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# A Fuzzy Logic Expert System for Automated Loan Application Evaluation

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**ABSTRACT**

***At present cost of undergraduate study in Palestine is increasing and average monthly income is low comparing it with life cost. As a result, request of undergraduate study loans is high. Therefore, there is a rises a need for an automated expert system that evaluate loan applications. Fuzzy logic is an approach to computing based on multivalued rather than Boolean logic (1, 0). In this paper, an expert system based on fuzzy logic proposed for undergraduate loan application evaluation. Process starts of input variables that feed to system. These inputs assigned a degree of one or more membership function (fuzzy sets). These membership functions then aggregated to output membership functions by linguistic fuzzy sets know as rule sets.***

**Keywords:** Fuzzy Logic, Expert System, Automated System, College Loan, College Loan Application Evaluation.

## 1. INTRODUCTION

Loan Fund for Undergraduate in Palestine (LFUP) [1] established on February 19, 2001 pursuant to resolution no. 1 for year 2001 issued by Minister of Higher Education in that time, and it has been reinforced through the issuance of President Decree no. 5 for year 2013.

The lending fund considered as an independent administrative body, which enjoys public legal entity, administrative and financial independence. The fund considered one of the government institutions that support the building, preparation and development of human resources in Palestine. In terms of specialization and scientific rehabilitation in various theoretical and applied fields, through its set of adopted objectives which are directed to promote and support students in Palestine socially and economically in Palestinian Higher Education institutions to build a believer in active community life and to live in peace and quiet.
The fund aims to achieve:

- Lending undergraduate students attending Palestinian Higher Education Institutions, in accordance to laws and mechanisms approved by board.
- Contribution of enabling of students to compete their higher education.
- Contribution on directions of students in specializations that contribute in building the state institutions and serve Palestinian community in light of approved general educational policy.

According to above background information about Loan Fund for Undergraduate in Palestine (LFUP). And my work on LFUP as Information Technology Head division from the year 2007 and my experience, my knowledge and contribution of Lending process, especially process of loan applications submission and evaluation, in addition the opportunity of my Master study and my new knowledge of fuzzy logic subject encourage me to write this paper. In addition, to propose a solution for loan applications evaluation based on fuzzy logic expert system for automated undergraduate loan application evaluation. In this paper, we are proposing a solution based on fuzzy logic with using two models Mamdani and Anfis. Then we are discussing and comparing the results between the two models in addition to available current computed system. Then we write our conclusion and acknowledgment sections.

## 2. PROPOSED SOLUTION

Our solution consists of the following steps:

- Extract necessary input parameters
- Assign linguistic labels and define membership functions
- Inference using rules
- Aggregate outputs of all rules

- Defuzzify the output

**Extract necessary input parameters**

According to Loan Fund for Undergraduate in Palestine (LFUP) instructions, loan application processed based on some parameters. Students submit their information through LFUP e-services portal, then student send hard copy of application documents needed to student affairs at his university. Student affairs audit electronic application data with student document and approve that all information is correct. The application parameters [2, 3] that considered on evaluation are:

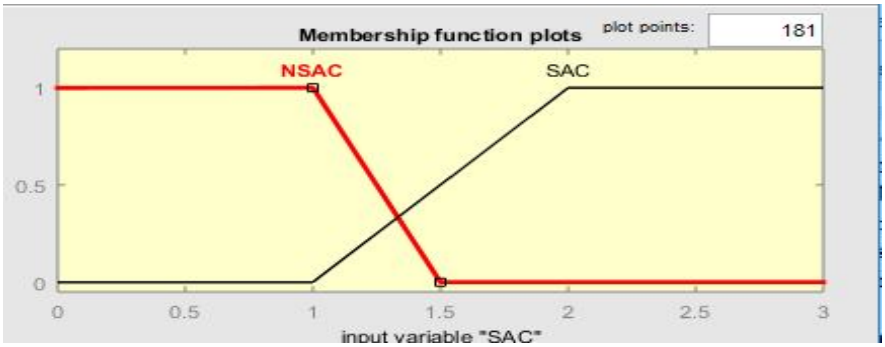
- Social Affair Case
- Family Members Count
- Family Abnormal Members Count
- Month Income
- Family Members in Universities
- Head of Family Case
- Student Housing Case
- Family Housing Case

**Assign Linguistic labels**

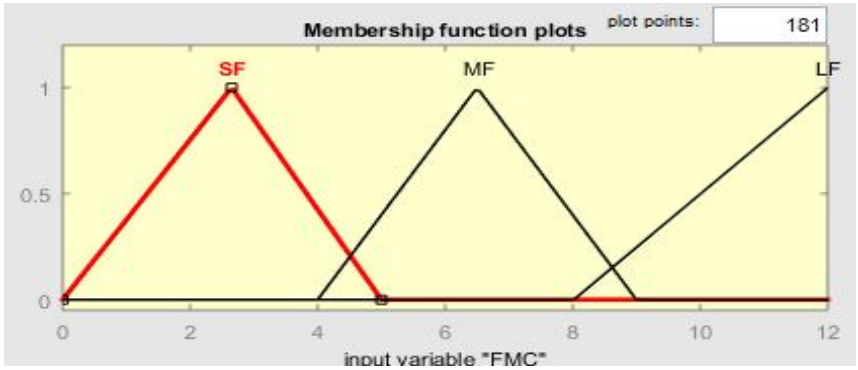
We assign linguistic labels for each parameter; determine each label range and we determine membership function. In all parameters, we used triangular membership function.

