IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Issue-5, May 2019 E-ISSN: 2347-2693

A Quality Based Software Requirement Prioritization Using Takagi-Sugeno Neuro Fuzzy Inference

A. Sandanasamy[1*], R. Thamarai Selvi[2]

[1,2] Department of Computer Applications, Bishop Heber College, Trichy – 620017

*Corresponding Author: santhansamy@gmail.com

DOI: https://doi.org/10.26438/ijcse/v7i5.642647 | Available online at: www.ijcseonline.org

Accepted: 20/May/2019, Published: 31/May/2019

Abstract-In recent years, the usage of software has increased radically. The dependence on the software places a huge responsibility on the developers to develop a quality software. Developing a cost effective, high quality software becomes a major challenge. Most of the time the software loses its quality and objective, when the software requirements are not implemented. This limitation happens due to improper requirement prioritization. Therefore it becomes significant to prioritize the software requirements. Prioritizing is the act of evaluating requirements to their importance by stakeholders. Over the years, numbers of prioritization methods, techniques and frame works have been devised. In this paper, a novel method of prioritization of software requirements is formulated using Takagi Sugeno fuzzy logic.

Keywords: Fuzzy logic, Software requirement prioritization, Takagi Sugeno Fuzzy Inference, Sugeno Fuzzy Logic.

I. INTRODUCTION

In most software development process, there are various stakeholders who wish to see their requirements implemented in the final software. The stakeholders could be users, customers, product managers, project managers, developers and testers. Each of these stakeholders put forth the requirement of their immediate concern. These requirements may bring different benefits and impose different costs. Sometimes there could be conflicting requirements. [1]

Requirement engineering is a vital part of software development life cycle. Requirement prioritization is a part of requirement engineering which identifies the most important requirements that has to be implemented in the software. As more prospective requirements are specified, careful selection of requirements is needed with available resources and limited time.[2] when a project has insufficient resource, high customer expectation, complicated implementation plan, the significant aspects must be catered beforehand. Thus prioritization of requirement becomes an unavoidable process of software development. Also the software's acceptability level is determined by the level the system has implemented the requirement. Hence eliciting and prioritizing the requirement are a critical factor in building the software.

This article discusses a novel method for prioritizing the software requirements using Takagi Sugeno inference. This paper is organized as follows: Section II describes the related work, Section III presents the proposed requirement prioritization method. Section IV explains the implementation of the proposed method. Section V analyzes the result and Section VI concludes the article.

II. RELATED WORK

As the software has become more multifaceted, requirement prioritization has become an important aspect in ensuring the success of the project. There are several software requirement prioritizing methods have been developed over the years. Many of the methods are quantitative, where a systematic approach is applied in gathering data and assigning values to factors related with requirements.[3] Some methods perform informal grouping and generalization before assigning priorities. [2]

Numerical Assignment is a simple method, which uses nominal scale to grade the requirements as low, medium and high. The name and the number are decided by the requirement engineer. The decision maker has the task of mapping the importance of each requirement to one of the grades. There is a chance of assigning same grade to many requirements. [4]

Table 1. NA Grades

Grade	Meaning
Low	Desirable but its absence does not affect.
Medium	Fundamental requirement and its absence will cause dissatisfaction

High	Crucial requirement and its absence cause the product unacceptable

Luay Alawneh [5] devised a prioritization method which gives importance to the relationship between the needs of the stakeholder and the derived requirements by the way of use cases along with non functional requirements. The new requirements are collected from the stakeholders. The relativeness is computed for the newly elicited requirement and they are prioritized. The cost-value method is used for prioritizing the requirements. The main process is depicted in Figure 1.

