Personalized Mobile App for Engineering Career Path Recommendation using Fuzzy Inference System

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***Abstract*— Most students today struggle to choose a career path as a result of poor choice of their undergraduate course due to lack of knowledge and misinformation. This research system is designed to suggest the most suitable undergraduate engineering course to be pursued by high schoolers. The system implements fuzzy algorithm, which requires Academic Performance, Personality type and Interests, while taking Job Opportunities that the course may provide in the future as inputs. The system is to be implemented as a mobile application which considers the mentioned factors and derives an individual suitability factor for engineering domains. The results derived from the inference system appear to provide more information about individual likeness and strengthens individual decision-making ability with regards to choosing an undergraduate course.**

***Keywords*— *Fuzzy Inference System, Fuzzy Logic, Random Forest Regression*.**

I. Introduction

Many high school students struggle to decide their future career engineering courses. So often it becomes a decision taken on compulsion, baseless recommendations, societal pressure and also due to the immense stress that parents apply upon their children on deciding what is best for them. It can also be due to a lack of awareness about the different options available to them, as well as a lack of understanding of their own skills, interests, and values. Additionally, students may not have access to adequate resources to help them explore different career options. As a result, students' mental stress rises, lowering their academic performance in colleges. Therefore, the dropout rates in engineering colleges rises.

Another main problem occurs in the industry. Due to lack of less – skilled, unmotivated and underperforming students who are clearly in the wrong or career path, the industry lacks quality workforce which can perform things more efficiently. All these problems combined leads to a less economic growth.

In India, many such students fail to pick a career path or course that is suitable for them on all aspects of life. A student should pursue a course which suits all their needs. The course selected should be a course in which the student is most interested in. Also, on the other hand, the student should also be academically gifted or skillfully talented to back interest on a course.

Moreover, the course should also suit the student's personality, which the student may or may not be able to get a good gauge of. To solve the above-mentioned problem, a personalized career path recommendation system is proposed using Fuzzy Algorithm that considers two factors as input: marks scored by the students in their respective examinations, like mathematics, physics, chemistry, and computer-related courses, and the personality type that a particular student obtained as a result of taking the personality test. Having the two factors as inputs to the system, Fuzzy algorithm uses those inputs, processes them, and gives the suitability for each engineering course in terms of percentage. The system is designed to consider the basic interests as an input.

In this article, design of the recommendation system is detailed. The system will be a platform that provides individuals with a comprehensive approach to career exploration. The system is designed to be in the form of a mobile application. The proposed system is designed to accept academic grades and personality test results as inputs for processing. The personality test designed for the system is based upon the Myers-Briggs Type Indicator (MBTI). The proposed system is designed to take into consideration the job opportunities that each engineering course will provide in the future using a prediction system.

In the Fuzzification process, the given crisp inputs are converted into non-binary values ranging between 0 and 1 on the basis of belonging of each factor in different self-defined fuzzy regions. The Inference Engine, applies the rules on the values and finds the "Suitability" value. The "Suitability" value is realized by a process called "Defuzzification". Many methods of defuzzification are available. Defuzzification is the process of converting the said value into human understandable crisp output. After Defuzzification, the result is arrived. The result is in the form of a "Percentage". The percentage shows the likeliness to be suitable for a particular engineering course. The system is designed to provide readable and easily understandable insights.

II. RELATED WORKS

In [1], Manar Qamhieh et al., suggest a personalized career recommendation system based upon academic scores, personality and interests of high school students using fuzzy logic with room to further improvements in terms of financial gains and status of individuals. In [9], Nhi N.Y. Vo et al., propose a hybrid Course Recommendation System (CRS) for user-specific suggestion of Massive Open Online Courses (MOOCs) based on courses, careers, jobs, industry-demanded skills required.

