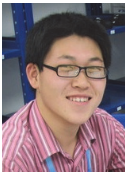
Efficient SRAM Failure Rate Prediction via Gibbs Sampling




Shupeng Sun **Xin Li**

Statistical analysis of SRAM has emerged as a challenging issue because the failure rate of SRAM cells is extremely small. In this project, we develop a fast statistical analysis engine via Gibbs sampling that is implemented for spherical coordinate systems. The key idea is to iteratively search the variation space, identify the high-probability failure region and then generate random samples in it. As such, the small failure rate of SRAM cells can be accurately estimated based on the theory of importance sampling with a few transistor-level simulations and, hence, a low computational cost. Given the same number of simulation runs, our proposed Gibbs sampling technique achieves superior accuracy over other traditional approaches including the existing Gibbs sampling algorithm that was previously developed for Cartesian coordinate systems.

In our preliminary experiment, the read current of a 90nm SRAM cell is considered as a testing example. The SRAM cell is considered as “Pass”, if and only if the read current is greater than or equal to a pre-defined threshold. For comparison purposes, we implement four different importance sampling methods: (1) mixture importance sampling (MIS), (2) minimum-norm importance sampling (MNIS), (3) Gibbs sampling for Cartesian coordinate systems (G-C), and (4) the proposed Gibbs sampling for spherical coordinate systems (G-S). To quantitatively assess the accuracy of these different approaches, we further implement the brute-force Monte Carlo (MC) method with 8.7 million random samples to provide the “golden” failure rate associated with the read current. As shown in Fig. 1 and TABLE 1, the proposed G-S technique is more accurate than the other three traditional methods (i.e., MIS, MNIS, and G-C). It, in turn, demonstrates the efficacy of the proposed G-S method for the application of SRAM failure rate prediction.

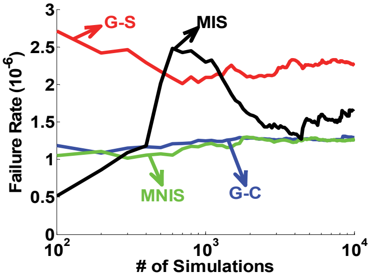


Fig. 1: Estimated failure probability as a function of the number of simulations.

	Number of Simulations	Failure Rate	Relative Error
MIS	1.5×10^{4}	1.64×10^{-6}	28.1%
MNIS	1.1×10^{4}	1.26×10^{-6}	44.7%
G-C	1.5×10^{4}	1.29×10^{-6}	43.4%
G-S	1.5×10^{4}	2.25×10^{-6}	1.32%
MC	8.7×10^{6}	2.28×10^{-6}	—

TABLE 1: Failure probability estimated by different importance sampling methods.