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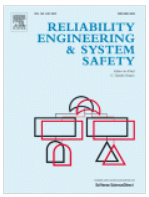

A Bayesian hidden Markov model for imperfect debugging

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Abstract

In this paper we present a new model to describe software failures from a debugging process. Our model allows for the imperfect debugging scenario by considering potential introduction of new bugs to the software during the development phase. Since the introduction of bugs is an unobservable process, latent variables are introduced to incorporate this property via a hidden Markov model. We develop a Bayesian analysis of the model and discuss its extensions. We also consider how to infer the unknown number of states of the hidden Markov model. The model and the Bayesian analysis are implemented to actual software failure data.

Keywords

Software reliability; Failure times; Bayes factor; Model selection

Figures and tables from this article:

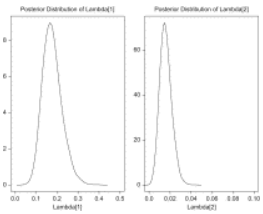

Fig. 1. Posterior distributions of λ_1 (estimated mean and standard deviation: 0.18 and 0.046) and λ_2 (estimated mean and standard deviation: 0.016 and 0.0056).

Figure options

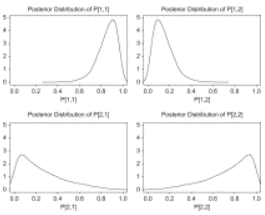

Fig. 2. Posterior distributions of transition probabilities. Estimated mean and standard deviation of P_{11}: 0.85 and 0.097. For P_{22}: 0.74 and 0.21.

Figure options

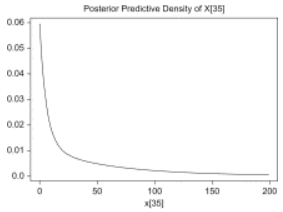

Fig. 3. Predictive distribution of 35-th observation. Estimated mean and standard deviation: 52 and 38.

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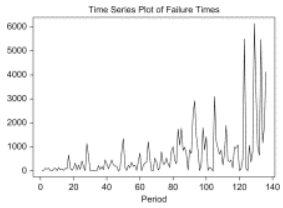

Fig. 4. Failure times.

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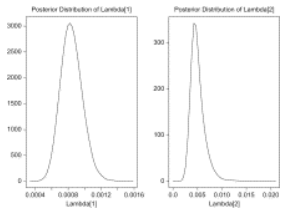

Fig. 5. Posterior distributions of λ_1 (estimated mean and standard deviation: 0.00085 and 0.00013) and λ_2 (estimated mean and standard deviation: 0.0051 and 0.0016).

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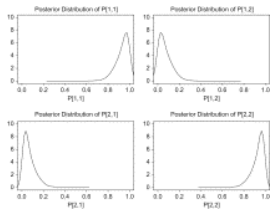

Fig. 6. Posterior distributions of transition probabilities. Estimated mean and standard deviation of P_{11}: 0.94 and 0.056. For P_{22}: 0.93 and 0.060.

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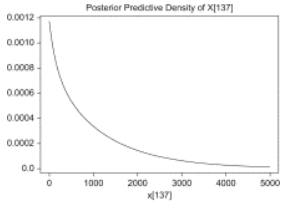

Fig. 7. Predictive distribution of 137-th observation. Estimated mean and standard deviation: 1145 and 297.

Figure options

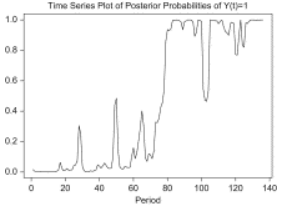

Fig. 8. Posterior probability of Y_t=1.

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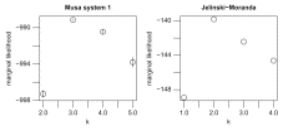

Fig. 9. Plot of marginal likelihood against the number of hidden states.

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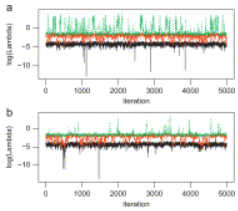

Fig. 10. Trace plots of the log-rates for the Jelinski – Moranda dataset: unconstrained model, after sorting of rates (a) and constrained model (b).

Figure options

Table 1. Posterior probabilities (pp) of state 1 over time.

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Table 2. Marginal likelihoods for a simulated dataset.

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