Estimation of Software Quality by using fuzzy (FIS)

Pinky Chandwal, A. S. Zadgaonkar, Abhinav Shukla

***Abstract*—As software are being used in more and more critical areas, therefore quality of software becomes a very important factor for business and human safety. Estimation of software quality is the key for achieving a high quality product. Quality of software is associated with number of quality attributes and estimation of software quality involves broad views and various perspectives which might involve natural description, in linguistic terms. Linguistic terms are more convenient to use when human express the subjectivity and imprecision of their evolution but these linguistic variables involve ambiguity and vagueness. Since fuzzy logic deals with the ambiguity, imprecision and vagueness therefore this study proposes the applicability of fuzzy along with ISO 9126 quality model for developing quality estimation framework.**

***Index Terms*— Quality, Quality attributes, FIS, Rule base, linguistic variable.**

I. INTRODUCTION

Software engineering is driven by three major factors that are Cost, Schedule and Quality. Today quality is main mantra and business strategies are designed around quality. There are many definitions of quality some of them are:-

Acc. to Heritage Dictionary Quality is *"*A Characteristics or attributes of something" [1]. Acc. to Pressman Software Quality is "ensuring that software organization does the right things at the right time in a right way" [1]. Acc. to McCall Software Quality is "a general term applicable to any trait or characteristics whether individual or generic, a distinguishing attribute which indicate a degree of excellence or identifies the basic nature of something*"* [2]. ISO 8402 define Software Quality is "totality of Characteristics of an entity that bear as its ability to satisfy stated and expected needs" [3].Developing high quality software is one of the fundamental goals of software engineering. Because now-a-days Software are used in almost every field like Telecommunication, Genetic Engineering, Education, Medical, Transportation, Entertainment, Industrial Process, Office Products and many more. Software Defects removal are very costly in terms of money and any compromise with the quality may result in the loss of reputation and life; Ariane 5 crash June 4, 1996: Maiden Flight of European Ariane 5 launcher crashed about 40 sec. after takeoff due to software error and lost was about half a million dollars[4]. Software that is delivered on time and within budget and also perform its stated function can't be considered as a high quality product because of many reasons. Some of the reasons are:-

1) Software product may not be user friendly so difficult to understand and use.
2) Software product may not provide any security to data and programs and may be misused.
3) Software product may be difficult or impossible to modify or maintain.
4) Software product may not be compatible with other programs and software in the system so, fail to interact with them.
5) Software product may not be machine independent (portable).
6) Software product may not be as efficient as expected by the client.

From the above discussion we can conclude that Software Quality does not depend upon only budget & schedule but also on so many other factors or attributes. And software quality is the degree to which software possess a desired combination of quality attributes.

II. REVIEW LITERATURE

In the context of software quality estimation different researcher have proposed different methods, techniques and mechanism, time to time, to estimate the software quality. To our knowledge there have been almost no or very little effort devoted to fuzzy logic for the estimation of software quality.

Jyothi G and Ch.Verra babu presents a technique for modeling code readability based on the judgment of human annotators and investigates its relationship to software quality for measuring software quality [5].

An approach for quality estimation is a suite of in-process metrics(strew metric suite) that leverages the software testing effort to provide an estimation of potential software field quality in early software development phases and the identification of low quality software program [6].

Krazysztof Sach provides a mechanism for software quality evaluation. The evaluation is based on set of criteria that are decided by stating questions and finding answer to those questions [7].

Another approach for quality estimation is based on clustering. Clustering technique along with the help of software engineering human expert is used for building a software quality estimation system. The system first clusters hundred of software modules in to small number of coherent group and presents the representative of each group to a software quality expert,

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who labels each cluster as either fault-prone or not fault prone based on his domain knowledge as well as some data statics[8].

Yaun et al also use clustering but with fuzzy to predict the number of faults in software module [9].

A method based on unsupervised learning and clustering is also proposed for quality estimation. An unsupervised approach for extracting principal components from software measurement data use Artificial Neural Network [10]. This study focuses on extracting the principal components for software measurement data. The extracted component are then used to train a supervised neural network based software quality classification model for predicting the quality of software modules as fault prone or not fault prone.

ISO 9126 Quality Model

A series of attempts to define the software quality has been made from time to time; say McCall Quality Model [2], Boehm's Quality Model [11] and many more. For this study, we choose ISO 9126 Quality Model [12].The International Organization for Standardization release ISO 9126 , which is a widely accepted standard for measuring quality of software. It is most widely accepted because it includes both internal and external quality characteristics of a software product.

