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A Simplified Interval Type-2 Fuzzy Implementation for Financial Credit Decision

Praveen Kumar Dwivedi, Surya Prakash Tripathi

Abstract*: Credit assessment of potential customers with the help of their previous history of credit transaction is one of the main issues in financial credit approval system. The credit rating of the customer shows that the financial stability of the individual or firm. Based on financial stability, the bankers can approve their credit grant. The basic factors that affect the credit rating of the customer is history of payment, the unsettled amount, period of credit history, types of credit and many other factors. The creditworthiness of the customer is assessing based on result obtained from these factors. The prime objective of the credit approval system is to avoid loss of amount that may be associated with an incorrect decision. To avoid such type of decisions, it requires designing of credit rating models for credit and their risk analysis. This type of models benefited the bankers to approve the credit grant or not. The bank credit system is a binary classification system that classifies the customer either the good or bad based on their previous credit history. In this context, several fuzzy classification systems have been designed to classify the customer. In this article, we have designed a simplified interval type-2 fuzzy system for financial credit decision using two different membership function based approaches and compared the performance in terms of accuracy of classification.

***Index Terms*: Interval Type-2, Fuzzy System, Credit Classification, Accuracy, Type-1 Fuzzy System etc.**

I. INTRODUCTION

In financial credit decision system, there is a possibility of uncertain data [1]. The uncertainty refers to the attribute of data. To handle the uncertainty, the fuzzy reasoning has been introduced. The fuzzy logic system handles the uncertainty of data and maps the data between the range of 0 and 1 with the help of type-1 fuzzy set. The type-1 fuzzy sets are more reliable than the rough set [2,3], but in this system, it is very difficult to choose an appropriate membership functions to handle the uncertainty of the data. To handle such type of situations, the type-2 fuzzy sets have been used [4, 5, 16]. In financial credit allocation system, the classification of data is based on the number of attributes and there is a possibility of data uncertainty. Many fuzzy based classification systems with the usage of multi-objective evolutionary algorithms have been implemented to classify the financial credit allocation as a good or bad. In this article, the interval type-2 fuzzy classification system has been implemented for financial credit decision system and tested on standard benchmark German credit data that is available from UCI machine learning repository. The experimental results highlights that the interval type-2 fuzzy classification system perform better than the type-1 fuzzy classification system and can be used for financial credit decision system. The section 2 of this article deals the type-1 and type-2 fuzzy system with the handling process of uncertainty. Section 3 discussed about the interval type-2 system for classification system. Section 4 deals with the implementation of the proposed model and section 5 present the experimental analysis and outcome of the proposed model with different membership functions. Finally, section 6 conclude the article and outlined the future scope.

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II. TYPE-1 AND TYPE-2 FUZZY SYSTEM

Zadeh 1965 [7] has introduced the type-1 fuzzy sets, that helps to design the fuzzy logic system called type-1 fuzzy logic system. It has successfully implemented in many application specifically for the non-linear complex system. But many study state that the type-1 fuzzy logic system fails in handling the uncertainty of data because, it considers the crisp membership function for each input of data. In type-1 fuzzy system, once the membership function is selected, all the uncertainty goes away from the set, for the reason that the type-1 membership functions are fixed. The fixed membership functions leads to the minimal accuracy. To overcome this, the type-2 fuzzy set has been introduced by the Zadeh in 1975. In type-2 fuzzy sets, all the sets are characterized by the membership functions and have three dimensions. The mapping of data is done in the form of fuzzy set i.e. 0 and 1. The third dimension of the type-2 fuzzy systems stores the additional information related to the data, which helps to choose the exact membership functions. The type-1 fuzzy sets consider the crisp membership functions that restrict to model the uncertainty; however, the type-2 fuzzy sets consider fuzzy membership to model the uncertainty of data [11, 15, 17]. If there is not uncertainty in data, then it is treated as type-1 fuzzy set.

III. INTERVAL TYPE-2 FUZZY SYSTEM

Type-1 fuzzy logic system works with the help of crisp set of data and the type-2 fuzzy logic system work on fuzzy set [7, 9-10] of data and the type-2 fuzzy logic systems is able to handle the uncertainty of the data. But still it required more attention to choose the proper membership functions to handle uncertainty efficiently [12].The interval type-2 fuzzy system successful implemented on various field [18-20]. In fuzzy data set there is a possibility of interval of data. The ordinary type-2 fuzzy system is not capable to handle the uncertainty with interval value. To resolve this, the interval type-2 fuzzy system has been introduced by the Zadeh 2005. This technique also has capability to handle the linguistic uncertainty. In this system, one of the fuzzy systems is rule based and the type reducer is required before defuzzification of the data. The process of the interval type-2 fuzzy system is shown in figure 1.

