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Design an Expert System for Ranking of Software metrics

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Abstract: This research paper represents a framework for ranking of software metrics based on expert opinion elicitation and fuzzy-based matrix methodology. The proposed methodology is able to accommodate the imprecise and inexact data involved in the problem of ranking of software engineering metrics, vagueness and ambiguity occurring during expert (human) decision making and to depart from the complexity of formulation of the objective and the constraint function.

The goal of performing this empirical research is to improve the understanding of software metrics that may have influence on software reliability and analyze the significance of their effects. Thus, it requires developing a fuzzy-based matrix methodology to systematically rank the existing software metrics with respect to their impact on the prediction of software reliability.

Key Terms: Fuzzy logic, MATLAB, Empirical Studies,

I INTRODUCTION

Software testing is an activity aimed to evaluate an attribute or capability of a program or system and determining that it meets its required results. Due to limited understandability of principles of software, software testing still remains an art for programmers and testers. The difficulty in software testing stems from the complexity of software where a program cannot be completely tested with moderate complexity. Testing is more than just debugging. The purpose of testing can be quality assurance, verification and validation, or reliability estimation. Testing can be used as a generic metric as well. Correctness testing and reliability testing are two major areas of testing. Software testing is a trade-off between budget, time and quality. Listed are some key terminologies that are used in testing.

Object oriented technology is most popular technology for software professionals. It is becoming more popular in several different contexts. The object-oriented techniques are applied in the areas of programming languages, databases, user interfaces, specification and design methodologies. As a result, perception towards object oriented software quality is changing very rapidly. Many design and analysis technologies assume that if the object oriented system is well designed then it will need minimum testing efforts. But object orientation is not a silver bullet in the area of software engineering. In spite of its good

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characteristics like inheritance, polymorphism, encapsulation, information hiding, the software designed using this technology may also contain errors similar to traditional procedure oriented technology.In the last one decade the main thrust area in the research has been the quality of the software. The researchers have emphasized on how to assess the quality of the software and how to achieve the quality actually.

According to the ISO model testability of a software system may be defined as attributes of software that bear on the effort needed to validate the software product. In other words, the testability of a software system is indicative of the amount of effort needed to test the system.

II SOFTWARE ENGINEERING MATRICS AND CRITERIA

Software metrics is developed and used for evaluating and assuring software code quality, operation, and maintenanceby the various software organizations. Software metrics measure various types of software complexity like size metrics, control flow metrics and data flow metrics. These software complexities must be continuously calculated, followed, and controlled. One of the main objectives of software metrics is that applies to a process and product metrics. It is always considered that high degree of complexity in a module is bad in comparison to a low degree of complexity in a module. Software metrics can be used in different phases of the software development lifecycle.

The software development process consists of five phases: analysis, design, coding, testing, and Operation. In each phase there are many factors that differentiate the software development process and lead to different quality levels of the final software product.Many metrics have been proposed for measuring testability of the object oriented software. These metrics are based upon inheritance, coupling, cohesion, polymorphism, complexity etc. None of the researchers till date have thrown some light on relative importance of these metrics in a particular case.All the metrics seems to be equally important in absence of any particular method for their ranking. The proper ranking of these metrics may be very helpful for the software professionals working on a particular project.

There are different matrices which are used for rankings.

The Mood Metrics: The set of metrics proposed by 'MOOD' may be of used by the project managers, as the metrics operate at a systems level. These metrics provide an overall assessment of a system. It is used to find following factors:

- Method Inheritance Factor (MIF)
- Attribute Inheritance Factor (AIF)
- Attribute Hiding Factor (AHF)
- Method Hiding Factor (MHF)
- Coupling Factor (CF)
- Polymorphism Factor (PF)

Chidamber and Kemerer Metrics: Set of six metrics proposed by Chidamber and Kemerer has been used. These are class level metrics. These are very helpful for the software professionals. The metrics are:

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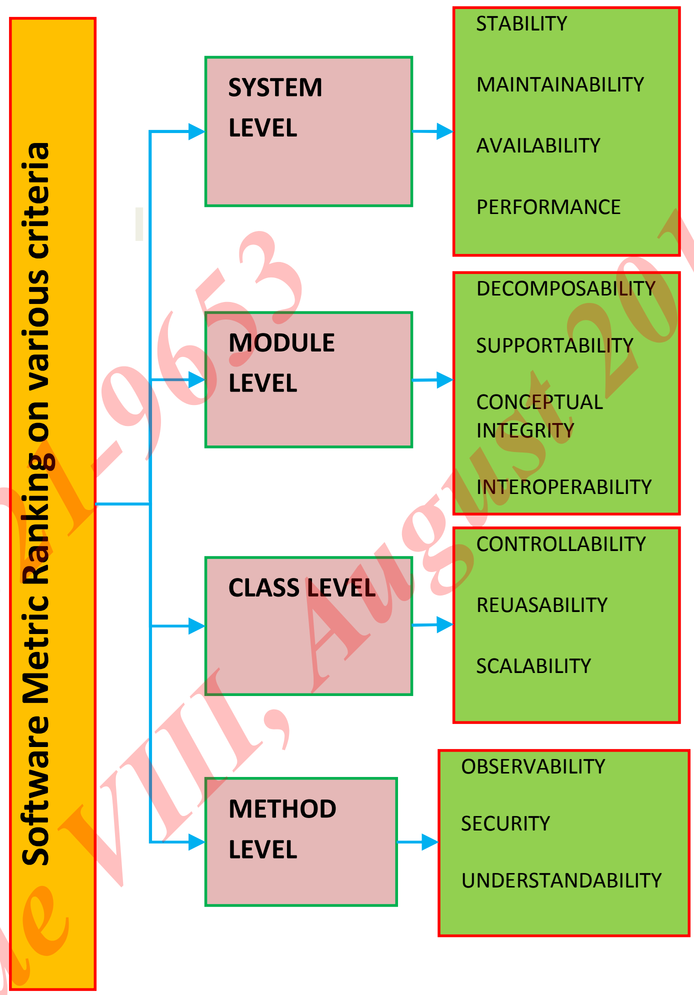
- Depth of inheritance tree (DIT)
- Number of Children (NOC)
- Response for Class (RFC)
- Coupling Between Objects (CBO)
- Lack of Cohesion in Methods (LCOM)
- Weighted Methods per class (WMC)

Li Metrics: Li proposed following metrics:

- Number of Descendant Classes (NDC)
- Number of Ancestor Classes (NAC)
- Coupling Through Message Passing (CTM)
- Coupling through Abstract Data Type (CTA)
- Number of Attributes (NA)
- Number of Methods Overridden (NMO)

Two new metrics have been developed to measure the program's complexity based on source code emphasizing on computational complexity. The metrics allow the programmer to evaluate the testing time of any object oriented project.

- Average Temporal Complexity (ATC)
- Relation Based Testability Metric (RTM)



The criteria for the software metrics ranking depends on deferent level which is defined as follows:

III RANKING METHODOLOGY

In existing software engineering, data that could constitute the basis for ranking the set of pre-selected metrics are unattainable, due to the lack of maturity in this field. Similarly, data mining of software engineering databases has proven infeasible in practice. Consequently, reliance on expert opinion was the optimal approach to the problem of collecting ranking data.

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Research methods have been demonstrated along-with the guiding principles for the enhanced creation of knowledge. It is necessary to solve the research problem by using the methodology according to the realities of the business world and satisfying the questionnaire of organizations. In order to conduct credible research, the circumstances and research problem under study are such that, the researcher must get close to the object of study. It is difficult for an engineer to identify the most appropriate method to get the appropriate objective.