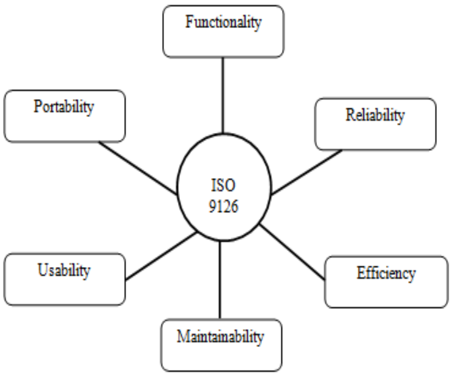

Figure1. ISO 9126 Quality Model

ISO 9126 standard defines six criteria called functionality, reliability, usability, efficiency, maintainability and portability. Each of these criteria consists of several sub criteria as shown in figure A:

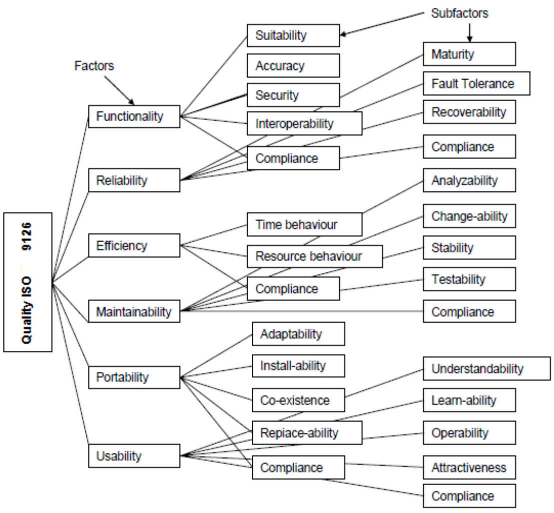

Figure2. Quality attributes and their sub attributes

Each quality factors is defined as follows:

1) *Functionality:* A set of attributes that relate to the existence of a set of functions and their specified properties. The functions are those that satisfy stated or implied needs.

2) *Reliability:* A set of attributes that relate to the capability of software to maintain its level of performance under stated conditions for a stated period of time.

3) *Usability:* A set of attributes that relate to the effort needed for use, and on the individual assessment of such use, by a stated or implied set of users.

4) *Efficiency:* A set of attributes that relate to the relationship between the level of performance of the software and the amount of resources used, under stated conditions.

5) *Maintainability:* A set of attributes that relate to the effort needed to make specified modifications.

6) *Portability:* A set of attributes that relate to the ability of software to be transferred from one environment to another.

III. METHODOLOGY

Fuzzy Logic

The term "fuzzy logic" was introduced with the proposal of fuzzy set theory by Lotfi A Zadeh in1965.Fuzzy logic is based on the concept of fuzzy sets. Fuzzy logic deals with the vagueness and uncertainty. Fuzzy set provides a mathematical framework in which vague conceptual phenomena can be handled efficiently. Fuzzy set theory is a suitable tool to reinforcement the comprehensiveness and correctness to decision making stages; Fuzzy set theory is an important approach to measure the uncertainty of concepts that are associated with human beings subjective judgements in terms of linguistic variables that are often vague. Conceptual theory distinguishes between those element that are the members of the group and those that are not, there being very clear or crisp boundaries. It has two-value logic either true (1) or false (0).In contrast with the traditional set theory, fuzzy set can have varying values that ranges between 0 to 1.The central concept of the fuzzy set theory is the membership function .The membership function is a graphical representation of the magnitude of participation of each input. An element of a fuzzy set can be full member (100% membership) or a partial member(between 0% to 100% membership) that is, membership value of an element is no longer restricted to just two values but can be any value between 0 to 1;So that we can draw definite conclusion from vague and imprecise information[13].