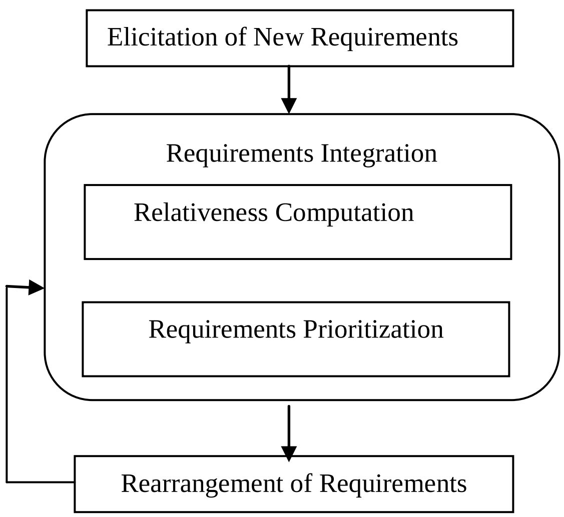


Figure 1: Hierarchical Dependencies Prioritization Steps

Binary Search Tree uses the property of binary tree, where the right node has greater value than the parent and the left node has smaller value than the parent. In the similar way, the requirement with less priority is placed on the left of the parent and requirement with higher priority is placed on the right of the parent. [6]

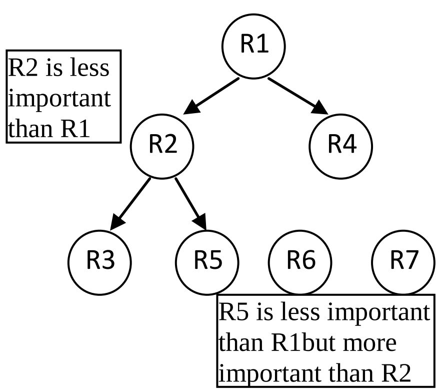


Figure 2 Binary Search Tree

Satty, T. L.,[7] proposed the analytic hierarchy process which uses the decision making process. All the requirements are paired and enumerated and they are ranked in relationship to its pair. It uses a nine point scaling mechanism to find the importance among the requirements. A software project with n requirements will have $n \cdot (n-1)/2$ pair-wise comparisons to make the decision. The most important requirement is assigned a value and the requirement with lesser importance is given reciprocal of that value. If there are three requirements R1, R2, R3, the pair wise comparison of these requirements will have the following result. R1 is more important than R2(intensity 5), R3 is moderately important than R1(intensity (1/3), R3 is very strongly important than R2(intensity 1/7) . Using the above value, the comparison matrix will be formed as given below.

	R1	R2	R3
R1	1	5	1/3
R2	1/5	1	1/7
R3	3	7	1

The priorities are calculated for the above matrix using eigenvalues and results are R1 gets 28%, R2 gets 7%, R3 gets 65%.

III. PROPOSED WORK: SOFTWARE REQUIREMENT PRIORITIZATION USING TAKAGI-SUGENO NEURO FUZZY INFERENCE

Fuzzy logic plays a vital role in knowledge representation sphere. The commonly used fuzzy inference system are Mamdani fuzzy inference and Takagi Sugeno fuzzy inference. The difference between Mamdani fuzzy inference and Takagi Sugeno fuzzy inference is found in defining consequents of fuzzy rules. Mamdani fuzzy inference uses IF-THEN rules with fuzzy propositions in the antecedents and also in consequents. The Mamdani rule is defined below

IF x_1 is A_1 .... x_n is A_n THEN y is B .... (1)

Where x_1 ……. x_n are linguistic variables
A_1 ...... A_n are linguistic terms
Y is the output variable
B is the linguistic term

Takagi Sugeno fuzzy inference uses fuzzy proposition in the antecedent and crisp function in the consequent. The first order Takagi Sugeno FIS rule is defined below

IF x_1 is A_1 .... x_n is A_n THEN $y = C_0 + C_1 . x_1 + ….. + C_n . x_n$…...(2)

Where x_1 ……. x_n are linguistic variables
A_1 ...... A_n are linguistic terms
Y is the crisp function
C_n are crisp values.

The simplest structure of fuzzy inference system is presented in Figure 3.

