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Analysis of correlation between software complexity metrics

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Abstract: Software quality is an important concern of any software development company. The software complexity metrics are one among the metrics which use the internal attributes of the software to know how they affect the software quality. This paper presents the impact of software metrics on software quality and discusses some important researches done to find the correlation between them and their findings. In future work, the application of feature selection on the correlated metrics set is suggested for better metrics utilisation and improved decision makingthat can also lead to secure software development.

Index Terms: Software Quality, Software complexity, Metrics, Correlation.

1. INTRODUCTION

People demand for software quality is increasing day by day . In IT industry,it is important to find and improve the quality factors. Due to the appearance of certain factors affecting the software quality, many researchers believe that there exists a direct relationship between internal attributes like-LOC,effort,speed,memoryetc and the external attributes like-efficiency,maintainability,reliability etc.[2]e.g.-greater value of LOC leads to greater software complexity.The internal attributes are the ones that can be measured directly and the external attributes are the ones we are interested in.In this paper section 2 presents a survey of some important software complexity metrics ,section 3 represents the motivation ,section 4 depicts the work done for finding correlation between software complexity metrics by various researchers and section includes the conclusion and future work.

2. Software complexity metrics

Software complexity metrics play an important role in improving software quality and project controllability[3].Lots of different software metrics are in use for measuring the software complexity. Some of the important complexity metrics are as under:

2.1 Lines Of Code(LOC):

It is mostly used to measure the size of software. LOC is computed by counted the lines of a program code, in general. It can be used to measure the complexity and can be computed in many ways:

- LOC: Lines Of Code.
- SLOC: Source Lines Of Code.
- CLOC: Comment Lines Of Code.
- S&CLOC: Source Lines Of Code with Comment Lines.
- BLOC: Blank Lines Of Code.
- PLOC: Physical Lines Of Code.
- LLOC: Logical Lines Of Code.

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2.2.Halstead complexity:

It is a composite complexity metrics introduced by Maurice Howard Halstead in 1977. Firstly it calculates four factors:[5]

n1=the number of distinct operators in a program

n2= the number of distinct operands in aprogram.

N1=the total number of occurrences of operators

N2=the total number of occurrences of operands.

Based on these factors, some formulas can be computed as follows:

- n=n1 + n2.
- N=N1+N2.
- $V=N*\log_2 n$.
- D=(n1/2)*(N2/n2).
- L=(2*n2)/(n1*N2),corresponded to (1/D).
- I=L*V
- E=D*V.
- T=E/18 where 18 is chosen based on Stroud number.

Where, n is vocabulary ,N is the program length, V is volume, D is difficulty, Lrefers to Level,I is program's Intelligent content,E is effort,T is the time required.

2.3 Cyclomatic Complexity:

It is calculated using the Control Flow Graph(CFG) which illustrates the cycle of instructions during execution. It measures the number of linearly independent paths through the source code. Cyclomatic complexity V(G) is calculated as:

V(G)=E-N+2

Where E is number of edges and N is number of nodes in the CFG.

3. Motivation

The internal and external attributes of a software product and the relationship between them directly affects its behaviour. The metrics are combination of these attributes. As the number of metrics used in a software project increases the management and controlling of the project also increases. Finding the relationships between different metrics can benefit the developers in many ways. E.g.- if there are two metrics A and B such that metric A is used to measure maintainability and B is used to measure complexity . If the metrics A and B are correlated such that as A increases B also increases then metric A can be used to compute complexity in addition to maintainability and metric B can be used to compute maintainability in addition to complexity. As such finding correlation between metrics can help in better controlling and management of different software development and maintenance activities. Using the same correlating techniques ,the software security metrics can also be correlated for better implementation of software security.

