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An Empirical Study of Correlations between Function Points and Software Defects

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Abstract

Software defects prediction research is converging on the use of function point elements for software defect predictions. Studies on the nature and behavior of the function point elements are expanding. Previous studies have analyzed the correlation between the function point elements. This paper presents correlation analysis between function point elements and the software defects. It is observed that external input count and external inquiry count function point elements show some correlation with software defects. Different data subsets were analyzed, where 4GL projects shows strong correlation with defects over 3GL and ApG/other projects, while enhancement software projects show more correlation with defects over new software projects.

Keywords*: Software Engineering, Software Projects, Software Defects, Function Point Elements*

1. Introduction

Function Point elements have attracted much attention in the software research and development industry. Ever since function point were introduced by IBM in 70's their nature, behaviour, impact, distribution and correlation have been studied by the software researchers and the software developers. The idea behind function points is to standardize the measurement of the various software functions to estimate the software development effort which is independent of the computer language, development methodology, technology and the capability of the team developed the software. The international Point users Group (IFPUG) was founded in the late eighties and is a membership governed, non-profit organization committed to promoting and supporting function point analysis and other software measurement techniques. There have been various releases of the Function Point by the International Function Point Users Group (IFPUG) which includes the 'Counting Practice Manual – 4.2' release.

Function point describes the size of the software using five elements: Internal Logical Files (ILF), External Interface Files (EIF), External Inputs (EI), External Outputs (EO) and external Enquiries (EQ). Each function point element is assigned a complexity level based on its associated file number such as Data Element Type (DET), File Type Referenced (FTR) and Record Element Types (RET).

Known correlation relationship between function point elements and the software defects can make it possible to predict the number of defects from a single function point element eliminating the need of having the full information of function point elements available. Previous studies focused on the correlation between different function point elements. Chris [1] presented the correlation analysis between different function elements; he analysed the large data set with different subsets to investigate any relationship between different function points. His findings shows that external input and internal logical files are always correlated and external logical files are generally uncorrelated with the other function point elements. Function point elements are not fully orthogonal

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and exert some degree of influence over each other, any correlation among function point elements could impact their correlations with other software components. This paper investigates the correlation between function point elements and software defects. Section 2 describes the data set used for the analysis; section 3 focuses on the correlation between function point elements and software defects, section 4 discusses conclusions.

2. The Dataset

The dataset for analysis is taken from the International Software Benchmarking Standards (ISBSG) repository [2]. ISBSG performs the data validation of the contributed data to make sure the data quality and consistency. The obtained repository contains data from 3024 different projects, where almost all the projects used IFPUG standard [3] for function points. Projects which used other methods then IFPUG were excluded from the study. Data sets with the missing function points and defects count values were also excluded. After this selection 115 projects remained for the analysis. 68 projects were developed inhouse and 19 projects were combined development.

In the selected projects largest projects were contributed from the financial industry (banking, financial services, and accounting) with 52 project in total and 12 projects form engineering (software, hardware and telecommunication). 52 were new developments and 65 were enhancement projects. The collected data set is not homogenous which would ensure linearity in statistical analysis. The variety in the data set ensures that the data sample represents different scenarios and possibilities in the software development industry.

Unadjusted function points represent the total size of the project since it represents the total number of function points counted together. Figure 1 shows a graph of unadjusted function with the number of projects.

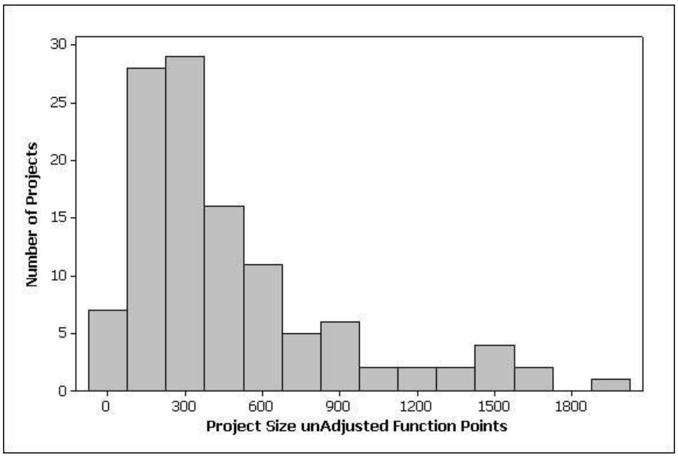

Figure 1. Project Sizes

Total number of projects is 117, the minimum size is 31 unadjusted function points and the maximum 1960 unadjusted function point, mean is 472.16, median is 327 and the standard deviation is 414.32, see Table 1 for description of the dataset.

