FAST: A framework to solve probabilistic inverse problems using factor graph analysis

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Abstract

Noise, stochastic interactions and device imperfections are inherent in many biosensing and communication circuits. To combat the effect of the above, those circuits can be formulated into equivalent inverse problem systems involving parameters which are random variables with partially known distributions. In this paper, we present a computer aided design (CAD) framework named FAST (Factor-graph based Analysis of Stochastic circuiTs), which can be used to solve the probabilistic inverse problems. The underlying principle of the framework is to use a factor-graph netlist as a user interface. Solving the inverse problem entails passing messages/signals between the internal nodes of the netlist. Stochastic analysis technique like density evolution is used to understand the dynamics of the circuit and the reliability of the solution. As one representative example, we apply FAST to estimate the reliability of a 10^3 size biosensor array where each element of the array is comprised of our previously reported antigen-antibody based biomolecular circuit. Another example is to apply the software to estimate the performance of a 32-bit binary code decoding system. The simulation as well as measurement results indicate that FAST is an efficient tool to design, verify, and optimize error-correcting communication systems.

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