Estimating Interval of the Number of Errors for Embedded Software Development Projects

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ABSTRACT

Previous investigation focused on the prediction of total and errors for embedded software development projects using an artificial neural network (ANN). However, methods using ANNs have reached their improvement limits, since an appropriate value is estimated using what is known as point estimation in statistics. This paper proposes a method for predicting the number of errors for embedded software development projects using interval estimation provided by a support vector machine and ANN.

Keywords: Artificial Neural Network, Embedded Software Projects, Error Estimation, Support Vector Machine

INTRODUCTION

Growth and expansion of the information-based society has resulted in increased use of a wide variety of information products using embedded software systems. The functionality of such products is becoming ever more complex (Hirayama, 2004; Nakamoto, Takada, & Tamaru, 1997), and because
of the focus on reliability, guaranteeing product quality is particularly important. It is, therefore, increasingly important for embedded software development companies to realize efficient development methods while guaranteeing delivery time and product quality, and maintaining low development costs (Boehm, 1976; Komiyama, 2003; Nakashima, 2004; Ogasawara & Kojima, 2003; Takagi, 2003; Tamaru, 2004; Ubayashi, 2004; Watanabe, 2004). Therefore, companies involved in the development of such software are focusing on a variety of improvements, particularly process improvements. Predicting effort (man-days cost) requirements for new software projects and guaranteeing product quality are especially important because effort is directly related to cost, while product quality affects the reputation of the corporation. In the embedded software field, considerable attention has been given to various development, management, testing, and reuse techniques, as well as real-time operating systems, tools, and other elements. However, there has been little research on the relationship between the scale of the development, the amount of effort, and the number of errors using data accumulated from past projects.

Previously, we investigated the prediction of total effort and errors using an artificial neural network (ANN) (Iwata, Nakashima, Anan, & Ishii, 2008; Iwata, Anan, Nakashima, & Ishii, 2009; Iwata, Nakashima, Anan, & Ishii, 2012, 2013). In earlier papers, we showed that ANN models are superior to regression analysis models for predicting effort and errors in new projects. In addition, we proposed a method for reducing this margin of error (Iwata, Nakashima, Anan, & Ishii, 2010). However, methods using ANNs have reached the limit in their improvement, because these methods estimate an appropriate value using what is known as point estimation in statistics. Therefore, we propose a method for reducing prediction errors using interval estimation provided by a support vector machine (SVM) (Cortes & Vapnik, 1995; Cristianini & Shawe-Taylor, 2000) and ANN. To predict an appropriate interval of the number of errors in a project, it is important to define the intervals. We investigate the distribution of the number of errors and set the interval of the class to 10 by considering the conditions of the distribution. An evaluation experiment was carried out to compare the accuracy of the SVM model with that of the ANN model using 10-fold cross-validation as well as by means of Welch’s $t$-test (Student, 1908; Welch, 1947).

**ESTIMATING ERROR INTERVAL MODELS**

**Original Data Sets**

Using the following data, we created models to estimate a class to which the number of planning errors ($Err$) belongs.

$Err$: ```Number of errors” in a project requiring the estimation of the interval to which it belongs.```
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