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Bayesian updating and model class selection with Subset Simulation

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7 Abstract

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Identifying the parameters of a model and rating competitive models based on measured data 8 has been among the most important and challenging topics in modern science and engineering, with 9 great potential of application in structural system identification, updating and development of high 10 fidelity models. These problems in principle can be tackled using a Bayesian probabilistic approach, 11 where the parameters to be identified are treated as uncertain and their inference information 12 are given in terms of their posterior probability distribution. For complex models encountered in 13 applications, efficient computational tools robust to the number of uncertain parameters in the 14 problem are required for computing the posterior statistics, which can generally be formulated as a 15 multi-dimensional integral over the space of the uncertain parameters. Subset Simulation has been 16 developed for solving reliability problems involving complex systems and it is found to be robust to 17 the number of uncertain parameters. An analogy has been recently established between a Bayesian 18 updating problem and a reliability problem, which opens up the possibility of efficient solution by 19 Subset Simulation. The formulation, called BUS (Bayesian Updating with Structural reliability 20 methods), is based the standard rejection principle. Its theoretical correctness and efficiency requires 21 the prudent choice of a multiplier, which has remained an open question. This paper presents a 22 fundamental study of the multiplier and investigates its bias effect when it is not properly chosen. A 23 revised formulation of BUS is proposed, which fundamentally resolves the problem such that Subset 24 Simulation can be implemented without knowing the multiplier a priori. An automatic stopping 25 condition is also provided. Examples are presented to illustrate the theory and applications. 26

27 Keywords: Bayesian inference, BUS, Subset Simulation, Markov Chain Monte Carlo, model

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