

A Systematic Literature Review of an Object Oriented Metrics Components: Case Study for Evaluation of Reusability Criteria

Neelamadhab Padhy*¹, R.P.Singh²,

Suresh Satapathy³, J.Sethlani⁴

^{1*}Research Scholar, Sri Satya Sai University of Technology and Medical Science

²Vice-Chancellor of Sri Satya Sai University of Technology and Medical Science

³Professor of Sri Satya Sai University of Technology and Medical Science

⁴Professor and Head of PVP institute, Vijayawada, (India)

ABSTRACT

The importance of object oriented metrics is highly essential in the software engineering domain. The object oriented metrics measures the complexity of the software, estimating the size of the product and quality of the software project. The Chidamber and Kemerer metrics suite is the best for measuring the object oriented designs. This paper reviews the object oriented metrics and we can analyze the difference between all the object oriented metrics through the comparison table. We have been taken a case study that how to evaluate the reusability by using machine learning regression algorithms and proved that Standard instance-based learning with no distance weighting is the best regression algorithms among others. Finally we have compare the novel regression algorithms and mentioned with a tabular form then we have been used WEKA software for compare and plotting the graph.

Keyword: Object Oriented Metrics, CK Metrics, Machine Learning Techniques

1.INTRODUCTION

The important area of the software engineering is the object oriented metrics which is popularly known as the CK(Chidamber & Kemerer) metrics suite .CK metrics was first introduced on the year of 1994[1].Many researchers have proposed [2][3] which have been summarized and studied[4][5].The traditional metrics cant measures the factors like coupling, inheritance and cohesion. The CK metrics was developed especially for handling the above factors. OOM is more suitable for software development environment .Now it is an important element to measure software quality over the environment [6]. According to et al. [7] Watts S. Humphery (1996) OOM is an aspect to be considered. During the system design metrics can be used as a set of standards to measure the effectiveness of object oriented analysis technique The main goal of an object oriented metrics is to improve the quality of the software. [8-

9]. To evaluate the quality of the object oriented software, we need to assess and analyze its design and implementation using appropriate metrics and evaluation techniques [10]. This set of six metrics shows a good potential in forming a complete measurement framework in an object-oriented environment. Neelamadhab et al [27] focused some reusability properties as well as they demonstrate the usage of reusability in the software industry. Muhammad Ali Khan et al.[28] described the properties of quality improvement of the software product. They have proposed the one model which is called as Kano Lean Six Sigma for software maintenance. N.Padhy et al.[29] examined by taking case study of two different object oriented program and demonstrate C# is better than .Net program as well as they proposed the models and algorithms to estimate the software metrics from mobile application. N.Padhy et al.[30-31-32] proposed object oriented algorithms and models to estimate the complexity from any object oriented program. They have taken CK-Metrics suite as well as demonstrate how dynamic reusability metrics can be feasible from the software code. Not only from object oriented program but also they have been used some Multiparadigm language like Java Script, Python etc. Their case study of this paper [31] is all about the java script code. They proposed a set of new metrics. Similarly in [32] they have discussed the reusability estimation structure, algorithm and proposed model. They described how reusability can be measured by using artificial intelligence techniques.

II. RESEARCH PROBLEM AND METHODOLOGY

The literature survey shows that there exist lapses in the measurement process in software engineering. Following this, several researchers have tried to propose a variety of criteria for different types of measurements in software engineering. OO programming, which is a relatively new programming paradigm in comparison to procedural languages, has received a lot of acceptance from the industry. Several researchers have also proposed software metrics to evaluate its complexity. However, a lack of standard guidelines makes it difficult to propose useful metrics based on a strong theoretical scientific foundation.

We are motivated to present this paper by the following research questions:

RQ.1. Do the existing criteria for the evaluation of OO metrics evaluate most of the features required for an OO metric

RQ.2. Should all the features suggested for metrics also be applicable to OO metrics?

