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INTRODUCTION

REVIEW OF LITERATURE

NEED/IMPORTANCE OF THE STUDY

STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESES

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

CONCLUSIONS

SCOPE FOR FURTHER RESEARCH

ACKNOWLEDGMENTS

REFERENCES

APPENDIX/ANNEXURE

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BOOKS

- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

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- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

UNPUBLISHED DISSERTATIONS AND THESES

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

ONLINE RESOURCES

- Always indicate the date that the source was accessed, as online resources are frequently updated or removed.

WEBSITES

- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

QUANTIFICATION OF QUALITY AS PER USER PERSPECTIVE IN SOFTWARE DEVELOPMENT

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ABSTRACT

Software quality is well understood by a software developer through his prolonged exposure to the SDLC (Software Development life Cycles). The quality till now is taken up to be a non-quantifiable entity. The quality itself is defined as "satisfaction of customer in many perspectives as per his requirements generated at the beginning of the development cycle". The definition clearly states it to be purely dependent upon the end-users discretion. The quality has been a factor which hasn't been quantified yet and varies upon the requisite of the customer evaluating it. The customer may have set a HIGH, MEDIUM or LOW standard as per developer's perspective; but, it may turn out to be sufficient as per his personal requirements. Due to standards followed by the developer as per his knowledge or techniques, the product developed may come out to be different as per user's requirements. This may cost him in terms of TIME, MONEY, WORK, TRAINING and even MAINTENANCE. This paper discusses how to overcome this problem of varying standards; we can set the requirements by QUANTIFYING QUALITY AS PER THE END USER of the software. However, as discussed earlier the Quality is an aspect which is non-quantifiable. However, the soft computing holds a technique in form of FUZZY LOGICS which allows one to quantify the quality.

KEYWORDS
SDLC, ISO

PROBLEM

The different perspectives of users lay down basis of my problem statement. The software under quality check has to go through rigorous testing to meet the standards set as per the ISO or SEI. Also, it should be noted that with growing quality standard of the software the cost of testing increases and so does the need of risk estimation; which in itself is one time consuming as well as cost incurring process. The risk estimation is brought into consideration for security against failures at any given step of software use cycle. This should also be noted that, risk estimation and testing incur maximum time. These two processes if minimized could be minimized in terms of duration and cost.
However, the basic question lies with the fact: when to stop testing?
If testing is closed in haywire junction of SDLC, it may lead to project failure itself. Thus there has to be few heuristics for determination of what AMOUNT OF QUALITY is to be achieved from software. These heuristics should be directly dependent upon the satisfaction of end-user. And for any end-user Quality is function of desired performance of the software as per his requirements.

BACKGROUND

ISO 9126 QUALITY MODEL

ISO 9126 quality model is an extension of the work done by McCall (1977), Boehm (1978), FURPS and others in defining a set of software quality characteristics. ISO 9126 represents the latest (and ongoing) research into characterizing software for the purposes of software quality control, software quality assurance and software process improvement (SPI).
The ISO 9126 software quality model identifies 6 main quality characteristics, namely:

- Functionality
- Reliability
- Usability
- Efficiency
- Maintainability
- Portability

Each characteristic can further be divided into various sub-characteristics, defined as follows:

Functionality - *A set of attributes that bear on the existence of a set of functions and their specified properties. The functions are those that satisfy stated or implied needs.*

- ✓ Suitability
- ✓ Accuracy
- ✓ Interoperability
- ✓ Security
- ✓ Functionality Compliance

Reliability - *A set of attributes that bear on the capability of software to maintain its level of performance under stated conditions for a stated period of time.*

- ✓ Maturity
- ✓ Fault Tolerance
- ✓ Recoverability
- ✓ Reliability Compliance

Usability - *A set of attributes that bear on the effort needed for use, and on the individual assessment of such use, by a stated or implied set of users.*

- ✓ Understandability
- ✓ Learnability
- ✓ Operability
- ✓ Attractiveness
- ✓ Usability Compliance

Efficiency - *A set of attributes that bear on the relationship between the level of performance of the software and the amount of resources used, under stated conditions.*

- ✓ Time Behaviour
- ✓ Resource Utilization
- ✓ Efficiency Compliance

Maintainability - *A set of attributes that bear on the effort needed to make specified modifications.*

- ✓ Analyzability
- ✓ Changeability
- ✓ Stability
- ✓ Testability
- ✓ Maintainability Compliance