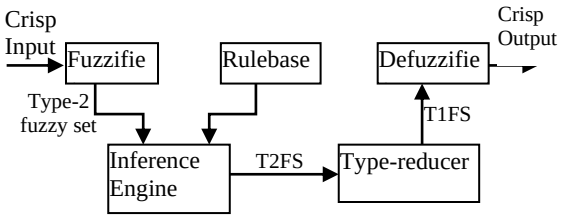
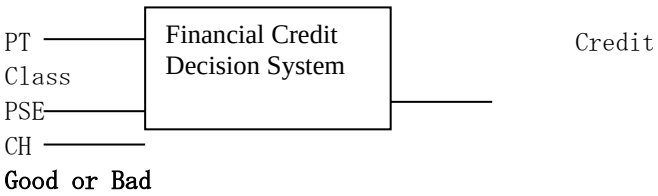


Figure 1: Process of Interval type-2 fuzzy system

IV. IMPLEMENTATION OF PROPOSED MODEL

In this section, we have discussed about the proposed model and their implementations. The proposed model is implemented and tested on German credit approval system data which are downloaded from UCI machine learning repository. The German credit allocation system contains 20 different attributes and every attribute contains a set of features. All those features are considered as a membership function of the particular attribute. In this paper, we have considered only three important attributes, i.e. Property Type of the customer, present employment status and the credit history of the customer. These three attributes plays an important role in credit approval decision system. The proposed credit decision system with the implementation of interval type 2 fuzzy system works as:



Here PT represents the Property Type, PSE represents the present status of Employment and CH represents the Credit History of customers. To classify the credit class of data, the Gaussian membership function has been used [13] and all the computation has been done with the help of online java based toolkit JUZZY [6]. The membership function of the input and the output variables of credit allocation system are shown in figure 2, 3, 4 and 5.

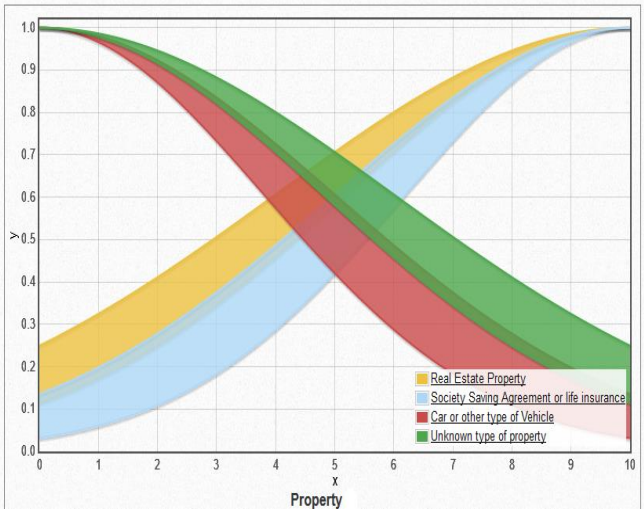


Figure 2: Membership function used for the property attribute.

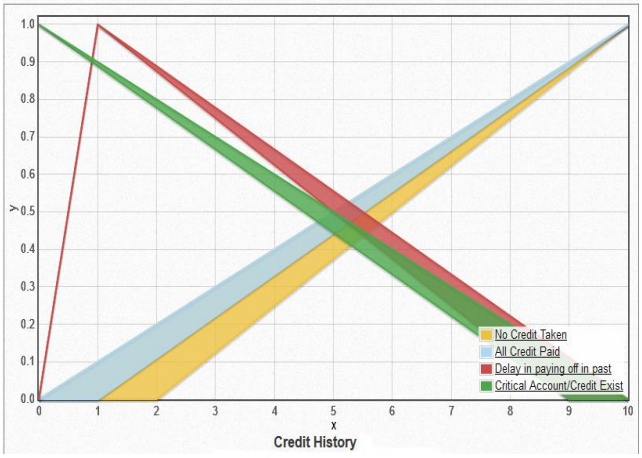


Figure 3: Membership function used for the credit history attribute.

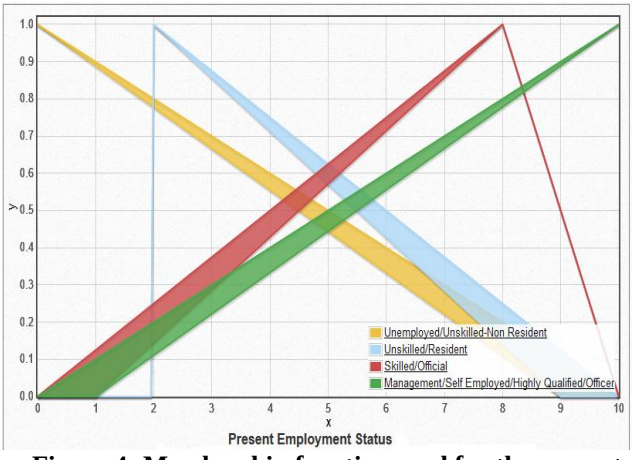


Figure 4: Membership function used for the present employment status attribute.

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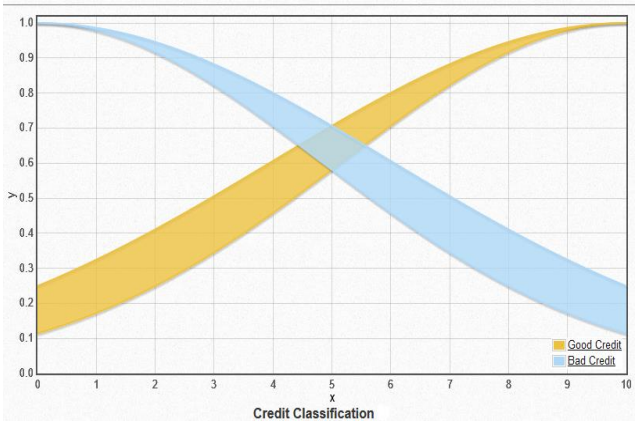

Figure 5: Membership function used for the Credit Class.