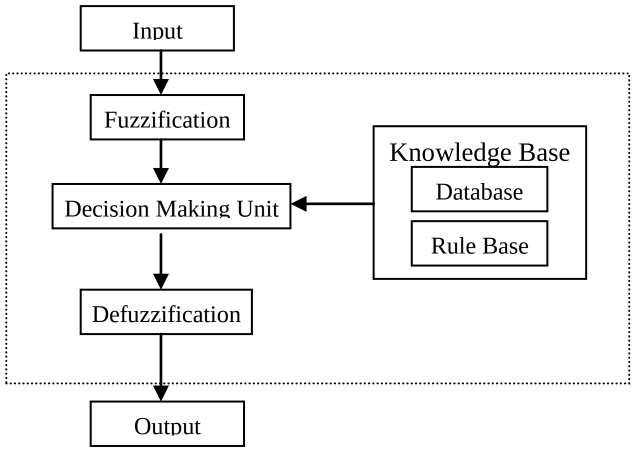


Figure 3: Structure of fuzzy inference

Fuzzification: It is the process where crisp inputs are converted into fuzzy input.
Knowledge Base: It consists of set of fuzzy IF-THEN rules, where antecedents and consequents are connected with fuzzy implication.
Decision Making Unit: It implements the fuzzy reasoning.
Defuzzification: It is the process where fuzzy outputs are converted to crisp output. [8]

The structure includes the following components:

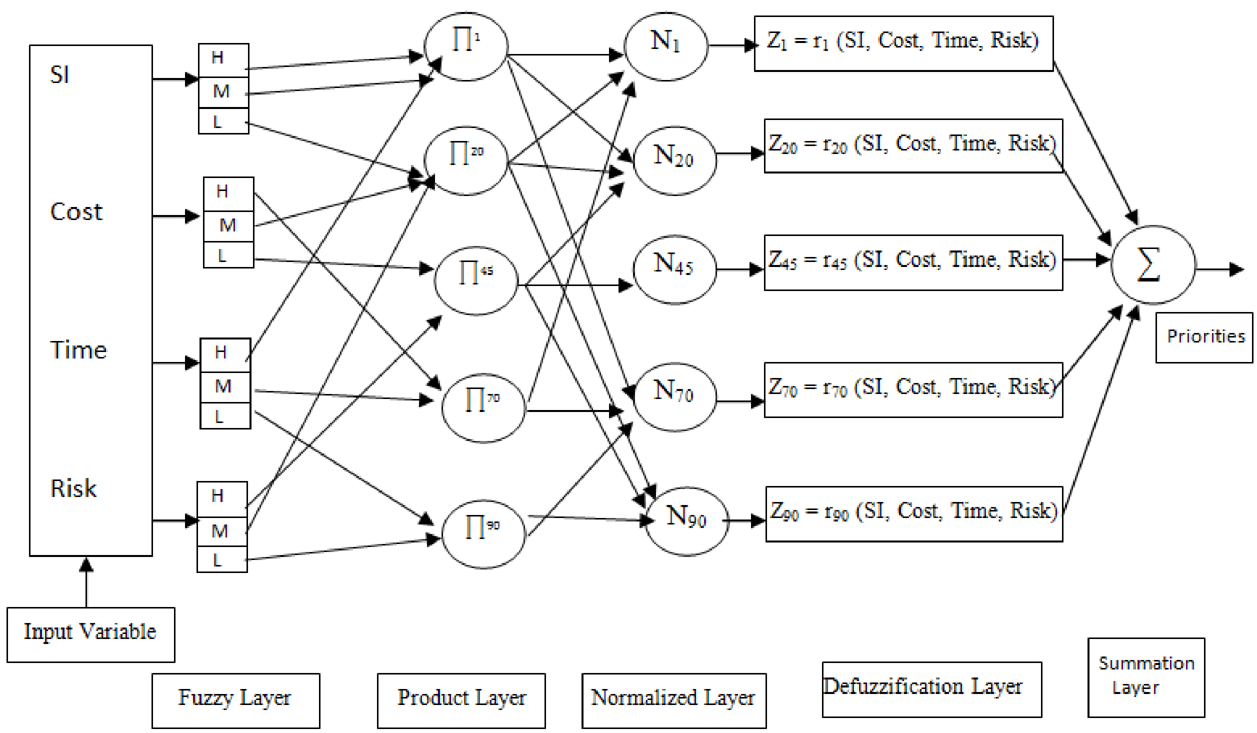


Figure 4: Block diagram of requirement prioritizing using Takagi Sugeno fuzzy inference.