To answer these questions, we keep the agenda of the present work as follows;

1. To evaluate the existing criteria which are used for evaluating OO metrics.
2. To extract the important features from the existing criteria for evaluating OO metrics (several well-known metrics are applied on these criteria to extract the features which are useful for OO metrics).



III. OBJECT-ORIENTED METRICS

OOD is more beneficial for software development environment and Object-Oriented design metrics is used to judge the quality of software in terms of size, complexity and performance. The quality of software can be measured depending upon the size of the project. It is a classifying approach, capable of decomposing the problems in terms of objects. Generally OOD follows the Divide-Conquer approach. The main aim of OO metrics is to evaluate macro level assessment of the systems and finally produce the high-quality results. To evaluate the quality of the object oriented software, we need to access and analyze its design and implementation using appropriate metrics and evaluation techniques [11]

IV. CHIDAMBER & KEMERER OBJECT-ORIENTED METRICS SUITE

The Chidamber & Kemerer metrics suite originally consists of 6 metrics calculated for each class: WMC, DIT, NOC, CBO, RFC and LCOM1. The original suite has later been amended by RFC', LCOM2, LCOM3 and LCOM4 by other authors

- ✓ Weighted Method Per Class
- ✓ Depth of Inheritance Tree
- ✓ Number of Children
- ✓ Response of a Class
- ✓ Message Passing coupling
- ✓ Data Abstraction coupling
- ✓ Number of local subunits.
- ✓ Inheritance Dependencies
- ✓ Factoring Effectiveness
- ✓ Reuse Ratio
- ✓

V. LITERATURE SURVEY

In this section we have done the literature survey of object oriented metrics briefly and we mentioned that what they have done in these papers and presented in a tabular form

SINO	Name of the Authors	Year & Publication	Work Done
01	et.al[11]Chidamber and Kemerer	“Towards to the metics for object oriented design”: Proceedings OOPSLA – July,1991,	They present theoretical work that builds a suite of metrics for object-oriented design

02	et.al[1] Chidamber and Kemerer	IEEE Transaction for Software Engineering, Vol-20 No.6, JUNE-1994	Further they have presented the empirical data to demonstrate that these metrics could be used in both C++ and Smalltalk environments
03	et.al[12] Li and Henry	Thesis on "Object oriented metrics which predicts maintainability" in the year of 1993-95	They study these metrics with reference to the maintenance effort in two commercial systems and conclude that these metrics in general can be used as predictors of maintenance effort, though two of the metrics are found to be not as good as expected Remarks: Li and Henry point out the ambiguities in the definition of one of the metric, LCOM - lack of Cohesion in Methods, and have attempted to rephrase the definition [Li and Henry, 1993].
04	et.al[13] Basili, and Briand,	Technical Report, Univ. of Maryland, Dept .of Computer Science, College Park, MD, 20742 USA. April 1995.	They have study the same as earlier and found that five of six metrics seem to be useful to predict class reliability during the early phases of the life cycle.
05	et.al[14] R. Kowalew	R. Kowalew, "Metrics in Object-Oriented Design and Programming," Software Development, Vol.	confirms (based on a field study) that two of the metrics (Class Coupling, and Response For Class) correlate with the defect densities

06	et.al[15] Abreu and Carapuca,	F.Abreu and R. Carapuca. Object-Oriented software engineering: Measuring and controlling the development process. In <i>Proceedings of the 4th International conference Software Quality</i> , 1994.	Abreu and other researchers have proposed a suite of six metrics called the MOOD metrics (Metrics for Object-Oriented Design). These metrics include Method Hiding Factor, Attribute Hiding Factor, Method Inheritance Factor, Attribute Inheritance Factor, Polymorphism Factor, and Coupling Factor
07	et.al[16]Abreu and Melo	F. Abreu, M. Goulˆao, and R. Esteves. Toward the design quality evaluation of object-oriented software systems. In <i>Proceedings of the 5th international Conference on Software Quality, Austin, Texas, USA</i> , pages 44–57, 1995.	Report that in an experimental study they found these metrics to correlate with the system reliability and maintainability