German credit data contains many features of a particular attribute but here we have taken only four different types of features for all three input attributes. From figure 2, one can conclude that, if we consider real state property or society saving agreement or life insurance, then there is no chance of bad credit, however, if we consider other two factors, then there is a chance of bad risk. Similarly, if we consider no credit taken or all credit paid, then there is a no chance of bad credit (Figure 3), but, if consider other factors from credit history, then there is a possibility of bad credit. If we consider the present employment of the customer for credit allocation system and consider only skilled and official employee, then there is no chance of bad credit. But other cases may lead to the bad credit (Figure 4). Figure 5 shows the good and bad credit of the customer based on the above discussed three attributes of the German credit data. The second phase of proposed model is the implementation of rules in the dataset. In this model there is a possibility of 32 rules in the rule base. To reduce the system complexity as well as improve the performance of the model, we have consider only eight important rules based on above discussed attributes. The rules are:

1. If Property is Real Estate Property and Present Employment Status is Skilled/Official and Credit History is No Credit Taken then Credit Classification is Good Credit.
2. If Property is Society Saving Agreement or life insurance and Present Employment Status is Skilled/Official and Credit History is All Credit Paid then Credit Classification is Good Credit.
3. If Property is Car or other type of Vehicle and Present Employment Status is Unemployed/Unskilled-Non Resident and Credit History is No Credit Taken then Credit Classification is Bad Credit.
4. If Property is Unknown type of property and Present Employment Status is Unemployed/Unskilled-Non Resident and Credit History is No Credit Taken then Credit Classification is Bad Credit.
5. If Property is Real Estate Property and Present Employment Status is Management/Self Employed/Highly Qualified/Officer and Credit History is Critical Account/Credit Exist then Credit Classification is Bad Credit.
6. If Property is Unknown type of property and Present Employment Status is Management/Self Employed/Highly Qualified/Officer and Credit History is All Credit Paid then Credit Classification is Good Credit.
7. If Property is Real Estate Property and Present Employment Status is Skilled/Official and Credit History is Delay in paying off in past then Credit Classification is Good Credit.
8. If Property is Society Saving Agreement or life insurance and Present Employment Status is Skilled/Official and Credit History is Critical Account/Credit Exist then Credit Classification is Bad Credit.

After implementation of the above discussed rules on the dataset, the antecedent and consequent of input and output is shown in figure 6.

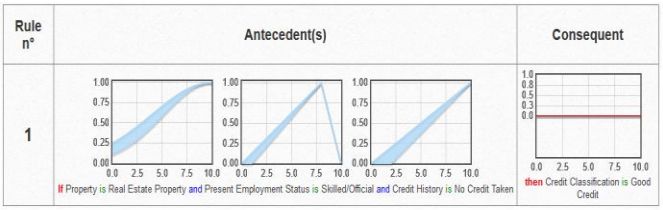

Fig.a: Antecedent and consequent of rule1 on given dataset.

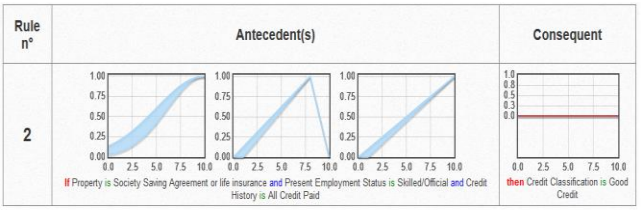

Fig.b: Antecedent and consequent of rule2 on given dataset.

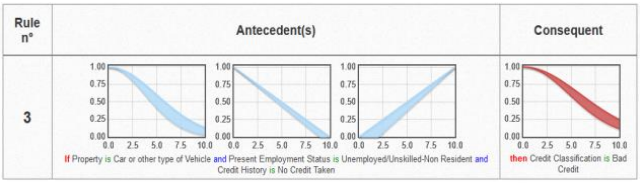

Fig.c: Antecedent and consequent of rule3 on given dataset.

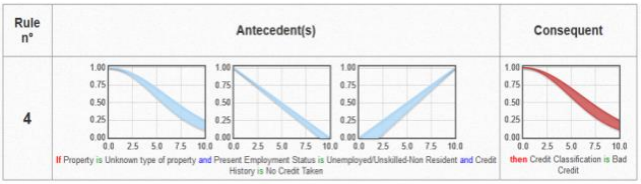

Fig.d: Antecedent and consequent of rule4 on given dataset.

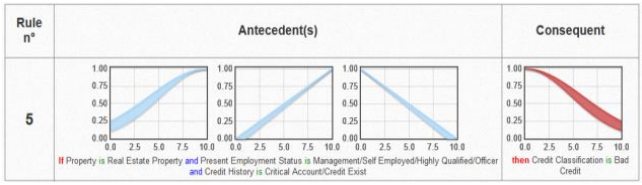

Fig.e: Antecedent and consequent of rule5 on given dataset.