In [4], Puji Catur Siswipraptini et al., review Career Recommendation System (CRS) which uses artificial intelligence to suggest jobs based on industry skillsets. In [6], Adib Hakimi Abdul Rashid et al., design a system which recommends career and jobs for computer science students. This system uses web scraping and content-based filtering technique that considers user preferences.

In [3], Mejia et al., suggest a career recommendation system implemented based on the Gardner test which measures students' performance abilities to understand the learning strengths of students. The system recommends careers with 88.2% success. In [2], Raghad Obeidat et al., suggest a collaborative recommender system to recommend online courses for students based on course history similarities employing the Apriori algorithm.

In [5], Lianfen Zhao et al., present a based on an improved online course recommendation system which suggests courses based on user implicit behaviour collaborative filtering. In [7] Gongwen Xu et al., propose a personalized course recommendation system involving an algorithm which combines knowledge graph and collaborative filtering.

In [8], Jindan Tan et al., propose a course suggestion system for students using MOOC platforms. The suggested system improves accuracy of recommendation by employing Attentional Manhattan Siamese Long Short Term Memory (AMSLSTM) network. The network considers students' interest and course relevance for making suggestions. In [10], Xiaoliang Chen et al., put forward a recommendation system that generates appropriate computer science related group that satisfies the requirements of IT enterprises, which can also be used to reform the curriculum accordingly.

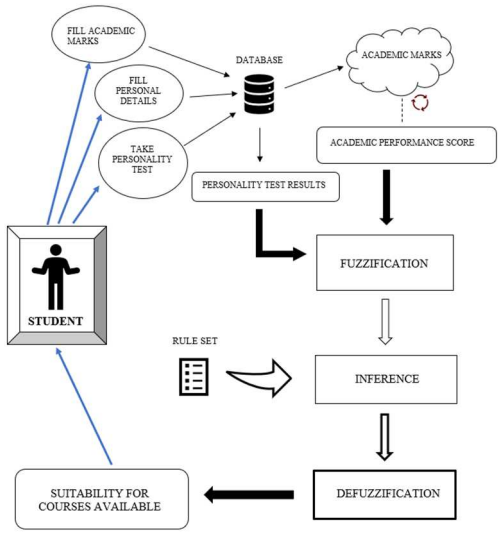

Fig.1. Framework architecture of PCRS

III. FRAMEWORK OF RECOMMENDATION SYSTEM

The system gets academic grades in accordance with STEM (Science, Technology, Engineering, Mathematics) subjects as the input. The personality type results from the conducted personality test are also provided as input to the system. The system is designed to implement a prediction system to analyze job opportunities that may occur in the future for a specific engineering domain. The results from the prediction system are taken as inputs to the Fuzzy Inference System.

A. ACADEMIC PERFORMANCE

Academic performance is an input to this recommendation system, and it is analyzed based on STEM scores in higher secondary schooling. STEM scores typically consist of grades in Science (Chemistry, Physics), Computer Technology (related courses), and Mathematics.

B. PERSONALITY INDICATOR

To determine the personality and obtain input for the Fuzzy Inference System, a personality test derived from Myers-Briggs Type Indicator (MBTI) is implemented. The test is implemented to accurately state the personality type for further processing. The personality type derived from the test is obtained as an input to the system.

C. INPUT DATA PROCESSING

The inputs obtained are converted to common values. The common values are used in processing of all engineering domains. Further the values are converted into numeric values or machine-readable forms that are given as inputs to the membership function of the Fuzzy Inference System. The phase ensures single membership function generated for all domains. w

