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A Neuro Fuzzy-based Guidance and Counselling System for Students

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ABSTRACT

Guidance and counselling is vital to student fruitful and significant well-being. Every one's aspiration is to be known with a respectable occupation, which can merely be realized through effective, functional guidance and counselling on the selections of career path. The absence and deficiency in guidance and counselling services in Nigerian schools, has been a great concern as a result of students being unable to attain the nation's target in order to contribute to national manpower development. This study provides solution to this problem by proposing and implementing an Adaptive Neuro Fuzzy Inference System (ANFIS) approach in providing guidance and counselling for students. The system was implemented using Matrix Laboratory (MATLAB) and Java Programming Language. MATLAB was used to develop the ANFIS component of the system. Java was used to design the Graphical User Interface (GUI), to implement the logic behind the counselling module of the system. The input set of the system comprises of different method used by guidance counsellors for providing guidance to students while the output set consists of various careers which students can study based on the inputted values given by the students. The system is also capable of providing counselling to the students.

Keywords: *Neural Network, Expert system, Fuzzy Logic, Adaptive Neuro-Fuzzy Inference System, Guidance and Counselling.*

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1. INTRODUCTION

Man who is a social being will inevitably at one time or the other need guidance and counselling for effective decision making (Olujide and Sussan, 2016). This in turn has created the need for guidance and counselling. Guidance and counselling is a practice by a guidance counsellor to help individuals to handle the difficulties facing them and also to guide them in making the right decision in order for them to be resourceful and impact the society in which they dwell positively. Guidance and counselling service is an essential factor of educational processes for every student as he/she advances through the educational system (Oye et. al., 2012). When guidance and counselling services are provided they help prepare students to assume increasing responsibility for their decisions and grow in their ability to understand and accept the results of their choices (Kauchak, 2011). Guidance and counselling service encompasses every area of human lives, but for the purpose of this research work,

this study will be limited to career guidance and counselling for students in higher secondary schools.

The National Policy on Education (NPE) (Federal Republic of Nigeria, 2014) states that education is an instrument for effective national development. This means that a student is expected to acquire skills and experiences required to be fit in the world of work. It is through the graduate's occupation that he/she is expected to serve the country, contribute and at the same time benefit from the economic growth and national development. But if the student is not properly guided on career decision-making as a result of non-functional and ineffective guidance and counselling services in higher secondary schools, it would not be possible for such student to contribute to economic and national development. This therefore has defeated the objectives of education as stated in the NPE of the Federal Republic of Nigeria (FRN) (Nweze and Okolie, 2014).

Therefore, there is a need to provide a solution to the problems facing effective guidance and counselling services in schools by using Adaptive Neuro Fuzzy Inference System (ANFIS) technique. ANFIS is a branch of Artificial Intelligence (AI) which plays a major role in prediction, modeling and inference. ANFIS is a Fuzzy Inference System (FIS) implemented in the framework of adaptive networks. It is a combination of fuzzy systems and neural network. ANFIS can construct an input-output mapping based on both human knowledge and reasoning processes in the form of fuzzy If-Then rules and stipulated input-output data pairs. In ANFIS, the knowledge representation of a FIS is combined with the learning power of Artificial Neural Networks (ANNs). The FIS contains the knowledge and experience of an expert, in the design of a system that controls a process whose input–output relations are defined by a set of fuzzy control rules (Jang, 1993).

ANFIS architecture comprises of six (6) layers, the layers are: Input, Membership function, Rule, Normalization, Defuzzification and Output Layer.

The ANFIS will ensure automation of the significant part of the guidance and counselling process in a way that it can complement human expertise by doing what the guidance counsellor can do, thereby creating a synergy that benefits both students and guidance counsellors. Hence, the essence of the system is not to totally eliminate guidance counsellor, but to stand in gaps for the guidance counsellors where there is absence of guidance counsellors and also to provide support for guidance counsellors to enhance the quality of guidance and counselling services in higher secondary schools.

ANFIS has proven to be effective in a number of problem domains which normally requires human expertise. Studies have shown that Expert System (ES) is a very powerful tool used in educational sector by students, teachers, Head of the Department (HoD) for taking career related decision (Jamsandekar and Waghmode, 2015). Ghalia and Maryam, 2017) employed the use of a rule based expert system for advising undergraduate students to select the appropriate courses for their career. (Ayman Al-Ahmar, 2012) developed a prototype rule-based (ES) with object-oriented modelling techniques for guiding high school students in selecting suitable undergraduate university courses. Some of the existing systems used to provide guidance and counselling have been able to provide guidance and advice to students but the guidance provided are limited to the parameters and techniques used in designing of the systems.

2. RELATED WORKS

Great deals of parameters affect career guidance and counselling and some complications in processing of the service have led to increased responsiveness to computer-based supportive career guidance (Shahnasarian and Peterson, 1988). Over the years, different researchers have used various techniques to propose, design and implement guidance and counselling system for students.