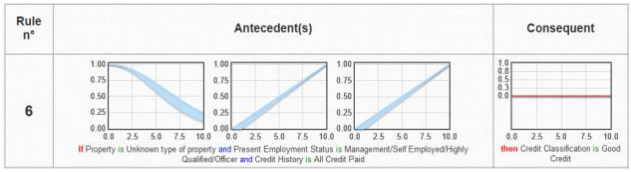

Fig.f: Antecedent and consequent of rule6 on given dataset.

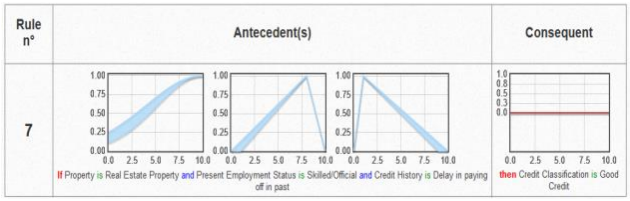

Fig.g: Antecedent and consequent of rule7 on given dataset.

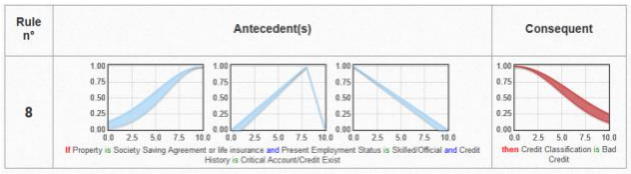

Fig.h: Antecedent and consequent of rule2 on given dataset.

Figure 6: Antecedent and consequent of all rules on given dataset.

Further, the model is implemented on interval type-2 fuzzy system with two different membership functions such that Triangular and Gaussian membership function.

Triangular function: defined by a lower limit X, an upper limit Y, and a value P, where P < N<Q.

$$\mu_A(Y) = \begin{cases} 0, & Y \le P \\ \frac{(Y-P)}{(N-P)}, & P < Y \le N \\ \frac{(Q-X)}{(Q-N)}, & N < Y < Q \\ 0, & Y \ge Q \end{cases} \quad (1)$$

Gaussian function: defined by a central value C and a standard deviation D> 0.

$$\mu_A(Y) = e^{\frac{-(Y-C)^2}{2D^2}} \quad (2)$$

We have implemented the proposed model on the given data set using two different approaches one is Triangular Membership Function Based Approach and another one is Gaussian Membership Function Based Approach. First, we have designed the membership function for three main attribute of the credit classification system such as type of property, present employment status and credit history with the help of Triangular and Gaussian membership function. After that, we have computed the antecedent and consequent for all eight rules discussed in previous section. Further centroid type-reduce has been performed on the output of the Triangular and Gaussian based approach. Finally, the defuziffication has been performed after centroid based reduction. All of the above computation is done in the Mamdani fuzzy inference system [8, 14].

a. Triangular MFs Based Approach

Here, the triangular Membership function based approach is used to for both type-1 as well as type-2 fuzzy set of data. The triangular membership function used for type-1 and type-2 fuzzy set for attribute Property, current employment status and credit history is shown in figure 7.

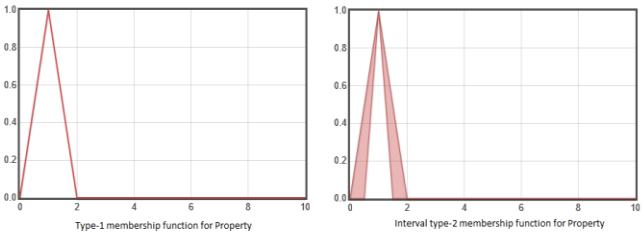

Fig.a: Type-1 and Interval type-2 membership function for Property.

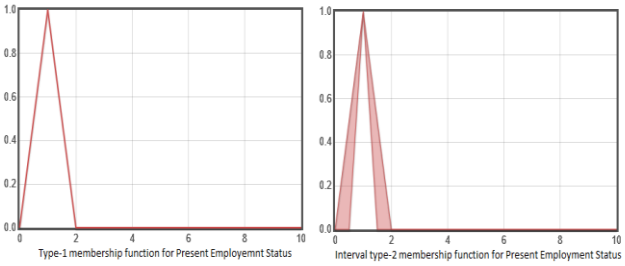

Fig.b: Type-1 and Interval type-2 membership function for Present Employment Status.

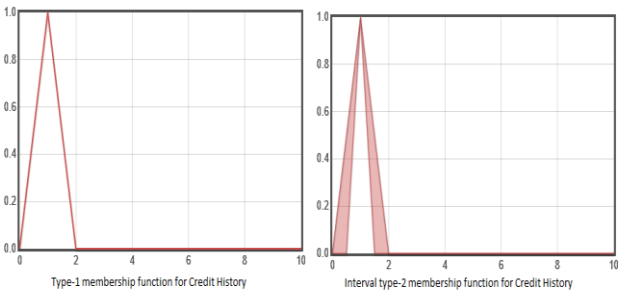

Fig.c: Type-1 and Interval type-2 membership function for credit history.

Figure 7: Comparative analysis of type-1 and interval type-2 membership with Triangular and Mamdani.

After that the antecedent and consequent of input and output for type-1 and interval type-2 fuzzy system has been computed with Triangular and Mamdani type model[8]. The antecedent and the consequent of input and output for type-1 and interval type-2 is shown in figure 8 and 9.