Portability - *A set of attributes that bear on the ability of software to be transferred from one environment to another.*

- ✓ Adaptability
- ✓ Installability
- ✓ Co-Existence
- ✓ Replaceability
- ✓ Portability Compliance

FUZZY LOGIC

Fuzzy logic can be defined as a form of knowledge representation suitable for notions that cannot be defined precisely, but which depend upon their contexts. Fuzzy logic provides an alternative way to represent linguistic and subjective attributes of the real world in computing. It's a three step process which is well understood in following steps:

1) Fuzzification (Using membership functions to graphically describe a situation)
2) Rule evaluation (Application of fuzzy rules)
3) Defuzzification (Obtaining the crisp or actual results)

Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth- truth values between "completely true" and "completely false". As its name suggests, it is the logic underlying modes of reasoning which are approximate rather than exact. The importance of fuzzy logic derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature. The essential characteristics of fuzzy logic as founded by Zadeh Lotfi are as follows.

In fuzzy logic, exact reasoning is viewed as a limiting case of approximate reasoning.

In fuzzy logic everything is a matter of degree.

Any logical system can be fuzzified

In fuzzy logic, knowledge is interpreted as a collection of elastic or, equivalently, fuzzy constraint on a collection of variables

Inference is viewed as a process of propagation of elastic constraints.

The third statement hence, defines Boolean logic as a subset of Fuzzy logic.

The whole idea of fuzzification/Defuzzification is based upon membership function. A membership function provides a measure of the degree of similarity of an element to a fuzzy set. The membership function of a fuzzy set is a generalization of the indicator function in classical sets. In fuzzy logic, it represents the degree of truth as an extension of valuation. Degrees of truth are often confused with probabilities, although they are conceptually distinct, because fuzzy truth represents membership in vaguely defined sets, not likelihood of some event or condition.

ISO 9126 QUALITY MODEL AND FUZZY

Both the terms comes from two different computing environments but if combined together can achieve better results. ISO 9126 has defined 6 quality characteristics, namely functionality, usability, maintainability, portability, reliability and efficiency. As we are concerned with end-user, so, we will consider only three quality characteristics that are more important for a user than others and will estimate quality based upon those three factors. These three factors are: Functionality, Usability and maintainability respectively. We will use fuzzy logic to estimate quality based upon these three factors.

IMPLICATION

Fuzzy logic system goes through three main steps or procedures which are as follows:

- Fuzzification
- Fuzzy Inference
- De-Fuzzification

The inputs for the fuzzification process will be Functionality, Maintainability and usability.

FUZZIFICATION

Three input variable to be fuzzified as mentioned are Functionality, Usability and maintainability. The terms LOW, MED, HIGH are used to depict INPUT and terms VLOW, LOW, MED, HIGH, VHIGH are used to depict OUTPUT in form of triangular membership functions.

The following figures i.e Figure 13, Figure 14, Figure 15 presents the input membership functions for the linguistic variables Functionality, Usability and maintainability respectively. The membership functions are divided into linguistic terms of LOW, MED, HIGH with the ranges as follows for the each:

LOW {0, 0, 0.5}
Med {0, 0.5, 1}
High {0.5, 1, 1}

It should be noted that when we talk of Functionality, Usability and maintainability, the above mentioned variables have standard meaning of the terms used as linguistic.

FIGURE 1: INPUT FOR "FUNCTIONALITY

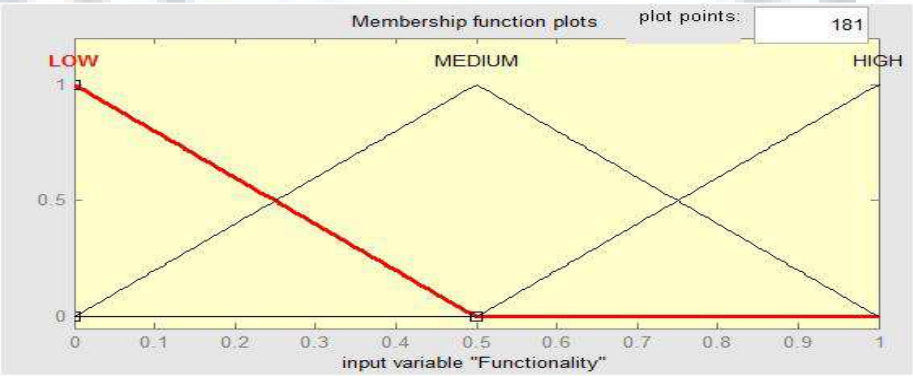


FIGURE 2: INPUT FOR "USABILITY"