Table 1. Data Set Information

	Projects	Minimum	Maximum	Mean	Median	Standard deviation
Full Data	117	31	1960	472.16	327	414.32
3GL	38	49	1512	408.44	296.5	366.08
4GL	65	31	1960	532.43	350	465.01
ApG/Other	11	42	1540	509.63	379	486.28
New Development	53	74	1960	673.15	550	513.48
Enhancement	63	31	1401	340.90	253	273.66
COBOL	16	96	1401	369.06	289	321.85
SQL	6	340	1674	754.83	590	494.30
Visual Basic	12	156	550	272.91	244.5	126.71
Natural	19	31	734	290.89	250	185.79

A box plot of the function point elements is shown in Figure 2. Line in the middle of the boxes represents the median value the upper line of the box represents the third quartile (Q3, 75% of the values are less than or equal to this value) while the lower line of the box represents the first quartile (Q1, 25% of the values are less then this value). Upper and lower whiskers extend to the upper and lower data limits (lower limit=Q1-1.5[Q3-Q1], upper limit =Q3+1.5[Q3-Q1]). Values larger than the whiskers are represented by the stars.

EI (Input count) function point element's size of the box and the length of the upper whisker show that the input count data is more spread then the rest of the function point elements, the median of all the function point elements are almost in the same range with the others.

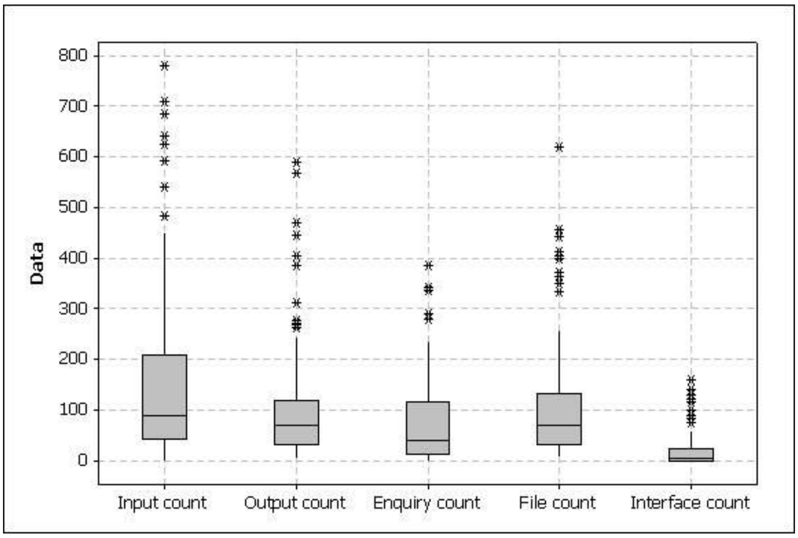

Figure 2. Box Plot of Function Point Elements

3. Function Points and Software Defect Correlations

Pearson's correlation method is adopted on the dataset which measures the strength of the linear relationship between two variables. The value of the correlation coefficient will range between 0 and 1, with higher values indicating a better fit between the two variables. Outliers were removed from the data set before correlations were performed and their inclusion shows a strong impact on the correlation coefficients as these points lie away form the rest of the data points.

Correlations of the function point elements and the software defects on the entire data set are shown in Table 2, where 'n.s.' means non-significant. Correlation values shown suggests that input count and the inquiry count function point elements shows more correlation with the software defects then other function point elements.

Table 2. Function Point Element Correlations with Software Defects

	EI(Input)	EO(Output)	EQ(Inquiry)	ILF(Internal)	ELF(External)
Defects	0.251	0.100	0.289	0.163	-0.068
p-value	0.007	0.287 (n.s.)	0.002	0.082 (n.s.)	0.469 (n.s.)

Chris [1] suggested that some factors have a statistically significant effect on the balance between function point elements:

- Projects involved using 3GL involves more files and fewer transactions then the projects using 4GL.
- Maintenance projects involve more transactions and fewer files then projects developing new systems.
- Projects from banks and business services use fewer inputs and produce more outputs then the projects from public utilities and government departments.
- The use of prototyping during development is associated with more inputs and queries and fewer outputs.