Figure 8: Output of type-1 credit classification system with all 8 rules with Triangular membership function.

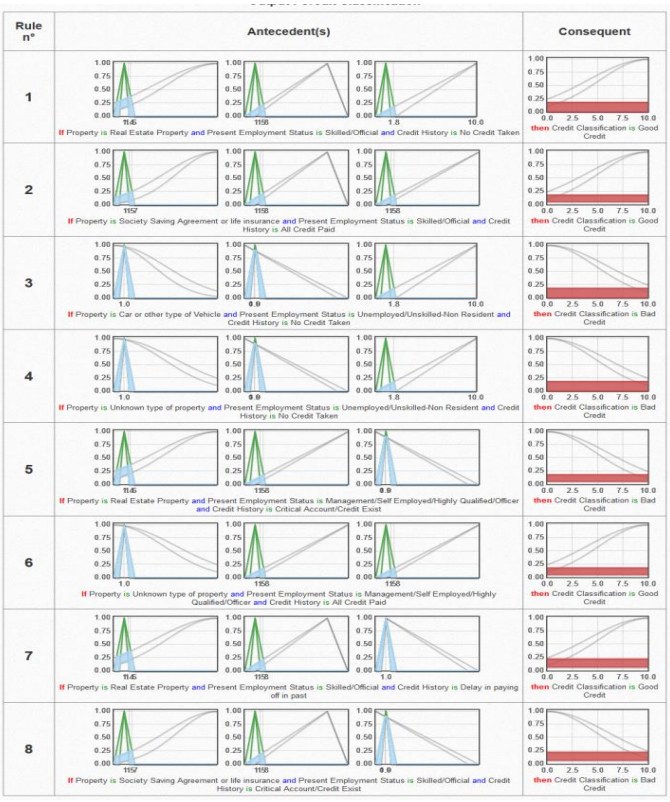

Figure 9: Output of interval type-2 credit classification system

b. Gaussian MFs Based Approach

In the Gaussian MFs based approach input types are used as Gaussian and Mamdani views of type-1 and interval type-2 membership functions with the selected criterion are shown in figure 10.

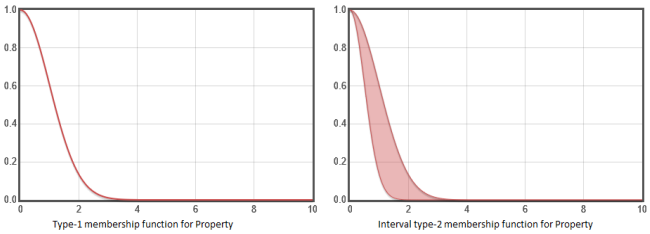

Fig .a: Type-1 and Interval type-2 membership function for Property

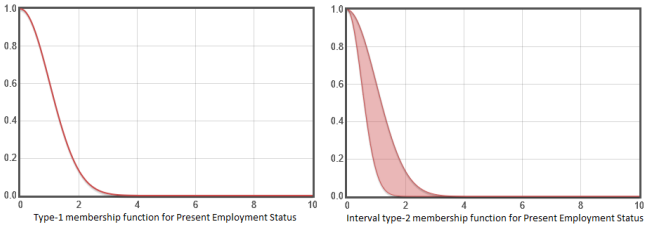

Fig .b: Type-1 and Interval type-2 membership function for Present Employment status.

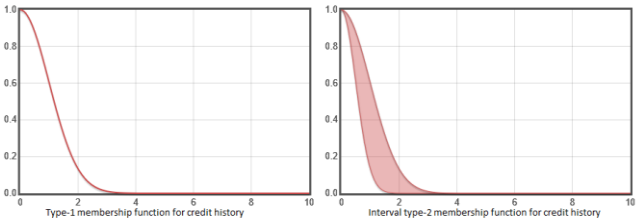

Fig .c: Type-1 and Interval type-2 membership function for Credit History

Figure 10: Comparative analysis of type-1 and interval type-2 membership functions.

After that the antecedent and consequent of input and output for type-1 and interval type-2 fuzzy system has been computed with Gaussian and Mamdani environment. The antecedent and the consequent of input and output for type-1 and interval type-2 is shown in figure 11 and 12.

