International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 /doi:10.14445/22315381/IJETT-V70I3P236

Volume 70 Issue 3, 319-326, March 2022

Original Article

Estimating the Employment Opportunity of Engineering Students with the Aid of Fuzzy Logic Controller

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Abstract *— The point of this exploration work exhibits a classification technique for analyzing engineering student's employment opportunities. From the given 60 attributes, take 46 attributes as inputs. In view of this input data, we design the fuzzy logic system. This design is utilized for finding the employment opportunity potential score of particular individuals. Based on these 46 attributes, generate the rule as low and high. At that point, we need to take the count of low and high; after analyzing the count, find the output level (low, medium, high). In the outcome, three diverse membership functions such as trapezoidal, Gaussian and triangle have been designed. In this three-membership function, we explore diverse designing and validation points (50-50, 60-40, 70-30 and 80-20). The sensitivity value for the triangle is 76%, the specificity value for the triangle is 93%, and the accuracy value for a triangle is 89%. From this, the triangle membership function is enhanced contrasted with other membership functions.*

Keywords — *Accuracy, Engineering Employment, Fuzzy Logic System, Sensitivity, Skills.*

I. INTRODUCTION

India, the second most crowded nation in the world, with more than 1 billion individuals, is home to one-sixth of humanity. It has additionally turned out to be one of the world's new financial giants.[1] The 21st century is a period in which each circle of human life is directly or indirectly influenced by advances. [2] Higher education assumes an essential part in the financial improvement of the country. Indian education framework has gained noteworthy ground in higher education in the past two decades.[3] An innovative educational environment suggests diverse developments (technical, didactic, technological, organizational), in light of the fact that lone their complex use can give genuine effect.[4] Technology gives speed and comfort to individuals and thus turns into a crucial instrument in the educational process.[5] Traditionally educational establishments are gathering substantial volumes of information identified with students, employees, the association and administration of the educational procedure, and other administrative issues.[6] Autonomous foundations are those organizations that have academic autonomy; however, they should be affiliated with an existing university.[7] The fundamental piece of Indians lives in deficiently populated and extensively scattered towns. Each such town taken together constitute rural India. [8] While this gathering of research gives basic bits of learning into the different characteristics of gatherers and the troubles of getting the opportunity to procure regions that occur in the country and urbanizing areas.[9]

Many of the scientific research has uncovered that the connection between education/education level and technological advancement is a direct one.[10] In education, teachers and instructors dependably characterize their students in light of information, inspiration and behaviour.[11] so as to detail the condition that contains a few imperative subjects and its denotes, their need values assumes the real part in the sensitivity analysis.[12] To prevail in this troublesome course, students must not just have a deep conceptual comprehension of conceptual ideas that underlie different dynamics issues, yet in addition, must have solid mathematical modelling abilities to produce rectify answers for those problems.[13] The investigation of student information utilizes an assortment of procedures. The classification of information assumes a key part in the analysis.[14] The main advantage of a fuzzy classification contrasted with a crisp one is that a component isn't constrained to a single class yet can be doled out to a few classes. Thus, we built up a decision model in light of fuzzy logic with which we can designate individuals, as indicated by their knowledge availability.[15]

II. LITERATURE REVIEW

Virginia Barba-Sanchez et al. [16] 2017, had proposed engineering education in that manner faces new difficulties and these incorporate furnishing engineers with greater entrepreneurship. That examination work plans to analyze the impact of entrepreneurial motivations on entrepreneurial aims among future engineers and distinguish the role that entrepreneurship education plays in the advancement of the engineers' entrepreneurship. The outcomes demonstrate that the requirement for independence was the key factor in the entrepreneurial expectation of future engineers and affirm the positive commitment that entrepreneurship education had to their entrepreneurial aims. Finally, proposals were offered which could help the different specialists, including increment the effectiveness of actions went for advancing firm creation around there.

Hashmia Hamsa et al. [17] 2016, had recommended on the educational field that includes Data Mining procedures was quickly expanding. That work means building up student's academic performance prediction model for the Bachelor and Master's degree students in Computer Science and Electronics and Communication streams utilizing two chosen characterization strategies; Decision Tree and Fuzzy Genetic Algorithm. Parameters like internal marks, sessional marks and admission scores were chosen to direct that work. Internal marks are the mix of attendance marks, average marks acquired from two sessional exams and assignment marks. Reputed companies having a tie-up with the institution can search students as per their prerequisites.

