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ScienceDirect
European Journal of Operational Research 182 (2007) 1188–1202
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/ejor

Stochastics and Statistics

Bayesian inspection model with the negative binomial prior in the presence of inspection errors

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Received 17 February 2006; accepted 2 September 2006
Available online 13 December 2006

Abstract

One of the basic assumptions in Bayesian inspection models is that we have some prior knowledge about the number of defects in a certain product or software system. The prior knowledge can be often described as a probability distribution (e.g., Poisson distribution). In the paper, we propose three conditions that should be put forth as desirable properties for a prior probability distribution of the number of defects in the product. We review various prior probability distributions and test if they meet those conditions. The negative binomial distribution is found to be the only one that satisfies all the desirable conditions. With the negative binomial prior, we analyze the effects of various parameters on the Bayesian estimate of the number of undetected errors still remaining in the product.

Keywords: Statistical quality control; Inspection errors; Bayesian inspection; Negative binomial distribution

1. Introduction

Suppose that a certain complex product or a software system is being inspected for any defects, errors, or non-conformities. Let Z denote the total number of defects in the product, where $Z = 0, 1, \ldots, \infty$. Due to inspection errors, all the defects are not detected during the inspection process. Based on the number of defects x discovered during the inspection process, we want to estimate: (i) the unknown number of defects, Z, and (ii) the unknown number of defects still remaining in the product, $Z - x$.

The estimation problem is an important aspect of quality control in manufacturing, in which each product is inspected via visual or machine-aided techniques. When the inspector is unable to identify every defect with certainty, estimation of the number of undiscovered defects in a complex product (e.g., circuit board, automobile, airplane, or mobile home) is the first step in setting quality assurance levels for the product.

Estimating the number of undiscovered errors is also an important task in software engineering. In software reliability, the defects correspond to program errors, faults, or "bugs" that can be detected and removed by a

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0377-2217/$ - see front matter
doi:10.1016/j.ejor.2006.09.081