08	et.al[17] Fernando Britoe Abreu, and Walcelio Melo,	Fernando Brito e Abreu, and Walcelio Melo, "Evaluating the Impact of Object-Oriented Design on Software Quality", Proceedings of the third international Software Metrics Symposium (Metrics'96), IEEE, Germany 1996.	In a very recent study Harrison, Counsels, and Nithi report that the MOOD metrics can be said to be theoretically valid, but only if appropriate changes are made to rectify existing problematic discontinuities.
09	et.al[18] Moreau and Dominick	D. R. Moreau and W. D. Dominick, "A programming environment evaluation methodology for object-oriented systems: part I - the methodology," <i>Journal of Object-Oriented Programming</i> , vol. 3, pp. 38-52, May/Jun. 1990	They argue that there are three major factors that affect the complexity of programming in an OO environment : <ol style="list-style-type: none"> 1. the number of unique messages that will be sent by the current object (message vocabulary size), 3. the complexity of the inheritance mechanism that must be interpreted to determine the characteristics of the objects that will be used, and 4 the number of messages to which the current object must respond (message domain size).

10	et.al[3] [19]Lorenz,	1993	Lorenz, takes a similar approach and proposes a set of Object-Oriented Design Metrics and Project Completion Metrics Lorenz is one of the few researchers who have proposed some process metrics for object-oriented software development.
11	et.al[3][19] Lorenz and Kidd	Book review: Object-Oriented Software Metrics by Mark Lorenz and Jeff Kidd -1995,Pg : 91-93	An exclusive book on Object-Oriented Software Metrics by Lorenz and Kidd contains about thirty OO metrics and rules of thumb for using them. Problems: The major weakness of this book is that the metrics have not been validated in anyform-theoretically, subjectively, or empirically.
12	et.al.[20] Chen and Lu	A thesis work on “ Complexity of metrics for object-oriented design”,1993	Chen, and Lu propose <i>Operation Argument Complexity</i> and <i>Attribute Complexity</i> metrics which utilize the complexity of the arguments
14	et.al[21] Chen and Lu ,Abott		They have worked combine on validation of metrics



15	et.al[21] Churcher and Shepperd	Comments on “A Metrics Suite for Object Oriented Design” IEEE transactions on software engineering, vol. 21 , no. 3, march 1995 .	They have argued that, it is premature to develop and apply OO metrics that there is not certainty about the qualitative understanding of structure and behavior of OO System and also not the precise definition of fundamental quantities.
16	Tegarden, Sheetz, and Monarchi (He has revised the work done of the previous authors)	Revised for : Decision Support Systems: The International Journal (1/93)	The above authors [Abbott,1993; Abreu,1994;De Champeaux, 1997; Lorenz and Kidd, 1994]. Proposes several metrics at different level. They [Tegarden, Sheetz, and Monarchi] present a software complexity model which defines the software complexcity at the variable,
17	et.al[22]Bansiya	IEEE Transaction for software Engineering ,Vol-28No.1 ,January 2002	He has developed a metrics over 30 metrics known as QMOOD++ (Quality Metrics for Object Oriented Development)
18	et.al[23] B.Murgante	A systematic review on the impact of CK metrics on the functional correctness of the Object oriented classes :ICCSA Part-IV, LNCS, 7336,PP-258-273, ,2012,	In this paper he mentioned that now WMC,RFC,CBO,LCOM metrics are good for the good indicators of the functional correctness of OO classes

(Table 1 for literature report of different researcher)



VI. Case Study: Evaluation of Reusability on Object Oriented Based Software Components

In this paper we have used the proposed methodology to evaluate the object oriented metrics by using the some of the regression algorithms

6.1 Criteria for Comparison:

In this part of this article we have uses some of the regression techniques are

- Mean Absolute Error
- (MAE), Root Mean Squared Error (RMSE),
- Root Relative
- Squared Error (RRSE) □ Correlation Coefficient

