A Sequential Bayesian Approach for Analyzing ALT Data

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In analyzing reliability data, the quality of parameter estimates depends heavily on the number of failures obtained during a test. As products become more reliable, failure data are scarce even for accelerated life tests (ALT). As a result, asymptotic properties of Maximum Likelihood Estimator (MLE) may not be able to offer good approximations for statistical inference as originally planned. In this paper, we propose a Sequential Bayesian Approach (SBA) for data analysis. The salient idea of the proposed SBA is that the prior distributions of the unknown parameters are constructed from partial data obtained under ALT. The sequential scheme starts by choosing a constant prior distribution for the unknown parameter at the highest stress test level which typically results in more failures than other stress levels. Then, from the posterior distribution derived from the highest stress test level and a pre-specified life-stress model, we construct the prior distributions of the unknown parameters at other lower stress levels. Under the proposed SBA scheme, we derive the closed-form solutions for constant stress ALT with Weibull failure times and multiple-step step-stress ALT with Exponential failure times. As an illustration, a numerical comparison based on a recent work by Yang (2005), in which MLE was used, is presented. It reaffirms the strength of SBA when failure times are heavily censored. Finally, using the results from the sensitivity analysis, we discuss how to effectively pre-specify the parameter values of a life-stress model.

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