(Ghalia and Maryam, 2017) proposed a rule-based expert system for providing academic advising (guidance) to students in Information Technology (IT) department, Al-Buraimi College, Oman. Their research work was to propose an alteration of the existing knowledge-based acquisition framework that was found in Mohammad and Al Saiyd (2010). The system was able to offers the undergraduate student a plan and advice with the suitable course according to the courses that have been taken in the past and also explanation within a short period of time as compared with the manual process of giving academic advice. The level of user satisfaction is calculated to be 79.04%. The empirical findings show that the implementation of the proposed model led to a major improvement in performance (Ghalia and Maryam, 2017).

Peker et. al. (2017) proposed and developed a Career Guidance System (CGS) that can automatically provide vocational guidance to students. The system is a Web-Based Career Guidance System (WEB-CGS) that incorporates fuzzy logic. The system input set consists of

the Grade Point Average (GPA) of students in ninth grade mathematics-based classes, social studies-based classes and teacher view values with career interest values. The output set consists of four (4) different careers path which are: Accounting, Information Technology (IT), Automotive and Electrical-Electronics. In the system, hundred (100) rules were established. The defuzzification method employed is centre of gravity (centroid) method. According to the results, the system calculated the GPAs of 270 out of 300 students correctly. The accuracy of the system was calculated to be 90 %.

Gorad et. al. (2017) proposed and designed a Career Counselling System (CCS) using data mining approach. The CCS is an online system that assists students undergoing their study in post-primary schools to choose a course for their career. The data mining algorithm used is C5.0. C5.0 is a sophisticated data mining tool for discovering patterns that delineate categories, assembling them into classifiers, and using them to make predictions. The system suggests to the student, a career option in-line with the student personality attribute, interest and their capability to take up the course. The system consists of questionnaire that was outputted to the student, for them to provide the necessary information needed to provide career counselling. The system suggests a specific course for the student based on the answer obtained from the student. The system had the accuracy of 94% for predicting career path.

Razak et.al. (2014) proposed and developed a Career Path Selection Recommendation System (CPSRS). The system was developed using fuzzy logic method. CPSRS was designed for offering direction and guidance to final year students in the faculty of computer and mathematical sciences, University of Technology, Mara, Malaysia for selecting appropriate career. The parameters considered for career selection are student's ability, skills, personality, interest and past academic records. The use of fuzzy logic method helps the students by suggesting a career recommendation based on the career test. Fuzzy Associate Memory (FAM) was employed as fuzzy inference method and it also contains the knowledge of an expert career counsellor. The system has 80% accuracy for predicting career path and an average error of 20%.

(Saraswathi et. al., 2014) designed an online expert career guidance system. The system assists the students in the selection of their undergraduate courses after the completion of higher secondary school education. The system consists of a knowledge-base that encompasses all the information about all the institutions in Pondicherry, India. The information is source from web pages using parsing and pattern matching technique. The system generates assuring results by guiding the secondary school students in selection of courses in-line with their career. The major drawback of the system is that it considers only student academic grade and type of student certificate to provide career guidance without considering other necessary parameters.

Anusha, et.al. (2006) designed a Career Advisory Expert System (CAES), named iAdvice for undergraduate in faculty of Information Technology (IT), University of Moratuwa, Sri Lanka. IAdvice was designed to guide students' commitment to define their career tracks and also to select their courses to be in-line with their career aim. The following expert system features; reasoning ability, providing explanations, providing alternative solutions, providing uncertainty and probability measures, questioning ability are found in iAdvice. The system takes into account the following parameters; previous academic result, student inclinations, skills and industry alliance with subjects. The evaluation carried out on the system shows that the model is 70% accurate in predicting career path.

3. RESEARCH METHODOLOGY

The guidance and counselling system is an Adaptive Neuro Fuzzy Inference System (ANFIS). ANFIS is a system that incorporates both Fuzzy Logic (FL) and Artificial Neural Network (ANN). It combines the computational power of both artificial neural network and explanative power of fuzzy logic (Jang, 1993). The ANFIS architecture is made up of six layers, the layers are described below:

Input Layer: the input layer contains twelve (12) neurons which correspond to the number of parameters used in providing career guidance. The 12 neurons are: personal interest, self-image, decision-making skills, aptitude (logical reasoning, verbal reasoning, and numerical reasoning), reaction speed, interpersonal relations skills, special talents, personality, attitudes and learning methods. The input layer is represented mathematically as shown in equation 1:

$$O_i^1 = x_i \qquad (1)$$

(Source: Jang 1993**)**

Where;

O_i^1 = is the i^{th} neuron output from the input layer

x = Value for each parameters

Membership function Layer: the membership function layer connects the output from the input layer to a fuzzy set. In this layer each parameter is mapped using the Gaussian membership function to a membership set. The Gaussian membership function is shown in equation 2.

$$\mu(x) = \exp\left(-\frac{(ci - x)^2}{2ai^2}\right) \qquad (2)$$

(Source: Jang 1993)

Where;
c_i= centre of the i^{th} fuzzy set
a_i= width of the i^{th} fuzzy set
x= is the value for each node input
μ(x) = membership function of x.