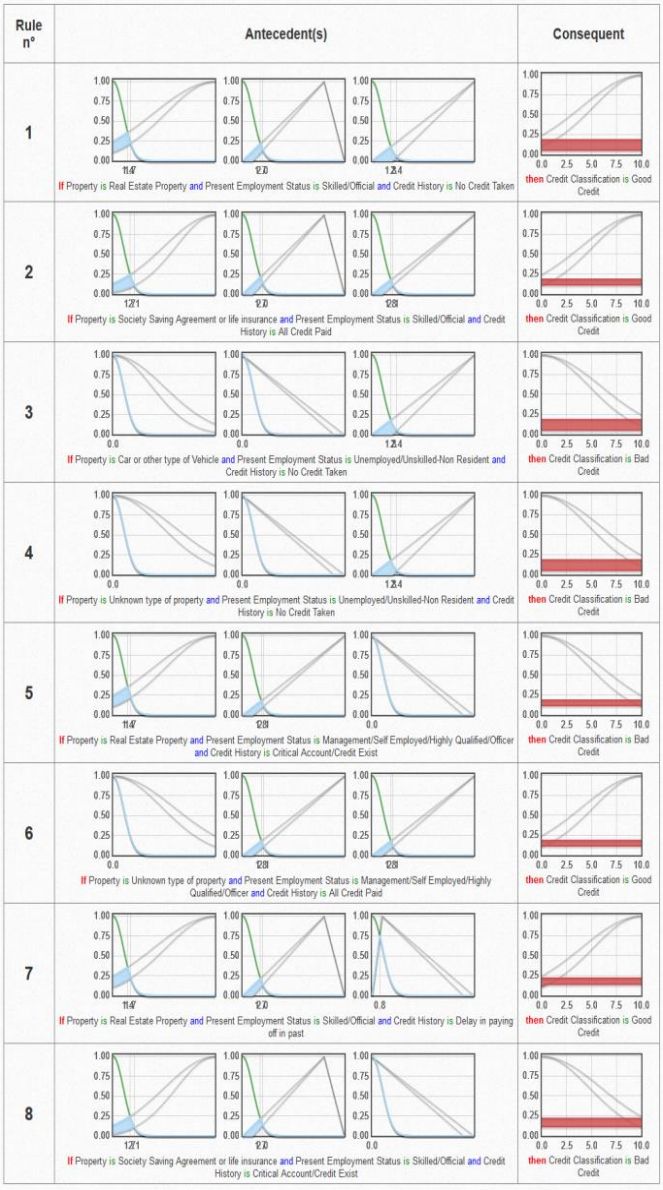

Figure 11: Output of type-1 credit classification system with all 8 rules for Gasusian with Mamdani type.

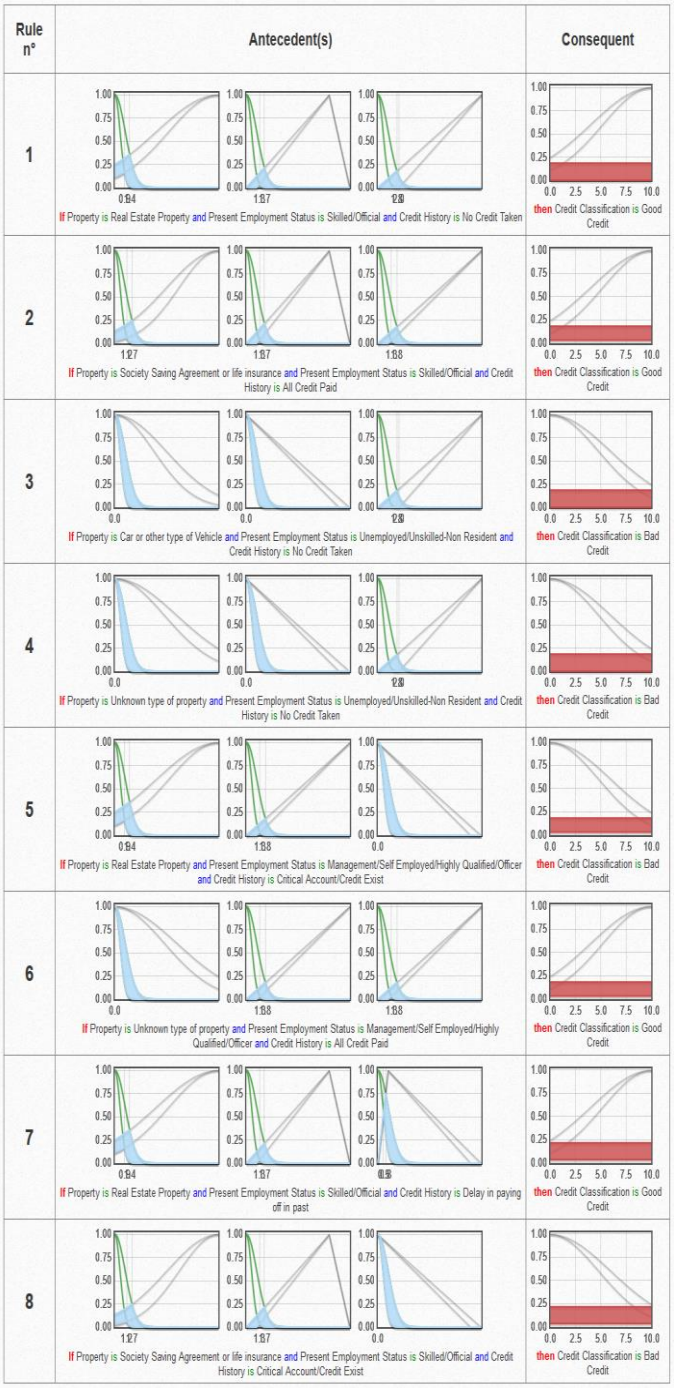

Figure 12: Output of Interval type-2 credit classification system with all 8 rules for Gasusian with Mamdani type.

V. RESULTS AND ANALYSIS

To find the appropriate approach with accuracy of the classification and used membership function, defuzzification has been performed with the help of centroid type reduction. The result of the defuzzification of both fuzzy systems with both membership functions is shown in Table 1.