VII. IMPLEMENTATION AND RESULTS

The WEKA software is used for comparing all the above machine learning regression algorithms which can be used for determining the reusability assessment of an Object oriented Metrics .The WEKA provides the set of machine learning algorithms as well as the data processing tools .WEKA provides the good comparative results[24].N.Padhy et al.[25-26] described the properties of the reusability. They have demonstrated how reusability used in software code to estimate the software complexity. As well as they have compare the C++,Java ad Python code and measure the software complexity by using Chidambaram and Kemerer 6 metrics . Again, N.Padhy et al.[27] discussed the reusability assets .They conduct the survey 100 numbers of papers and found only 11 reusability assets which are frequently used in the software code .

a. FINAL RESULTS DISCUSSION

In this part of the article we have presented the comparative results in the tabular form. This value that we are generated by using the above machine learning algorithms and finally we plot the graph

Algorithms used for Regression Purpose	Mean Absolute Error	Root Mean Squared Error	Root Relative Squared	Correlation Coefficient
Multi	0.0741	0.0741	30.8442	0.949
LinearRegression		0.0951		
TreeM5P	0.0658	0.0658 0.088	28.5504	0.9558
AdditiveRegression with M5P	0.0655	0.0843	0.0843	0.9634
IBk with No distance	0.0481	0.0841	27.3604 27.303	0.961

VIII. FOR COMPARISON OF DIFFERENT MACHINE LEARNING REGRESSING ALGORITHMS

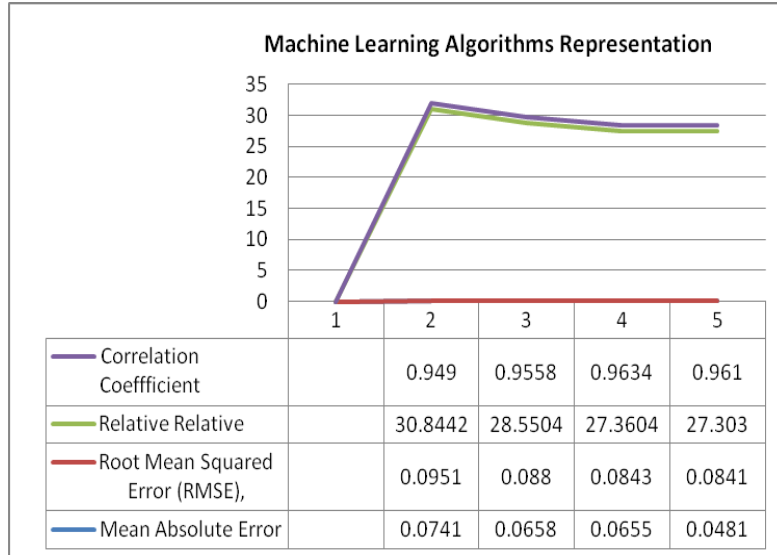


Fig.1 Comparison of Machine learning Algorithms

From the above plotted graph it is conclude that the performance of “IBk with No distance Weighting” is good as compare to above mentioned regression algorithms. The Mean Absolute Error (MAE) and RSME give the better prediction

IX.FEATURE WORK FOR RESEARCHERS

One possible feature work is point out the data/attributes involved in any kind of object oriented metrics and implement the data mining techniques to reduce the complexity of data analysis for any system. The metrics is to be designed to find the attributes leads the difficulty in maintaining classes as well as attributes that describes potential effects of class changes.In feature we will use the good technique for reusability evaluation model with more accuracy The researcher can able to correlate between individual parameters and dependent variable.

X.CONCLUSION

From the above studies we conclude that object oriented software can be developed by using the features of object oriented metrics effectively. In this review we have presented a set of six number of well established object oriented metrics and we have compared all the object oriented software metrics which focuses all the attributes, methods are used the software environment. We have used the four different types of regression algorithms but “IBk with No Distance Weighting” is proved to be best than other regression algorithms. Hence it is conclude that “IBk with No Distance Weighting” algorithms can be used frequently for evaluation of reusability of an Object Oriented Metrics.