A. *Membership functions*

There is different membership function, some of them are:-

1) Triangular membership function

Consider the temperature and plot the membership function for high, if we plot triangular membership function; we get a graph shown in figure below:

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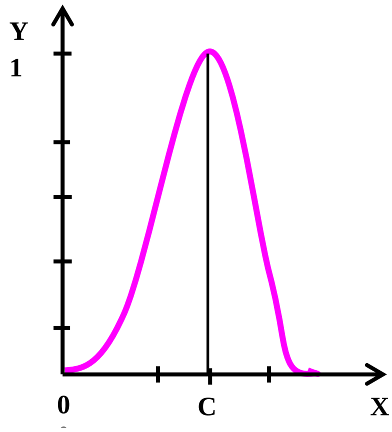

Figure3. Triangular membership function

2) Trapezoidal membership function

Consider the temperature and plot the membership function for low, if we plot trapezoidal membership function; we get a graph shown in figure below:

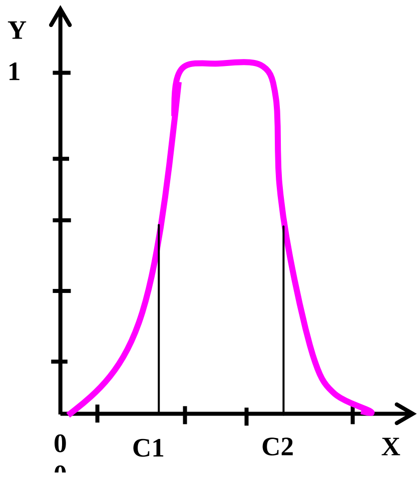

Figure4. Trapezoidal membership function

3) Gaussian membership function

Consider the temperature and plot the membership function for medium, if we plot Gaussian membership function; we get a graph shown in figure below:

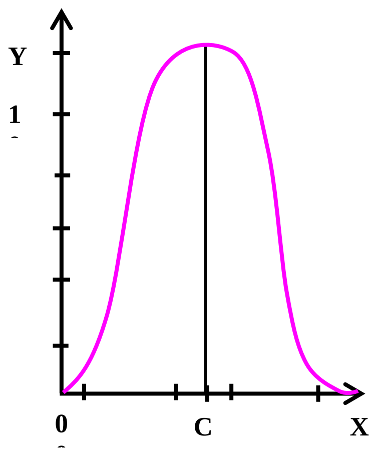

Figure5. Gaussian membership function

B. ***Fuzzy set operations***

1. Intersection of two fuzzy sets.

$$\mu_{AUB}(X) = \mu_A(X) \otimes \mu_B(X)$$

Or

Often $\min[\mu_A(X), \mu_B(X)]$

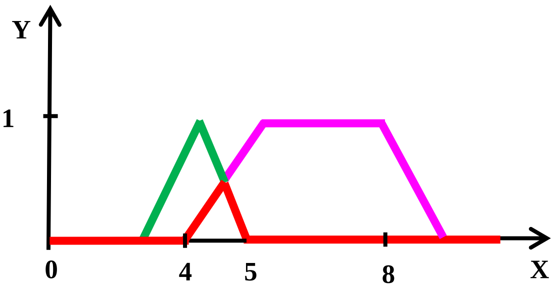

Figure6. Intersection of two fuzzy sets

2. Union of two fuzzy sets.

$$\mu_{AUB}(X) = \mu_A(X) \oplus \mu_B(X)$$

Or

$\max[\mu_A(X), \mu_B(X)]$

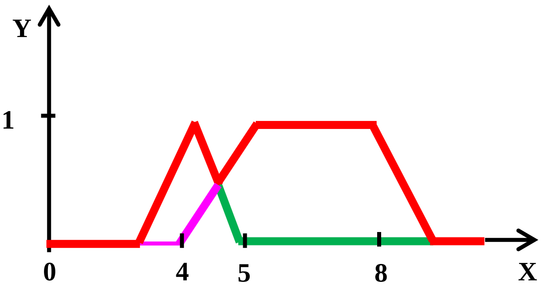

Figure7. Union of two fuzzy sets

3. Complement.

$$\mu_{-A}(x) = 1 - \mu_A x$$

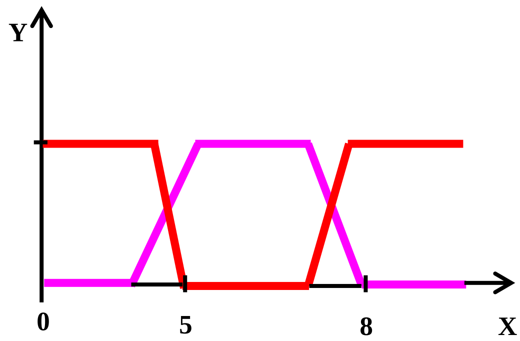

Figure8. Complement

C. ***Fuzzy inference system***

It is the process of formulating the mapping from a given input to an output using rule base.

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1) Fuzzification

To convert the crisp set in to fuzzy set.

2) Fuzzy Rule base

It consists of a set of antecedent-consequent linguistic rule in the form of:

If (temperature is high) and (fan is slow) then cooling is started.