Figure 4 depicts the block diagram of requirement prioritizing using Takagi Sugeno fuzzy inference, where the stakeholder importance (SI), cost, time and risk are provided as the input. The fuzzy linguistic terms are defined for both input and output variables. In the fuzzy layer, the crisp input values are converted to the fuzzy values. In the product layer, weighted factor for each rule is computed. In the normalized layer, the normalized weighted factor is computed. In the defuzzification layer defuzzification is processed.

Procedure for prioritizing the requirements are given below:

Step 1: The requirements are collected from various stakeholders.

Step 2 : The value of Stakeholder Importance is calculated on a scale ranging from 1.0 to 100.0. The 1.0 is assigned for low importance and 100.0 is assigned for high importance. As more number of stakeholders are involved, the value is assigned to each requirement by each stakeholder and they are divided in equal range of groups. Group having highest number of counts will be considered winner and their average value will be considered for input

Step 3: The relative cost to implement each requirement is calculated and assigned on the range from 1.0 to 10.0 .

Step 4: the relative time to implement each requirement is estimated and assigned on the range of 1.0 for short time and 10.0 for long time.

Step 5 : The relative risk associated with each requirement is identified and assigned on the range of 1.0 for less risk and 10.0 for high risk.

Step 6: Stakeholder importance (SI), Cost, time and risk are used as input parameters and priority is used as output parameter in the process of fuzzification and defuzzification.

Step 7: Priority for each requirement is calculated

IV IMPLEMENTATION AND ANALYSIS

Software Requirement Prioritization system using Takagi Sugeno Neuro Fuzzy inference System is designed and experimented in FisPro. FisPro (Fuzzy Inference System Professional) is an open source toolkit for fuzzy inference design and optimization. It is based on fuzzy rules, which have the capability for managing progressive phenomenon. It allows both approaches, such as expert rule design and automatic induction to create more complete and better performing systems. The first step in implementing Takagi Sugeno inference in FisPro is to define the input and output parameters.

The input parameters are SI(stake holder Importance), cost, time, risk. These input parameters are defined with following member functions; LOW, MEDIUM, HIGH as shown in figure 5. The output parameter priority is defined with the member function of VERY LOW, LOW, MEDIUM, HIGH, VERY HIGH as shown in figure 6.

