Electric Power and Power Electronics Institute

ALGORITHMIC ENGINES FOR CONTROL SYSTEM DESIGN

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Abstract

I will present a framework that aims to accomplish the following goals:

1. Understand the computational complexity of controlling nonlinear and hybrid physical systems. Such problems are commonly considered to be wildly undecidable because of the involvement of real numbers, differential equations, and so on. I show that reasonable and informative upper bounds can be obtained through a practical formulation.

2. Enhance automation in the design and implementation of control systems through automated reasoning engines. These engines are designed to cope with NP-hard problems, matching the complexity of the problems to be solved. The key is to combine the full power of combinatorial search, numerical optimization, and machine learning methods. I introduce our solver dReal and show some promising experimental results.

3. Certify correctness of control software through formal proofs. To ensure correctness-by-construction of control systems, all algorithms that are used for the design and analysis of these systems should automatically produce mathematical proofs that can be machine-checked. This requires a rigorous formal analysis of techniques in control theory and numerical methods.

Making good progress in these directions is crucial for building computing systems that can physically engage us in intricate and safety-critical ways.

Biography

Dr. Sicun Gao is a postdoctoral researcher at MIT CSAIL. His research focuses on rigorous and automated methods for building safe, optimized, and secure cyber-physical systems. He received his PhD in Logic from Carnegie Mellon University in 2012, and BS in Logic and Mathematics from Peking University in 2006. He is a recipient of the Carnegie Mellon School of Computer Science Distinguished Dissertation Honorable Mention Award, and a Silver Medal for the Kurt Goedel Research Fellowship Prize.