R Natarajan [18] 2015 had suggested the real parts of the status of Engineering Education in India were portrayed in that paper. A SWOT investigation features the activities, which had served the framework well, work in advance, and furthermore what should be done in the close, medium and long term. The last areas portray the Contributions of Engineering Education to National Technology and Economic Development and Contributions of Indian Engineers to Technology and Economic Development Internationally.

R. Natarajan [19] 2014 had recommended the Engineering Education framework in India had a few particular highlights, for example, huge size; considerable diversity of many sorts; several strengths and weaknesses; several pending Bills; several policy pronouncements; few numbers of institutions of quality in a sea of mediocrity; the rise of the private division as a noteworthy player; and so forth. With an adjustment in government at the middle, it is trusted that few pending bills, for example, the foundation of National Council for Higher Education (NCHER); National Accreditation Regulatory Authority (NARA); Entry of Foreign Universities; and so forth, will be cleared, and furthermore, the guarantees made in the survey declaration would be followed upon. These are the developing Opportunities for Change– for the better.

K.G. Durga Prasad et al. [20] 2012 had proposed six sigma five-stage technique, i.e., DMAIC (Define - Measure - Analyze - Improve - Control) was received to build up an approach with a view to enhancing quality in an engineering educational institution. Critical to Quality (C.T.Q.) flow down was built up, and SIPOC (Supplier - Input-Process-Output - Customer) outline was developed in the Define period of the technique. In the Analyze stage, the Fishbone outline was built up to recognize different causes, and a Pareto graph was developed to arrange the problems in the request of significance. Failure mode impact examination was completed in the Improvement stage to foresee the conceivable sorts of failures. In the Control stage, Control diagrams help to screen the general population associated with the procedures of the engineering education system.

Patil et al. has proposed a fuzzy classifier to build a prototype from the dataset through an offline training process and uses it to develop a fuzzy inference system for classification. Once trained, the classifier continuously learns from streaming data and later adapts the changing facts by updating the system structure recursively [21]. Machine learning algorithms [22] and metaheuristic approaches [23] can play a significant role in selecting important features, and work is still going on.

The significant objective is to find the engineering student's employment opportunity potential score with the help of given attributes. From the given 60 attributes, we have filtered and taken 22 attributes as inputs which are listed below:

English speaking skills
English writing/reading/grammar skills
Confidence,
Attitude and teamwork,
Employee Satisfaction & working in the same company for the longer term,
Willingness to learn new technologies
Innovative/Creative Thinking
Leadership
Flexibility/Readiness to work at any location,
Domain/Functional knowledge (Banking/Insurance/Manufacturing etc.)
Aggregate Percentage in Engineering Degree
Internship in industry
Number of companies visiting the engineering college for recruitment
Practical projects are done during Engineering
Aptitude Preparation Course during SE/TE/BE
Performance / Score in Aptitude Assessment
Performance / Score in Exams like GATE
The practice of solving Aptitude papers
Parent's Education & Profession
Type of Eng. college
Industry connects of college
Type of companies visiting the college for recruitment

These 22 attributes have been categorized into the following six classes:

- Professional skills (P.S.)
- Technical skills (T.S.)
- Academic skills (AS)
- Communication skills (C.S.)
- Aptitude skills (A.P.S.)
- Educational background (E.B.)

The selected attributes are grouped under each class as described in Table 1

Table 1. Classification of attributes into 6 classes

Professional skills (P.S.)	Technical skills (T.S.)	Academic skills (AS)	Communication skills (C.S.)	Aptitude skills (A.P.S.)	Educational Background (E.B.)
1.Confidence (ps1) 2. Attitude and teamwork (ps2) 3. Employee Satisfaction & working in the same company for longer-term (ps3) 4. Willingness to learn new technologies (ps4) 5. Leadership (ps5) 6. Flexibility/Readiness to work at any Location (ps6)	1.Domain/Functional knowledge (ts1) 2. Innovative/Creative Thinking (ts2)	1. Aggregate Percentage in Engineering Degree (as1) 2. Internship in the industry (as2) 3. Practical projects are done during Engineering (as3)	1. English speaking skills (cs1) 2. English writing/reading/grammar skills (cs2) 3. Certification in Foreign Language (cs3) 4. Using the English Language for communication in day to day life (cs4)	1. Aptitude Preparation Course during SE/TE/BE (aps1) 2.Performance / Score in Aptitude assessment (aps2) 3. Performance/ Score in Exams like GATE (aps3) 4. Practice solving Aptitude Papers (aps4)	1. Parent's Education & Profession (eb1) 2.Type of Eng.college (eb2) 3. Industry connect of college (eb3) 4. Type of companies visiting the college for recruitment (eb4)

