

# FUZZY LOGIC BASED TOOL FOR LOAN RISK PREDICTION

Sangeet Kumar<sup>1</sup>, Nitin Bhatia<sup>2</sup> and Namarta Kapoor<sup>3</sup>

<sup>1,2&3</sup> Assistant Professor, Department of Computer Science, DAV College, Jalandhar-144008, India.

## ABSTRACT

*Loan risk is a major decision for any financial organization like banks or for decision maker for loan applicant. The uncertain domain of risk assessment has long been in need of a reliable and consistent system to help simplify the decision making process. Fuzzy Logic provides a completely different, unorthodox way to approach a control problem. This method focuses on what the system should do rather than trying to understand how it works. One can concentrate on solving the problem rather than trying to model the system mathematically, if that is even possible. This almost invariably leads to quicker, cheaper solutions. This research work will help in analysis risk for a loan applicant according to different factors like its job, salary, loan amount and loan period etc. the decision factor helps in making decision about how to select correct loan applicant. Using fuzzy logic decision variable has been defined, new rules defined, according to different rules added and takes average decision based on questionnaires filled by different categories of applicant's. The analysis of case studies shows the consistency and effectiveness of the approach in making correct decision.*

**Keywords:** Fuzzy logic, Loan risk predictor, Decision support system, MATLAB.

## 1. Introduction

It is very difficult to evaluate risk factors for any financial organization or Bank. The main problem of the research work is that to evaluate different factors about a new loan applicant .so in very short time it is difficult to analyze to whom we will give loan or whom not. As human brain is capable of analyzing few factors regarding new applicant, because every case is new or different even for average experienced person. The question though is how to resolve the pressure from human perception in making a judgment. If humans all follow the same criterion, this being a risk analysis system, then the decision is effectively in the hands of the system and not the user. Traditionally approach attempts to develop a credit risk analysis system based on the fuzzy logic using two structures: traditional fuzzy reasoning of all inputs that map to one single output and stage-wise fuzzy reasoning of input parameters in accordance with their importance. These models are advanced but sometimes complex and can only be understood by specialists [1].

The popularity of fuzzy logic has caught the eyes of many researchers working in risk analysis [2, 3]. The nature of its modeling ensures the decision process is human like and most importantly it captures experienced expert knowledge as it is modeled around company knowledge [3]. Fuzzy logic has been used for decades to embed expert input into computer models.

Many concepts can be implemented using MATLAB fuzzy logic tools. Fuzzy logic tool helps in meet new advancement of technology [3,11]. The expert rules were constructed using the Mamdani fuzzy reasoning in order to adequately analyze the inputs. The defuzzification technique was done using Centroid technique. The implementation of the design is done using MATLAB fuzzy logic tool because of its ability to implement fuzzy based systems [4]. Fuzzy logic plays an important role in diverse areas including banking and finance. Fuzzy logic is introduced into data envelopment analysis (DEA) to workout various environmental parameters to access the performance of banks [5]. Fuzzy Analytic Hierarchy Process (FAHP) and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) methods are integrated to evaluate the performance of banks in turkey [6]. A neural network based approach is presented to predict bank failure [7]. The work is also compared with linear classifier, logistic regression, kNN and ID3. Takagi-Sugeno (TS) probabilistic fuzzy systems is used to analyse the behavior of financial markets [8]. A neuro-fuzzy based model is proposed to differentiate between good credits and bad credits [9]. Fuzzy Multiple Criteria Decision Making (FMCDM) approach is proposed for banking performance evaluation [10]. The work highlights the aspects of evaluation criteria critical for banking performance.

This paper investigates way of fuzzy logic implementation for a loan risk predictor. It's a basically Decision Support system which helps in decision making regarding new loan applicant. The approach

considers all risk influencing input parameters in single stage of the decision making process. Member functions have been plot according to the different input variables and their rules are defined. From different rules added, decision has been taken according to percentage of decision as accepted or rejected. Number of test case has been conducted for this approach for accurate results studies are presented .the rest of the paper is organized as follows: section 2 deals with the design of the proposed system, section 3 describes about the test cases to check the working of loan application and in the last Section 4 concludes the finding of the proposed research work and future or scope of the research work.