4. Survey on work done:

Meine J.P. et.ol[1] investigated the relationship between different internal and external software metrics by analysing a large collection of C/C++ programs submitted to a programming competition ,the Online Judge. The authors found that a very strong correlation exists between the internal software metrics –LOC,Halsted Volume(V) and CyclomaticComplexity(Fig.1 [1]). Authors derived relations between means of distribution of these metrics as follows:

V=45×LOC-428

CC= 0.22 ×LOC1.9

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Which gives the best estimates of V and CC when LOC is already available.×

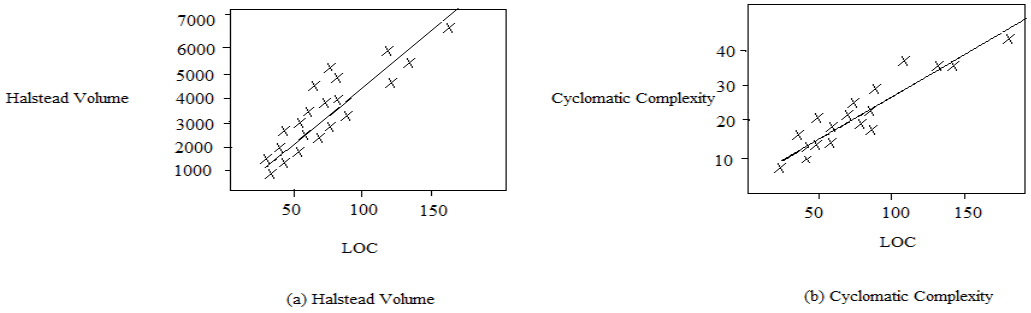

Figure 1

Kevrekidiset.ol[4] used the relationship between software reliability and software complexity for evaluating the effectiveness of testing strategies.

YashTashtousget.ol [2] analysed the 5 public domain software defect datasets provided by NASA IV & V Facility and Metrics Program (MSP) repository to find correlation between different software complexity metrics . It was found that Cyclomatic Complexity has strong correlation with Halstead Complexity and LOC.(Fig2. & Fig3. [2]). Halstead Complexity was found to have strong correlation with Cyclomatic Complexity but weak correlation with LOC(Fig.4 [2]). Cyclomatic Complexity and Halstaed Complexity are strongly correlated and used together, Cyclomatic Complexity for measuring control flow and Halstead Complexity for measuring data flow.