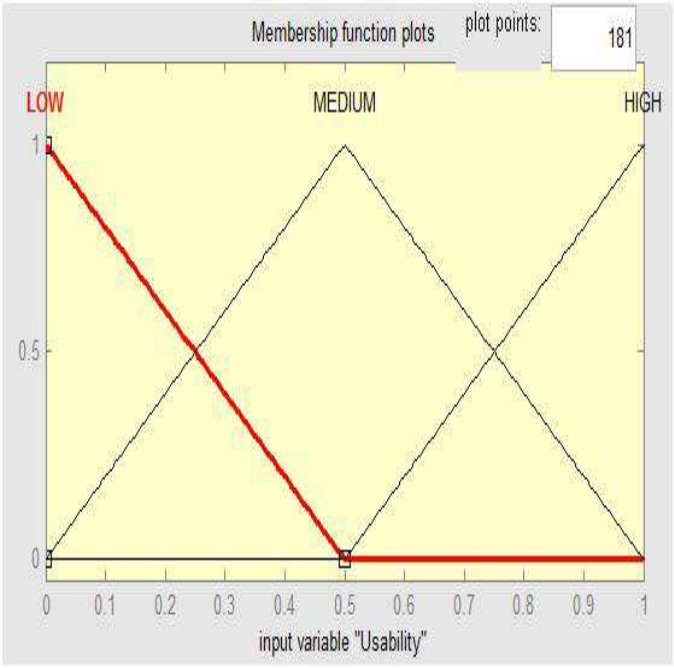
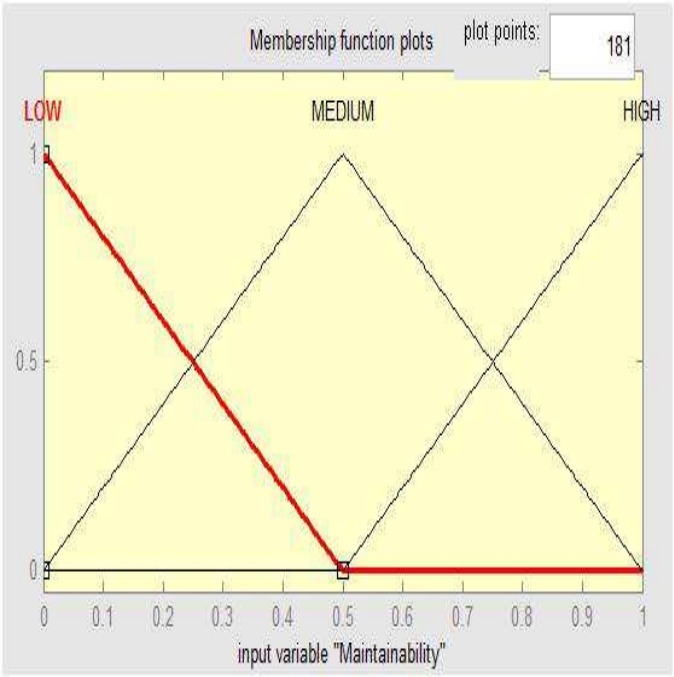


FIGURE 3: INPUT FOR "MAINTAINABILITY"



FUZZY INFERENCE

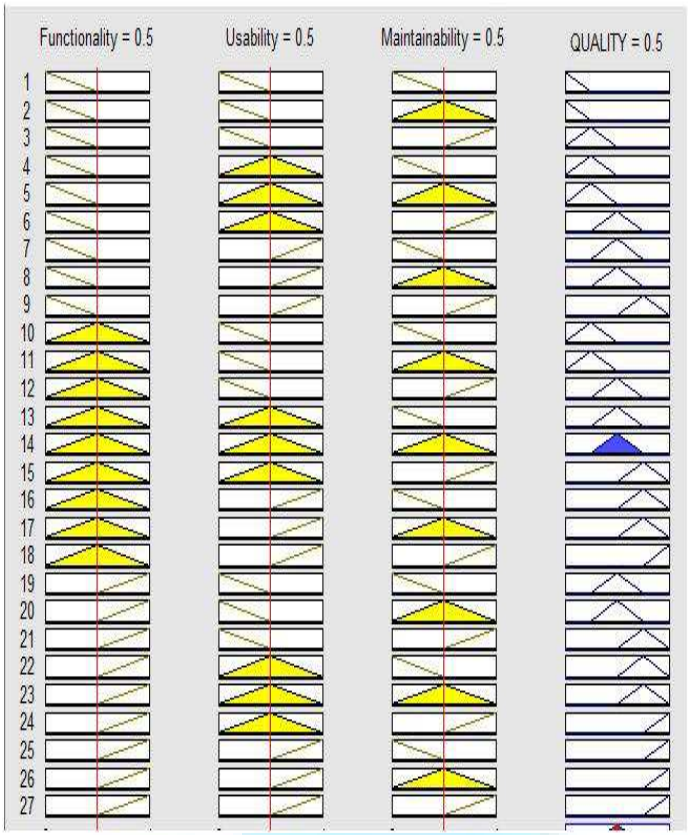
The input to the fuzzy systems are worked upon using Mamdani's mom method wherein "AND" operator is set to minimum such that each input variable contribute to the output created by the inference mechanism. The following rule base presents the base of simulation for the proposed fuzzy based method of quality estimation.

