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IFPUG Function Points to COSMIC Function Points convertibility: A fine-grained statistical approach

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ABSTRACT

Background: Functional size measurement is widely used in software organizations because it supports the estimation of software development effort. Function Point Analysis was the first functional size measurement method and became quite popular. The COSMIC method is considered a second-generation method, due to its novel design, and has also gained wide acceptance. Since the proposal of the COSMIC method, the measure convertibility issue arose. Many studies have investigated this issue: several conversion techniques have been proposed and their accuracy has been evaluated through empirical studies.
Objective: The goal of the paper is to explore statistic conversion criteria that leverage the similarity between the Base Functional Components of the considered functional measurement methods, especially concerning elementary processes and functional processes.
Method: Statistical models of the relationship between the considered measures were built, using Least Median of Squares linear regression. The models use measures of Function Point Analysis Base Functional Components and COSMIC Base Functional Components as independent and dependent variables, respectively. Accuracy of conversion was assessed via leave-one-out cross validation.
Results: The proposed method was tested on three datasets, and was compared with other conversion methods. The proposed method achieved results that are never less accurate – and sometimes much more accurate – than alternative methods'.
Conclusions: The proposed method requires that when traditional Function Points are measured, information concerning Base Functional Components are recorded. If such information is available, the proposed approach is – according to the collected evidence – preferable to other conversion methods, with respect to both the effort required to obtain the results and their accuracy.

1. Introduction

Functional size measurement (FSM) is important because functional size measures – being based on the specifications of functional user requirements – are available in the early phases of development. Accordingly, functional size measures are widely used in software organizations for estimating the software development effort in the early stages of development, when estimates are most needed.

Function Point Analysis (FPA) was the first functional size measurement method [1] and became quite popular. Currently, the Function Point (FP) measurement method is defined and maintained by the International Function Point User Group (IFPUG) [2]. In this paper, we make reference to IFPUG FP.

The COSMIC method [3] is a second-generation method, which has been proposed with the aim of overcoming a few shortcomings of IFPUG FP. The COSMIC method has also gained wide acceptance.

Since the proposal of the COSMIC method, the measure convertibility issue arose: organizations that have been using IFPUG FP face a problem, when they want to switch to using the COSMIC method. The problem is that these organizations have typically accumulated a wealth of functional measures in the past, and would like to continue using the knowledge embedded in those historical data. The solution to the problem consists in converting measures expressed in IFPUG Function Points into COSMIC Function Points. This is possible because both IFPUG and COSMIC FP conform to the principles of ISO 14143 standard series [4], which describes the characteristics that functional size methods must have, and advocates that functional size measures should be convertible from a functional measurement unit (e.g., IFPUG Function Points) into another functional measurement unit (e.g., COSMIC Function Points).

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The problem of functional size measure conversion has been widely studied, as described in Section 3. Researchers proposed two broad methods of conversion:

Statistical methods. If a set of applications have been measured using both IFPUG FP and COSMIC Function Points, it is possible to study the correlations between the measures obtained via the two methods. Several researchers found statistically significant relationships between IFPUG FP and COSMIC FP. The statistical models can be used for conversion.

Theoretical methods. These methods exploit the definition of the functional size measurement methods. The elements of Functional User Requirements (FURs) considered by IFPUG and COSMIC methods are quite similar. If the data concerning these elements – named 'Base Functional Components' (BFCs) – were stored when the original measurements were performed, it is possible to exploit this information to identify COSMIC BFCs, and sometimes even to derive their measures. Unfortunately, not all COSMIC BFC can be identified and measured based on IFPUG BFC. Therefore, theoretical methods are either approximate, or they need to be complemented by analysis and measurement activities carried out by humans.

All studies found in the literature deal either with statistical conversion or with theoretical conversion.

In this paper, we propose a new approach to FSM conversion that draws from both the statistical and theoretical approaches. Specifically, from the theoretical approaches we take the idea that it is possible to exploit the similarity between IFPUG and COSMIC BFCs to perform a conversion at the level of BFCs. We propose to perform the conversion at the process level: the sizes of COSMIC functional processes are obtained from measures of IFPUG elementary processes. From the statistical approaches we take the idea that the conversion can be obtained via statistical models that represent quantitatively the relationship between IFPUG measures and COSMIC measures. That is, we do not work out the measure of every functional process from the characteristics of the corresponding elementary process (as done, for instance, in [5]). Instead, we build the statistical model that summarizes the quantitative relationship between a set of IFPUG elementary processes and the corresponding set of COSMIC functional processes.