Rule Layer: each neuron in this layer accepts input from the membership function layer and calculates the truth value for each rule. Takagi-Sugeno inference rule was used in this layer to generate output for each neuron. Takagi-Sugeno is a fuzzy inference technique that develops a systematic approach to generate fuzzy rules from a given input – output data set. Takagi-Sugeno has fuzzy inputs and a crisp output. Takagi-Sugeno uses weighted average to compute the crisp output. It is computationally efficient and suitable to work with optimization and adaptive techniques, so it is very adequate for control problems, mainly for dynamic nonlinear systems (Takagi and Sugeno, 1985). It can be represented mathematically as shown in equation 3.

$$O_i^3 = \mu(x) * \mu(y) \qquad (3)$$

(Source: Jang 1993)

Where;
O_i^3 = i^{th} neuron output from layer 3
μ(x) and μ(y) = membership function of x and y.

Normalization Layer: each neuron in this layer links to exactly one neuron in the rule layer and it computes the firing strength of each rule. It can be denoted mathematically as shown in equation 4.

$$O_i^4 = \frac{O_i^3}{O_1^3 + O_2^3 + \cdots + O_n^3} \qquad (4)$$

(Source: Jang 1993)

Where;
O_i^4 = the i^{th} neuron output for normalization layer
O_i^3 = the i^{th} neuron output from the rule layer
n= is the total number of neuron in normalization layer.

Defuzzification Layer: consists of a single neuron to which all the neurons from the normalization layer are linked. The defuzzification layer output is determined by multiplying the firing strength of a rule by its subsequent parameters. The defuzzification method used in this layer is wtaver. It can be represented mathematically as shown in equation 5.

$$O_i^5 = O_i^4(p_i(x) + q_i(y) + r) \qquad (5)$$

(Source: Jang 1993)

Where;
O_i^5 = the i^{th} neuron output for defuzzification layer
O_i^4 = the i^{th} neuron output for normalization layer
p_i, q_i = consequent parameters
r= bias

Output Layer: the neurons in this layer determined the total output of the ANFIS. The input into this layer is received from the defuzzification layer and it creates its output by adding the inputs from the defuzzification layer. It can be represented mathematically as shown in equation 6.

$$O_i^6 = \sum_i^n O_i^5 \qquad (6)$$

(Source: Jang 1993)

Where;
O_i^6 = the total output
O_i^5 = the i^{th} neuron output from defuzzification layer.

The dataset used for this neuro-fuzzy based guidance and counselling system is a career guidance data collected from guidance and counselling unit, Fortuneland College, Akute, Ogun State, Nigeria. The dataset comprises of 120 career guidance data instances. Data instance is a particular piece of information. The career guidance data instances are career guidance data collected, processed and stored at a particular moment of time. Approximately 67% (80) of the dataset was used in training of the system while the remaining 33% (40) of the dataset was used in testing the system. The ANFIS component serves as an

engine for the Neuro-Fuzzy based guidance and counselling system. The system was developed upon the ANFIS component. The system was implemented using Matrix Laboratory (MATLAB) and Java Programming Language. MATLAB was used to develop the ANFIS component of the system. Java was used to design the Graphical User Interface (GUI), to implement the logic behind the counselling module of the system.

4. RESULTS AND DISCUSSION

The ANFIS model has 12 inputs which are: personal interest, self-image, decision-making skills, logical reasoning, verbal reasoning, numerical reasoning, reaction speed, interpersonal relations skills, special talents, personality, attitudes and learning methods. The counselling module of the system is developed using List control of Netbean IDE (Java Application) to display list of problems/questions and answers to the questions. The membership function for each input has five (5) linguistic labels which are; very poor, poor, average, good and very good. The system was trained using hybrid optimization method with error tolerance at 0.5 with epochs at 40. Subtractive clustering (Sub-clustering) was used to produce the Fuzzy Inference System (FIS) for the training of the data.

The idea behind sub-clustering method is to divide the data space into fuzzy clusters, each representing a particular part of the system behaviour. Subtractive clustering is one-pass algorithm for estimating the number of clusters. The result obtained from training the model showed that the system had a training error of 8.1057e-007 at epoch 1 and an average testing error of 0.435 on the test dataset, which indicates that the model was accurately able to classify approximately 99.6% of the test dataset.

Table 1: Results of Testing Evaluation

Actual (%)	Average Testing Error (%)	Test (%)
100	0.435	99.6

The rules layer comprises of 80 rules which obeys the Takagi-Sugeno inference rule. Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11 show the structure of the proposed anfis based guidance and counselling system, fuzzy inference engine, membership function for the linguistic variables, training dataset, training process, testing process, career guidance form and counselling form respectively.