The following table presents the complete rule base designed for the fuzzy inference mechanism.

INPUTS			OUTPUT
FNTC.	USB.	MNTN.	QUALITY
LOW	LOW	LOW	VLOW
LOW	LOW	MEDIUM	VLOW
LOW	LOW	HIGH	LOW
LOW	MEDIUM	LOW	LOW
LOW	MEDIUM	MEDIUM	LOW
LOW	MEDIUM	HIGH	MEDIUM
LOW	HIGH	LOW	MEDIUM
LOW	HIGH	MEDIUM	MEDIUM
LOW	HIGH	HIGH	HIGH
MEDIUM	LOW	LOW	LOW
MEDIUM	LOW	MEDIUM	LOW
MEDIUM	LOW	HIGH	MEDIUM
MEDIUM	MEDIUM	LOW	MEDIUM
MEDIUM	MEDIUM	MEDIUM	MEDIUM
MEDIUM	MEDIUM	HIGH	HIGH
MEDIUM	HIGH	LOW	HIGH
MEDIUM	HIGH	MEDIUM	HIGH
MEDIUM	HIGH	HIGH	VHIGH
HIGH	LOW	LOW	MEDIUM
HIGH	LOW	MEDIUM	MEDIUM
HIGH	LOW	HIGH	HIGH
HIGH	MEDIUM	LOW	HIGH
HIGH	MEDIUM	MEDIUM	HIGH
HIGH	MEDIUM	HIGH	VHIGH
HIGH	HIGH	LOW	VHIGH
HIGH	HIGH	MEDIUM	VHIGH
HIGH	HIGH	HIGH	VHIGH
HIGH	MED	LOW	VHIGH
HIGH	HIGH	HIGH	HIGH
HIGH	HIGH	MED	VHIGH
HIGH	HIGH	LOW	VHIGH