**Input Variables**

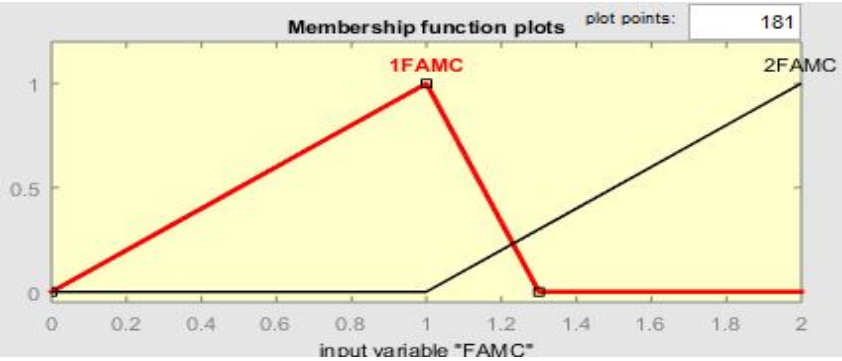
| Social Affair Case - SAC | |
|---|---|
| Not Social Affair Case - NSAC | [0 – 3] |
| Social Affair Case – SAC | |



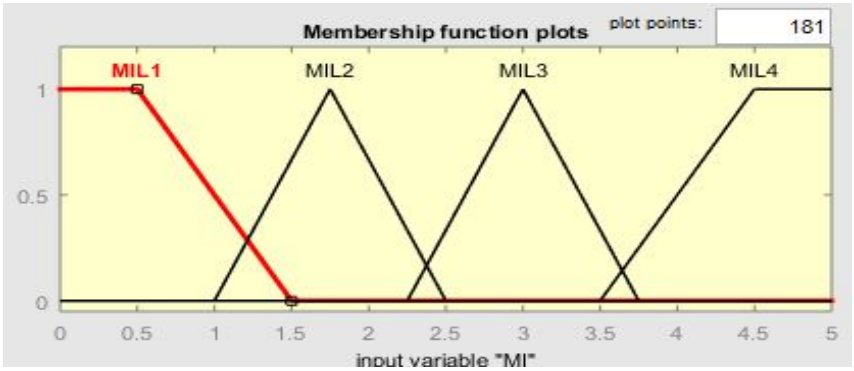

| Family Members Count - FMC | |
|---|---|
| Small Family – SF | [1 – 12] |
| Mid Family – MF | |
| Large Family – LF | |



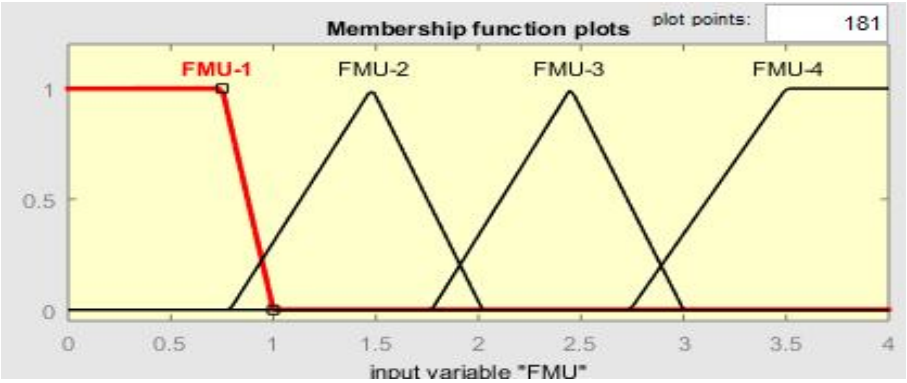
| Family Abnormal Members Count - FAMC | |
|---|---|
| One FAMC – 1FAMC | [0 – 2] |
| Two FAMC – 2FAMC | |



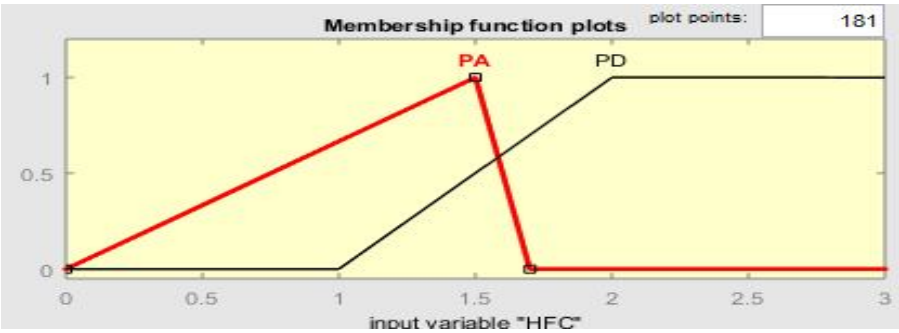

| Month Income - MI | |
|---|---|
| Level 1 – MIL1 | [0 – 5] |
| Level 2 – MIL2 | |
| Level 3 – MIL3 | |
| Level 4 – MIL4 | |