D. PROCESSING OF ACADEMIC PERFORMANCE

Academic performance in certain subjects corresponds to suitability in certain engineering departments. According to the research paper [1] there is an association between STEM subjects and engineering courses. Table-1 depicts the relationship between Engineering Courses and STEM Subjects. Each engineering course has certain weightage for each subject. For example, consider mechanical engineering, for which the most important subjects are: mathematics and physics, so weightage value is set as 2 for those subjects in Table-1, while other subjects are assigned with weightage 1 owing to their less essentiality for pursuing mechanical engineering; The average score for each engineering domain is derived using the weighted average formula, and is provided as input to the membership function of the Fuzzy Inference System. In the research paper [1], we refer to a formula to find the weighted average score of given students for a specific engineering course d, where gradelist(s,i) is the ith grade of the list of STEM subjects of student s, and weight(i,d) is the weight of the course i for particular engineering course d. For instance, if a student has scored 98 in computer science, 79 in physics, 95 in mathematics, and 69 in chemistry, the student's weighted average score for computer engineering course will come out to be 89.

$$Acadamic(s,d) = \frac{\sum_i^n (gradelist(s,i) \times weight(i,d))}{\sum_i^n weight(i,d)} \quad (1)$$

TABLE 1. Subject weights mapped to engineering courses

Engineering courses	Mathematics	Computer Science	Physics	Chemistry
Computer Engineering	2	2	1	1
Electrical Engineering	2	2	2	1
Civil Engineering	2	1	2	1
Industrial Engineering	2	2	1	1
Mechanical engineering	2	1	2	1
Architectural	2	1	2	1
Chemical Engineering	2	1	1	2

E. PROCESSING OF PERSONALITY

After obtaining personality type results from the designed personality test, the input is obtained by the system for application of Fuzzy Logic. The personality test assessment is based on decision making, character traits, social ability and emotional ability. The test encompasses a variety of personality variables related to engineering career success, ensuring a comprehensive assessment and is based on the well-established Myers-Briggs Type Indicator (MBTI). The test categorizes a person by assigning one of the two traits of the following: introversion or extraversion, sensing or intuition, thinking or feeling, and judging or perceiving. One letter from each identified trait is taken and a result is produced by conjoining the four letters together to form a "personality type" which will fall under the 16 possible types that can be generated with 4 letter combinations like "ENFJ" or "ISTP". For example:

- **ENFJ**: extraversion (E), intuition (N), feeling (F), judgment (J)
- **ISTP**: introversion (I), sensing (S), thinking(T), perception (P)

According to the research paper [1] the type of personality is an important factor in determining a career in engineering. The research found that engineering students fall into the following personality categories: analysts, diplomats, sentinels, and explorers. Each of those personalities has four specific or exact personality types grouped together.

For instance, The personality type "analyst" groups the personality types INTJ, INTP, ENTJ, and ENTP together. Likewise, for each category, 4 personalities can be grouped together. Therefore, forming 16 personalities grouped into 4 major categories.

It is important to refer that engineering courses are mapped to personality categories with a percentage of the number of students who have personalities to corresponding engineering courses, similarly for the exact personality type that is given in tables 2 and 3.

The system calculates the personality score with the personality type inputs. The personality score is calculated by multiplying the percentage of the personality category by the percentage of the exact personality type from the personality test. For example, if the personality type of one particular student is ISTJ, the personality score for mechanical engineering is $0.631 * 34\% = 21.454\%$. Here, the percentage of ISTJ personality from table 3 is 34% for mechanical engineering, and it comes under the sentinel's personality category, which is 63.1% for mechanical engineering in Table 2. For every engineering domain the process is undergone.

TABLE 2. Personality types of engineering students

Engineering courses	Analysts	Diplomats	Sentinels	Explorers
Computer	20%	6.8%	55.9%	17.3%
Electrical	12.3%	5.7%	66.4%	15.6%
Civil	16.1%	8.8%	59.3%	15.8%
Industrial	18%	5.8%	62.2%	14%
Mechanical	13.1%	3.6%	63.1%	20.2%
Architecture	40.6%	9.4%	40.6%	9.4%
Chemical	16.5%	12.4%	48.4%	22.7%

F. ARCHITECTURE OF PREDICTION SYSTEM

A prediction model is included in the proposed system to ascertain the job opportunity factor of an engineering domain. The prediction model is designed to predict the extent of job opportunities a particular engineering domain will offer in the future as a result of an individual pursuing that domain. The obtained factor from the prediction model is pipelined as an input to the Fuzzy Inference System. The following depicts the flow of the prediction model according to Fig. 2.