## 2. Design of Loan Risk Predictor Tool

In the process of designing a loan risk predictor the most important task is to identify those factors that contribute primarily to a financial company’s decision concerning loan applications. In order to identify the process and influencing factors those contribute to an applicant’s loan assessment, the analysis work of an experienced loan officer at a local branch was observed for different scenarios. After discussion with the loan officer we identified the seven main factors: age, income, job stability, assets, loan amount, loan period and job held the rating factor is the most important factor which carried the same bearing as the other seven factors put together.

Different parameters and their descriptions regarding loan applicants are:

Table 1: Parameters chosen and relative input levels.

Parameters	Impact	Impact Levels
Age of applicant	Positive	Low, Medium, High
Income of applicant	Negative	Very High, High, Average, Low, Very Low
Stability of the income	Negative	Low, Medium, High
Assets of applicant	Negative	Very High, High, Average, Low, Very Low
Loan amount applied	Positive	Low, Medium, High
Loan period applied	Negative	Low, Medium, High
Status of job held/business	Negative	Very High, High, Average, Low, Very Low

The impact levels of various parameters can be set or change according to the system of the different financial organization. We provided sample survey forms to 40 (forty) different competent persons like Bank managers, Insurance consultants Teachers, Financial managers etc. giving them a set of fictitious data randomly chosen. The survey resulted in recommended decision by these people. A percentage of acceptance and rejection recommended by the survey results is taken into consideration while framing the rules of fuzzy inference system. The sample data provided in survey and the corresponding percentages is shown in appendix A.

The procedure resulted in 80 rules whereby we accept or reject a particular application on the basis of the chosen parameters with fuzzy membership. We use max aggregation and Centroid function for Defuzzification and Gaussian membership functions for all parameters. The GUI based tool is developed according to different rules added, which is developed using MATLAB tool as shown in fig 1(a) and corresponding recommended decision by the proposed tool is shown in fig 1(b).

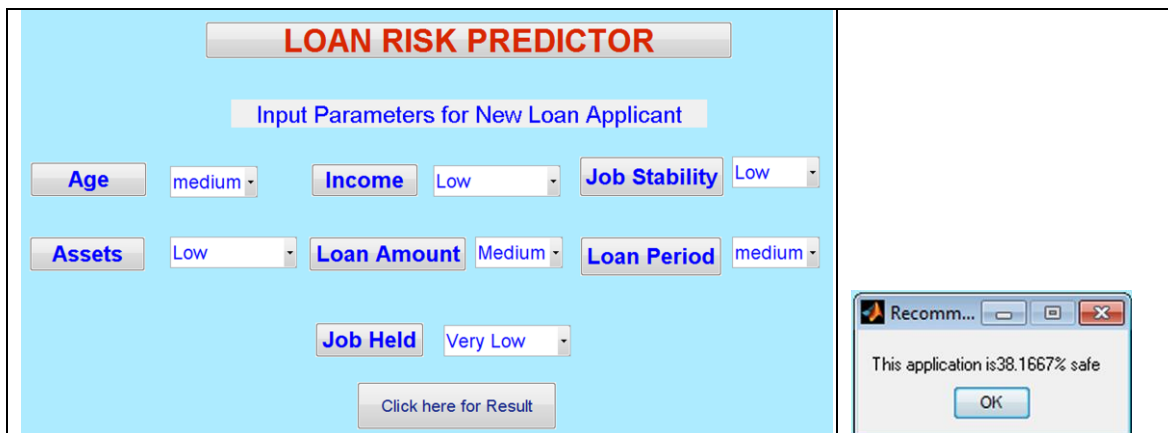


Fig 1(a): Loan risk predictor application window 1(b) Decision recommended by the proposed tool.