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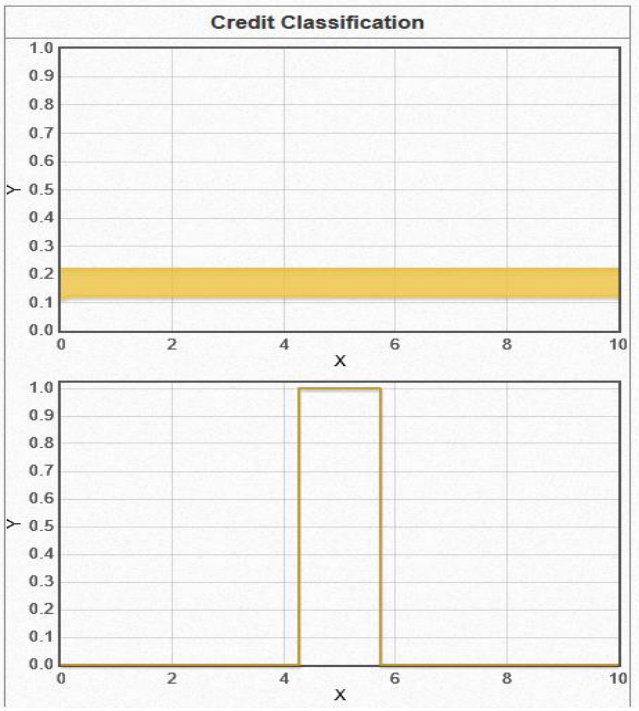
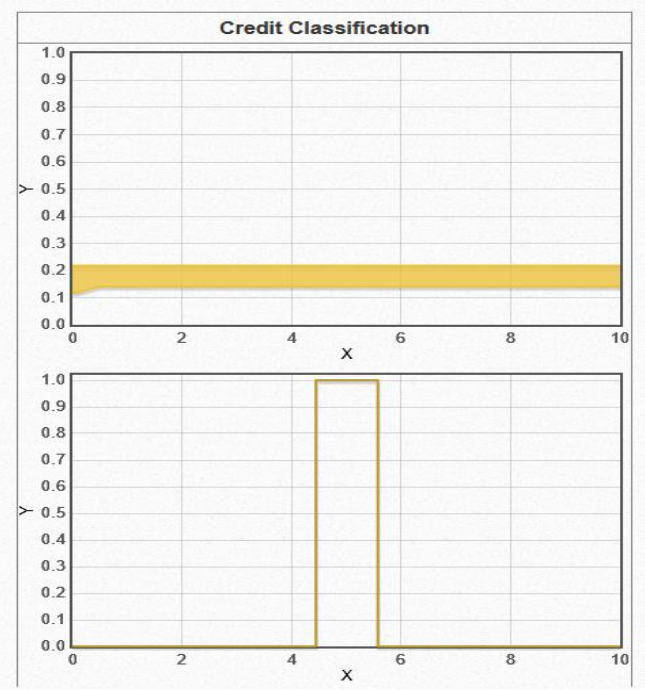
Table 1: Result of the defuzzification of both fuzzy system.

Input / Type / Fuzzy System	Triangular MFs	Gaussian MFs
Type-1	**Credit Classification :** [4.269561284486662, 5.7347014949634] **Defuzzified: 5.0021313897250455**	**Credit Classification :** [4.446032880629018, 5.5767474748664325] **Defuzzified : 5.011390177747725**
Interval Type-2	**Credit Classification :** [3.519201562160993, 6.480798437839009] **Defuzzified : 5.000000000000001**	**Credit Classification :** [2.9202279540827334, 7.0797720459172675] **Defuzzified : 5**

Result of credit classification system for type-1 fuzzy system using Triangular and Gaussian membership is shown in figure 13.



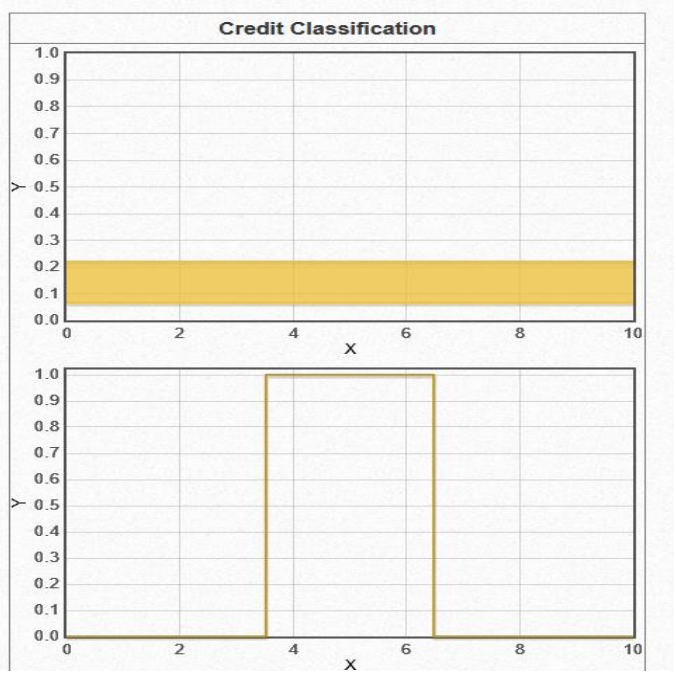
a: Classification result of the Type-1 fuzzy system with Triangular membership function.