Selection of ranking criteria: Software engineering metrics can be compared by means of several attributes, collectively termed ranking criteria. Examples of such attributes are: repeatability, cost, credibility, etc.

The study of Lawrence *et al.*based its ranking of measures on a total of eight criteria, which are cost, benefit, credibility, directness, timeliness, repeatability, experience, and validation.

Fuzzy Logic Theory: Fuzzy logic theory was introduced by Zadeh [1965] and since then, has proved to be essential for numerous applications. The fields of process control, flexible manufacturing systems, automation etc., have been influenced, in a great level, by fuzzy logic.

A fuzzy set theory has been proposed to deal with several vague issues. In such a fuzzy environment fuzzy numbers are very useful for the processing and representation of the information. In a space of point 'X', a fuzzy subset 'A' of 'X' is defined by a membership function fA(x) which associates with each 'x' in the interval [0, 1].The function values 'fA(x)' represents the grade of membership of 'x' in 'A'. The nearer the values of 'fA(x)' to unity, the higher the grade of membership of 'x' in 'A'.

Fuzzy Numbers: A real fuzzy number A is described as any subset of the real line R with the membership function $f_A(x)$ which processes the following properties, Dubois and Prade [1979], where a, b, c and d are real numbers:

f_A is a continuous mapping from R to a closed interval [0, 1]

f_A (x) = 0 for all $x \in (-\infty, a]$

$f_A$is strictly increasing on [a, b]

f_A(x) = 1, for all $x \in [a, c]$

f_A is strictly decreasing on [c, d]

f_A(x) = 0, for all $x \in [d, -\infty)$

Alternatively, it may be $a = -\infty, ora = b, orb = c, orc = dord = +\infty$. The membership function f_A of the fuzzy number A can also be expressed as:

$$f_A(x) \begin{cases} f_A^L(x) a \le x \le b \\ 1 \quad b \le x \le c \\ f_A^R(x) c \le x \le d \\ 0 \quad otherwise \end{cases}$$

Where, f_A^L(x) and f_A^R(x) are the left and right membership functions of fuzzy number 'A', respectively. The fuzzy number

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A is a triangular fuzzy number if its membership function f_A is given by Kaufmann and Gupta [1988]:

$$f_A(x) = \begin{cases} \dfrac{x-a}{b-a} & a \le x \le b \\ (x-c)/(b-c) & b \le x \le c \\ 0 & otherwise \end{cases}$$

Where a, b and c are real numbers.

By the extension principle proposed, Zadeh [1965], the extended algebraic operations on triangular fuzzy numbers can be expressed as:

Changingsign : $-(a,b,c) = (-c,-b,a)$

Inversesing : $(a,b,c)^{-1} \cong (1/c, 1/b, 1/a)$

Addition : $(a_1,b_1,c_1) \oplus (a_2,b_2,c_2)$
$= (a_1 + a_2, \quad b_1{+}b_2, c_1 + c_2)$

Subtraction : $(a_1,b_1,c_1) \ominus (a_2,b_2,c_2)$
$= (a_1 - c_2, \quad b_1{-}b_2, c_1 - a_2)$

Multiplication: $k \oplus (a,b,c)$
$= (ka,kb,kc)(a_1,b_1,c_1) \oplus (a_2,b_2,c_2)$
$\cong (a_1a_2, b_1b_2, c_1c_2)$

Division: $(a_1,b_1,c_1)\theta(a_2,b_2,c_2)$
$\cong (a_1/a_2, b_1/b_2, c_1/c_2)$

If $c_1 \ge 0, c_2 \ge 0$

Defuzzification: This assignment of a real value to a fuzzy number is called defuzzification.In weighted average defuzzification technique the output is obtained by the weighted average of the each output of the set of rules stored in the knowledge base of the system. The weighted average defuzzification technique can be expressed by the following equation:

$$x^* = \frac{\sum_{i=1}^{n} m^i w_i}{\sum_{i=1}^{n} m^i}$$

When x^* is the defuzzified output, m^i is the membership of the output of each rule, and w_i is the weight associated with each rule. This method is computationally faster and easier and gives fairly accurate result.

