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My principal research interest is the use of artificial intelligence for automated modeling and simulation of physical system behavior. I have worked on automating several aspects of this problem: creation of behavioral models of a physical situation, intelligent control of computational simulations based on these models, and analysis of simulation output both to determine whether the output makes physical sense and to predict a system's long-term behavior by using carefully controlled short-term simulations.

My dissertation research had two principal goals: the automated creation of behavioral models of machines directly from models of their raw physical structure, and the automated inductive prediction of a machine's long-term behavior. I found and implemented algorithms which generate behavioral models for mechanical devices by first using kinematic analysis to find state variables and then using dynamics to find differential equations relating the state variables. The input for these algorithms is a CAD/CAM solid model of the geometric structure of a machine, supplemented with information about masses, spring constants, and coefficients of friction. I also found and implemented algorithms for predicting a machine's long-term behavior. These algorithms form hypotheses about a machine's future behavior by examining the results of short, carefully controlled behavioral simulations. The algorithms test these hypotheses both by using simulated experiments and by checking for certain known types of hypothesis failures. A successful hypothesis is a compact symbolic representation of a machine's long-term behavior which is generated numerically.

More recently, I've been focusing on the particular problems that arise in trying to embed a computational simulation within a system whose goal is the automated design of complex artifacts. In order to evaluate candidate designs, an automated design system must be capable of predicting their behavior, typically by computational simulation. Many powerful simulation programs exist today. However, using these programs to reliably analyze a physical situation requires considerable human effort and expertise to set up a simulation, determine whether the output makes sense, and repeatedly run the simulation with different inputs until a satisfactory result is achieved. I've considered the automation of this process for two fairly different sort of physical systems: clockwork mechanisms and ocean racing yachts. Automating this process is not only of considerable practical importance but also raises significant AI research issues in the areas of spatial reasoning and modeling of physics and numerical methods.

Publications:

Using Artificial Intelligence to Control Fluid Flow Computations. Proceedings, NASA Workshop on Software Systems for Surface Modeling and Grid Generation, Langley Research Center, Hampton, Virginia, April 1992.

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From CAD/CAM to Simulation: Automatic Model Generation for Mechanical Devices. In Paul A. Fishwick and Richard B. Modjeski, editors, *Knowledge-Based Simulation: Methodology and Application*, 1991. Springer-Verlag.

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Automated Reasoning about Machines. PhD thesis, Yale University, April 1990. YALEU/CSD/RR#785.

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Automated Physical Modeling. In *Proceedings of the 11th International Joint Conference on Artificial Intelligence*, Detroit, Michigan, August 1989.

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Automatic Model Generation for Mechanical Devices. 2nd Workshop on AI and Simulation, 6th AAAI Conference, Seattle, Washington, July 1987.

Automated Reasoning about Machine Geometry and Kinematics. In *Proceedings of the Third IEEE Conference on Artificial Intelligence Applications*, Orlando, Florida, February 1987. Also published in Daniel S. Weld and Johan de Kleer, editors, *Readings in Qualitative Reasoning about Physical Systems*, Morgan Kaufmann 1990.