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Web Effort Estimation: Function Point Analysis vs. COSMIC

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ABSTRACT

Context: software development effort estimation is a crucial management task that critically depends on the adopted size measure. Several Functional Size Measurement (FSM) methods have been proposed. COSMIC is considered a 2nd generation FSM method, to differentiate it from Function Point Analysis (FPA) and its variants, considered as 1st generation ones. In the context of Web applications, few investigations have been performed to compare the effectiveness of the two generations. Software companies could benefit from this analysis to evaluate if it is worth to migrate from a 1st generation method to a 2nd one.

Objective: the main goal of the paper is to empirically investigate if COSMIC is more effective than FPA for Web effort estimation. Since software companies using FPA cannot build an estimation model based on COSMIC as long as they do not have enough COSMIC data, the second goal of the paper is to investigate if conversion equations can be exploited to support the migration from FPA to COSMIC.

Method: two empirical studies have been carried out by employing an industrial data set. The first one compared the effort prediction accuracy obtained with Function Points (FPs) and COSMIC, using two estimation techniques (Simple Linear Regression and Case-Based Reasoning). The second study assessed the effectiveness of a two-step strategy that first exploits a conversion equation to transform historical FPs data into COSMIC, and then builds a new prediction model based on those estimated COSMIC sizes.

Results: the first study revealed that, on our data set, COSMIC was significantly more accurate than FPs in estimating the development effort. The second study revealed that the effectiveness of the analyzed two-step process critically depends on the employed conversion equation.

Conclusion: for Web effort estimation COSMIC can be significantly more effective than FPA. Nevertheless, additional research must be conducted to identify suitable conversion equations so that the two-step strategy can be effectively employed for a smooth migration from FPA to COSMIC.

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1. Introduction

A crucial task for software project management is to accurately estimate the effort required to develop an application, since this estimate is usually a key factor for making a bid, planning the development activities, allocating resources adequately, and so on. Indeed, development effort, meant as the work carried out by software practitioners, is the dominant project cost, being also the most difficult to estimate and control. Significant over- or under-estimates can be very expensive and deleterious for the competitiveness of a software company [1].

FSM methods are meant to measure the software size by quantifying the "functionality" provided to the users. In particular, the Function Point Analysis (FPA) was the first FSM method, defined in 1979 [2]. Since then, several variants have been proposed (e.g., MarkII and NESMA) with the aim of improving the size measurement or extending the applicability domains [3]. As a consequence, FSM methods are nowadays widely applied in the industrial field for sizing software systems and then using the obtained functional size as independent variable in estimation models. It is worth noting that all the above methods fall in the 1st generation of FSM methods, distinguishing them from COSMIC, which is considered a 2nd generation FSM method, due to several specific characteristics. In particular, COSMIC was the first FSM approach conceived to comply to the standard ISO/IEC14143/1 [4]. It is based on fundamental principles of software engineering and measurement theory, and it was developed to be suitable for a broader range of application domains [5].

In the context of Web applications, few investigations have been performed to analyze and assess the use of FPA (e.g., [6–8]).

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A few studies have also been carried out on the use of COSMIC for sizing Web applications and estimating development effort [9–13]. However, no study compared the effectiveness of using COSMIC with respect to the use of FPA for Web effort estimation. Moreover, only few studies were based on industrial experiences, also due to the lack of suitable data sets including information about both COSMIC and FPA sizes, and effort data. Thus, there is the need for more empirical studies in this context that can support software companies in the choice of one of these measurement methods. A possible empirical evidence that COSMIC is more effective than FPA for effort estimation could motivate those software companies that usually employ FPA to migrate to COSMIC. It is evident that the migration from the 1st generation measurement methods to the 2nd generation requires some additional costs. Indeed, not only it is necessary to acquire new expertise within the company, but there is also the need to compute again the size of the applications measured in the past with FPA, in order to use them to build new effort estimation models based on COSMIC [14,15] or for other purposes (e.g., productivity benchmarking).

These issues motivated our investigation. Thus, the main aim of this work is to assess whether COSMIC is more effective than FPA for the effort estimation of Web applications. To this end, we investigated the following research question:

$RQ1_a$ Is the COSMIC measure significantly better than FPs for estimating Web application development effort by using Simple Linear Regression and Case Based Reasoning?

In the case we have indications that size in terms of COSMIC is more informative than the size in terms of FPs, it would be interesting to highlight which characteristics contribute more in such information [16]. Since for each application we have data about the Base Functional Components (BFCs) that give cumulatively the COSMIC size and FP sizes, we employed them to investigate which BFCs are more informative for predicting the effort. To this end, we investigated the following research question:

$RQ1_b$ Which COSMIC and FP BFCs are significant in estimating Web application development effort?