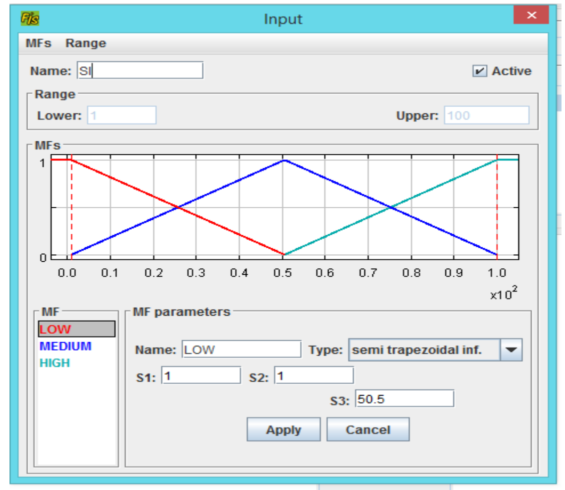


Figure 5: Setting Input Parameter

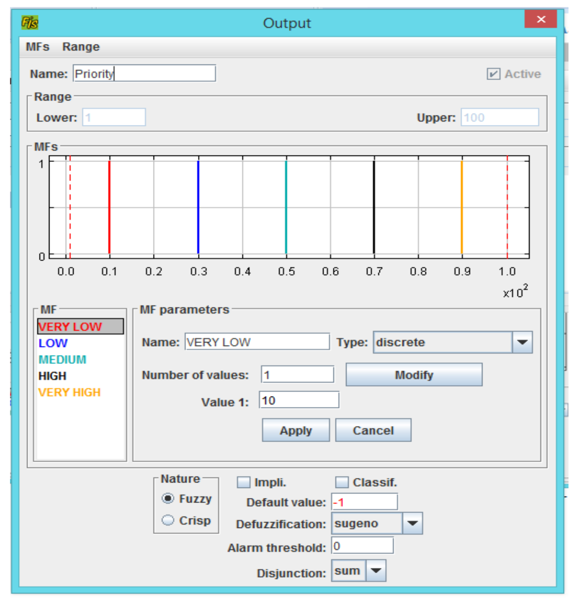
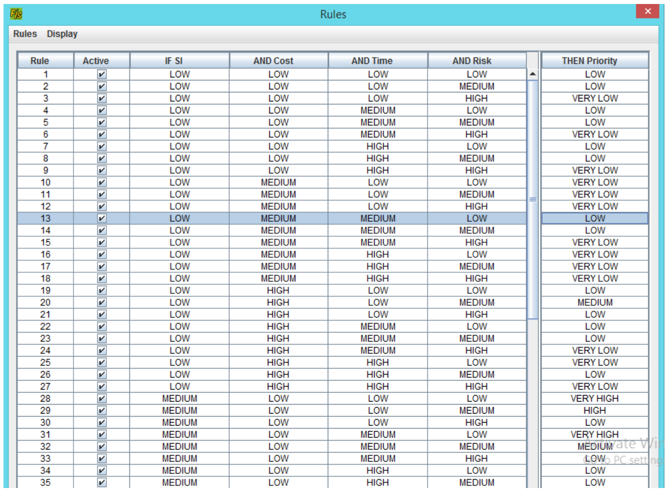


Figure 6: Setting Output Parameter

In order to execute the output function, fuzzy rules should be defined. A fuzzy rule is IF-THEN rule with condition and action. The rules are designed in FisPro using rule edition as shown in figure 7.

Rules are produced by expert judgments and the result provided will help the project to be completed on time, within budget and provide higher customers' satisfaction. Figure 8 depicts the surface view where the relationship between stakeholder importance, cost, time and priority are plotted.



Rule	Active	IF SI	AND Cost	AND Time	AND Risk	THEN Priority
1	✓	LOW	LOW	LOW	LOW	LOW
2	✓	LOW	LOW	LOW	MEDIUM	LOW
3	✓	LOW	LOW	LOW	HIGH	VERY LOW
4	✓	LOW	LOW	MEDIUM	LOW	LOW
5	✓	LOW	LOW	MEDIUM	MEDIUM	LOW
6	✓	LOW	LOW	MEDIUM	HIGH	VERY LOW
7	✓	LOW	LOW	HIGH	LOW	LOW
8	✓	LOW	LOW	HIGH	MEDIUM	LOW
9	✓	LOW	LOW	HIGH	HIGH	VERY LOW
10	✓	LOW	MEDIUM	LOW	LOW	VERY LOW
11	✓	LOW	MEDIUM	LOW	MEDIUM	VERY LOW
12	✓	LOW	MEDIUM	LOW	HIGH	VERY LOW
13	✓	LOW	MEDIUM	MEDIUM	LOW	LOW
14	✓	LOW	MEDIUM	MEDIUM	MEDIUM	LOW
15	✓	LOW	MEDIUM	MEDIUM	HIGH	VERY LOW
16	✓	LOW	MEDIUM	HIGH	LOW	VERY LOW
17	✓	LOW	MEDIUM	HIGH	MEDIUM	VERY LOW
18	✓	LOW	MEDIUM	HIGH	HIGH	VERY LOW
19	✓	LOW	HIGH	LOW	LOW	LOW
20	✓	LOW	HIGH	LOW	MEDIUM	MEDIUM
21	✓	LOW	HIGH	LOW	HIGH	LOW
22	✓	LOW	HIGH	MEDIUM	LOW	LOW
23	✓	LOW	HIGH	MEDIUM	MEDIUM	LOW
24	✓	LOW	HIGH	MEDIUM	HIGH	VERY LOW
25	✓	LOW	HIGH	HIGH	LOW	VERY LOW
26	✓	LOW	HIGH	HIGH	MEDIUM	LOW
27	✓	LOW	HIGH	HIGH	HIGH	VERY LOW
28	✓	MEDIUM	LOW	LOW	LOW	VERY HIGH
29	✓	MEDIUM	LOW	LOW	MEDIUM	HIGH
30	✓	MEDIUM	LOW	LOW	HIGH	LOW
31	✓	MEDIUM	LOW	MEDIUM	LOW	VERY HIGH
32	✓	MEDIUM	LOW	MEDIUM	MEDIUM	MEDIUM
33	✓	MEDIUM	LOW	MEDIUM	HIGH	LOW
34	✓	MEDIUM	LOW	HIGH	LOW	LOW
35	✓	MEDIUM	LOW	HIGH	MEDIUM	LOW