A. Fuzzy Logic System

Fuzzy Logic System (F.L.S.) is the procedure of nonlinear mapping system of input dataset to a scalar output. F.L.S. architecture consists of four major divisions, specifically Fuzzification, Rule generation, Inference System and defuzzification, expressed in figure 1.

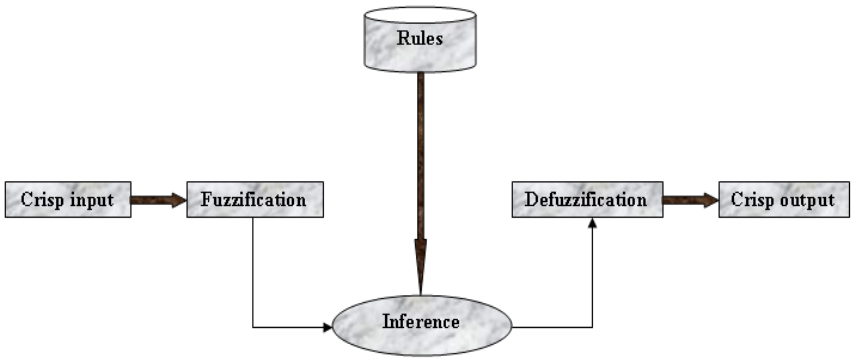

Fig. 1 A schematic diagram of the fuzzy logic system

B. Fuzzification

The way toward exchanging a scalar value into a fuzzy set value is said to be fuzzification, and fuzzy sets are zero; however, the inputs in the F.L.S. are usually mapped by a set of membership functions; in universal, the procedure of converting a crisp input value to a fuzzy value is called "fuzzification". A fuzzy subset A of a set X represents a function A: X→L, where L means the interval [0, 1]. This function is additionally called a membership function.

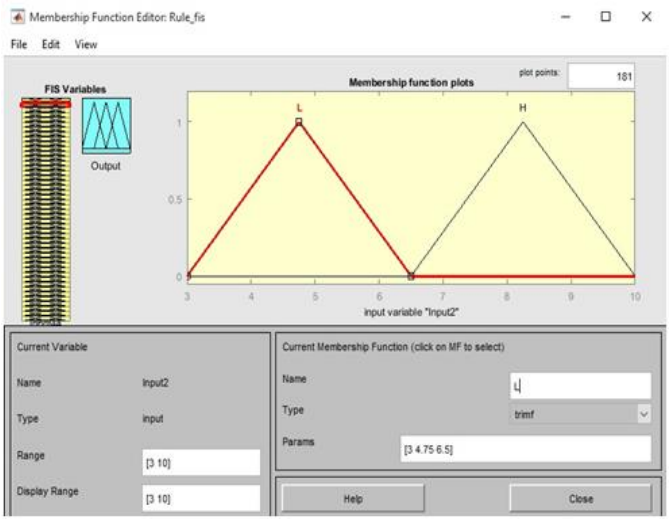

Fig. 2 Input variable of membership function

Fig. 2 exposed the input variable of the membership function. By using 46 input data, the level of membership function as low or high was identified and classified.

C. Membership function

A membership function invested with dissimilar shapes for evaluation in fuzzy logic. Among the three different membership functions as the trapezoidal membership function, Gaussian membership function and the triangular membership function.

The equation for triangle membership function follows,

$$f(x,[u,v,w]) = \begin{cases} 0 & x \le u \\ \dfrac{x-u}{v-u} & u \le x \le v \\ \dfrac{w-x}{w-v} & v \le x \le w \\ 0 & w \le x \end{cases}$$

A triangular membership function is specified by three parameters {u, v, w}.
The equation for trapezoidal membership function follows,

$$f(x,[u,v,w,d]) = \begin{cases} 0 & x \le u \\ \dfrac{x-u}{v-u} & u \le x \le v \\ 1 & v \le x \le w \\ \dfrac{d-x}{d-w} & w \le x \le d \\ 0 & d \le x \end{cases}$$

A trapezoidal membership function is specified by four parameters {u, v, w, d}
The equation for the Gaussian membership function follows,

$$f(x,[w,\sigma]) = e^{-\frac{1}{2}\left(\frac{x-w}{\sigma}\right)^2}$$

In this equation, w represents the membership function centre, and σ determines the membership function width.