XI.ACKNOWLEDGEMENTS

I would like to thank my guide Prof. (Dr.) R.P. Singh, Vice Chancellor of the Satya sai University of Technology and Medical Science, Sehore (Madhyapradesh) and my co-guide Prof. (Dr.) Suresh Chandra Satapathy, LMCSI, senior member IEEE and Head of Department of PVP Siddhartha Institute of Technology, Vijayawada Andhra Pradesh for their understanding, patience and provided me with unending encouragement and support. Their mentorship was paramount in providing a well rounded experience for my long-term carrier goals. They encouraged me not only grow as a research scholar also as an independent thinker. I would like to thank my wife for her moral support as well the faculties of Department of Computer Science and Engineering at the SSSUTM University, Sehore, especially for their input, valuable discussions and accessibility. At least not last, I would never forget Prof. (Dr) Puspender Sharma (Dy. Registrar) Sri Satya Sai University of Technology and Medical Sciences, Sehore (M.P.) 466001).

REFERENCES

- [1] C. Shyam and C. F. Kemerer, "A Metrics Suite for Object Oriented Design", IEEE Transactions on Software Engineering, Vol. 20, No. 6, June 1994, pp. 476-493.
- [2] B. Henderson-Sellers, The mathematical validity of software metrics, Software Engineering Notes 21 (1996) 89– 94.
- [3] M. Lorenz, J. Kidd, Object-Oriented Software Metrics, Prentice Hall, Englewood Cliffs, NJ, 1994.
- [4] L.C. Briand, J.W. Daly, J.K. Wust, A unified framework for coupling measurement in object-oriented systems, IEEE Transactions on Software Engineering 25 (1) (1999) 91–121.
- [5] D. De Champeaux, S. Horner, G. Miller, OO process and metrics for effort estimation, OOPS Messenger 6 (4) (1995) 138–142.
- [6] C. Neelamegam, M. Punithavali, "A survey on object oriented quality metrics", Global journal of computer science and technologies, pp 183-186, 2011.
- [7] Watts S. Humphery(1996) " Object oriented metrics "
- [8] Dr.B.R.Sastry,M.V.Vijaya saradi "Impact of software metrics on the Object oriented software development life cycle", Int.Journal of Engineering Science and Technology,Vol 2(2),Pg 67-76,2010
- [9] Amjan Sahik, Dr.C.R.K.Reddy. A Damodaran "Statistical Analysis for Object Oriented Design Software security metrics", Int. Journal of Engineering Science and Tech.,Vol 2(5),pg 1136-1142,2010
- [10] Pressman, R. "A Practitioner's Approach to Software Engineering," Mc-Graw hill Publications,2001,pp.658-662
- [11] "Towards to the metics for object oriented design": Proceedings OOPSLA – July,1991,
- [12] Wei Li and Salilie Henry "Object oriented metrics which predicts maintainability" in the year of 1993-95
- [13] Basili and Briand presented a technical Report, Univ. of Maryland, Dep. Of Computer Science, and College Park, MD, 20742 USA. April 1995.
- [14] R. Kolewe ""Metrics in Object-Oriented Design and Programming," Software Development, Vol. 1, No. 4, October 1993, pp. 53-62.