Matrix Method: The proposed matrix method is a unified approach that enables the optimum selection of a particular vendor among a number of alternate vendors based on selection criteria considering all the indices concurrently in an integrated manner. This method combines various selection criteria relevant to a vendor into a single measure so that a comprehensive ranking of the vendors could be made. This single measure is known as the suitability index. The vendor with the highest suitability index is ranked as #1, which with the second-highest suitability index as rank #2, and so on. This method is applied in two phases, namely criteria matrix and permanent function representation.

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Vendor Rating Matrix: This matrix is formed on the basis of deterministic values (crisp scores) of the aggregated ratings of the vendors versus different vendor selection criteria.

$$\begin{bmatrix} a_{11} & 0 & 0 & \cdots & 0 \\ 0 & a_{22} & 0 & \cdots & 0 \\ \vdots & & & & \\ 0 & 0 & 0 & \cdots & a_{nn} \end{bmatrix}$$

Criteria Relative Weight Matrix: The Criteria Relative Weight Matrix is formed on the basis of the aggregated weights of different criteria

$$\begin{bmatrix} 0 & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & 0 & a_{23} & \cdots & a_{2n} \\ \vdots & & & & \\ a_{n1} & a_{n2} & a_{n3} & \cdots & 0 \end{bmatrix}.$$

Thus the 'Criteria Matrix' corresponding to 'n' criteria, in general, is written as:

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ \vdots & & & & \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn} \end{bmatrix}$$

Permanent Function Representation: Variable Permanent Function or simply known as Permanent is a standard matrix function that is used in combinatorial mathematics. Computer software is developed to determine the value of the permanent of the 'Criteria Matrix'. The algorithm is:

$$(A) P \leftarrow 0;\ X_i \leftarrow a_{in} - \frac{1}{2}\sum_{i,j=1}^{n} a_{ij};\ \text{sgn} \leftarrow -1$$

$$(B) \text{sgn} \leftarrow -\text{sgn};\ P \leftarrow \text{sgn},$$

Get next subset of $(1, 2, ..., n-1)$ *from NEXSUB;*

if empty, go to (C) *and if* j *was deleted, then:*

$z \leftarrow -1;$ *otherwise,* $z \leftarrow 1;$

$x_i \leftarrow x_i + z\, a_{ij}\ (i = 1, 2, ..., n)$

$$(C) P \leftarrow P.x_i\ (i = 1, 2, ..., n);\ p \leftarrow p + p$$

if more subsets remain, to (B);

$Permanant \leftarrow 2(-1)^{n-1} p;\ EXIT.$

ALGORITHM NEXSUB

$(A)[First\,entry]\ m \leftarrow 1;\ j \leftarrow 1;\ z \leftarrow 1;\ exit.$

$(B)[Later\,entry]\ m \leftarrow m+1;\ x \leftarrow m;\ j \leftarrow 0;$

$(C)\ j \leftarrow j+1;\ x \leftarrow \frac{x}{2};\ if\ x\ is\ an\ integer,\ to\ (C).$

$(D)\ z \leftarrow (-1)^{\frac{x+1}{2}};\ if\ = 2^n,\ final\ exit;\ EXIT.$

IV RESULTS AND ANALYSIS

All the metrics were ranked according to their importance with respect to the various criteria and sub criteria which were decided in order for better ranking of the metrics so that they could be used as per the requirement of the product and according to the need of the developer for developing a reliable software product. The various criteria as explained above are:

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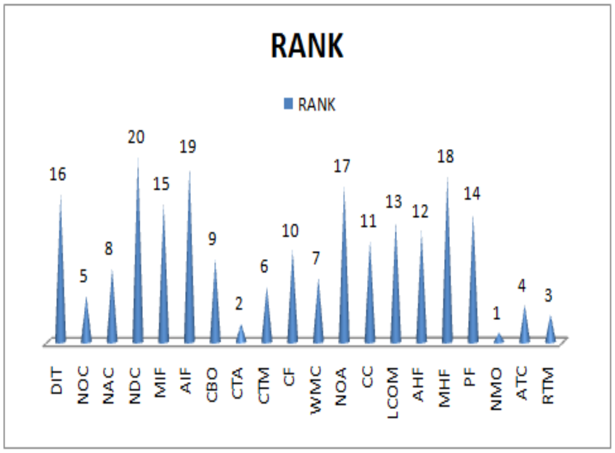

Fig.1. the rank of the various metrics with respect to the importance level at system level.

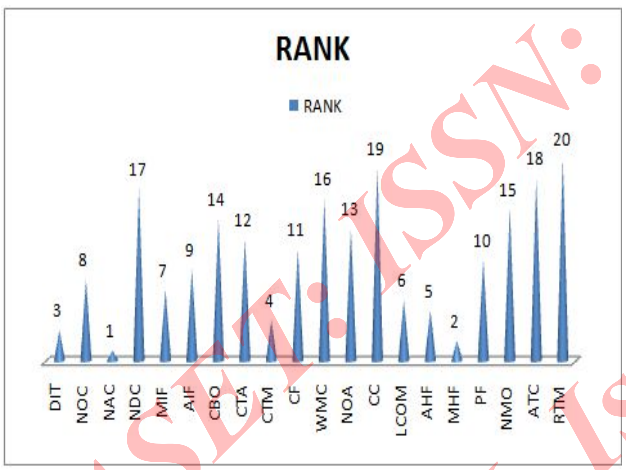

Fig.2. The rank of the various metrics with respect to the importance level at module level

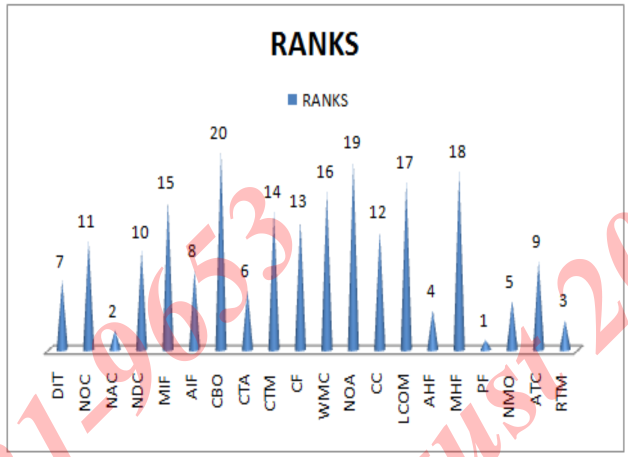

Fig.3. The rank of the various metrics with respect to the importance level at class level

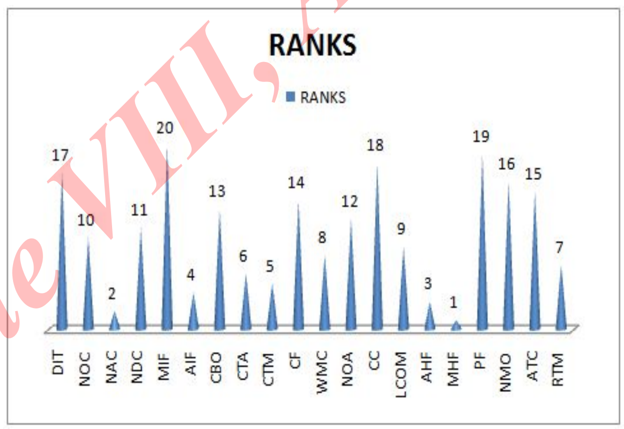

Fig.4. The rank of the various metrics with respect to the importance level at method level

All the given metrics are ranked according to the various sub criteria and the ranking is shown with proper figure and chart diagrams.