Figure 3 shows the structure of the proposed ANFIS based guidance and counselling system. It has 12 inputs which are personal interest, self-image, decision-making skills, logical reasoning, verbal reasoning, and numerical reasoning, reaction speed, interpersonal relations skills, special talents, personality, attitudes and learning methods. These inputs are parameters used for providing career guidance.

Figure 4 shows the fuzzy inference engine. The fuzzy inference engine contains the fuzzification layer, rule layer and defuzzification layer.

Figure 5 shows the membership function used in mapping logic reasoning values into fuzzy sets. The Gaussian membership function was used to map the parameters into fuzzy set.

Figure 6 shows the training dataset, the ANFIS was loaded with one to eighty of the career guidance data for training of the system.

Figure 7 shows the training process of the ANFIS. The ANFIS was trained for 40 epochs with an error tolerance of 0.5.

Figure 8 shows the loading of the testing dataset. The ANFIS was loaded with 40 career guidance data for testing of the system.

Figure 9 shows the testing process of the ANFIS. The ANFIS testing data was tested against the training data. The system had an average testing error of 0.435 on the 40 test cases used to train the ANFIS.

Figure 10 shows the Career Guidance (CG) Interface. The Interface allows the user to interact with the system by providing the necessary input to the system in order for the system to predict career path based on the selected values fed to the system.

Figure 11 shows the Counselling Interface. The Interface allows the user to interact with the system by selecting questions from the list of questions provided and it gives answer to the users based on the question selected.

The developed system was used to conduct an experiment to test the accuracy of the career path prediction of the system against those of guidance counsellor(s). Those that participated in the system evaluation testing; are students and guidance counsellor(s) of Fortuneland College, Akute, Ogun State, Nigeria and Barachel Model College, Olambe, Ogun State, Nigeria. The level of computer literacy of the Guidance Counsellors who participated in the test is high. The guidance counsellors carried out the test, by using the developed system to perform career guidance on their students. The total number of students that participated is 100 students and four (4) guidance counsellors participated in the test. The 100 students that participated are Senior Secondary School Three (SSS 3) students, they were selected randomly from both school. 50 students were selected from Fortuneland College, Akute, Ogun State, Nigeria and the remaining 50 students were selected from Barachel Model College, Olambe, Ogun State, Nigeria.

The 100 students that participated in the test were given career guidance test question, the career guidance test question can be found in the appendix section. The career path predicted by the system is determined by the value of the following input parameters; "logical reasoning, verbal reasoning, numerical reasoning, special talents, personality, self-image, decision making skill, values and attitudes, interpersonal relation skill, reaction speed, learning method and interest" selected by the students.

The experimental result collected from the guidance counsellors indicated that the developed system was 99.6% accurate in predicting career path. The students agreed that the predicted career path reveal a true possibility according to their ability. The guidance counsellors found the system useful and supportive in finding the most suitable career path for students.

5. CONCLUSION

In this study a Neuro Fuzzy Based Career Guidance and Counselling System was proposed and implemented. The system had a prediction accuracy of 99.6%, which is higher than other models or systems utilized in predicting career path.

The system will be able to provide solutions to schools that do not have guidance counsellor by performing the work of a guidance counsellor. The system will be useful to career guidance counsellors by assisting them in predicting career path. The future enhancement of the system could be extending the input and output sets of the system and also implementing it as a web based application.

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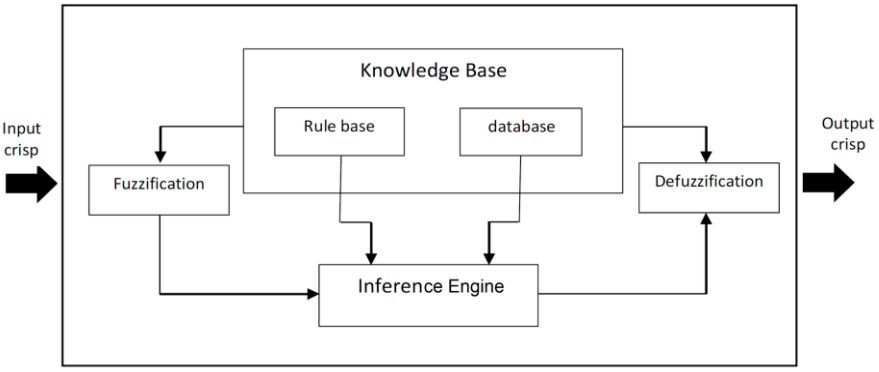

Figure 1: Block Diagram of FIS
(Source: Jang 1993)