- [15] F.Abreu and R. Carapuca. Object-oriented software engineering: Measuring and controlling the development process. In Proceedings of the 4th International conference on Software Quality, 1994.
- [16] Abreu, M. Goul'ao, and R. Esteves. Toward the design quality evaluation of object-oriented software systems. In Proceedings of the 5th international Conference on Software Quality, Austin, Texas, USA, pages 44–57, 1995.
- [17] Fernando Brito e Abreu, and Walcelio Melo, "Evaluating the Impact of Object-Oriented Design on Software Quality", Proceedings of the third international Software Metrics Symposium (Metrics'96), IEEE, Germany 1996.
- [18] D. R. Moreau and W. D. Dominick, "A programming environment evaluation methodology for object-oriented systems: part I - the methodology," Journal of Object-Oriented Programming, vol. 3, pp. 38-52, May/Jun. **1990**
- [19] Lorenz Book review: "Object-Oriented Software Metrics" by Mark Lorenz and Jeff Kidd, Published by ACM 1995 Article.
- [20] Chen and Lu, A thesis work on "Complexity of metrics for object-oriented design", **1993**
- [21] Churcher and Shepperd Comments on "A Metrics Suite for Object Oriented Design" IEEE transactions on software engineering, vol. 21, no. 3, march 1995.
- [22] Bansiya "A hierarchical model for object oriented design quality assessment" IEEE Transaction for Software Engineering, vol-28 No.1, January **2002**
- [23] B.Murgante, "A systematic review on the impact of CK metrics on the functional correctness of the Object oriented classes" :ICCSA Part-IV, LNCS, 7336, PP-258-273, **2012**,
- [24] E. Frank, M. Hall, G. Holmes, R. Kirkby, B. Pfahringer and I.H. Witten, WEKA, A Machine Learning Workbench for Data Mining, Data Mining and Knowledge Discovery Handbook, 2nd Edition, **Springer**, **2010**, pp 1269-1277
- [25] Padhy Neelamadhab, Rasmita Panigrahi, Sarada Baboo : "A Systematic Literature Review of an Object Oriented Metric: Reusability" **IEEE**, **2015**, pp.191-192, **DOI: [10.1109/CINE.2015.44](https://doi.org/10.1109/CINE.2015.44)**
- [26] Padhy Neelamadhab, Rasmita Panigrahi : "The Statistical Measurement of an Object-Oriented Programme Using an Object Oriented Metrics", Springer International Publishing, Switzerzlerland, **2015** **January**, pp.:605-618, DOI: 10.1007/978-3-319-12012-6_67
- [27] Padhy Neelamadhab, Satapathy S and Singh R.P(**In Press**). "State-of-the-Art Object-Oriented Metrics and Its reusability : A Decade Review", Springer, Smart Inovation, System and Technologies, https://doi.org/10.1007/978-981-10-5544-7_42, https://doi.org/10.1007/978-981-10-5544-7_42, **2018** (**Press**).
- [28] Muhammad Ali Khan, Sajjad Mahmood : Measuring Flexibility in Software Project Schedules, Computer Engineering and Computer Science May **2015**, Volume 40, Issue 5, pp 1343-1358.
- [29] N. Padhy, S.C. Satapathy, R.P. Singh(**Press**): Estimation utility of an object-oriented metrics component: examining the feasibility of .Net and C# Object-oriented program from the perspective of mobile learning, Int Journal of Networking and Virtual Organization, **2017**, **Inderscience**.

- [30] Padhy, N., Satapathy, S.C.and Singh, R. P. (xxxx) ‘Estimation of complexity by using an object oriented metrics approach and its proposed algorithm and models’, *Int. J. Networking and Virtual Organisations*, Vol. X, No. Y, pp.xxx–xxx.(Press),**2017,Inderscience**
- [31] Padhy, N., Satapathy, S.C.and Singh, R.P. (xxxx) ‘Complexity estimation by using Multiparadigm approach: a proposed metrics and algorithms’, *Int. Journal of. Networking and Virtual Organisations*, Vol. X, No. Y, pp.xxx–xxx.(Press),**2017,Inderscience**.
- [32] Padhy, N., Satapathy, S.C.and Singh, R.P (2017) Software reusability metrics estimation: Algorithms, models and optimization techniques, *Computers and Electrical Engineering, Elsevier* ,<https://doi.org/10.1016/j.compeleceng.2017.11.022> ,0045-7906/© 2017,Press