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V CONCLUSIONS

The study was conducted to rank the software engineering metrics using the state-of-art knowledge in the field of software engineering. In particular, a fuzzy-based matrix method (a multiple attribute decision-making method) has been developed. It is established that once a complete set of criteria and software engineering metrics have been identified, their important weights and ratings are assigned using linguistic terms using expert elicitation, and then this method can be applied for their ranking. The interdependencies of the ranking criteria have been given due consideration in the matrix method. The use of fuzzy set theory improves the decision-making procedure by considering the vagueness and ambiguity prevalent in real-world system. The computer software that has been developed for determining the aggregated weights, ratings, and Permanent of the criteria matrix is user friendly and also does not require extensive technical knowledge of software engineering metrics and/or ranking criteria.

REFERENCES

[1] Pham H, Zhang X. “A software cost model with warranty and risk costs”. *IEEE Transactions on Computers* 1999.

[2] Ramamoorthy CV, Bastani FB. “Software reliability: Status and perspectives”. *IEEE Transactions Software Engineering* 1982; 8(4):354–371.

[3] Li M, Smidts CS. “A ranking of software engineering measures based on expert opinion”. *IEEE Transactions on Software Engineering*,2003, 811824,DOI:,10.1109/TSE.2003.1232286.

[4] Parastoo M, Dehlen V. “Existing model metrics and relations to model quality”. *ICSE Workshop on Software Quality*, Vancouver, BC, Canada, May 2009; DOI: 10.1109/WOSQ.2009.5071542.

[5] Ordonez JM, Haddad HM. “The state of metrics in software industry”. *Information Technology*: *New Generations, 2008.ITNG 2008*. *Fifth International Conference*, Las Vegas, NV, April 2008; 453–458. DOI:10.1109/ITNG.2008.106.

[6] Roberts TL Jr, Gibson ML, Fields KT, Rainer RK Jr. “Factors that impact implementing a system development Methodology”. *IEEE Transactions on Software Engineering* 1998; 24(8):640–648. DOI: 10.1109/32.707699.

[7] Evanco WM, Lacovara R. “A model-based framework for the integration of software metrics”. *The Journal of Systems Software* 1994; 26:77–86. DOI: 10.1016/0164-1212(94)90098-1.

[8] Schneberger SL. “Distributed computing environments: Effects on software maintenance difficulty”. *The Journal of Systems and Software* 1997; 37(2):101–116. DOI: 10.1016/S0164-1212(96)00107-0.

[9] Zhang X, Pham H. “An analysis of factors affecting software reliability”.*The Journal of Systems and Software* 2000; 50:43–56. DOI: 10.1016/S0164-1212(99)00075-8.

[10] Chidamber, Shyam and Kemerer, Chris, “A metrics Suite for Object Oriented Design”, IEEE Transactions on Software Engineering, June, 1994, pp. 476-492.