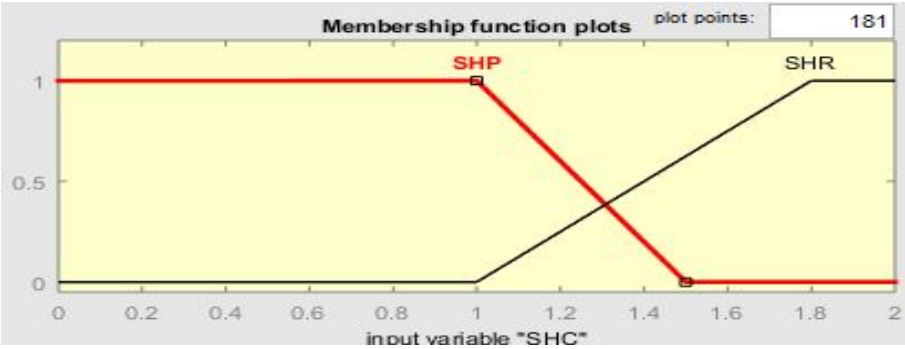

| Family Members in Universities - FMU | |
|---|---|
| One FMU – FMU-1 | [0 – 4] |
| Two FMU – FMU-2 | |
| Three FMU – FMU-3 | |
| Four FMU – FMU-4 | |



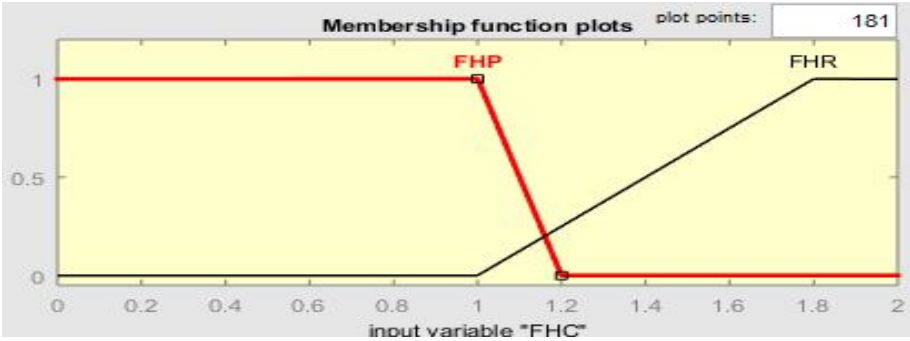
| Head of Family Case - HFC | |
|---|---|
| Parents Alive - PA | [0 – 3] |
| Father/Parents Dead - PD | |




| Student Housing Case - SHC | |
|---|---|
| House Property - SHP | [0 – 2] |
| House Rent - SHR | |

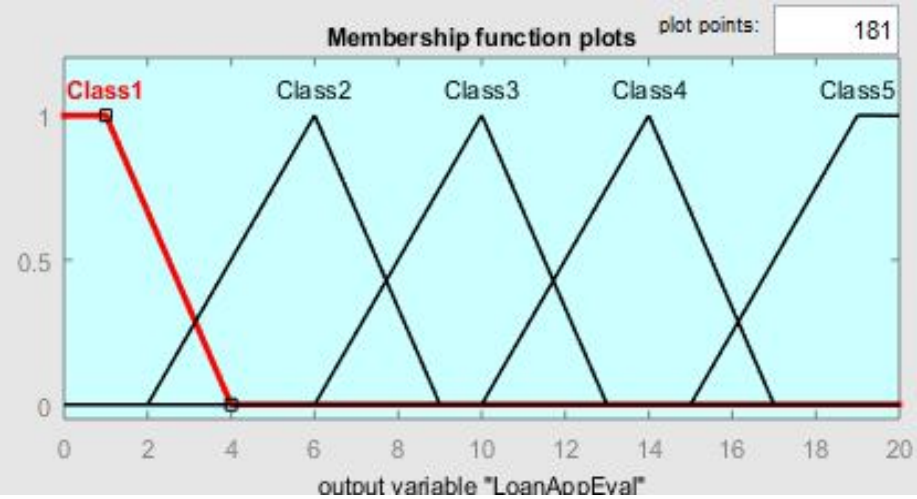



| Family Housing Case - FHC | |
|---|---|
| House Property - FHP | [0 – 2] |
| House Rent - FHR | |




**Output Variables**

| Loan Application Evaluation - LoanAppEval | |
|---|---|
| Class 1 | [0 – 20] |
| Class 2 | |
| Class 3 | |
| Class 4 | |
| Class 5 | |




We assign five classes for application evaluation, class 1 is the less needed student for loan, and class 5 is the most needed student for loan.