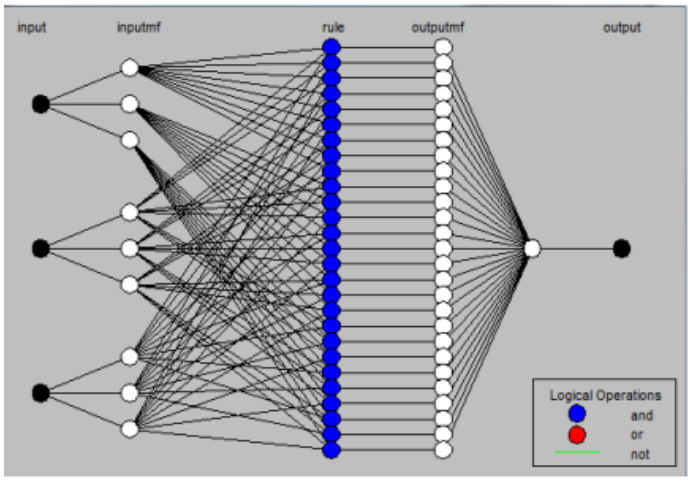

Figure 2: ANFIS Architecture
Source: Jang 1993

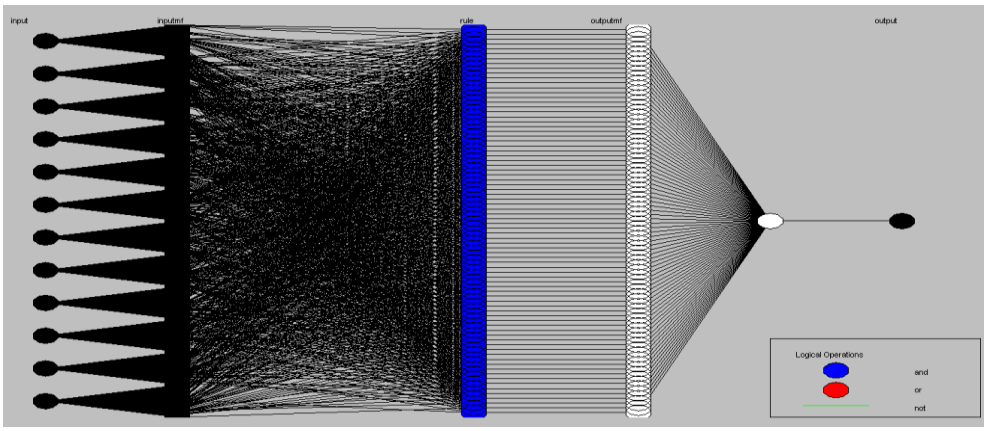

Figure 3: The Structure of the Proposed ANFIS based Guidance and Counselling System

