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An adaptive neuro fuzzy model for estimating the reliability of component-based software systems

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Abstract Although many algorithms and techniques have been developed for estimating the reliability of component-based software systems (CBSSs), much more research is needed. Accurate estimation of the reliability of a CBSS is difficult because it depends on two factors: component reliability and glue code reliability. Moreover, reliability is a real-world phenomenon with many associated real-time problems. Soft computing techniques can help to solve problems whose solutions are uncertain or unpredictable. A number of soft computing approaches for estimating CBSS reliability have been proposed. These techniques learn from the past and capture existing patterns in data. The two basic elements of soft computing are neural networks and fuzzy logic. In this paper, we propose a model for estimating CBSS reliability, known as an adaptive neuro fuzzy inference system (ANFIS), that is based on these two basic elements of soft computing, and we compare its performance with that of a plain FIS (fuzzy inference system) for different data sets.

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1. Introduction

Software generally has two user requirements: reliability and availability. Reliability is required when the product's nonperformance will have the greatest impact, while availability is required when downtime will have the greatest impact. Although it is difficult to formally define reliability, we cannot simply define it as a binary notion by saying that if a program is correct its reliability is 1, and if it is incorrect its reliability is 0. Instead, reliability can usually be measured probabilistically as

$$R_{\mathrm{SYS}} = (1 - \text{probability of failure}).$$

Specifically, software reliability is defined as a software system's probability of failure-free operation for a specified period of time in a specified environment. As the complexity of software applications continues to grow, greater emphasis has been placed on reuse. Therefore, component-based software system (CBSS) applications have come into existence.

Component-based software engineering (CBSE) is a specialized form of software reuse concerned with building software from existing components, including commercial off-the-shelf (COTS) components, by assembling them together in an interoperable manner. Achieving a highly reliable software application is a difficult task, even when high-quality, pretested, and trusted software components are combined. Several techniques have therefore emerged to analyze the reliability of component-based applications. These fall into two groups:

- System-level reliability estimation: reliability is estimated for the application as a whole.
- Component-based reliability estimation: application reliability is estimated based on the reliability of the individual components and their interconnection mechanisms.

Traditional approaches to software reliability analysis treat the software as a whole and use test data during the software test phase to model only the software's interactions with the outside world. These are known as black-box models. However, black-box models ignore the structure of software constructed from components as well as the reliability of individual components and are therefore not appropriate for modeling CBSS applications. Recently, soft computing techniques have emerged. Since reliability is a real-world issue, many run-time parameters are associated with reliability. This makes soft computing techniques ideal for estimating CBSS reliability, as these techniques deal mainly with uncertainty. The two basic soft computing techniques are neural networks and fuzzy logic. In this paper we combine these two techniques to estimate CBSS reliability.

This paper presents an adaptive neuro fuzzy inference system (ANFIS) model for estimating CBSS reliability. In a fuzzy inference system (FIS), the if-then rules