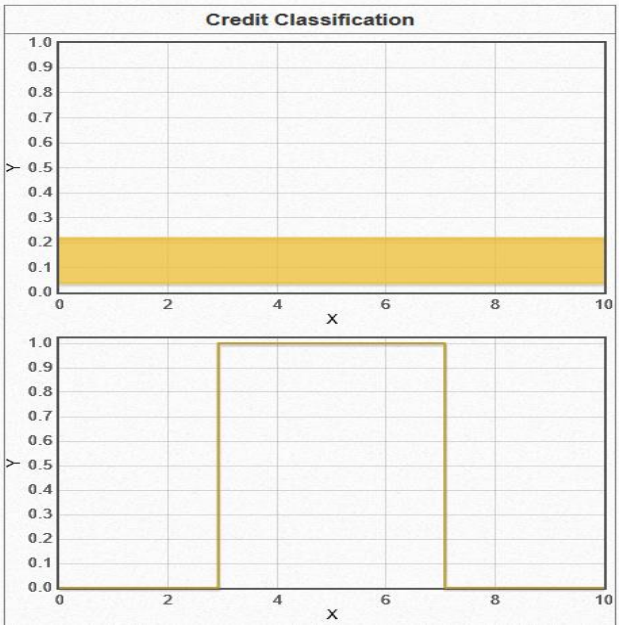
b: Classification result of the Type-1 fuzzy system with Gaussian membership function.

Figure 13: Result of the credit classification system based on fuzzy type-1 using Triangular and Gaussian membership function.

Result of credit classification system for Interval type-2 fuzzy system using Triangular and Gaussian membership is shown in figure 14.



a: Classification result of the Interval Type-2 fuzzy system with Triangular membership function.



b: Classification result of the Interval Type-2 fuzzy system with Gaussian membership function.

Figure 14: Result of the credit classification system based on fuzzy interval type-2 using Triangular and Gaussian membership function.

From above it has been observed that interval type-2 classification is more accurate than type-1 and further Gaussian MFs based approach is more suitable than triangular approach. Hence Gaussian interval type-2 classification is best approach for financial credit decision. Finally, we have performed mapping between attributes to know the possible inference of the attribute in the classification and decision making. In this context, the mapping between Property and Credit history has been done in interval type-2 fuzzy system with Gaussian input type. Result of mapping between property and credit history is shown in figure 15.

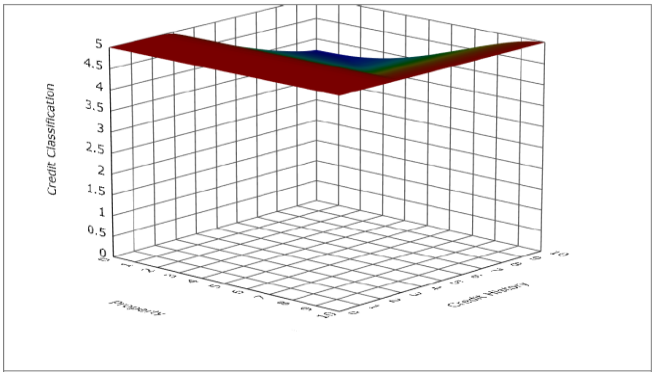


Figure 15: Mapping between Property and Credit history in interval type-2 fuzzy system with Gaussian input type.

Further, the mapping between property and present employment status with the help of Gaussian input has also been performed, shown in figure 16.

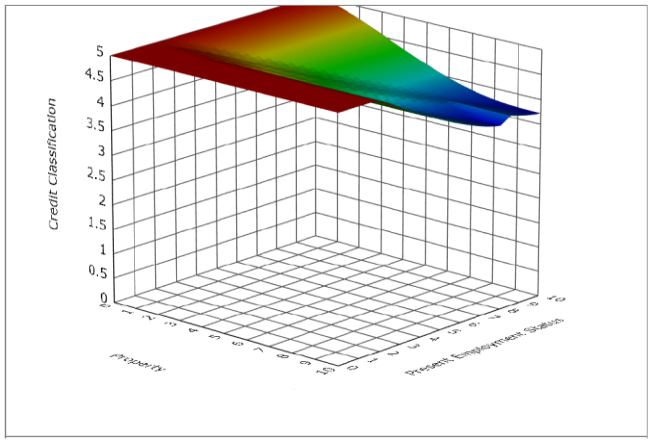


Figure 16: Mapping between Property and Present Employment Status in interval type-2 fuzzy system with Gaussian input type.

From the above, we can conclude that the financial credit decision has been made simple and accurate with the help of interval type-2 fuzzy system using Gaussian membership function.

VI. CONCLUSION AND FUTURE SCOPE

In this paper, a simplified interval type-2 fuzzy system with Gaussian and Triangular membership function is introduced, implemented and tested on standard benchmark data of German credit system and the interval type -2 financial credit decision system with Gaussian membership function gives the accurate classification. This system provides a fair and transparent system to take decision related to the credit granting system. The proposed credit decision system can be used in other decision support systems wherever uncertainty of data occurs. In this research, we have considered a single objective to take the decision. In future this system can be improved taking into consideration of multi objective and also performance of the system in terms of accuracy and interpretability can be improved with the help of Multi Objective Evolutionary optimization which may give more balanced results in terms of performance compared to the discussed model in this paper.

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