**Inference using rules**

We extract rules from LFUP instructions, in addition to historical data, which used as training data. We extract four hundred and fourteen rules in Mamdani model, which are cover all cases of inputs. Below are some of these rules:

1. (SAC==SAC) => (LoanAppEval=Class5) (1)
2. (SAC==NSAC) & (FMC==SF) & (MI==MIL3) & (FMU==FMU-1) & (HFC==PA) & (SHC==SHP) & (FHC==FHP) => (LoanAppEval=Class1) (1)
3. (SAC==NSAC) & (FMC==SF) & (MI==MIL4) & (FMU==FMU-1) & (HFC==PA) & (SHC==SHP) & (FHC==FHP) => (LoanAppEval=Class1) (1)
4. (SAC==NSAC) & (FMC==SF) & (MI==MIL4) & (FMU==FMU-1) & (HFC==PA) & (SHC==SHP) & (FHC==FHR) => (LoanAppEval=Class1) (1)
5. (SAC==NSAC) & (FMC==SF) & (MI==MIL4) & (FMU==FMU-1) & (HFC==PA) & (SHC==SHR) & (FHC==FHP) => (LoanAppEval=Class1) (1)
6. (SAC==NSAC) & (FMC==MF) & (MI==MIL4) & (FMU==FMU-1) & (HFC==PA) & (SHC==SHP) & (FHC==FHP) => (LoanAppEval=Class1) (1)
7. (SAC==NSAC) & (FMC==MF) & (MI==MIL4) & (FMU==FMU-1) & (HFC==PA) & (SHC==SHP) & (FHC==FHR) => (LoanAppEval=Class1) (1)
8. (SAC==NSAC) & (FMC==MF) & (MI==MIL4) & (FMU==FMU-1) & (HFC==PA) & (SHC==SHR) & (FHC==FHP) => (LoanAppEval=Class1) (1)
9. (SAC==NSAC) & (FMC==SF) & (MI==MIL1) & (FMU==FMU-1) & (HFC==PA) & (SHC==SHP) & (FHC==FHP) => (LoanAppEval=Class2) (1)
10. (SAC==NSAC) & (FMC==SF) & (MI==MIL1) & (FMU==FMU-1) & (HFC==PA) & (SHC==SHP) & (FHC==FHR) => (LoanAppEval=Class2) (1)

**Aggregate outputs of all rules**
The output degrees of all of the fuzzy rules combined and aggregated to obtain one fuzzy output distribution. This done by using the min implication and max aggregation as the output from each rule.

**Defuzzify the output**
A crisp number obtained in this process. The Centroid Defuzzification method used to find the crisp output, which provides the decision to the loan officer.

**Sample Processing of an Application**
Here we consider an application where the inputs have following given values along with their membership in labels as shown on Figure 1 and Figure 2.