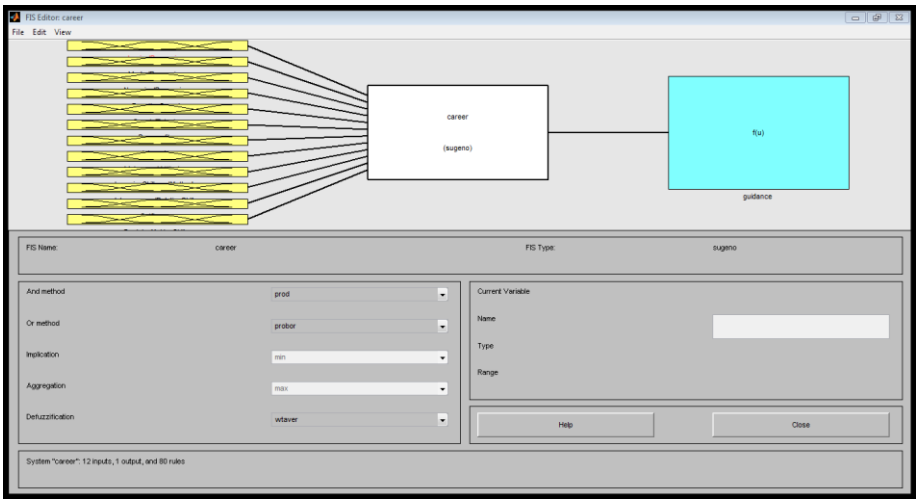

Figure 4: Fuzzy Inference Engine

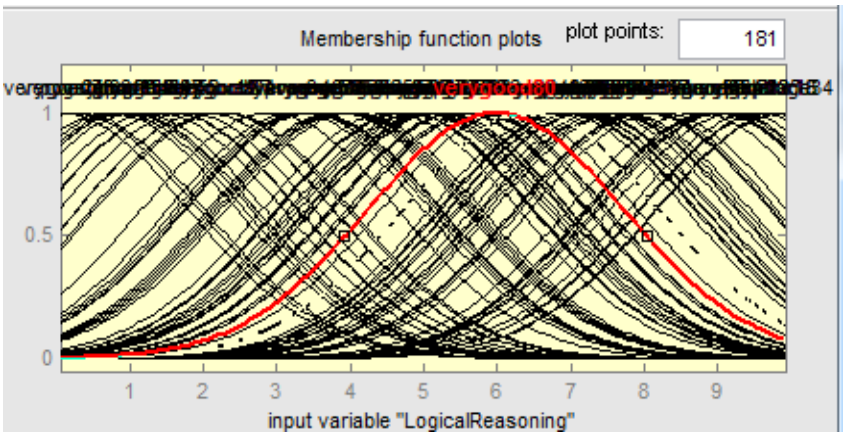

Figure 5: Logic Reasoning Membership Function Plot

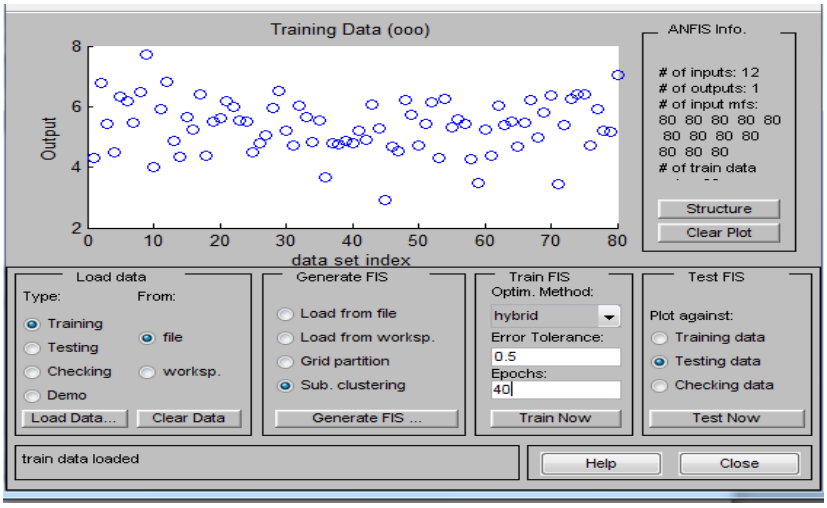

Figure 6: Training Data

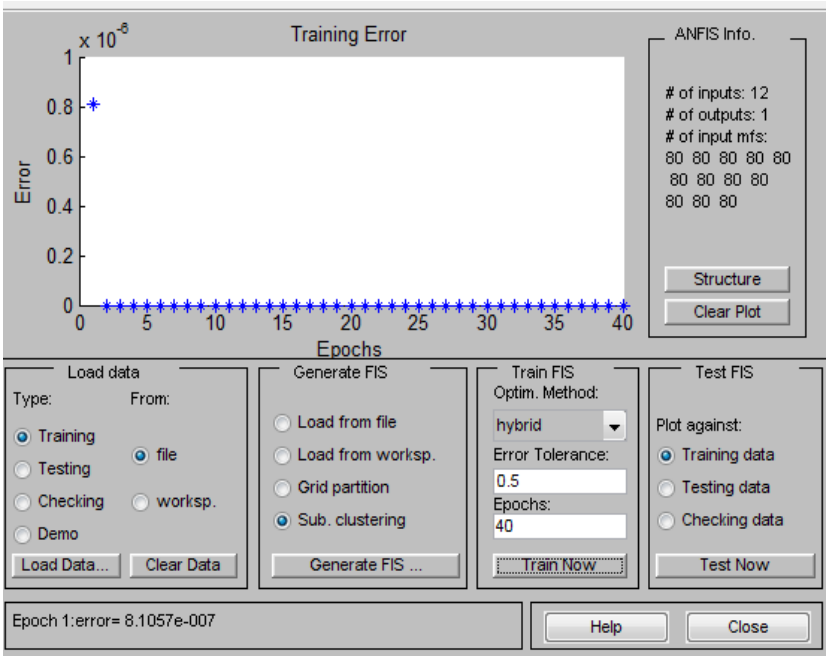

Figure 7: Training Process

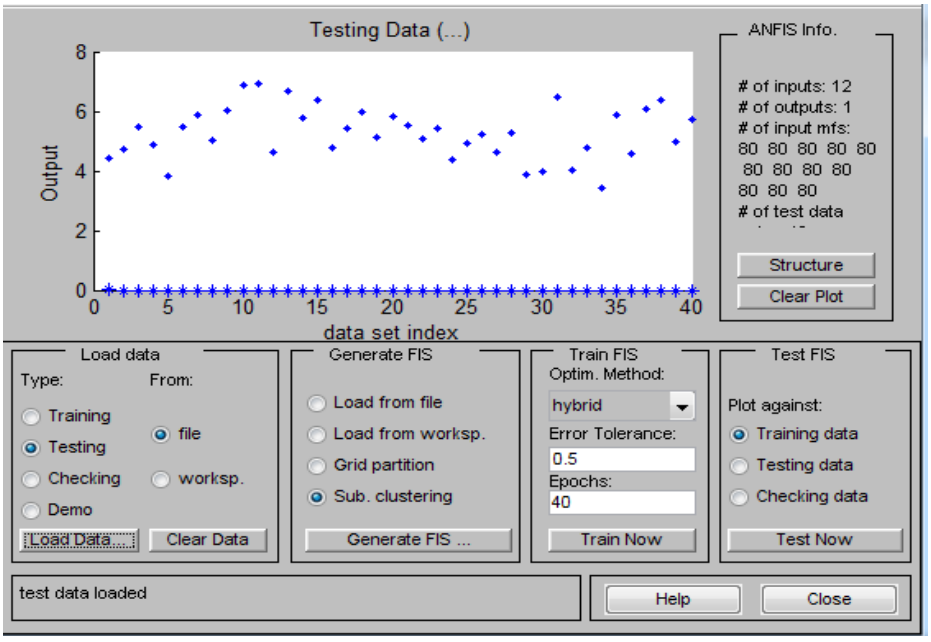

Figure 8: Testing Data

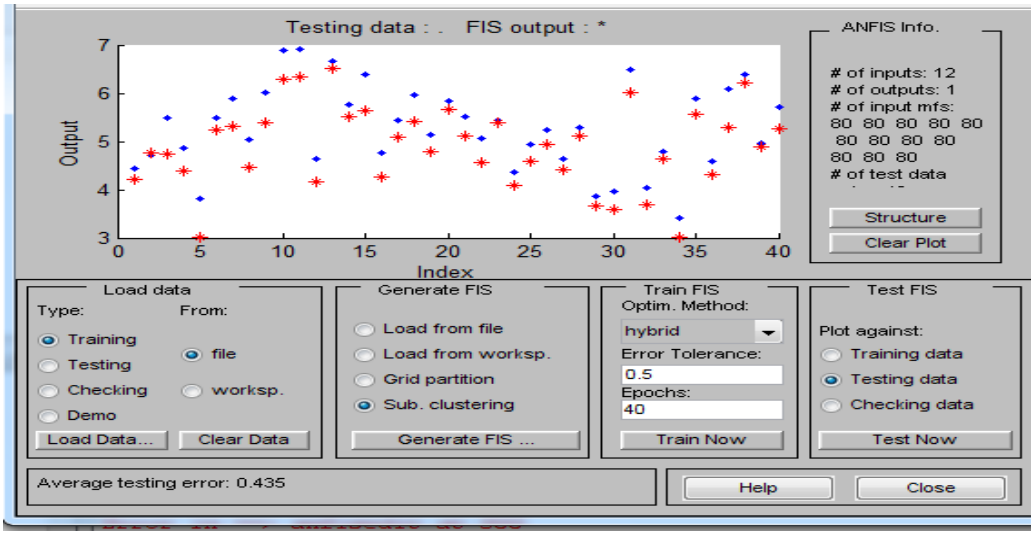

Figure 9: Testing Process of the ANFIS

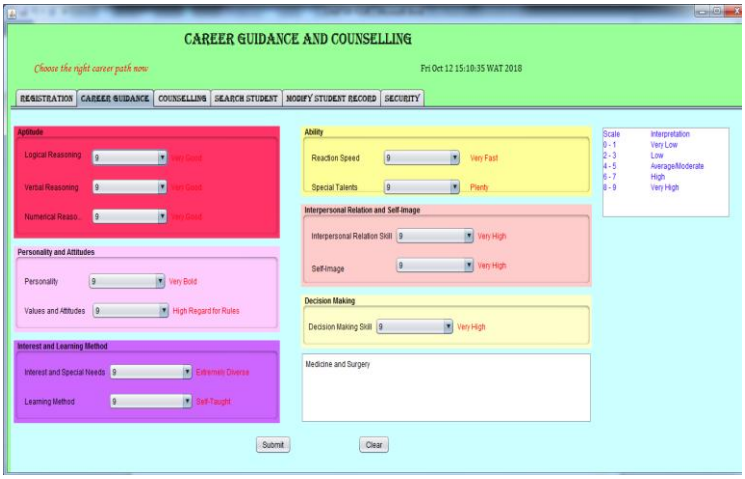

Figure 10: Career Guidance form

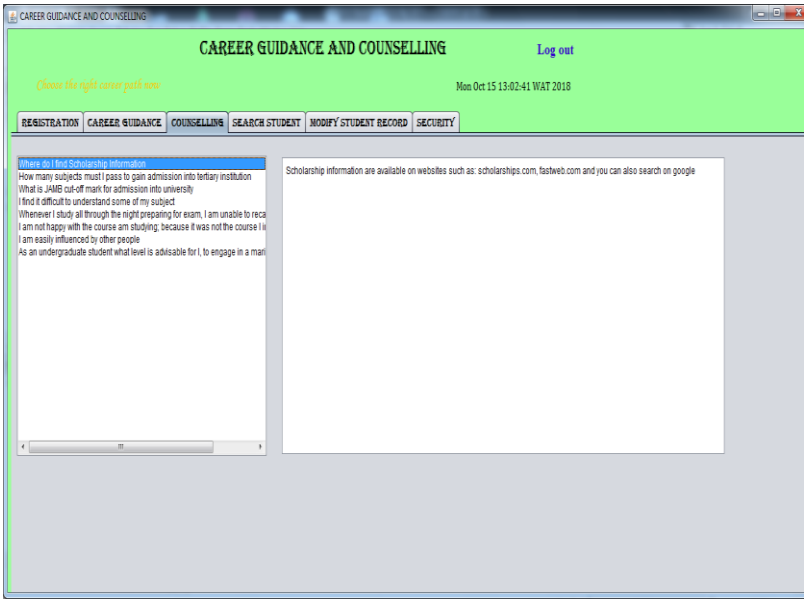

Figure 11: Counselling Form

APPENDIX

CAREER GUIDANCE TEST

Section A: Verbal Reasoning
Instruction: Unscramble or re-arrange the answers.

1. What kinds of stones are never found in the oceans?
   Answer: stones dry
   _____

2. What do sea monsters eat?
   Answer: and fish ships
   _____

3. What has teeth but cannot eat?
   Answer: bmoc
   _____

4. What do dentists call the astronauts cavity?
   Answer: hole a black
   _____

5. What is greater than God, more evil than devil, poor people have it, and if you eat it you will die?