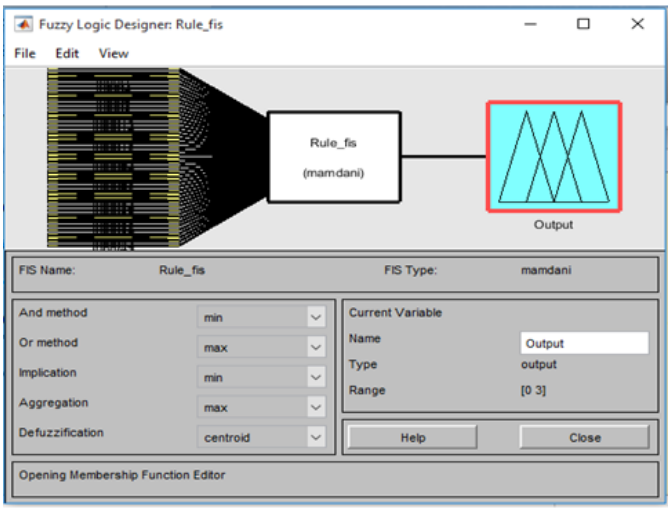

Fig. 3 F.I.S. generation for 46 attributes

Fig. 3, appeared F.I.S. generation for 46 attributes. This work comprises a primarily three-membership function of fuzzy interference systems for 46 attributes.

D. Rule generation

Although in the essential membership function, the rules have been generated, in light of the input and output, the rules will be generated independently, and the strategy is procured in the fuzzy logic controller that appeared in Fig. 4. The system produces fuzzy if-then rules with non-fuzzy singletons (i.e. genuine numbers) in the resultant portions. From the predestined input and output sets of training data, a resultant real number is obtained for each fuzzy if-then rule created from the fuzzy subspaces is shaped on the supposition that the space interval of each input variable is isolated equally into fuzzy sets.

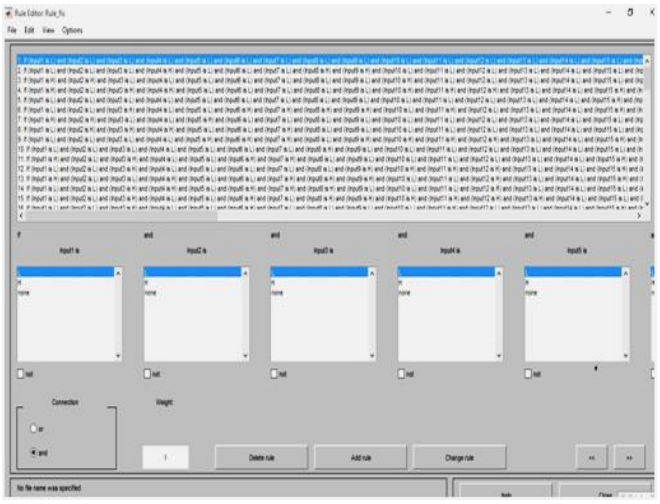

Fig. 4 Rule generation

E. Defuzzification

In light of the rule, the defuzzification is analyzed by various procedures for anticipating output. There are a couple of techniques for defuzzification like the centroid method, maximum method, height method and so on. In the centroid technique, the crisp value of the output variable is surveyed by finding the variable estimation of the centre of gravity of the membership function for the fuzzy value. In the maximum technique, one of the variable qualities at which the fuzzy set contains its most noticeable truth-value is taken as the crisp value for the output variable.