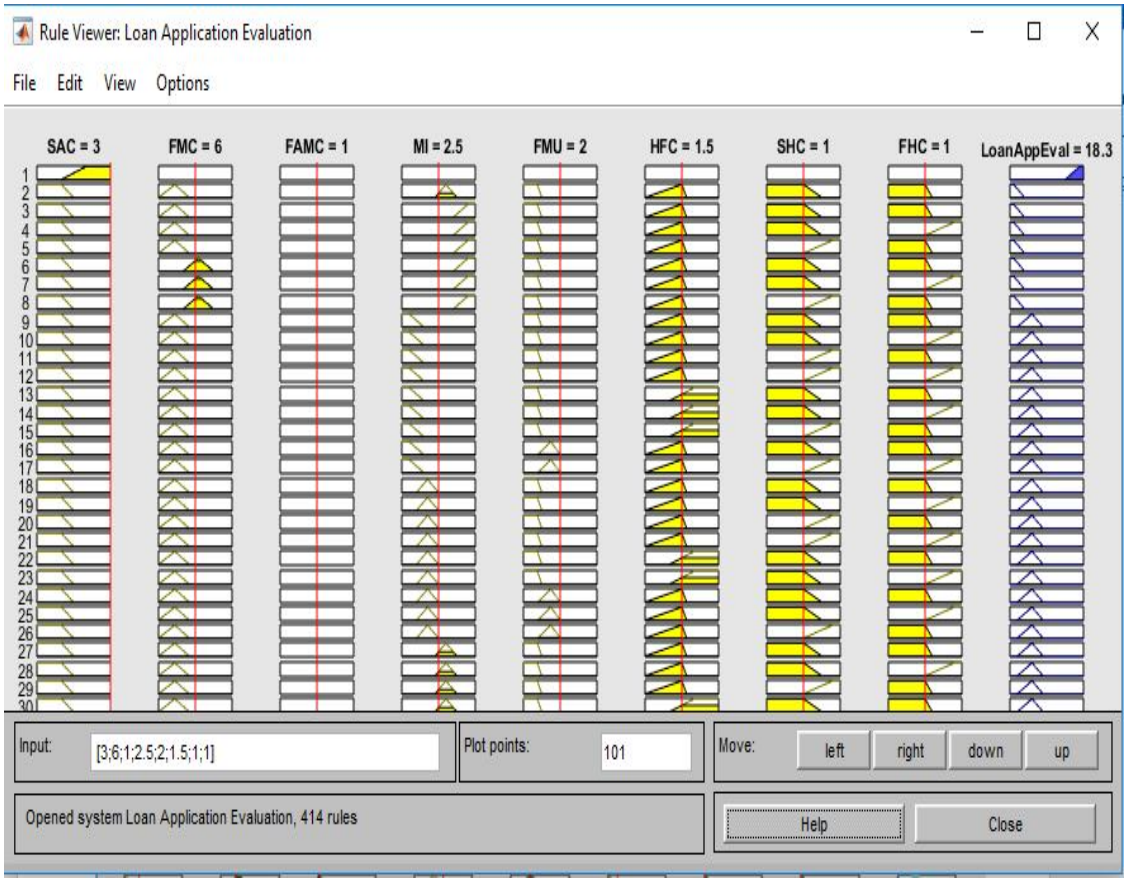



**Figure 1** Sample Loan Application Inputs and Output – Mamdani Model

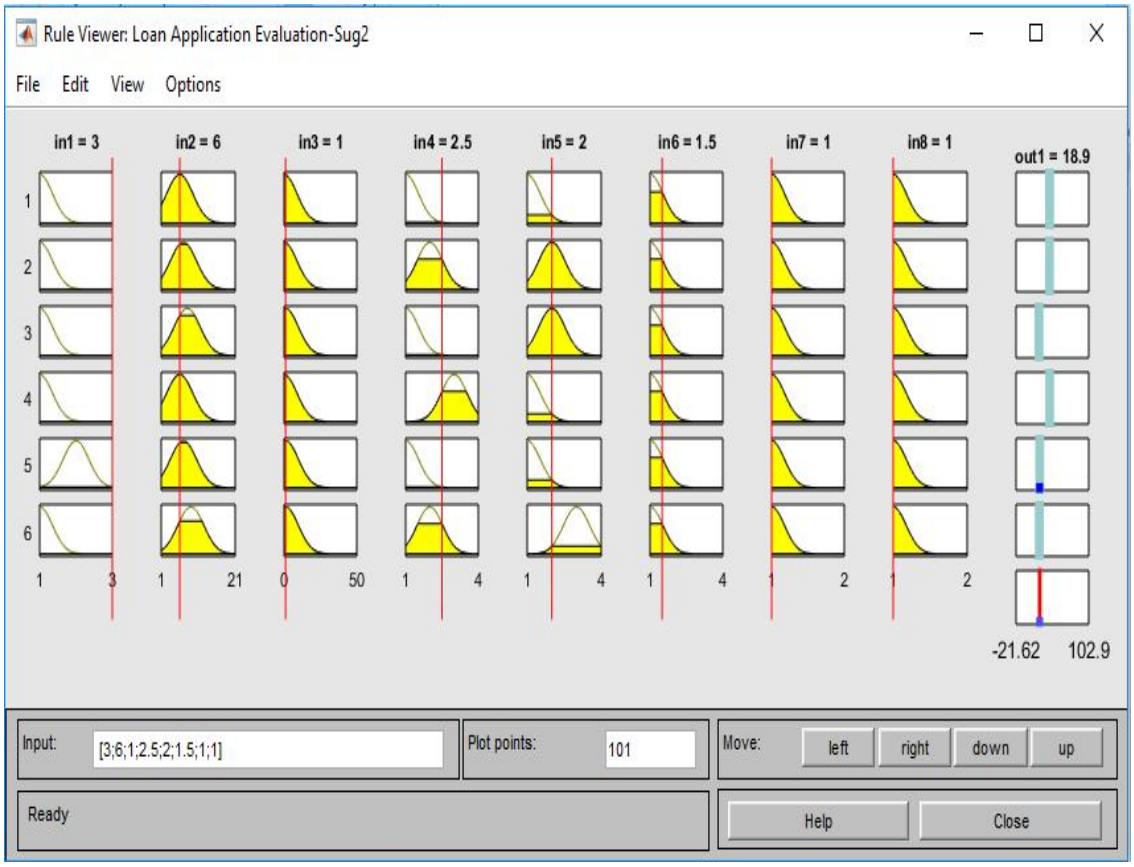



**Figure 2** Sample Loan Application Inputs and Output – Anfis Model

## 3. COMPARISON OF FUZZY SYSTEM WITH TRADITIONAL SYSTEM FOR LOAN APPLICATION EVALUATION

In traditional approach after application, information collected and audited, a mathematic calculation applied. It depends on a weight for each parameter and a numeric mark for each parameter classes. For example, family member count has a weight of 15%, 1.25 mark for each member with a maximum of 12 members. For social affair cases, the mark given is 19.18, which is the maximum application evaluation. So in our example at Fig 1. We are using Mamdani model; the example show that the application social affair parameter numeric value is 3 which indicate that the student is a social affair case. In tradition approach, the application evaluation is 19.18 given directly to this application without any referring to other parameters. In Mamdani model the output parameter as shown with its crisp value, which depends on rules we generated, the value is 18.3. By using Anfis Model and dynamic generation of rules, for this dynamic generation we are using random 70% of dataset as training data from 5810 records. We used custom parameters as shown for generating Inference system rules as shown on Figure 3.

