

Software Reliability Assessment: Modeling and Algorithms

Vidhyashree Nagaraju

*Department of Electrical and Computer Engineering,
University of Massachusetts Dartmouth
North Dartmouth, MA, USA
email: vnagaraju@umassd.edu*

Abstract—Non-homogeneous Poisson process (NHPP) software reliability growth models (SRGM) enable quantitative assessment of the software testing process. Software reliability models ranging from simple to complex have been proposed to characterize failure data that results from a variety of testing factors as well as non-uniform expenditure of testing effort. In order to predict the reliability of software accurately, it is important to apply models that both characterize the observed failure data well and make accurate predictions of the future. Efficient and robust algorithms to quickly estimate the model parameters despite inaccuracy in the initial estimates are also highly desirable. Ultimately, emphasis should be placed on predictive accuracy over complexity to best serve users of the research.

This work presents the results of the preliminary contributions of the proposal including: (i) a heterogeneous single changepoint framework considering different models before and after the changepoint and (ii) comparison of testing effort models with a simple model as well as a testing effort model fit with an ECM algorithm to emphasize the importance of model predictive accuracy over increased model complexity. The preliminary findings will be used to serve as the basis of the overall contributions of the dissertation.

Index Terms—Non-homogeneous Poisson process, software reliability growth models, changepoint, testing effort, optimal release, expectation conditional maximization algorithm, least squares estimation

I. INTRODUCTION

Critical systems have become increasingly software intensive, necessitating reliable software to ensure proper operation. Non-homogeneous Poisson process (NHPP) software reliability growth models (SRGM) are commonly used to characterize the fault detection process as a function of testing time, which enables quantitative assessment of software reliability and assists in making decisions about the software testing process such as mean time to failure, reliability, and optimal release time. While traditional models characterize the failure data as a function of testing time, the fault detection process can be affected by various factors such as non-uniform testing-effort. Incorporating such factors into software reliability models tends to increase model complexity and may not characterize the failure data any better than simpler models. Moreover, parameter estimation becomes more challenging when models are complex and it is therefore critical to avoid unnecessary

model complexity as well as apply stable and efficient algorithms to estimate the parameters of these models.

Some of the preliminary contributions of this thesis includes framework for heterogeneous single changepoint software reliability growth models and an improved algorithm for SRGM incorporating testing-effort.

A. A Heterogeneous Single Changepoint Software Reliability Growth Model

Most software reliability growth models characterize the software testing process as a function of time. However, many factors influence failure during testing such as the test strategy and environment. These factors manifest in the fault detection process as changepoints with visibly distinct curves before and after a changepoint. Several researchers have proposed non-homogeneous Poisson process software reliability models with one or more changepoints to better characterize data sets. However, a striking limitation of previous research is that only homogeneous combinations of failure distributions before and after changepoints are considered, which is often not the case when real data sets are plotted.

Work accomplished to date: Preliminary work on the dissertation presents a heterogeneous single changepoint framework, considering different models before and after the changepoint and applies algorithms to maximize the likelihood of these models. An exponential and S-shaped distributions are considered before and after the changepoint. Heterogeneous models are compared with existing homogeneous models using goodness-of-fit measures such as Akaike information criterion (AIC). The proposed expectation conditional maximization (ECM) algorithm identifies the maximum likelihood estimates of the model parameters. Online changepoint analysis is also described. Experimental results suggest that heterogeneous changepoint models characterize six out of 10 failure data sets better, indicating that the heterogeneous modeling framework complements existing homogeneous models well.

B. An Improved Algorithm for Non-homogeneous Poisson Process Software Reliability Growth Models Incorporating Testing-Effort

Many early software reliability models assumed that testing-effort was constant throughout software testing. To remove this assumption, researchers proposed models incorporating

This work was partially supported by (i) the Naval Air Warfare Center (NAWC) under contract N00421-14-T-0073 and (ii) the National Science Foundation under Grant Number #1526128.

Models Algorithms For Automatic Reliability

JS Bruner



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