1. If (Functionality is LOW) and (Usability is LOW) and (Maintainability is LOW) then (QUALITY is VLOW) (1)
2. If (Functionality is LOW) and (Usability is LOW) and (Maintainability is MEDIUM) then (QUALITY is VLOW) (1)
3. If (Functionality is LOW) and (Usability is LOW) and (Maintainability is HIGH) then (QUALITY is LOW) (1)
4. If (Functionality is LOW) and (Usability is MEDIUM) and (Maintainability is LOW) then (QUALITY is LOW) (1)
5. If (Functionality is LOW) and (Usability is MEDIUM) and (Maintainability is MEDIUM) then (QUALITY is LOW) (1)
6. If (Functionality is LOW) and (Usability is MEDIUM) and (Maintainability is HIGH) then (QUALITY is MEDIUM) (1)
7. If (Functionality is LOW) and (Usability is HIGH) and (Maintainability is LOW) then (QUALITY is MEDIUM) (1)
8. If (Functionality is LOW) and (Usability is HIGH) and (Maintainability is MEDIUM) then (QUALITY is MEDIUM) (1)
9. If (Functionality is LOW) and (Usability is HIGH) and (Maintainability is HIGH) then (QUALITY is HIGH) (1)
10. If (Functionality is MEDIUM) and (Usability is LOW) and (Maintainability is LOW) then (QUALITY is LOW) (1)
11. If (Functionality is MEDIUM) and (Usability is LOW) and (Maintainability is MEDIUM) then (QUALITY is LOW) (1)
12. If (Functionality is MEDIUM) and (Usability is LOW) and (Maintainability is HIGH) then (QUALITY is MEDIUM) (1)
13. If (Functionality is MEDIUM) and (Usability is MEDIUM) and (Maintainability is LOW) then (QUALITY is MEDIUM) (1)
14. If (Functionality is MEDIUM) and (Usability is MEDIUM) and (Maintainability is MEDIUM) then (QUALITY is MEDIUM) (1)
15. If (Functionality is MEDIUM) and (Usability is MEDIUM) and (Maintainability is HIGH) then (QUALITY is HIGH) (1)
16. If (Functionality is MEDIUM) and (Usability is HIGH) and (Maintainability is LOW) then (QUALITY is HIGH) (1)
17. If (Functionality is MEDIUM) and (Usability is HIGH) and (Maintainability is MEDIUM) then (QUALITY is HIGH) (1)
18. If (Functionality is MEDIUM) and (Usability is HIGH) and (Maintainability is HIGH) then (QUALITY is VHIGH) (1)
19. If (Functionality is HIGH) and (Usability is LOW) and (Maintainability is LOW) then (QUALITY is MEDIUM) (1)
20. If (Functionality is HIGH) and (Usability is LOW) and (Maintainability is MEDIUM) then (QUALITY is MEDIUM) (1)
21. If (Functionality is HIGH) and (Usability is LOW) and (Maintainability is HIGH) then (QUALITY is HIGH) (1)
22. If (Functionality is HIGH) and (Usability is MEDIUM) and (Maintainability is LOW) then (QUALITY is HIGH) (1)
23. If (Functionality is HIGH) and (Usability is MEDIUM) and (Maintainability is MEDIUM) then (QUALITY is HIGH) (1)
24. If (Functionality is HIGH) and (Usability is MEDIUM) and (Maintainability is HIGH) then (QUALITY is VHIGH) (1)
25. If (Functionality is HIGH) and (Usability is HIGH) and (Maintainability is LOW) then (QUALITY is VHIGH) (1)
26. If (Functionality is HIGH) and (Usability is HIGH) and (Maintainability is MEDIUM) then (QUALITY is VHIGH) (1)
27. If (Functionality is HIGH) and (Usability is HIGH) and (Maintainability is HIGH) then (QUALITY is VHIGH) (1)

RULEBASE DESIGNED IN MATLAB



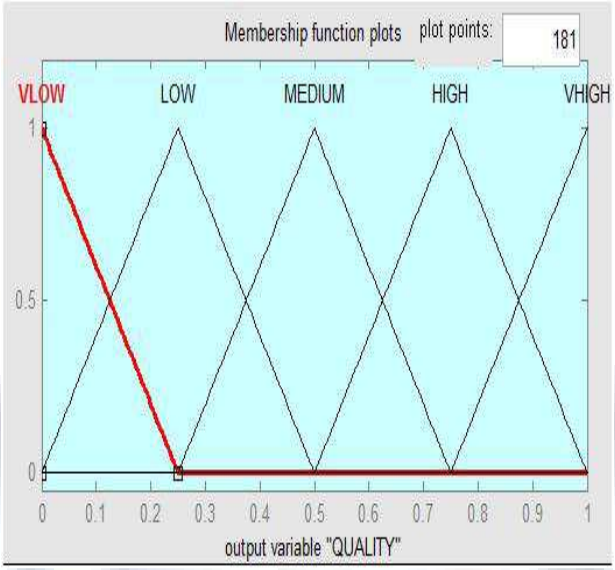
FUZZY RULE BASE DESIGN AS PER TRIANGULAR MEMBERSHIP FUNCTION PLOT

If Functionality is LOW, Usability is LOW and Maintainability is HIGH then quality LOW.

As we are having three INPUT states to every fuzzy input, therefore the total no of possible inference rule could be 27 (3*3*3).

DEFUZZIFICATION

It's a process where we extract crisp values from the output parameter in the knowledge base.