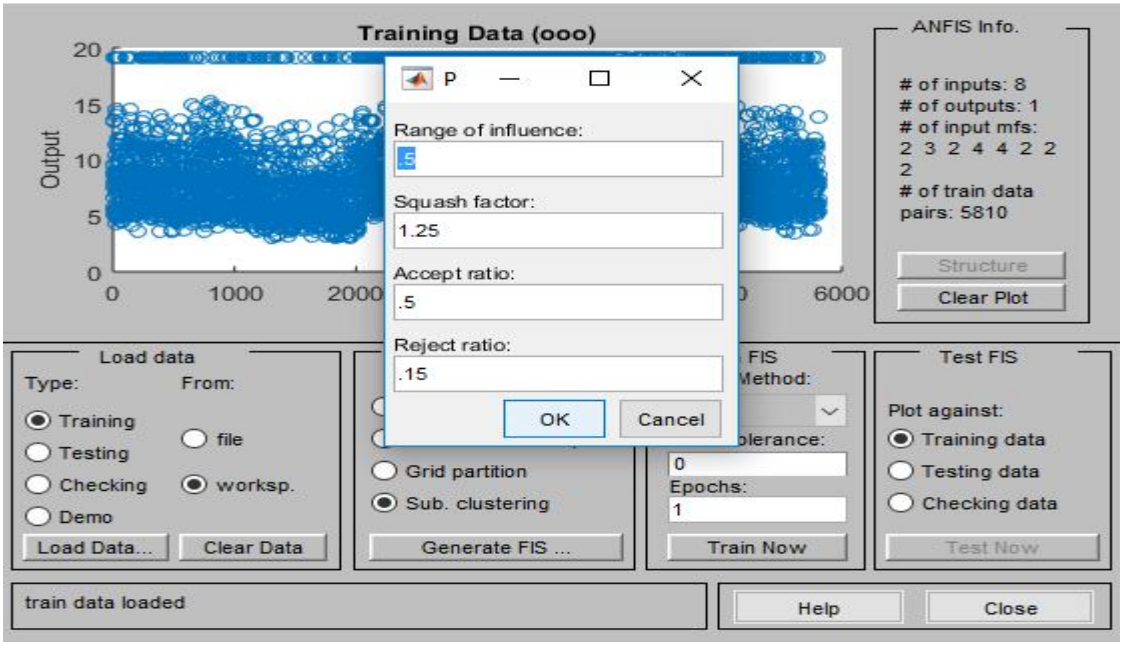



**Figure 3** Anfis Generate FIS

After applying train data, as shown on Figure 4 with Epochs 3 the error is 0.24.

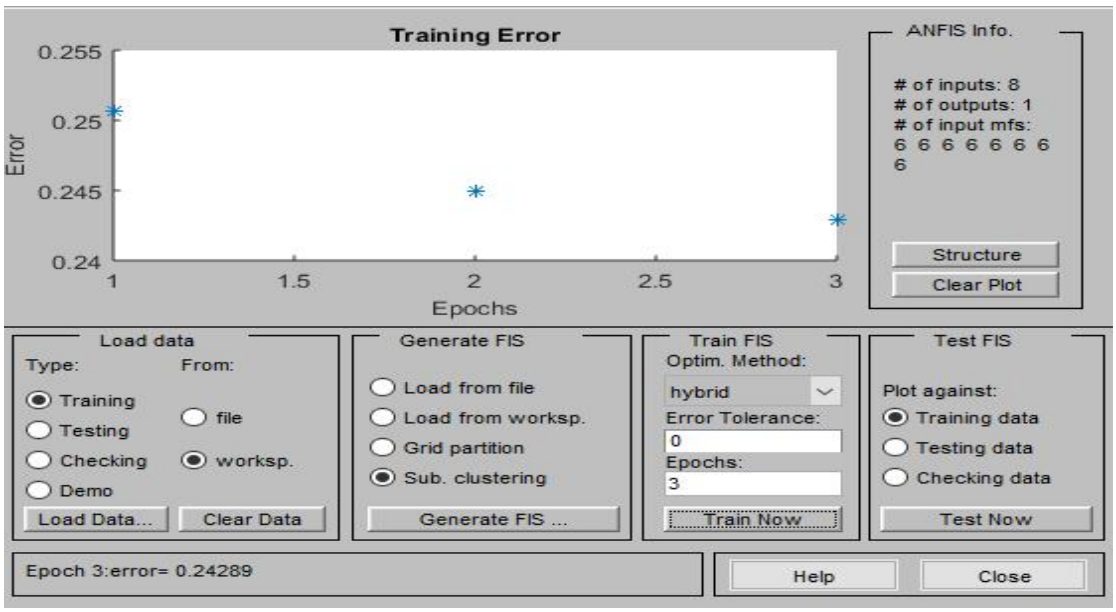



**Figure 4** Anfis Training Error

The new generated Inference System has 6 roles as shown on Figure 5.

