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Serial Inspection Plan in the Presence of Inspection Errors: Maximum Likelihood and Maximum Entropy Approaches

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A high-quality inspection must ensure most of the detectable faults are, indeed, detected. In practice, however, the effectiveness of inspections varies widely from inspector to inspector and, in some cases, multiple inspectors are assigned to inspect the same product in a sequential manner. For such a serial inspection, we propose two new methods that can estimate the number of undetected faults in the product. In a numerical analysis, we compare the performances of the maximum likelihood estimator and the maximum entropy method with that of an existing method. The maximum entropy method is shown to perform very well, particularly when the detection probabilities are not the same among the inspectors.

Keywords Product reliability; Inspections; Entropy.

INTRODUCTION

Inspection is an important aspect of quality control in a single product or a certain production lot, for which the inspectors may use visual or computer-aided techniques to inspect a portion or all the items. For some complex products, however, inspection will be imperfect, and an inspector may not be able to identify every defect, error, bug, flaw, or nonconformity in a product. The purpose of inspection is to detect and correct these defects before they leak through subsequent phase of operations in the production cycle.

To improve the quality of the product, the product may be inspected by more than one inspector in a sequential manner, or may be examined by several inspectors in parallel. Thus, we can imagine two types of multiple inspection plans. In the *serial* inspection plan, a number of sequential independent inspections are conducted to detect the faults. Any faults observed during an inspection will be corrected or removed. One inspector may examine the same product repeatedly, or several inspectors with different detection rates p_i may inspect the same product sequentially.

In the *parallel* inspection plan, several inspectors with different competencies are put to work on identical copies of the product, or they work in some sequence on a single product, secretly identifying, but not removing, the defects that they find. For example, software engineers usually produce documents that are reviewed by a small group of software engineers (Eick et al., 1993). The engineers individually read the document and note "issues" they believe should be resolved before the software feature is developed further. At the review meeting, data are collected showing which software engineers discovered which faults. Some faults detected by one engineer could also be detected by other engineers.

In such multiple inspection cases with a presence of inspection errors, the number of undetected errors still left in the product is one of the most important decision variables in quality control. For example, in software reliability, the estimation of undetected errors remaining in the software program not only helps certify the application readiness of the software, but also provides an indication of the effort that will be needed for customer support and for the upgrading of future program releases. In manufacturing quality control, estimation of the number of undiscovered defects in the sample scrutinized is the first step in setting quality assurance levels for the entire lot. A similar interpretation arises in the proofreading of manuscripts for typographical errors.

One technique that has been widely used to estimate the number of undetected faults in the *parallel inspection* plan is a class of statistical methods known

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