If (temperature is low) and (fan is fast) then cooling is stopped.

3) Defuzzification

To extract the crisp value from fuzzy set

Mat lab Fuzzy Logic Toolbox

For implementation we use Met lab environment with fuzzy logic tool box [14].

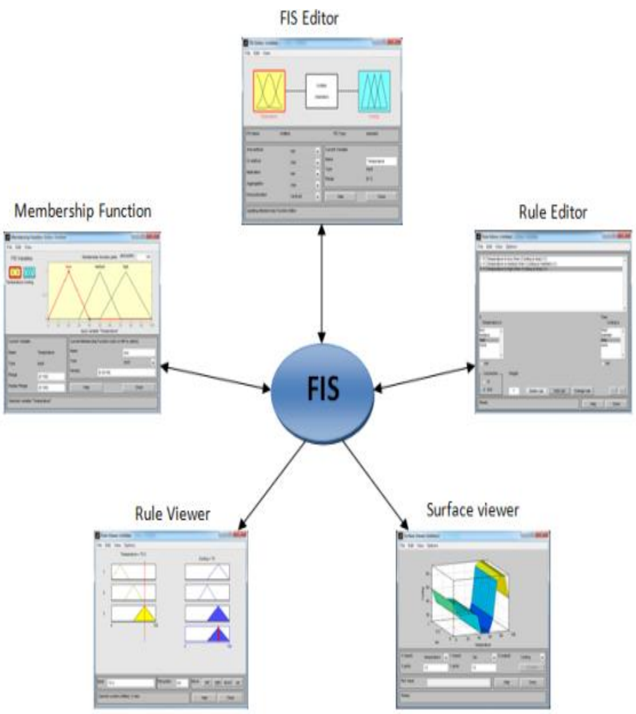

Figure9. Mat lab Fuzzy Logic Toolbox

1) Fuzzy Editor

It handles issues like name and number of input, output variables.

2) Rule Editor

It is used for developing and editing the list of rules that describes the behavior of the system.

3) Membership Function

It is used for defining and editing membership value and their shape associated with each variable.

4) Rule and Surface viewer

They are strictly read-only tools and are used for looking at, as opposed to editing to FIS.

IV. FRAMEWORK DEVELOPMENT FOR QUALITY ESTIMATION

For this study input parameters are the different attributes of quality that are defined by the ISO 9126 model.

INPUT PARAMETES	OUTPUT PARMETER
1. Functionality	1. Quality
2. Reliability	
3. Usability	
4. Efficiency	
5. Maintainability	
6. Portability	

Table1. Show input parameters and there range with respect to linguistic Variables

INPUT	INPUT NAME	LINGUISTIC VARIABLE	RANGE
INPUT 1	FUNCTIONALITY	LOW	0-40
		MEDIUM	20-60
		HIGH	50-100
INPUT 2	RELIABILITY	LOW	0-40
		MEDIUM	20-60
		HIGH	50-100
INPUT 3	USABILITY	LOW	0-40
		MEDIUM	20-60
		HIGH	50-100
INPUT 4	EFFICIENCY	LOW	0-40
		MEDIUM	20-60
		HIGH	50-100
INPUT 5	MAINTAINABILITY	LOW	0-40
		MEDIUM	20-60
		HIGH	50-100
INPUT 6	PORTABILITY	LOW	0-40
		MEDIUM	20-60
		HIGH	50-100

Table2. Show output parameter and its range with respect to linguistic Variables

OUTPUT	OUTPUT NAME	LINGUISTIC VARIABLE	RANGE
OUTPUT 1	QUALITY	POOR	0-50
		GOOD	35-95
		BEST	90-100

A. Fuzzification

It is the process of converting crisp value into a range of membership for linguistic terms of fuzzy set. The membership function is used to set the range for each linguistic variable.

