logic, spatial and intrapersonal skills in order to enhance their chances of being employed, while one subject (ID 03) required the four skills as well as the interpersonal skill. Meanwhile, Subject 04 needed to improve three skills only: kinaesthetic, math-logic and intrapersonal. The other three skills, music, verbal and naturalist, were not identified for improvement for these subjects.

Table 6. The Results of the Employability Model Application for 6 Patients

Patient ID	Employability Status	f^*	Actual Probability	Targeted Probability	Skills to be Improved
03	Unemployed	0.643	0.683	0.928	i) Kinaesthetic ii) Math-logic iii) Spatial iv) Interpersonal v) Intrapersonal
69	Unemployed	0.599	0.838	0.942	i) Kinaesthetic ii) Math-logic iii) Spatial iv) Intrapersonal
99	Unemployed	0.604	0.845	0.943	i) Kinaesthetic ii) Math-logic iii) Spatial iv) Intrapersonal
02	Employed	0.632	0.876	0.943	i) Kinaesthetic ii) Math-logic iii) Spatial iv) Intrapersonal
04	Employed	0.643	0.886	0.949	i) Kinaesthetic ii) Math-logic iii) Intrapersonal

4. Conclusions

Fuzzy algorithms are introduced in this chapter in order to determine how the chances of PWE getting hired could be improved. According to Gardner, a person's intelligence can be enhanced if the person focuses and practices regularly (Gardner, 1983). PWE need to undergo ATIE, have the result analysed using the Fuzzy Inverse ATIE (FIA), and their weaknesses identified. Based on this diagnosis, the PWE concerned could then embark on specific remedial actions to overcome their weaknesses and improve their chances of being hired.

The process of developing an employability model for PWE has been demonstrated in detail. Based on the results of the logistic regression and the fuzzy model, the optimal combination of the eight intelligences was derived. Since the probability of employability, $P(Y=1)$ was close to 1, one may conclude that the approach adopted by this study would help to enhance the likelihood of a PWE being employed. The model has been coded in C# programming to enable it to be conveniently estimated.

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