ISSN: 2321-9653

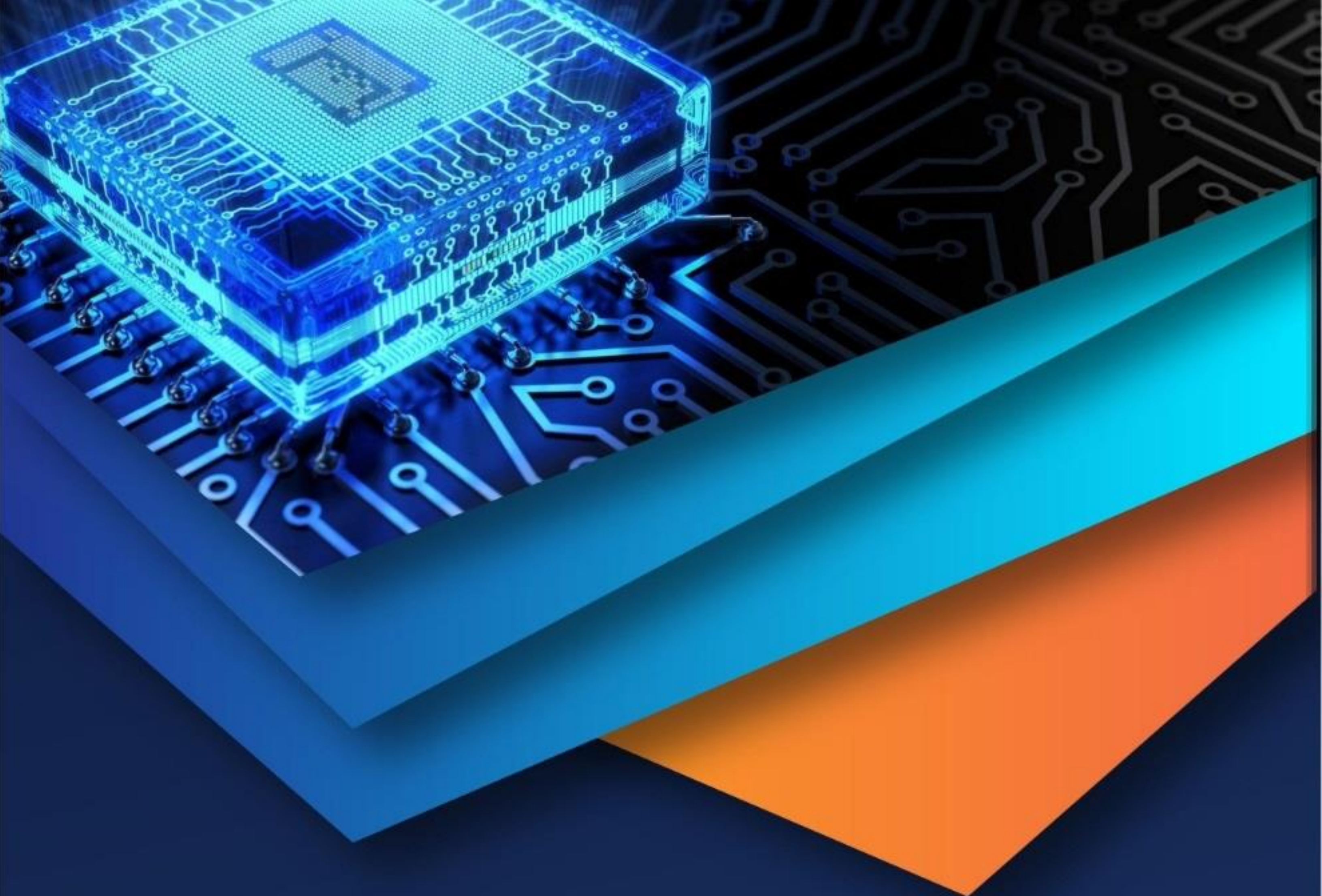
INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

[11] Tu Honglei1,Sun Wei1, Zhang Yanan1, "The Research on Software Metrics and Software Complexity Metrics", International Forum on Computer Science-Technology and Applications, 2009.

[12] Rakesh.L , Dr. Manoranjan Kumar Singh ,and Dr. Gunaseelan Devaraj , "Software Metrics: Some degree of Software Measurement and Analysis" ,(IJCSIS) International Journal of Computer Science and Information Security, Vol. 8, No. 2, 2010.

[13] Arti Chhikarai, R.S. Chhillar , "Impact of Aspect Orientation on Object Oriented Software Metrics". Vol. 2 No. 3 Jun-Jul 2011, Indian Journal of Computer Science and Engineering (IJCSE).

[14] The study of Lawrence *et al.* based its ranking of measures on a total of eight criteria, which are cost, benefit, credibility, directness, timeliness, repeatability, experience, and validation.



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