To answer $RQ1_a$ and $RQ1_b$ we performed an empirical study using data from 25 industrial Web applications. In particular, for $RQ1_a$ we employed two widely and successfully used techniques [17] for building effort estimation models, namely Simple Linear Regression (SLR), that is a model-based approach, and Case-Based Reasoning (CBR), that is a Machine Learning-based solution, for predicting the development effort.[1] On the other hand, to answer $RQ1_b$, we verified the correlation between each BFC and the effort and analyzed the distribution of the BFCs with respect to the final size.

A positive answer to the first research question might motivate software companies to migrate from FPA to COSMIC for sizing new Web applications, but also raises the question on how to manage such a transition. Indeed, a company would be interested in how to start using COSMIC for effort estimation having only an internal database of past project measured with FPA, thus without any suitable estimation model for the new measure. The simplest strategy to estimate the effort of new applications, until there is not enough historical data based on COSMIC, is to remeasure the past projects with this method, but this requires a lot of time and effort and in some cases it cannot be possible due to the lack of appropriate information. Another solution could be to exploit a (linear or

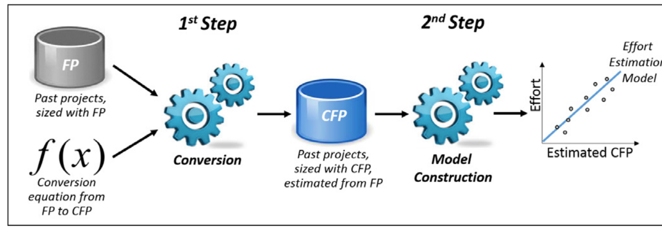

Fig. 1. The two-step process for building effort estimation models (2SEP).

non-linear) conversion equation proposed in the literature to obtain COSMIC sizes from the old FPs ones [14]. This allows the company to exploit its historical FPs data using a two-step estimation process (2SEP from here on) for building effort estimation models as shown in Fig. 1. In more details, the first step consists of applying a conversion equation to each project in the historical data set, to get an estimated COSMIC size starting from the FP one. This gives to the software company a new historical data set based on the estimated COSMIC. In the second step, it is possible to exploit this data set and SLR (or another estimation technique) to build a COSMIC based effort estimation model. This model can be used to predict the effort of the new applications, now sized with COSMIC.

We are aware of the possibility that effort estimations based on estimated sizes can be less accurate than the ones based on measured sizes. A company would be interested in using 2SEP for a smooth migration if the obtained effort predictions have an accuracy at least not significantly worse than that obtained still using FPA. So, to analyze the effectiveness of 2SEP we investigated the following research question:

$RQ2_a$ Is the Web effort estimation accuracy obtained employing 2SEP, with (linear and non-linear) *external* conversion equations, not significantly worse than the accuracy achieved by exploiting FPs in models built with SLR?

It is worth noting that another strategy for a software company could be to remeasure a sample of projects with COSMIC and use that subset to build an internal conversion equation that can be exploited in the first step of 2SEP to get an estimated COSMIC size for all the other projects of the historical data set. Nevertheless, this approach requires the extra effort to remeasure in terms of COSMIC at least a sample of projects. In the present paper we investigated also the effectiveness of 2SEP using conversion equations built on a sample of the 25 projects by analyzing how good was effort estimation using such company-specific equations. To this end, we investigated the following research question:

$RQ2_b$ Is the Web effort estimation accuracy obtained employing 2SEP, with (linear and non-linear) *internal* conversion equations, not significantly worse than the accuracy achieved by exploiting FPs in models built with SLR?

To answer $RQ2_a$ and $RQ2_b$ we performed a second empirical study employing the same data set of 25 Web applications used in the first one, some external conversion equations and the internal conversion equations built considering a small sample of Web applications. To the best of our knowledge, the previous studies (e.g., [14,22,23]) investigating the conversion from FPs to COSMIC sizes focused only on showing that it is possible to build conversion equations, while the present study is the first that assesses the effectiveness of the sizes obtained using some conversion equations for effort estimation purposes.

The remainder of the paper is organized as follows. In Section 2 we briefly describe the FSM methods employed in our study, namely FPA and COSMIC, and then we present related work on the

[1] Notice that we did not take into account other estimation methods, e.g., Support Vector Regression [18], [19], Search-based approaches [20], and Web-COBRA [10], or combination of techniques, e.g., [21], since our focus was to compare FSM methods rather than specific techniques.

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