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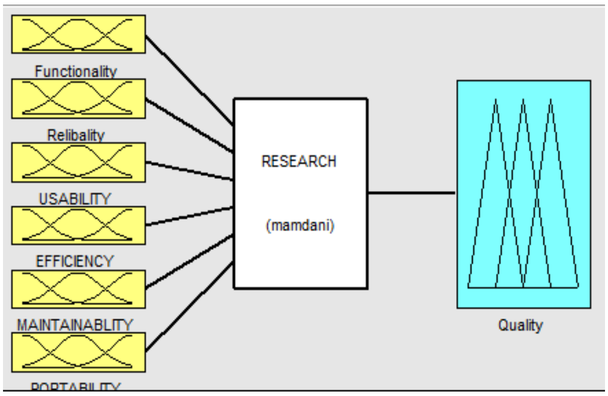

Figure10. Development of FIS with Six inputs with one output

The above figure shows that there are six input parameters and one output parameter that estimate the quality of the software product by developing and applying different rules to the FIS

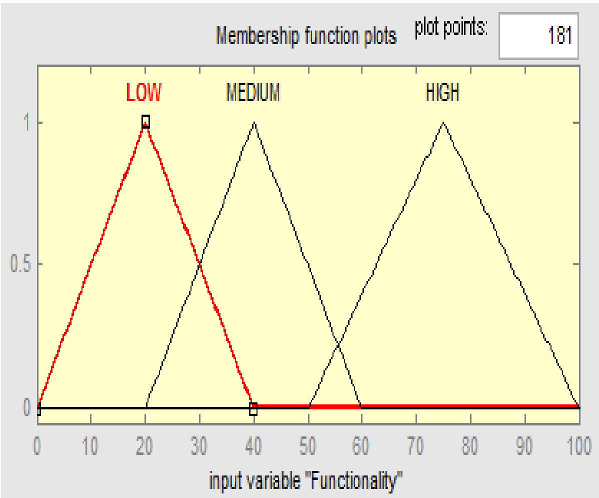

Figure11. Fuzzification of functionality

The above figure shows the Fuzzification of input parameter functionality by defining name, shape and range of its membership functions that correspond to its linguistic variables.

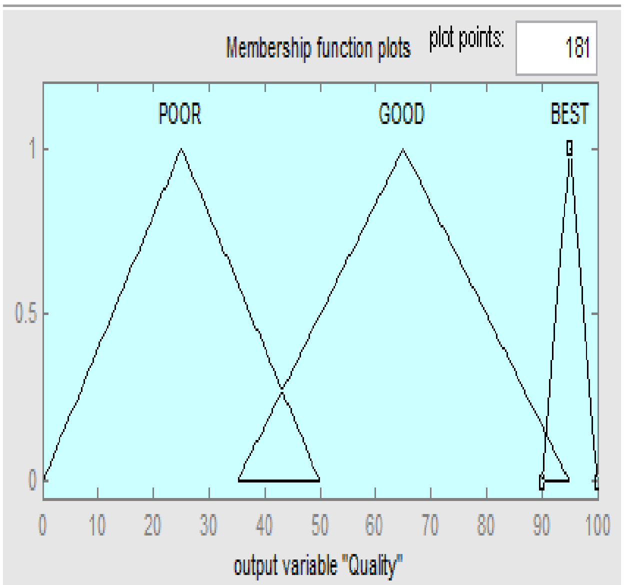

Figure12. Fuzzification of Quality

The above figure shows the Fuzzification of output parameter quality by defining name, shape and range of its membership functions that corresponds to its linguistic variables.

B. Rule base

According to the fuzzified input and output parameter rule base has been generated by applying our own reasoning as experts for making decision and drawing conclusion in order to estimate the quality of the software product. We develop 103 rules by using AND operator. Some of them are:-

Rule No.1 If (functionality is low) then (quality is poor)

Rule No.12 If (functionality is medium) and (reliability is medium) and (usability is medium) then (quality is good)

Rule No.22 If (functionality is medium) and (reliability is medium) and (usability is medium) and (efficiency is medium) and (maintainability is medium) then (quality is good)

Rule No.53 If (reliability is high) and (usability is high) and (efficiency is high) and (maintainability is high) and (portability is high) then (quality is best)

Rule No.103 If (usability is medium) and (efficiency is medium) and (maintainability is medium) and (portability is medium) then (quality is good)