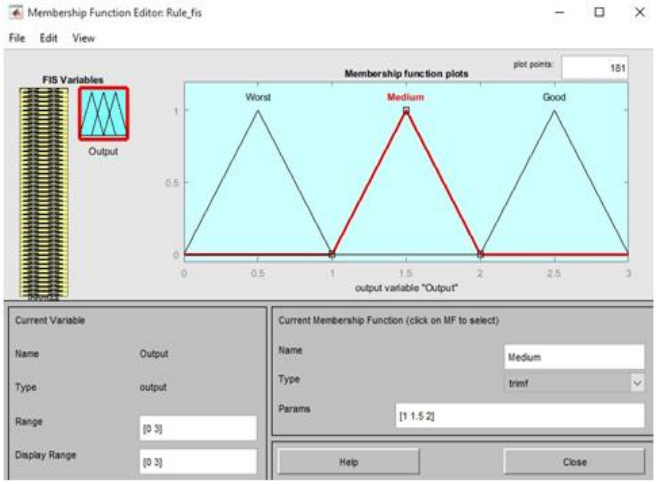

Fig.5 Output variables of membership function

Fig. 5 exposed the output variable of the membership function. The levels of output membership function as low, medium and high with this find the level and classified.

F. Computation of Employability Index using Linear equation

In this section, based on the defuzzified outputs, the employability index (E.I.) for a candidate can be estimated using a linear equation:

E.I. = W1. PS + W2.TS + W3.AS + W4.CS + W5. E.B. + W6. A.P.S.

Where

PS = a1. ps1 + a2.ps2 + a3.ps3 + a4.ps4 + a5.ps5 + a6.ps6

TS = b1.ts1 + b2. ts2

AS = c1.as1 + c2. as2 + c3.as3

CS = d1.cs1+d2.cs2 + d3.cs3 + d4.cs4

EB = e1.eb1 + e2. eb2 + e3.eb3 + e4.eb4

APS = f1.aps1 + f2.aps2 + f3.aps3 + f4.aps4

Equation (4) gives the weight factors for the 6 main classes, and equation (5) gives the corresponding sub-weights for the individual factors in each class. The estimated values of the weights and sub-weights are presented in the results section.

G. Computation of Employability Index using Linear Regression

In this section, based on the defuzzified outputs, the employability index (EI) for a candidate can be estimated using linear regression:

EI = α + W1. PS + W2.TS + W3.AS + W4.CS + W5.EB + W6.APS

Where

PS = [psi1 psi2 psi3 psi4 psi5 psi6]

TS = [tsi1 tsi2]

AS = [asi1 ai2 asi3]

CS = [csi1 csi2 csi3 csi4]

EB = [ebi1 ebi2 ebi3 ebi4]

APS = [apsi1 apsi2 apsi3 apsi4]

Here i represents the index of the data set, i=1,2.....n

W1 = [PST.PS]-1. [PST.Y]

W2 = [TST.TS]-1. [TST.Y]

W3 = [AST.AS]-1. [AST.Y]

W4 = [CST.CS]-1. [CST.Y]

W5 = [EBT.EB]-1. [EBT.Y]

W6 = [APST.APS]-1. [APST.Y]

Where $Y = \begin{bmatrix} Y_1 \\ Y_2 \\ .... \\ ..... \\ Y_n \end{bmatrix}$ is the responses (or) output set of values.

III. RESULTS AND DISCUSSION

This section is comprised of various analyses for identifying the employment opportunity of engineering students. This design is used for finding the employment opportunity potential score of the particular person.

We have collected responses from various types of organizations by conducting a survey comprising 60 attributes. From the collected responses, we have considered

6 classes of 22 attributes and major employers like Core (9), I.T. services (13), It Product (11) and Other Types of companies (4). The numbers in brackets indicate the number of responses obtained from each employer. In order to test the employability index, a survey was conducted among 1000 engineering students from various fields for the 60 attributes.

A. Results of Fuzzy Logic

Table 2. Comparison of Evaluation metrics with membership function

Membership function	Trapezoidal				Gaussian				Triangle			
Designing & Validation	50-50	60-40	70-30	80-20	50-50	60-40	70-30	80-20	50-50	60-40	70-30	80-20
Sensitivity	0.71	0.72	0.73	0.74	0.72	0.73	0.74	0.751	0.73	0.74	0.75	0.76
Specificity	0.88	0.89	0.90	0.91	0.89	0.90	0.91	0.923	0.90	0.91	0.92	0.93
Accuracy	0.84	0.85	0.86	0.87	0.85	0.86	0.87	0.88	0.86	0.87	0.88	0.89

From table 2, the validation for three membership functions was designed. Three different membership functions are trapezoidal, Gaussian and triangle. In each function, different training and testing are validated (50-50, 60-40, 70-30 and 80-20).