### 3 Case Studies

In case studies, the details of different four applicants are summarized in Table 1 and according to seven parameter's inputs are given in table .according to these seven parameters of applicant decision has to be decided. The decision parameter score of each applicant is between 0 and 1.for Applicant 1 age is low but income is good and job stability seems to be high, if we consider assets its average and he/she wants medium loan amount and opted high loan period bud his/her job held is good so from these parameters out decision tool gives 0.795 output which is considered to be very low risk factor. If we consider applicant 2 which is risky applicant according to the data given in table 1 for applicant 1 the output given my our tool is 0.1151.applicant 3 score is average for different inputs of different parameters, so it depends upon the loan company or any other financial organization to allow these type of applicant or not. In the last applicant 4 seems to be average very strong applicant and there is a minimum risk for credit loan to applicant 4 according to the different parameters.

Table 2: Details of applicant's profiles

Applicants	Age	Income	Job stability	Assets	Loan Amount	Loan Period	Job Held	Fuzzy Decision	Recommended Decision
Applicant 1	Low	Good	High	Average	Medium	High	Good	0.795	Accepted
Applicant 2	High	Low	Medium	Low	Medium	Low	Very low	0.1151	Rejected
Applicant 3	Medium	Good	High	Good	High	High	Good	0.515	Accepted
Applicant 4	Low	Very good	High	Very good	Low	Medium	Very low	0.9148	Accepted

### 4. Conclusion

A fuzzy logic based loan risk predictor system is developed to assist financial organizations in decision-making. The fuzzy knowledge base has been developed capturing an expert knowledge on dealing with different scenarios. It can be Medium treated as an expert to the Banks during credit loan process or choosing right applicant for loan. A simple GUI based application which is developed using MATLAB tool is simple and easy to understand. The main focus of the case studies revolves around the processing of four varied loan applications. From different cases of four applicants in case study, it is very clear to analysis decision whether accepted or rejected according to different inputs parameters for particular applicant. From this research paper, another research scholar's and students can take idea about the application of fuzzy logic in new research areas.

#### 4.1 Appendix A

Following is average sample survey form provided to 40 different assessors to evaluate the candidature of various applicants whose parameters are selected randomly. The assessors provided us with the recommended decision in terms of accepted or rejected for each case. The table 3 contains the percentage of affirmative decisions and negative decision in the last two columns respectively.

Table 3: Sample cases provided to assessors for recommendation and percentage of recommended decisions

Age	Income	Stability	Assets	amount	Period	Job held	Percentage	
							Accepted	Rejected
Low	Good	low	Low	Low	High	Very good	90%	10%
Medium	Very low	High	Very low	Medium	Medium	Good	75%	25%
Low	Average	High	Very good	High	Low	Average	80%	20%
High	Very low	Low	Very low	Low	High	Low	50%	50%
Medium	Average	Medium	Good	Medium	Medium	Very low	75%	25%
High	Good	High	Very good	Medium	Low	Very good	95%	5%
Low	Average	High	Average	High	High	Low	30%	70%
Medium	Low	Medium	Average	Low	High	Good	35%	65%
Medium	Good	Low	Very low	Low	Medium	Good	95%	5%
Low	Very low	Low	Very low	High	Low	Average	10%	90%
Low	Average	High	Very good	Medium	High	Average	45%	55%
High	Good	High	Good	Low	Medium	Low	30%	70%
Low	Good	Medium	Good	Low	Medium	Very low	25%	75%
Medium	Low	Low	Very low	Medium	High	Average	15%	85%
High	Very low	High	Low	High	Low	Good	45%	55%
Medium	Average	Medium	Very good	Low	Low	Good	90%	10%
Low	Average	High	Very low	Medium	Medium	Average	25%	75%
High	Very low	Low	Good	High	High	Low	80%	20%