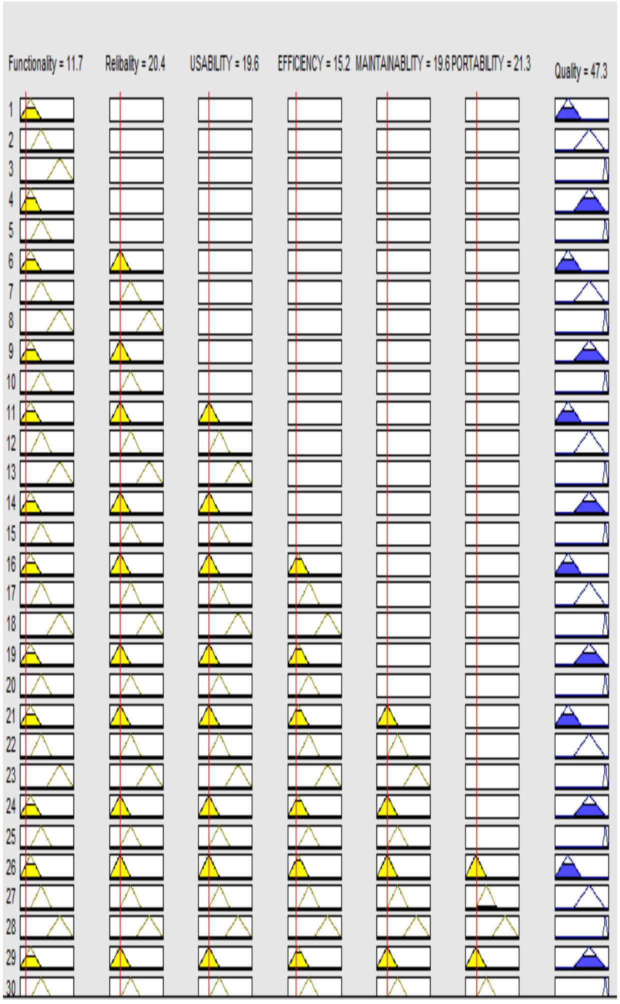

Figure13. Inference process when functionality = 11.7, Reliability = 20.4, Usability = 19.6, Efficiency = 15.2 Maintainability = 19.6, Portability = 21.3 then Quality = 47.3

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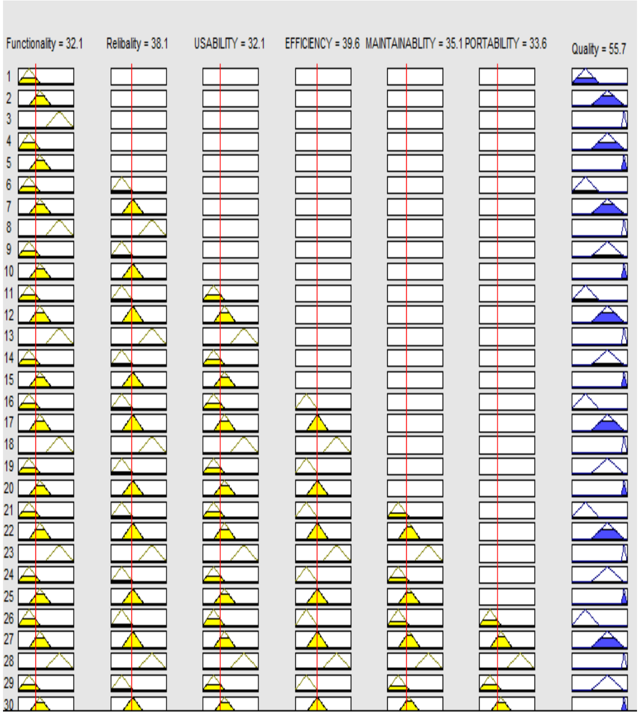

Figure14. Inference process when functionality = 32.1, Reliability = 38.1, Usability = 32.1, Efficiency = 39.6 Maintainability = 35.1, Portability =33.6 then Quality = 55.7