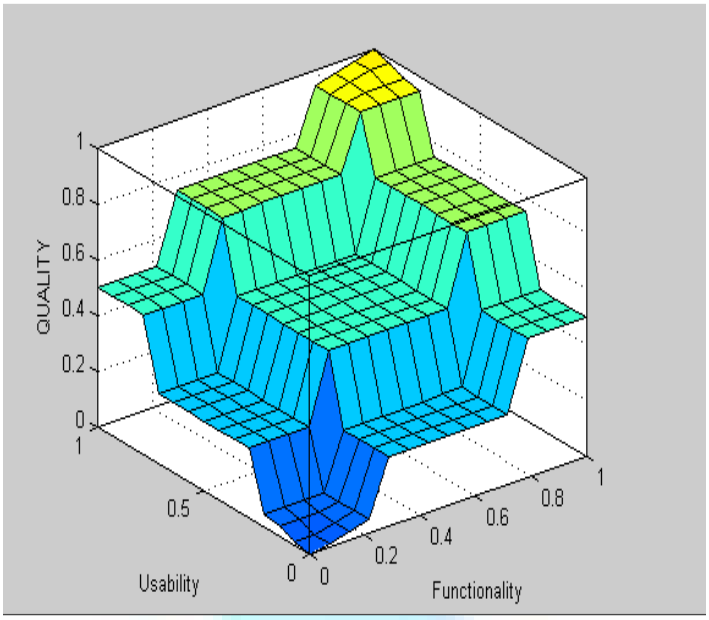
OUTPUT AS "QUALITY"

The output membership function is generated while the fuzzification process however, is depicted and referenced in this section as Figure 18 for a clear understanding of the output result evaluation. The Linguistic Variable Quality is generated with Linguistic Terms VERY LOW, LOW, MED, HIGH, VERY HIGH with the following fuzzy sets:

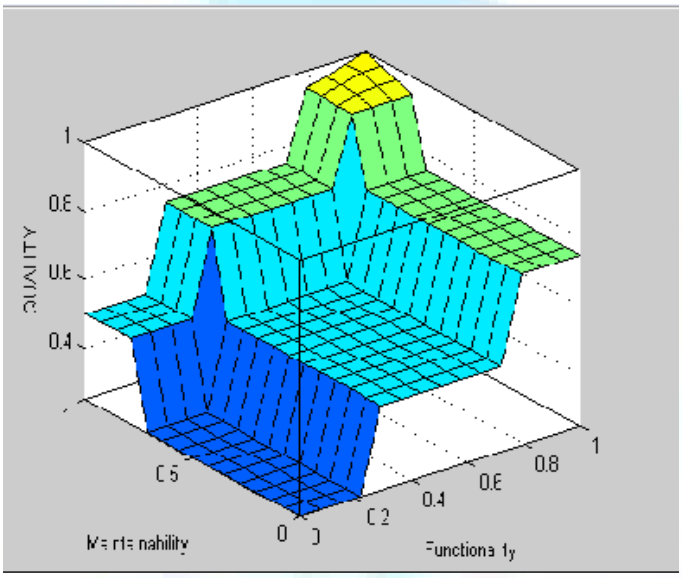
- VERY LOW {0, 0, 0.25}
- LOW {0, 0.25, 0.5}
- MED {0.25 0.5, 0.75}
- HIGH {0.5, 0.75, 1}
- VERY HIGH {0.75, 1, 1}

RESULT

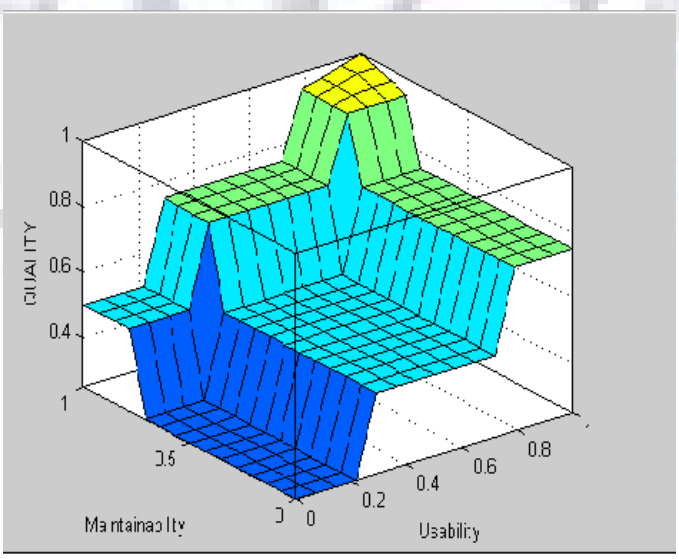
The following output shows the effect of usability and functionality on quality when maintainability is kept constant.



The following output shows the effect of maintainability and functionality on quality when usability is kept constant.



The following output shows the effect of maintainability and usability on quality when fucntionality is kept constant.



FUTURE SCOPE

In future all the 6 factors of ISO 9126 and their subparts can also be considered to determine the quality of software being delivered.

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