1) Data Collection: For data to be gathered for analysis, the prediction system is designed to collect data from several engineering courses databases, job market trends databases and alumni career paths databases. Such datasets are required for accurate predictions about future job market trends in accordance with engineering domains.

2) Preprocessing: The gathered data undergoes typical preprocessing for machine learning models The datasets are

TABLE 3. Fuzzy Rules - Sample

Personality	Academic performance				
	fail	***satisfactory***	***good***	***very good***	***excellent***
Lowly appropriate	inadequate	inadequate	inadequate	neutral	neutral
Moderately appropriate	inadequate	neutral	neutral	neutral	adequate
Highly appropriate	inadequate	neutral	neutral	adequate	adequate

cleaned to remove inconsistencies and irrelevant data. Further, the relevant features like job demand, industry status, etc., are extracted from the cleaned data. Normalization process is applied on the relevant data to ensure a standard scale for processing.

3) Prediction Model: To implement the actual prediction of future market trends and job opportunities, the proposed prediction model is implemented with the Random Forest Regression model. The Random Forest Regression model is trained with the previously mentioned diverse datasets to output a job opportunity factor. The model handles the diversity and the several non-linear relationships that exist within the varied datasets.

4) Integration with Fuzzy Inference System: The prediction model is implemented to process and output job opportunity factors for the available engineering domains. The obtained factor is pipelined to the existing Fuzzy Inference System as a crisp input for Fuzzification.

IV. IMPLEMENTATION OF FUZZY LOGIC

The proposed system is designed using Fuzzy Logic and is implemented using a Fuzzy Inference System with multiple variables or factors. A Fuzzy Inference System is used to provide non – binary values as solutions to several recommendation problems. In this specific case, the system is provided with three crisp values as inputs. The three inputs are Academic Marks, Personality Type and Job Opportunity factor. The Fuzzy Inference System is powered by a set of pre-defined rules.

In this case, written rules are in accordance with the three inputs. The computation process of the system and the decision-making process are bounded within the Fuzzy Rules. Using these pre-defined rules, the system undergoes a process known as "Fuzzification". In the Fuzzification process, crisp inputs are computed into values ranging between 0 and 1 on the basis of belonging of each factor in different fuzzy regions.

The different regions are framed on general human understanding of the problem. The Inference Engine, applies the rules on the values and finds the "Suitability" value which denotes the likeliness of an individual to an engineering domain.

This "Suitability Percentage" is calculated for every engineering course. During fuzzification, the graph, also known as the membership function, is used to find out fuzzy variables from the input. In order to find a fuzzy variable for academic performance, the membership function is divided into five categories: fail, average, good, and excellent. In India, several education systems are prevalent across various states with varied standards, this presents a problem in calculating a singular pass score for all the systems as a whole. But it is safe to consider 35% as the passing grade across every education system present in the country. The weighted score from the academic performance processing phase is plotted on a graph, and it finds the degree of belongingness of each distributed category, which is called a fuzzy variable.

Similarly, fuzzy variables are found for all inputs under fuzzification. According to research paper [1], reference is made to the possible outcomes of the personality score, which is derived from the personality processing phase, as a range between 15% and 45%, and they provide the distribution, which is, that a personality between 0% and 20% is considered lowly appropriate, a score between 24% and 32% is considered moderately appropriate, and a score between 33% and 40% is considered highly appropriate and the membership is also distributed accordingly. After fuzzification, the fuzzy variables are entered into the fuzzy inference system, which consists of a set of 15 sample rules that are given in Table 4; these rules are applied to the fuzzy variable for evaluation of suitability factor.