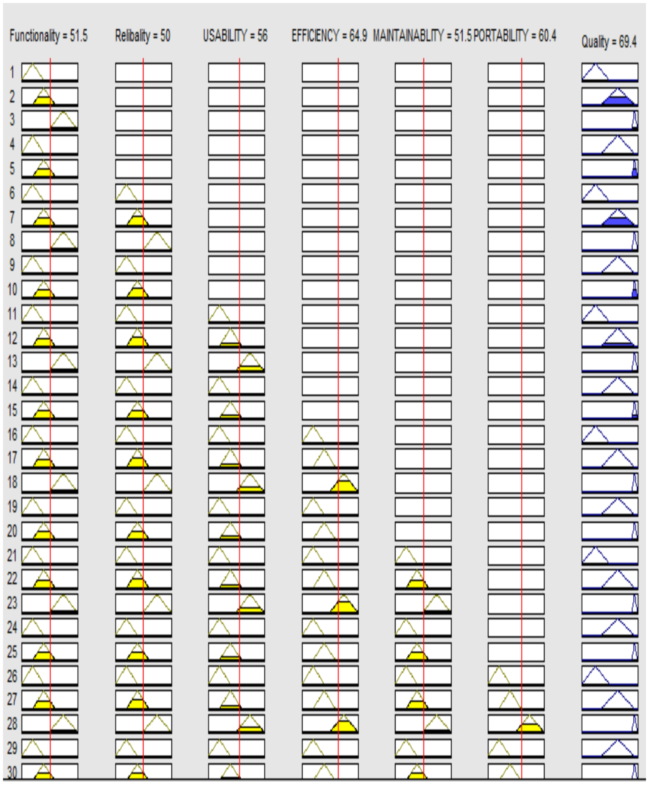

Figure15. Inference process when functionality = 51.7, Reliability = 50, Usability = 56, Efficiency = 64.9 Maintainability = 51.5, Portability = 60.4 then Quality = 69.4

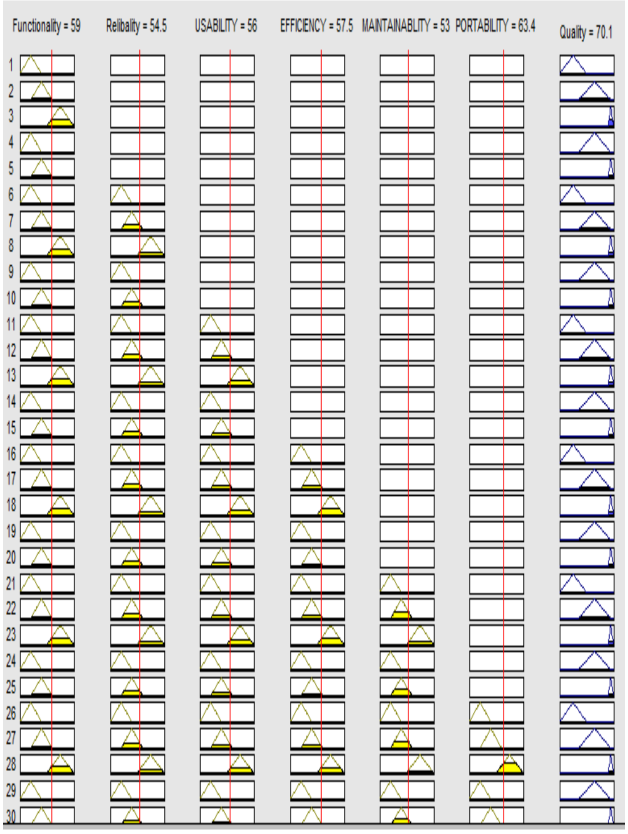

Figure16. Inference process when functionality = 59, Reliability = 54.5, Usability = 56, Efficiency = 57.5 Maintainability = 53, Portability = 63.4 then Quality = 70.1

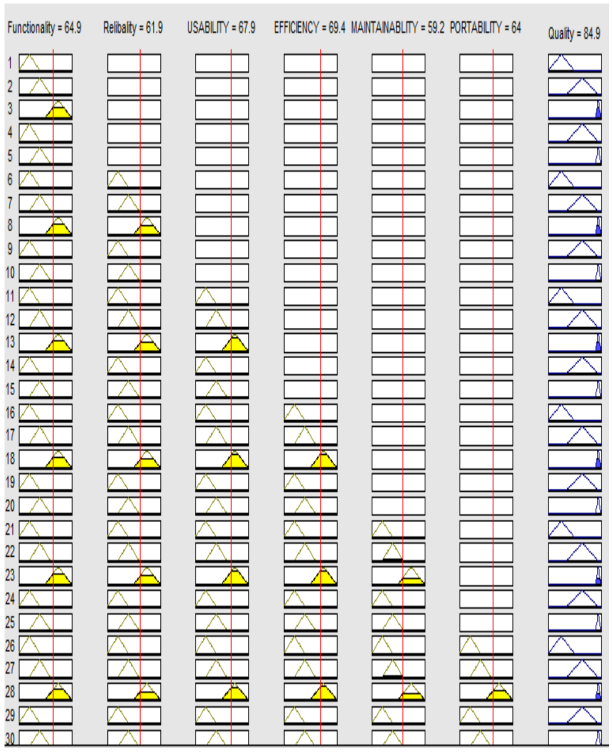

Figure17. Inference process when functionality = 64.9, Reliability = 61.9, Usability = 67.9, Efficiency = 69.4 Maintainability = 59.2, Portability = 64 then Quality = 84.9