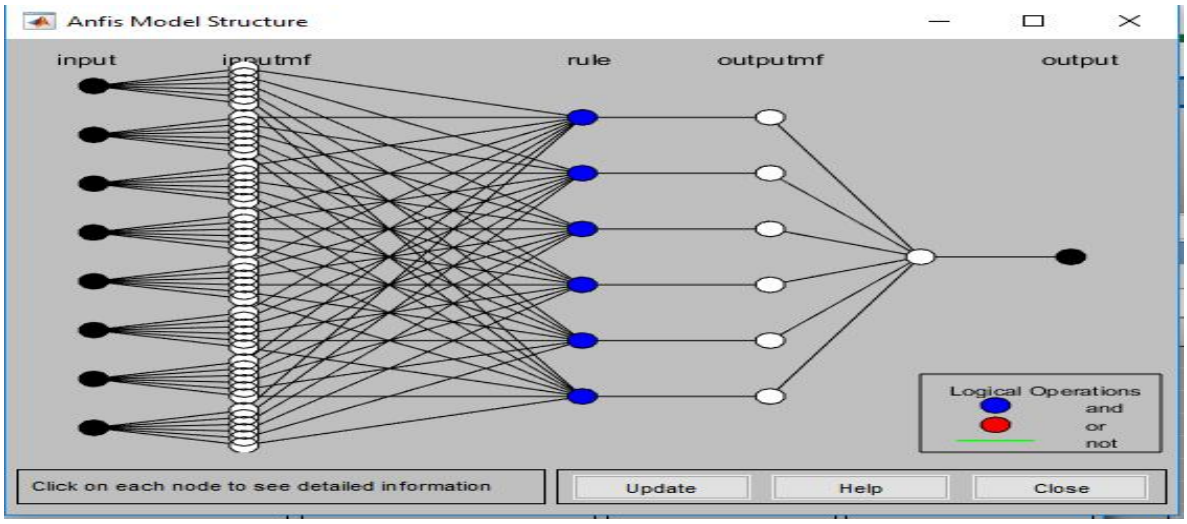



**Figure 5** Anfis Model Structure

The output from Anfis model as shown in Figure 2 is 18.9. So the results from Anfis is very closer to traditional than Mamdani and this caused by manual insertion of rules in Mamdani with comparing of Anfis which its rules generated dynamically using Anfis model.
For determining the more accurate model, which is closer to traditional computing system, we compare three generated fuzzy inference system with traditional computing system results. Testing data used 20% of dataset with 2488 record. We used three measures, which are Correlation Coefficient (CC), Mean Absolute Percentage Error (MAPE) and Max Percent Error (MPE). Our results as shown on Table 1, and we plot each fuzzy inference system outputs with traditional computing system output as shown on Figure 6, Figure 7 and Figure 8.

**Table 1** Fuzzy Model Measures

| Fuzzy Model | CC % | MAPE % | MPE % |
|---|---|---|---|
| Mamdani Model | 95.127 | 29.046 | 1.950 |
| Anfis Model Sub-Clustering Hybrid | 99.851 | 1.322 | 0.415 |
| Anfis Model Sub-Clustering Backpropagation | 99.835 | 1.526 | 0.410 |

