Integrated Modeling, Planning, and Control for Intelligent Automation

Ashis Gopal Banerjee
Complex Systems Engineering Laboratory
General Electric Global Research, Niskayuna, NY 12039, USA

Abstract: Automation has played a central role in enhancing the efficiency, productivity, and reliability of manufacturing systems for several decades. However, today's systems operate in dynamic and uncertain environments where challenges arise from partially known system-environment interaction models, sensing noise, stochastic system behavior, and varying operational goals and constraints. These challenges necessitate bringing about a greater degree of intelligence to create more robust and flexible automated systems. Such intelligence requires an effective integration of system modeling with operation planning and system component control.

In this talk, I will first demonstrate the benefit of an integrated approach using optical robotic manipulation of micro-scale objects as a case study. A high-fidelity Langevin dynamics simulator is developed to model the probability of trapping an object in an optical field. The model is used in a partially observable Markov decision process algorithm to plan paths for multiple objects concurrently with collision avoidance and recovery steps. Experiments show successful transport of 2 micron diameter silica particles across the imaged workspace leading to manipulation of biological cells indirectly using the particles as optical fingers.

A novel functional analysis-based regression algorithm is then presented to scale up such coordinated operations to large multi-agent systems by learning the optimal solutions of decomposed but similar planning problems modeled as stochastic integer linear programs. I will conclude by briefly discussing other successful applications for human robot collaboration in assembly kitting and aircraft engine parts supplier performance prediction, and outline future research directions.

Biography: Ashis Gopal Banerjee is a Research Scientist in the Complex Systems Engineering Laboratory at General Electric Global Research (GEGR). Prior to joining GEGR, he was a Research Scientist and Postdoctoral Associate at Massachusetts Institute of Technology. He obtained his Ph.D. and M.S. in Mechanical Engineering from the University of Maryland, College Park, and B.Tech. in Manufacturing Science and Engineering from the Indian Institute of Technology, Kharagpur. He has received several honors including the 2012 Most Cited Paper Award from the Computer-Aided Design journal, the 2009 Best Dissertation Award from the Department of Mechanical Engineering, and the 2009 George Harhalakis Outstanding Systems Engineering Graduate Student Award from the Institute for Systems Research at the University of Maryland. His research interests include cyber physical systems, dynamic system simulation, human robot collaboration, micro-bio robotics and automation, mobile multi-robot control, mathematical modeling, predictive data analysis, and smart manufacturing.