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Stochastic Drift Model for Discrete Parameters

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In the context of semiconductor reliability, predictive maintenance and calculation of residual useful life are important topics under the greater umbrella of prognostics and health management.
Especially in automotive applications, with higher expected usage times of self-driving autonomous vehicles, it becomes more and more important to recognize degradation processes early, so that preventive maintenance actions can be taken automatically. For semiconductor producers, it is important to account for life-time degradation of electronic devices when guaranteeing quality standards for their customer.
For this, accurate and fast statistical models are needed to identify degradation by parameter drift. Typically, electrical parameters have specified limits in which they need to stay over their whole life cycle.
Efficient life-time simulations are performed by so-called accelerated stress tests. In those tests, electrical parameters are measured before, during, and after higher-than usual stress conditions. These stress test data represent the expected life-time behavior of these parameters.
Using models based on these data, tighter limits, so called test limits, are then introduced at production testing to guarantee life-time quality of the devices for the customer.
Based on this data, quality control measures like guard bands are introduced. Guard bands are the differences between specification and test limits and account, amongst others, for lifetime drift effects of electrical parameters.
Models to calculate lifetime drift have to be flexible enough to accurately represent a large number of stress test behaviors while being computationally light-weight enough to run on edge devices in the vehicles.
We present a statistical model for discrete parameters based on nonparametric interval estimation of conditional transition probabilities in Markov chains that allows for flexible modelling and fast computation. We then show how to use the model to formulate an integer optimization problem to calculate optimal test limits. Calculation for both arbitrary parameter distributions at production testing as well as defined initial distributions are shown. Finally, we give an approach to calculate remaining useful lifetime for electronic components.
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