The "Suitability" value is computed by a process known as "defuzzification". Many methods of defuzzification are available. The proposed system uses the "Centroid Method". Defuzzification is the process of converting the said value into human understandable crisp output. After Defuzzification, a result is derived. The result is in the form of a "Percentage". The percentage shows how likely an individual is suitable to an engineering domain.

TABLE 4. Engineering Courses Distribution over 16 personality types

	Analysts				**Diplomats**			
	INTJ	***INTP***	***ENTJ***	***ENTP***	***INFJ***	***INFP***	***ENFJ***	***ENFP***
Computer	33.3%	13.1%	45.2%	8.4%	44.9%	6.9%	31%	17.2%
Architecture	46.2%	0.2%	46%	7.6%	33.1%	0.2%	66.4%	0.3%
Chemical	37.5%	0.2%	43.6%	18.7%	16.6%	0.1%	41.6%	41.7%
Industrial	45.2%	6.5%	38.7%	9.6%	30%	20%	30%	20%
Civil	26.4%	5.7%	50.9%	17%	37.9%	24.2%	20.7%	17.2%
Electrical	13.3%	13.3%	53.4%	20%	0.2%	14.1%	71.4%	14.3%
Mechanical	54.5%	18.2%	9.1%	18.2%	66.6%	0.1%	33%	0.3%
	Sentinels				**Explorers**			
	ISTJ	***ISFJ***	***ESTJ***	***ESFJ***	***ISTP***	***ISFP***	***ESTP***	***ESFP***
Computer	28.6%	13.3%	44%	14.1%	25%	12.5%	40.3%	22.2%
Architecture	46%	0.2%	46.2%	7.5%	0.1%	0.4%	66.3%	33.3%
Chemical	23.4%	8.5%	44.7%	23.4%	18.2%	9%	40.9%	31.9%
Industrial	18.7%	11.3%	60.7%	9.3%	20.8%	4.2%	58.3%	16.7%
Civil	33.3%	6.1%	49.3%	11.3%	32.7%	9.6%	38.5%	19.2%
Electrical	29.6%	1.2%	53%	16.2%	26%	0.3%	47.4%	26.3%
Mechanical	34%	3.8%	54.7%	7.5%	11.8%	5.9%	82.1%	0.2%