Medium	Average	Medium	Average	High	Low	Very good	90%	10%
Low	Good	Low	Very low	Medium	High	Good	35%	65%
High	Very low	Low	Very good	Low	Low	Average	25%	75%
Medium	Average	High	Very good	High	Medium	Very low	30%	70%
Low	Very good	Medium	Average	Medium	High	Very good	85%	15%
High	Low	Medium	Good	Medium	High	Very good	15%	85%
Medium	Very low	Low	Very good	High	High	Average	35%	65%
Medium	Average	High	Low	Low	Low	Very low	30%	70%
High	Low	Low	Average	High	Medium	Average	30%	70%
High	Good	Medium	Average	Medium	Medium	Good	35%	65%
High	Very good	Low	Very low	High	High	Good	60%	40%
Low	Good	High	Very good	Low	Low	Average	90%	10%
Low	Average	Medium	Low	Medium	Medium	Very low	30%	70%
High	Very good	Low	Average	Low	High	Very good	80%	20%
High	Very good	High	Average	High	Low	Low	60%	40%
High	Very low	Medium	Very low	High	High	Very good	30%	70%
high	Average	Low	Good	Low	Medium	Low	60%	40%
High	Good	High	Good	Medium	High	Very low	70%	30%
Low	Very good	Medium	Average	High	Low	Very low	70%	30%
high	Average	Low	Very low	Medium	Medium	Average	80%	20%
Low	Low	Low	Very low	High	Low	Low	00%	100%

**References:**

- [1] K. Dahal, Z. Hussain and M.A. Hossain, "Loan Risk Analyzer based on Fuzzy Logic", Proceedings of the IEEE International Conference on e-Technology, e-Commerce and e-Service (EEE'05) on e-Technology, e-Commerce and e-Service, 2005.
- [2] S. Shah, "Measuring Operational Risk Using Fuzzy Logic Modeling", Available at: <http://www.irmi.com/Expert/Articles/2003/Shah09.aspx>.
- [3] A.Z. McCord, "Fuzzy Logic and Its Applications in Hardware", Senior Seminar, CPSC 491-01, March 4, 2009.
- [4] L.H. Chen and T.W. Chiou, "A fuzzy credit-rating approach for commercial loans: a Taiwan case", Omega Volume 27, Issue 4, August 1999, Pages 407-419.
- [5] D. Wu, Z. Yang and L. Liang, "Efficiency analysis of cross-region bank branches using fuzzy data envelopment analysis", Applied Mathematics and Computation, Volume 181, Issue 1, 1 October 2006, Pages 271-281.
- [6] N. Y. Seçme, A. Bayraktaroğlu and C. Kahraman, "Fuzzy performance evaluation in Turkish Banking Sector using Analytic Hierarchy Process and TOPSIS", Expert Systems with Applications, Volume 36, Issue 9, November 2009, Pages 11699-11709.
- [7] K.Y. Tam and M. Y. Kiang, "Managerial Applications of Neural Networks: The Case of Bank Failure Predictions", Management Science, Vol. 38, No. 7, July 1992.
- [8] J. Berg, U. Kaymak and W. Bergh, "Financial markets analysis by using a probabilistic fuzzy modelling approach", International Journal of Approximate Reasoning, Volume 35, Issue 3, March 2004, Pages 291-305.
- [9] R. Malhotra and D.K. Malhotra, "Differentiating between good credits and bad credits using neuro-fuzzy systems", European Journal of Operational Research, Volume 136, Issue 1, 1 January 2002, Pages 190-211.
- [10] H.Y. Wu, G.H. Tzeng and Y.H. Chen, "A fuzzy MCDM approach for evaluating banking performance based on Balanced Scorecard", Expert Systems with Applications, vol. 36, 2009, pp. 10135-10147.
- [11] Mago, Jagmohan, and Parvinder S. Sandhu. "Model to Evaluate Education System in India using Fuzzy Logic", "Apeejay Journal of Computer Science and Applications", Vol. 1, 2013, pp 21-26.