Value of different variables changes depending on the type and nature of the project and thus changes the correlation relationship with other factors. To understand that affects the entire data set was divided into following sub project groups; 3GL, 4GL, ApG/Other, New Development, Enhancement, COBOL, ORACLE, SQL, Visual Basic, Natural languages. These subsets were taken from the data set which already has the outliers removed. Pearon's correlation was used the same as on the entire data set.

Table 3 shows correlations of software defects with function point elements of different groups of software projects with p-value set at 5%.

The correlation results shows that overall 4GL projects shows more correlation with software defects then 3GL and ApG/Other based projects. In this group, EQ function point element of 4GL shows significant results, while the rest of the correlations produce insignificant p-values.

Also enhancement projects show more correlation as compared to the new projects. In this group, the external input (EI) produced significant results.

In programming languages COBOL based projects has a high correlation with the software defects over ORACLE, SQL, Visual Basic and Natural languages based projects. In this group, the COBOL and Natural languages produced significant results; for COBOL external input (EI), external output (EO) and internal logical files (ILF) while for Natural languages internal logical files (ILF) shows significant result

Table 3. Correlation of Software Defects with Different FP Groups

3GL

	EI(Input)	EO(Output)	EQ(Inquiry)	ILF(Internal)	ELF(External)
Defects	0.361	0.541	0.371	0.167	-0.154
p-value	0.02 (n.s.)	0.00 (n.s.)	0.022 (n.s.)	0.317 (n.s.)	0.357 (n.s.)

4GL

Defects	0.206	0.014	0.341	0.154	-0.108
p-value	0.100 (n.s.)	0.914 (n.s.)	0.005	0.220 (n.s.)	0.392 (n.s.)

ApG/Other

Defects	-0.125	-0.048	-0.060	-0.073	0.186
p-value	0.714 (n.s.)	0.888 (n.s.)	0.862 (n.s.)	0.831 (n.s.)	0.584 (n.s.)

New Development

Defects	0.225	0.114	0.011	0.259	-0.212
p-value	0.105 (n.s.)	0.416 (n.s.)	0.937 (n.s.)	0.061 (n.s.)	0.128 (n.s.)

Enhancement

Defects	0.391	0.238	0.496	0.340	-0.000
p-value	0.002	0.060 (n.s.)	0.000 (n.s.)	0.006	0.999 (n.s.)

COBOL

Defects	0.751	0.755	0.713	0.207	-0.115
p-value	0.001	0.001	0.002	0.442 (n.s.)	0.671 (n.s.)

ORACLE

Defects	0.924	0.781	0.633	0.832	-0.842
p-value	0.025 (n.s.)	0.119 (n.s.)	0.252 (n.s.)	0.080 (n.s.)	0.074 (n.s.)

SQL

Defects	-0.326	-0.530	-0.174	-0.387	-0.673
p-value	0.528 (n.s.)	0.280 (n.s.)	0.741 (n.s.)	0.449 (n.s.)	0.143 (n.s.)

Visual Basic

Defects	-0.276	-0.057	-0.216	-0.069	-0.069
p-value	0.384 (n.s.)	0.860 (n.s.)	0.500 (n.s.)	0.830 (n.s.)	0.830 (n.s.)

Natural

Defects	0.589	0.126	0.623	0.364	0.401
p-value	0.008 (n.s.)	0.606 (n.s.)	0.004	0.126 (n.s.)	0.089 (n.s.)

4. Conclusions

Correlation between function point elements and software defects are presented. On the entire data set external input count and external inquiry count function point elements showed some correlation with the software defects. This trend is only observed in the COBOL based projects, rest of the projects subsets shows correlation with different function point elements.

References

[1] C. J. Lokan, "An Empirical Study of the Correlation between Function Point Elements", Software Metrics Symposium, 1999 Sixth International Proceedings, pp. 200-206.
[2] International Software Benchmarking Standards Group. Release 9.
[3] IFPUG. Function Point Counting Practices Manual release 4.2.

Author

Masood Uzzafer, he has 20 years of experience of which 10 years in the US high-tech industry and 10 years in the research and academics. Dr. Masood has worked for companies like Allied-Signal Aero-Space in Florida and Philips Semiconductors Silicon Valley California. His industrial experience encompasses designing and developing software for variety of products including Radar Systems, Digital TV, cable modem and Multi-Media processors.

His research has multiple streams including software engineering, project management and risk management. Currently, he is leading a research project to calibrate the Framingham Cardiovascular risk prediction model and Framingham Coronary heart disease risk prediction model for the population in Dubai.