Figure 7: Fuzzy Rules in FisPro

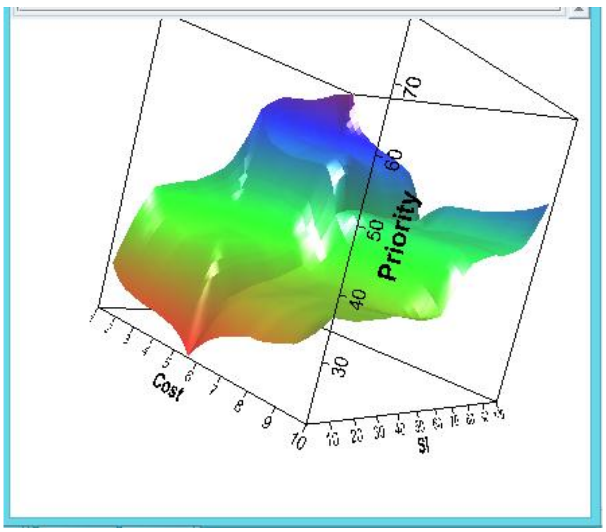


Figure 8: Surface View

V. RESULT

The software requirement prioritization using Takagi Sugeno inference system has been developed using FisPro toolkit. Using the created inference system, priority can be calculated for the requirements of a software . Four input parameters are considered for a requirement such a stakeholder importance, cost, time and risk. Table 2 depicts the requirements from R1 to R10 with their input parameter values. The priority value for these requirements are calculated using infer option in the FisPro toolkit as shown in figure 8. Table 3 shows the priority order of the requirements that are calculated through Takagi Sugeno inference.

