Statistical Analysis of Data without Probability Theory: Building Degradation Models to Predict the Need for Maintenance

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Abstract

Traditionally, the discipline of statistics relies very highly on probability theory as the basis for the proper analysis of data. The foundation for most data analyses is hypothesis testing based on "*p*-values." These tests assume that a specific "hypothesis" (the null hypothesis) is true. The analyst collects appropriate data and calculates the probability that this hypothesis accurately describes the observed data. Small p-values indicate strong evidence that the claimed null hypothesis does not explain the data well enough.

The classical approach for the analysis of hypothesis tests is an exercise in pure mathematics. The fundamental assumptions underlying hypothesis tests are that the data are "random" in the formal probabilistic definition of "independent and identically distributed" and that the behavior of the data is well explained by an appropriate probability distribution function. In nature, neither of these assumptions is ever true, which is a serious issue. The discipline of statistics is now re-evaluating the use of *p*-values for making decisions based on real data.

This talk illustrates an approach for analyzing data which recognizes that in nature the data are never random in the formal mathematical statistics sense and never truly follow any mathematical probability distribution function. The key to this approach is the construction of prediction models that explain the behavior of the observed data.

This talk begins by giving appropriate background on the proposed approach. It then illustrates the basic approach through two real data sets. One is an "observational" study involving the degradation in jet engine performance over time. The second is the analysis of a split-plot experiment involving batteries for train engines in Europe. The focus of the analysis for both of these examples is the degradation of the critical quality characteristic over time. The ultimate goal for both examples is to predict accurately when maintenance is warranted for the system under study. The battery study for train engines is supported by the PRIN project.