Note that the proposed models cannot be used by organizations that have only UFP size measures of whole applications, and did not record measures of BFCs.

The proposed technique is compared with 'traditional' statistical techniques via an empirical study.

The work described in this paper advances the state of practice concerning IFPUG to COSMIC convertibility in a few important respects:

- We show that convertibility at the process level is actually possible, and that the obtained accuracy compares favorably with that of traditional application-level conversion methods.
- One of the most important known problems with IFPUG–COSMIC convertibility is the 'cut-off' effect, i.e., the fact that the size of an IFPUG elementary process is limited to 7 FP, while the size of a COSMIC functional process is not limited [6,7]. This fact can lead to inaccurate results when the conversion is carried out at the application level [6]. Instead, with process-level conversion we can use process measures that are not limited in any way, thus do not suffer from any 'cut-off' effect.
- To build statistical models at the application level, the IFPUG and COSMIC measures of several applications are needed. This means that in the conversion from IFPUG to COSMIC it is necessary to spend a good deal of time and effort to measure several applications using the COSMIC method, to be able to derive a model and then use it to compute the COSMIC size of the remaining applications. With process-level conversion, measuring a single application using the COSMIC method may be enough (under the conditions described in Section 6.2). Hence, process-level conversion is much cheaper than application-level conversion.

The paper is organized as follows. Section 2 briefly describes the two functional size measurement methods used in this paper: IFPUG Function Points and COSMIC Function Points. Section 3 recalls the previous proposals concerning IFPUG to COSMIC measure conversion. Section 4 illustrates our proposal. Section 5 illustrates the empirical validation of the proposed method and the comparison with previously proposed methods. Section 6 discusses the main results of the empirical study and the merits of the proposed conversion technique. Section 7 discusses the threats to the validity of the proposal and the empirical study. Finally, Section 8 draws some conclusions and outlines future work.

In this paper, we deal only with "unadjusted" FP (UFP). This choice is supported by the observation that ISO recognized UFP as a standard, rather than adjusted FP [8]. Therefore, in what follows, by "IFPUG FP" or just by "FP" we always mean unadjusted FP.

2. Functional size measurement methods

This section provides a brief introduction to the FSM methods considered in this paper. Readers are referred to the official documentation [3,8–11] for further details.

2.1. The IFPUG method

Function Point Analysis was originally introduced by Albrecht to measure the size of data-processing systems from the end-user's point of view, with the goal of estimating the development effort [1].

The initial interest sparked by FPA, along with the recognition of the need for maintaining FPA counting practices led to founding the IFPUG (International Function Points User Group).

The IFPUG (http://www.ifpug.org/) maintains the counting practices manual [9], provides guidelines and examples, and oversees the standardization of the measurement method.

The IFPUG method is an ISO standard [8] in its "unadjusted" version. The adjustment factor originally proposed by Albrecht and endorsed by IFPUG is meant to obtain measures more apt for effort estimation, by accounting for factors not dealing with functional requirements, namely with product and process features that do not belong to the notion of functional size. As such, the adjustment was not accepted by ISO and was disregarded by COSMIC as well.

Albrecht's basic idea – which is still at the basis of the IFPUG method – is that the "amount of functionality" released to the user can be evaluated by taking into account (1) the data used by the application to provide the required functions, and (2) the transactions (i.e., operations that involve data crossing the boundaries of the application) through which the functionality is delivered to the user. Both data and transactions are evaluated at the conceptual level, i.e., they represent data and operations that are relevant to the user. Therefore, IFPUG Function Points are counted on the basis of the user requirements specification. The boundary indicates the border between the application being measured and the external applications and user domain.

FURs are modeled as a set of BFCs, which are the measurable elements of FURs: each of the identified BFCs is measured, and the size of the whole application is obtained as the sum of the sizes of BFCs.

The IFPUG model of a software application to be measured is shown in Fig. 1. IFPUG BFCs are data functions (also known as logical files), which are classified into internal logical files (ILF) and external interface files (EIF), and elementary processes (EP) – also known as transactional functions – which are classified into external inputs (EI), external outputs (EO), and external inquiries (EQ), according to the activities carried out within the process and its main intent.

Each function, whether a data or transactional one, contributes a number of Function Points that depends on its "complexity." Each function is weighted on the basis of its complexity according to given tables.