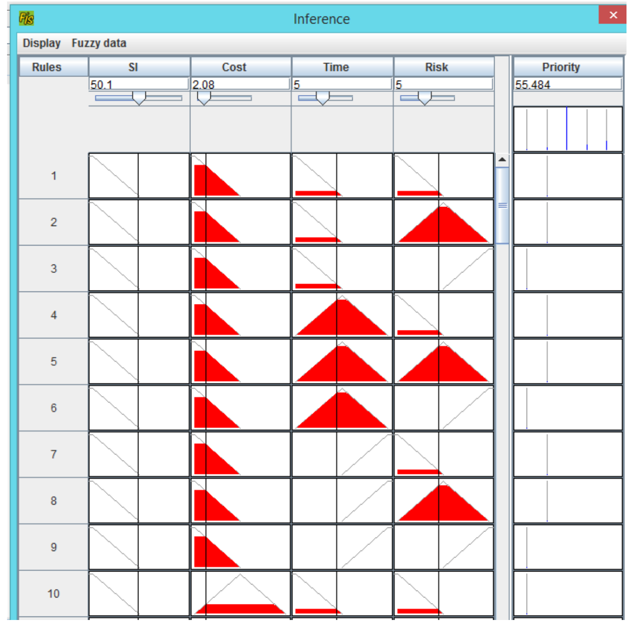


Figure 8: Inference Viewer in FisPro

Table 2: Sample Requirements with Input Parameters

S.No	Req.	SI	Cost	Time	Risk	Priority
1	R1	50	2	5	5	55.4
2	R2	10	6	6	6	26.6
3	R3	92	1	1	1	90.5
4	R4	65	10	6	6	37.5
5	R5	28	1	8	10	14
6	R6	50	1	8	3	48.5
7	R7	30	5	5	2	43.3
8	R8	68	2	2	1	74
9	R9	75	1	1	1	88.5
10	R10	47	6	5	8	33.8

Table 3: Priority Order of Requirements

S.No	Req.	SI	Cost	Time	Risk	Priority
3	R3	92	1	1	1	90.5
9	R9	75	1	1	1	88.5
8	R8	68	2	2	1	74
1	R1	50	2	5	5	55.4
6	R6	50	1	8	3	48.5
7	R7	30	5	5	2	43.3
4	R4	65	10	6	6	37.5
10	R10	47	6	5	8	33.8
2	R2	10	6	6	6	26.6
5	R5	28	1	8	10	14

Table 3 depicts the sorted final result of the requirement prioritization. R3 has got the highest priority with 90.5%. As it is seen, R3 has higher SI and low cost, time and risk. R9 has the next priority of 88.5, where R9 has low SI and higher cost, time and risk than R3. Hence the final result proves that the requirements can be prioritized to produce quality software using Takagi Sugeno inference.

VI. CONCLUSION

A quality based software requirement prioritization using Takagi Sugeno neuro fuzzy inference is developed and tested through FisPro toolkit. The developed inference system will assign priority in a way that the project will be implemented in time, within the budget and provide higher satisfaction of the stakeholder. The rules are generated once can be used for any size of the project. The result proves that as the stakeholder importance is high, cost, time and risk are low, the priority is high. This work can be further developed so as to classify the prioritized requirements as critical, essential, peripheral etc,

REFERENCES

[1] M. Asaem, M. Ramzan and A. Jaffar, *"Analysis and optimization of software requirements prioritization techniques,"* International Conference on Information and Emerging Technologies, karachi, Pakistan, June 2010, pp. 1-6.

[2] Perini, A. Susi, A. and Avesani, P. 2013. "*A Machine Learning Approach to Software Requirements Prioritization"*, IEEE Transactions on Software Engineering., 4(39): 445-460.

[3] J. Azar, R. K. Smith and D. Cordes, "*Value-oriented requirements prioritization in a small development organization,"* IEEE Software, vol.24, no. 1, pp. 32-37, January-February 2007.

[4] Persis Voola, A Vinaya Babu, "*Comparison of Requirements Prioritization Techniques Employing Different Scales of Measurement*"**,** ACM SIGSOFT Software Engineering Notes, July 2013 Volume 38 Number 4

[5] Luay Alawneh, "*Requirements Prioritization Using Hierarchical Dependencies*", Advances in Intelligent Systems and Computing , 2017, pp. 459-464

[6] Manju Khari and Nikunj Kumar *"Comparisons of Techniques of Requirement prioritization*," Journal of Global Research in Computer Science 2013,Volume 4, No. 1, pp.38-43

[7] Saaty, T. L., "*The Analytic Hierarchy Process".* Mc-Graw-Hill, 1980

[8] Igor V. Anikin, Igor P. Zinoviev, "*Fuzzy Control Based on New Type of Takagi-Sugeno Fuzzy Inference System"*, International Siberian Conference on Control and Communications, 2015.