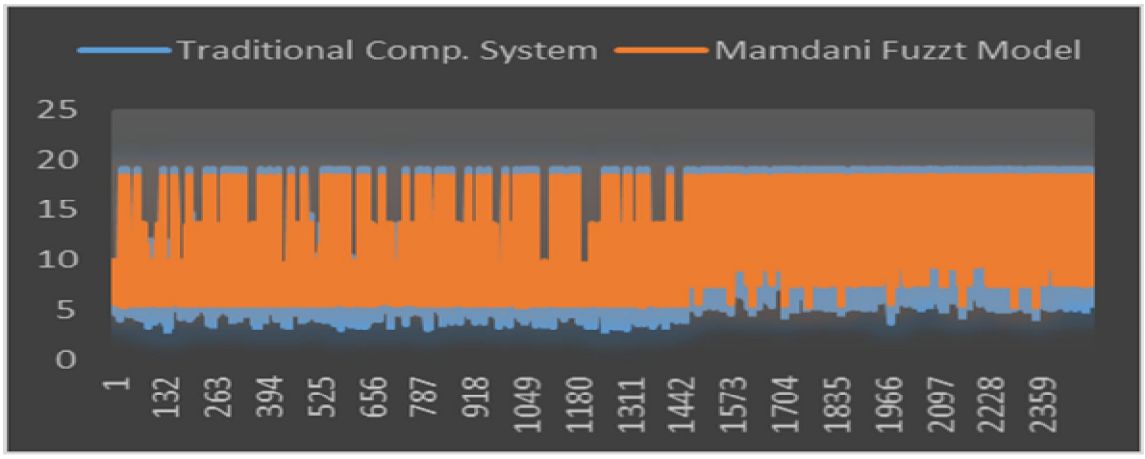



**Figure 6** Mamdani Model with Traditional Comp. Sys Outputs

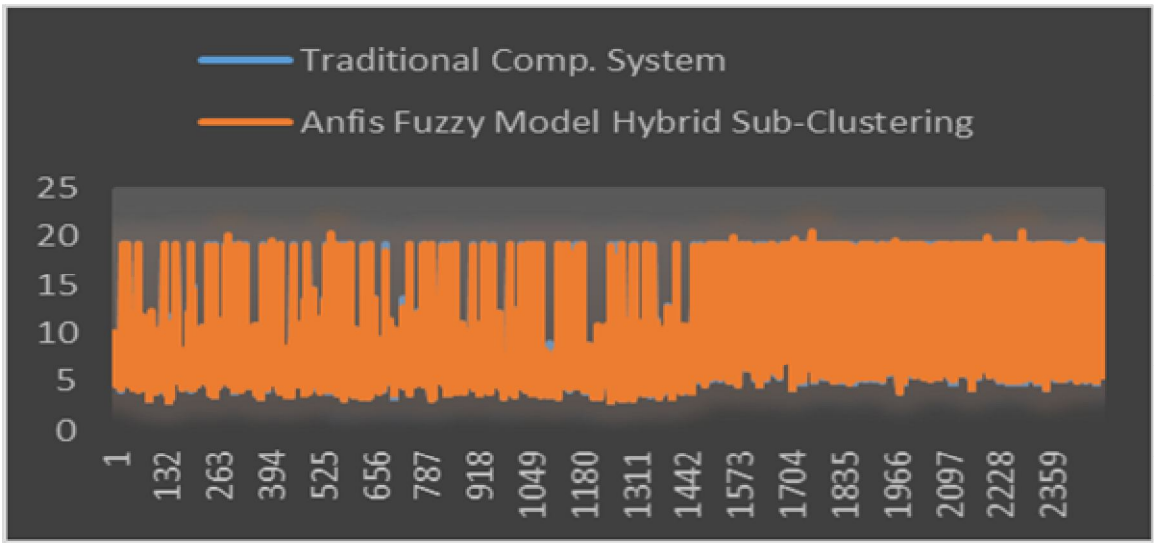



**Figure 7** Anfis Model Hybrid Sub-Clustering with Traditional Comp. Sys Outputs

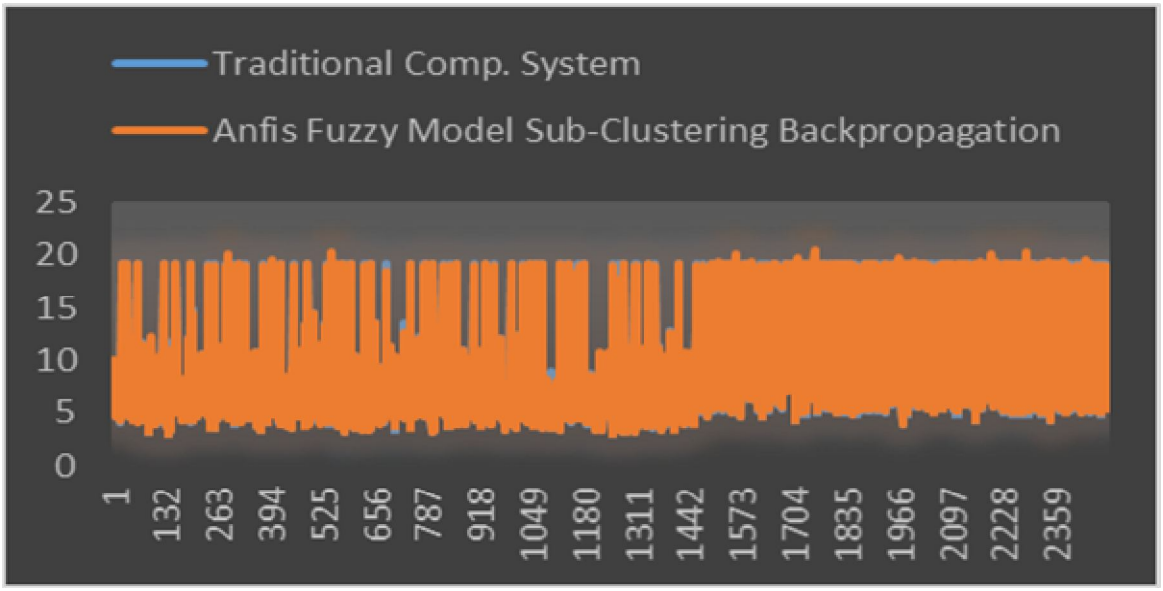



**Figure 8** Anfis Model Backpropagation Sub-Clustering with Traditional Comp. Sys Outputs

From measures we are apply and calculate and as shown on Table 1, the more accurate fuzzy inference model is Anfis with Hybrid Sub-Clustering since the high correlation coefficient and less mean absolute percentage error.

## 4. CONCLUSION

In this paper we proposed fuzzy logic expert system for automated undergraduate loan application evaluation with two models, mamdani and anfis in addition we used anfis model for generating fuzzy inference system. As we describe all configuration we used in two model, anfis outputs is closer to traditional than mamadani.

## 5. ACKNOWLEDGMENT

We thank Mr. Murad Obaid, executive director of Loan Fund for Undergraduate in Palestine (LFUP), for his help in supplying us with needed information, and giving us training and testing data.

## REFERENCES

[1] Meeting with Mr. Murad Obaid "Executive Director of Loan Fund for Undergraduate in Palestine", 22-05-2016.
[2] Loan Fund for Undergrauate in Palestine Application Evaluation Instructions and Procedures.
[3] http://iqrad.edu.ps/infoDT/loans , 22-05-2016

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