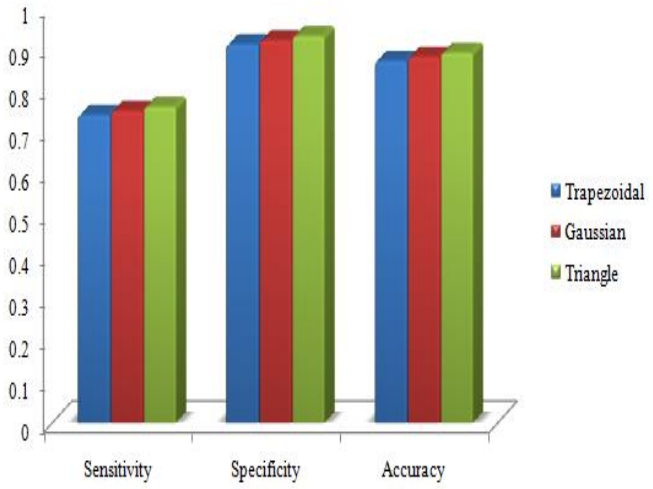

Fig. 6 validation graph for the three-membership function

In this figure 6, the sensitivity, specificity and accuracy values for trapezoidal, Gaussian and triangle membership functions have been shown. The sensitivity for triangle (80-20) is 76%, trapezoidal (80-20) 74% and Gaussian (80-20) 75%. The specificity for triangle (80-20) is 93%, trapezoidal (80-20) 91% and Gaussian (80-20) 92% then the accuracy for triangle (80-20) is 89%, trapezoidal (80-20) 87% and Gaussian (80-20) 88%. From this analysis, the triangle membership function is performed better when compared with other functions.

B. Results of E.I. using Linear Equation

This section presents the calculated values of various weight values and sub-weight values corresponding to equations (4) and (5).

The sub weights a1,a2...a6 for the class P.S. is presented in Table-3 for the major types of employers.

Table 3. Sub-weights of Professional Skills class for various employers

Employer	a1	a2	a3	a4	a5	a6
Core	8.91	9.25	7.81	9.14	7.94	8.45
IT Services	8.46	9.07	7.92	9.38	7.30	8.53
IT Product	9.18	9.45	7.72	9.09	7.81	7.72
Other	8.95	9.24	7.83	9.10	7.92	8.48

The sub weights b1,b2...b5 for the class T.S. is presented in Table-4 for the major types of employers.

Table 4. Sub-weights of Technical Skills class for various employers

Employer	b1	b2
Core	7.50	7.32
IT Services	6.69	9.0
IT Product	7.09	9.0
Other	7.51	7.34

The sub weights c1,c2 and c3 for the class AS is presented in Table-5 for the major types of employers.

Table 5. Sub-weights of Academic Skills class for various employers

Employer	c1	c2	c3
Core	8.81	8.99	8.97
IT Services	8.07	8.0	8.22
IT Product	7.09	8.18	9.36
Other	8.78	8.96	8.95

The sub weights d1,d2...d4 for the class C.S. is presented in Table-6 for the major types of employers.

Table 6. Sub-weights of Communication Skills class for various employers

Employer	d1	d2	d3	d4
Core	8.44	8.41	5.65	8.39
IT Services	8.69	8.53	5.07	8.76
IT Product	7.45	7.45	5.18	7.27
Other	8.39	8.36	5.51	8.34

The sub weights e1,e2...e4 for the class E.B. is presented in Table-7 for the major types of employers.

Table 7. Sub-weights of Educational Background class for various employers

Employer	e1	e2	e3	e4
Core	5.88	8.22	8.44	7.33
IT Services	4.69	6.92	7.76	6.84
IT Product	4.54	6.09	7.45	6.54
Other	3.75	5.0	7.75	6.25

The sub weights f1,f2...f4 for the class A.P.S. is presented in Table-8 for the major types of employers.

Table 8. Sub-weights of Aptitude Skills class for various employers

Employer	f1	f2	f3	f4
Core	7.95	7.31	7.37	7.97
IT Services	7.84	7.46	7.38	7.69
IT Product	7.27	6.90	6.63	8.09
Other	7.83	7.30	7.31	7.98

The weights W1, W2, ... W6, corresponding to equation (4) for the 6 main classes, are presented in Table-9 for the major types of employers.