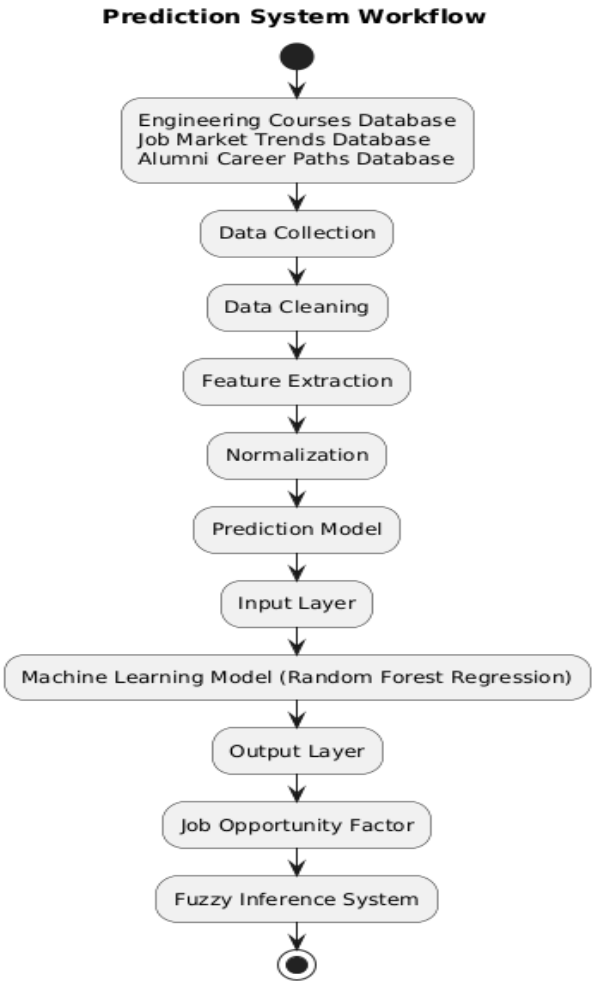

Fig. 2. Work Flow of Prediction System

V. SYSTEM IMPLEMENTATION

The proposed system will be implemented as a mobile application. The system will be designed to be user-friendly and accessible to students of all ages and abilities. It will be marketed to high students to help them explore different career paths and make informed decisions about their future careers. The application requires the STEM subject scores as one of its inputs, refer to Fig. 3. The application provides a personality test in accordance with MBTI to gather personality type data, refer to Fig. 4.

A prediction system is implemented to gather job opportunity factor for each engineering domain using Random Forest Regression model. The Fuzzy Inference System obtains the three factors as inputs and computes the individual suitability score for each engineering domain. The resulting suitability percentage is designed to be displayed for all domains in engineering in form of graphs and informative scores, refer to Fig. 5. The application is designed to use several graphical tools to provide neat, understandable, and meaningful charts or graphs that convey statistics in a less burdensome manner and contain more insights about suitable domains.

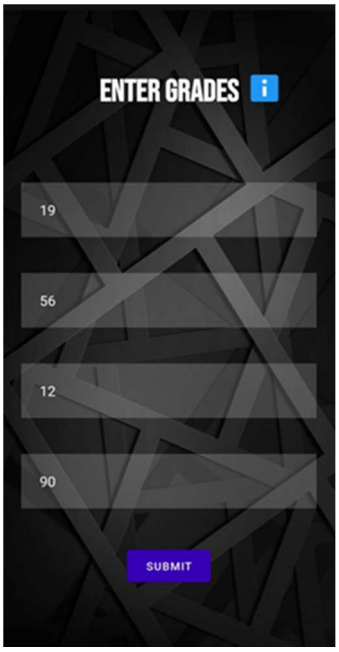

Fig.3. Interface for Score input

Fig.4. Interface for Personality Test

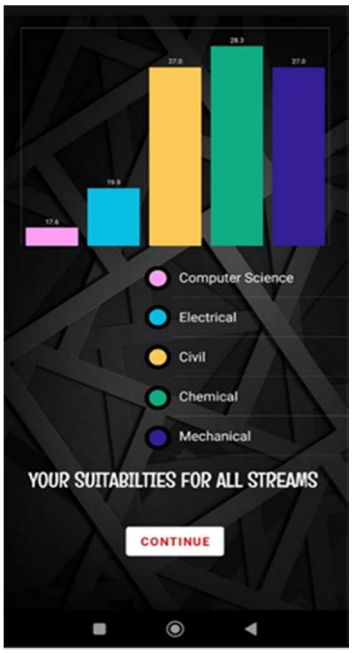

Fig.5. Suitability results for engineering domains

VI. CONCLUSION

In India, many students pursue engineering and related studies without any personal interest or passion. Most of them complete or enroll in engineering courses just to attain a degree and to fulfil the society's high expectations. They are not clear about their future before they take a decision about the engineering course they are going to pursue.

Many parents in India fall prey to false perception of certain popular courses and make their wards join in engineering streams without their consent. Both the students and the parents are not sure about what course is the best suited according to the student's academic performance, personality, interests. This situation has made students drop out of their colleges before completion of the degree. Even if the student completes the course, the student is under – performing or lacks skills to enter the workforce. Universities and colleges also show poor results from the students due to lack of interest. This leads to students failing to excel in their domain.

The application also suggests the course considering the job opportunity that the course may provide the student in the future, this ensures a good economic base for the individual to build upon. In future, the system can also be developed by considering the family background, financial statuses of the students. The proposed system only provides recommendations for a handful of engineering courses, this aspect might be enhanced by including courses from more educational domains.

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