Table3.Show various inputs with their corresponding estimated quality

INPUT							OUTPUT
S. no	Functionality	Reliability	Usability	Efficiency	Maintainability	Portability	Quality
INPUT 1	11.7	20.4	19.6	15.2	19.6	21.3	47.3
INPUT 2	32.1	38.1	32.1	39.6	35.1	33.6	55.7
INPUT 3	51.5	50	56	64.9	51.5	60.4	69.4
INPUT 4	59	54.5	56	57.5	53	63.4	70.1
INPUT 5	64.9	61.9	67.9	69.4	59.2	64	84.9
INPUT 6	81.3	75.4	72.4	78.4	75.4	81.3	95

Figure18. Inference process when functionality = 81.3, Reliability = 75.4, Usability = 72.4, Efficiency = 78.4 Maintainability = 75.4, Portability = 81.3 then Quality = 95

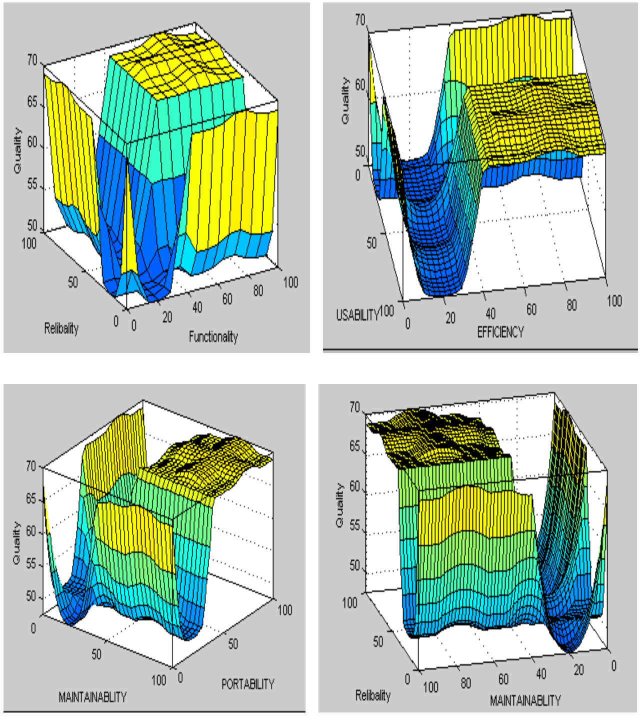

Figure20. The surface viewer of rule base

Overall quality can be estimated by dividing the sum of the individual qualities (outputs) by no. of inputs.

Overall quality = (47.3 + 55.7 + 69.4 + 70.1 + 84.9 + 95) / 6 =70.4

V. CONCLUSION

The proposed work is summarized as the development of framework based on fuzzy for the estimation of software quality. Since software quality is the totality of different quality attributes. Therefore, for choosing different quality attributes we select ISO 9126 model and define membership functions along with their shape, name and range that corresponds to the various linguistic variables for the chosen attributes and output quality. Then, we develop various rules for FIS to estimate the software quality.

REFERENCE

1. Software Engineering Fifth Edition -A Practitioner's approach by Roger S. Pressman.
2. McCall JA et al (1977)- Factors in Software Quality: Volume 1-3, RADC-TR77-369 Sunnyvale CA: general electric co.
3. ISO (1994) ISO 9000- Quality Management and Quality Assurance Vocabulary 2nd Edition: Geneva ISO.
4. http://www.ima.umn.edu/~arnold/disasters/ariane.html
5. Jyothi G and Ch.Verra babu-_An integrated approach for measuring software quality and code readability.
6. Nachippan, Laurie Williams, M laden vauk,Jason Osborne-Early estimation of software quality using in process testing metrics; A controlled case study.
7. Krazysztof Sacha- Evaluation of software quality
8. Shi Zhong,Taghi M.Khoshgoftaar and Naeem Seliya- Unsupervised learning for expert based software quality estimation
9. X.Yuan,T.M.Khoshgoftarar,E.Allen and K.Ganesan-An application of fizzy clustering to software quality predication
10. R.Kumar, S.Rai, and J.L. Trahan-Neural- network techniques for software quality evaluation.
11. Boehm, B.W. et al-Characteristics of Software Quality

12. ISO,International Organization for Standardization,"ISO 9126-1:2001,Software engineering-Product quality,Part1:Quality Model"2001
13. L.A. Zadeh, Fuzzy Sets, Information and Control, 1965
14. Fuzzy Logic Toolbox™ 2 User's Guide

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