Table 9. Weights of six classes for various employers using linear equation

Employer	W1	W2	W3	W4	W5	W6
Core	8.58	7.41	8.92	7.72	7.99	7.65
IT Services	8.44	7.84	8.09	7.76	7.17	7.59
IT Product	8.49	8.04	8.21	6.83	6.59	7.42
Other	8.58	7.42	8.19	7.65	6.33	7.20

Table 10. Employability Index for various employers using linear equation

Employer	E.I.
Core	48.27
IT Services	46.89
IT Product	45.58
Other	45.37

From Table-9, we can infer that the professional skills class is the most demanded criteria for all the employers, followed by the academic and technical skills. The communication skills and education background have nearly equal weightage in the employability index. Moreover, I.T. product companies mostly demand high professional, technical and academic skills but fewer demand communication skills. Table-10 presents the final estimated E.I. values for each employer.

C. Results of E.I. using Linear Regression

In order to apply linear regression, the responses from 945 students are collected. (i.e.) n=945. By applying equations (7) and (8) for the n data sets, the values of slopes W1, W2, W6 corresponding to equation (6) are obtained.

Table 11. Weights of six classes for various employers using linear regression

Employer	W1	W2	W3	W4	W5	W6
Core	8.08	7.21	8.52	7.32	7.59	7.25
IT Services	8.14	7.34	7.89	7.26	6.87	7.19
IT Product	8.19	7.84	8.01	6.53	6.39	7.02
Other	7.88	6.82	8.29	7.15	6.03	7.30

Table 12. Employability Index for various employers using linear regression

Employer	E.I.
Core	45.97
IT Services	44.69
IT Product	43.98
Other	43.47

After finding the E.I. of all the students from the input data set, the number of eligible students for various employers using Linear equation (L.E.), Linear regression (L.R.) and Fuzzy logic is determined as depicted in Figure 7.

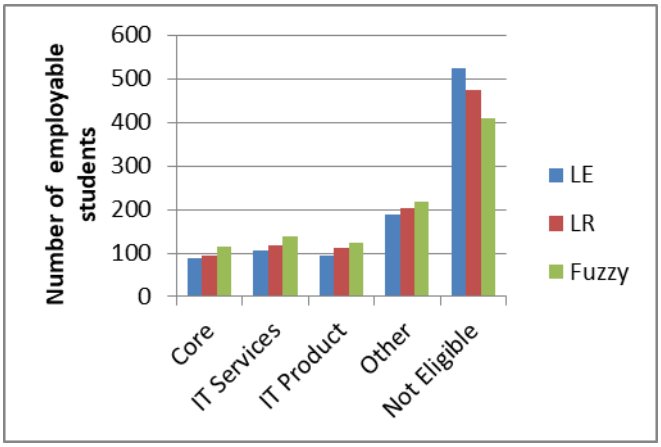

Fig. 7 Number of employable candidates based on the 3 schemes

From Figure 7, the number of not eligible candidates (students whose E.I. falls below the required level of all the employers) in the case of L.E. is 524, in case of L.R. is 473 and in the case of Fuzzy is 408. We can see that Fuzzy logic yields more eligible candidates compared to other schemes. The L.E. scheme selects the least number of candidates. Since fuzzy supports more combinations of decision rules, the output set comprises more eligible candidates. Since the L.E. scheme directly depends on the weighted coefficients, it leads to high E.I. values. Hence the L.R. scheme, which relies on the prediction of responses, can be considered more reliable.

IV. CONCLUSION

The intention of revealing employment opportunities of engineering candidates is analyzed in the result. The Employability Index (E.I.) of engineering students has been determined using three schemes: Linear equation (L.E.), linear regression (L.R.) and Fuzz logic decision system. A fuzzy logic system was used for identifying the level and validating the score of students. Three-membership functions are utilized as trapezoidal, Gaussian and triangle. In each function, the evaluation metrics such as sensitivity, specificity and accuracy were investigated. The triangle membership function is enhanced compared with other membership functions. After finding the E.I. of all the students from the input data set, the number of eligible students for various employers using Linear equation (L.E.), Linear regression (L.R.) and Fuzzy logic is determined. From the experimental results, we can infer that the professional skills class is the most demanded criteria for all the employers, followed by the academic and technical skills. The communication skills and education background have nearly equal weightage in the employability index. Moreover, I.T. product companies mostly demand high professional, technical and academic skills but fewer demand communication skills. The number of students whose E.I. falls below the required level of all the employers is around 500 in all the schemes, which indicates that only half of the total set of students have the required E.I. as demanded by various companies.

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