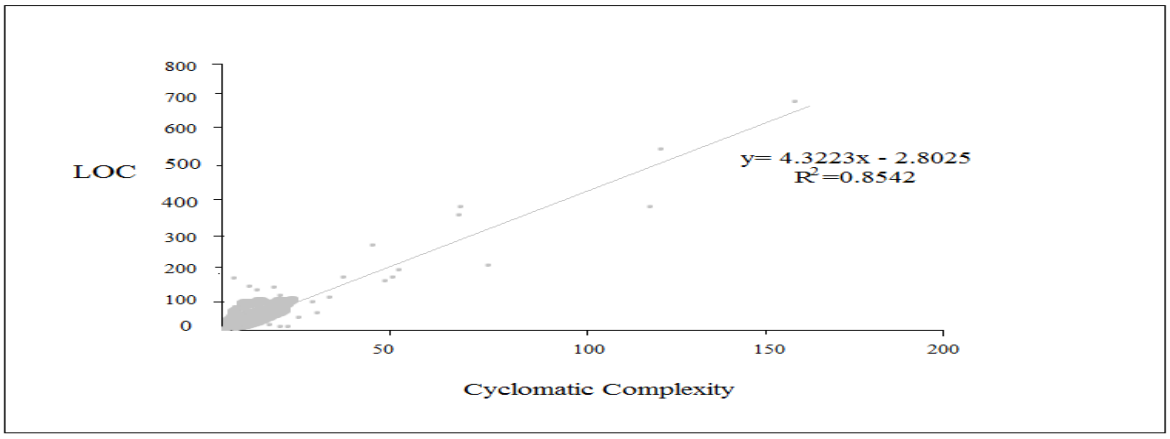

Figure 2

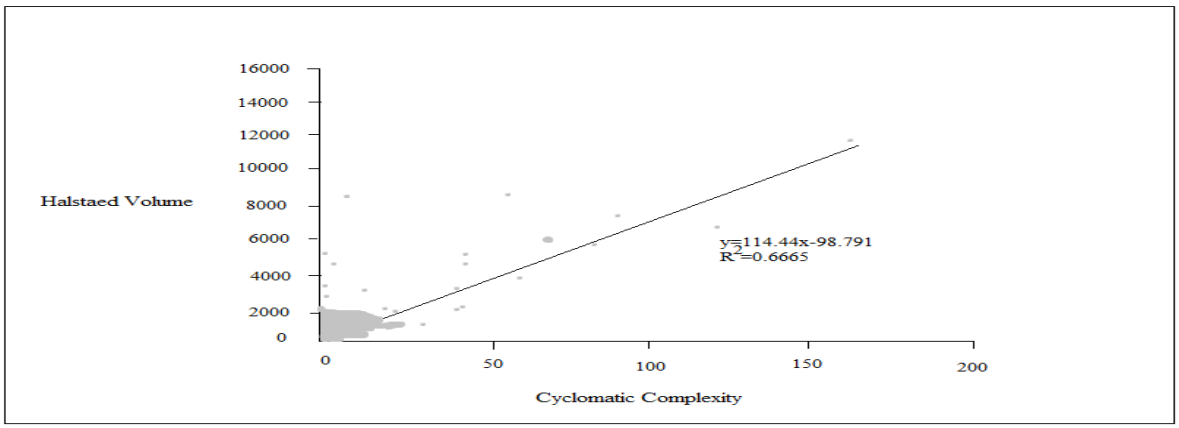

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Figure 3

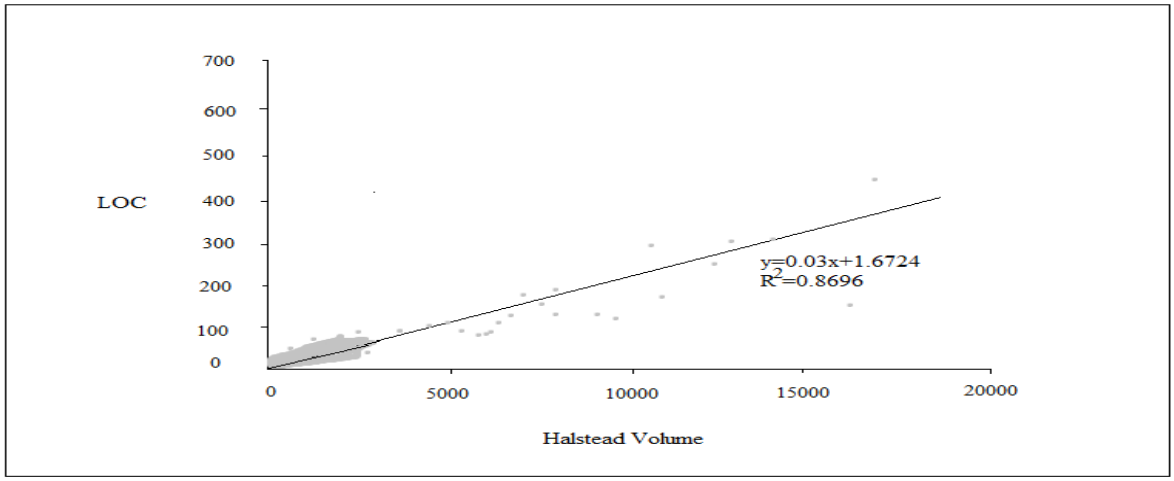

Figure 4

5. Conclusion and Future work:

The above mentioned findings by different researchers shows that there exists a strong correlation between Cyclomatic Complexity metric and the Halstead Complexity Metric. Cyclomatic Complexity metric is also found to have strong correlation with LOC.

Similarly correlation between many other metrics can be found that can assist practitioners in different decision makings. Future work includes correlating different internal metrics and correlating them to different external metrics, and **the feature selection** can be applied on correlated metrics set for more beneficial and controlled use of the software metrics and for better decision making and secure software development.Similarly,the security metrics can also be correlated for getting better security features selected for enhancing software security.

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