QUALITY ENGINEERING
2021, VOL. 33, NO. 1, 113–127
https://doi.org/10.1080/08982112.2020.1777427

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Repetitive inspection scheme based on the run length of test results: A Markov chain Monte Carlo approach

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ABSTRACT

We propose a repetitive inspection plan that is based on the run-length of positive and negative test results. In a numerical analysis, we show that the new inspection plan outperforms previous ones in terms of the expected total cost as well as the average outgoing quality. The model parameters are often assumed to be known in advance, but we propose the use of a Bayesian method to estimate the point and interval estimates of the unknown parameters. We show that computational difficulties with prior distributions of the three parameters can be easily overcome with an appropriate MCMC method.

KEYWORDS

inspection; product quality; reliability; MCMC estimation; simulation; Markov chain model

Introduction

Inspection is one of the most effective tools that can improve and assure the quality of parts, materials, and final products in the manufacturing industry. Consider a manufacturing firm that receives raw materials from various vendors, performs certain operations on them, and then delivers finished goods to customers. There can be an inspection at each stage: (i) acceptance inspection of the raw materials received from the vendors before they are fed into the production line, (ii) process inspection of the production line, and (iii) final inspection of completed goods before shipping them to customers.

We can also find various types of inspection and audit in the service industry. For example, financial records, such as income tax returns or social security payments, are routinely reviewed by auditors for accounting errors or fraud (Chun 2020). At the airport, whole body imaging systems and explosives chemical trace detection devices are being used to screen all airline passengers and carry-on baggage to detect any potential threats to aviation security. Army recruits are screened for certain diseases and mental disorders and are subject to security background checks.

Consider a typical inspection process, in which a batch of components, such as computer chips, consists of "defective" and "non-defective" items. The "incoming" quality π is defined as the proportion of defective items in the population. Each item is tested at the inspection point, and the test result is either "positive" or "negative". Based on the test result, the acceptance-rejection decision is made, and only the accepted items are shipped to customers. The "outgoing" quality of accepted items is obviously better than the incoming quality under any effective inspection procedures.

However, inspection or misclassification errors are inevitable in any inspection and testing processes. This implies that non-defective items may be tested positive (α error), or some defective items may be tested negative erroneously (β error). That is why some expensive and critical components are inspected more than once to ensure a high level of outgoing quality. Under a repetitive inspection plan, an item is either accepted or rejected based on the number of positive or negative test results. One performance measure of the repetitive inspection plan is the outgoing quality of accepted items. To estimate the average outgoing quality (AOQ), the type I and II errors are assumed to be known *a priori* or should be estimated based on inspection results. We may also consider the costs of inspection and misclassifications and compare various repetitive inspection plans in terms of the expected total cost.

As a concrete example of repetitive inspection, consider the automatic testing of computer chips in a high-speed, high-volume production line (Greenberg

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