   Answer: gnihton
   _____

Section B: Numerical Reasoning

6. 

7. 2 4 4 12

4 4 8 ?

8. 2 P 3 = 5, 4 M 2 = 2, 10 M 2 P 12 =?

9. 15 D 3 = 5, 4 T 4 = 16, 4 T 5 D 10 =?

10.

1	2	4	8

3	?	?	24

Section C: Personality, Personal Interest, Values, Reaction Speed and Skills Test
Instruction: Tick the boxes to answer the questions.

11. **Personality:** I am _____.

❑ Quiet ❑ Serious ❑ Dependable ❑ Practical ❑ Realistic ❑ Responsible ❑ Logical ❑ Orderly ❑ Organized ❑ Friendly ❑ Conscientious ❑ Committed ❑ Thorough ❑ Accurate ❑ Loyal ❑ Considerate ❑ Sensitive ❑ Thoughtful ❑ Visionary ❑ Insightful ❑ Decisive ❑ A motivator ❑ Original ❑ Driven ❑ Goal-oriented ❑ Theoretical ❑ Skeptical ❑ Independent ❑ Competent ❑ A performer ❑ A perfectionist ❑ Dramatic ❑ Adventurous ❑ Tolerant ❑ Flexible ❑ An observer ❑ An analyzer ❑ Efficient ❑ Kind ❑ Respectful ❑ Idealistic ❑ Moral ❑ Curious ❑ Seeking harmony ❑ Open-minded ❑ Understanding ❑ Accepting ❑ Theoretical ❑ Abstract ❑ Adaptable ❑ Focused ❑ A problem-solver ❑ A critical thinker ❑ Conceptual ❑ Energetic ❑ Spontaneous ❑ Active ❑ Involved ❑ Outgoing ❑ Fun ❑ Imaginative ❑ Appreciative ❑ Supportive ❑ Well-spoken ❑ Outspoken ❑ Resourceful ❑ Strategic ❑ Systematic ❑ Forceful ❑ Warm ❑ Inspiring ❑ A negotiator ❑ Cooperative ❑ Determined ❑ Empathetic ❑ Sociable ❑ Knowledgeable ❑ A risk-taker ❑ Confident ❑ Innovative ❑ People-oriented ❑ Perseverant ❑ Assertive

12. **Personal Interest:** I am interested in _____.

❑ Doing ❑ Analyzing ❑ Creating ❑ Helping ❑ Leading ❑ Organizing

13. **Values:** I values _____.

❑ Security ❑ Variety ❑ Independence ❑ Competition ❑ Recognition ❑ Freedom ❑ Status ❑ Money ❑ Creativity ❑ Decision-making ❑ Contact ❑ Working alone ❑ Leadership ❑ Expertise ❑ Stability ❑ Balance ❑ Technology ❑ Structure ❑ Learning ❑ Spirituality ❑ Problem-solving ❑ Physical challenge

14. **Skills:** My skills are in the areas of _____.

❑ Leading ❑ Doing ❑ Helping ❑ Creating ❑ Financial ❑ Researching ❑ Administrating ❑ Communicating ❑ Technical ❑ Decision-making ❑ Contact ❑ Working alone ❑ Leadership ❑ Expertise ❑ Stability

15. **Reaction Speed:** How do you react to situations_____?

❑ Very slow ❑ slow ❑ Normal ❑ Fast ❑ Very Fast