Numerical and Qualitative Hybrid Simulation:
A Unified Framework for Reasoning about Continuous Systems

By Daniel Berleant

Numerical simulations can have limitations related to numerical error and to the various distinct behaviors a system can have due to varying initial conditions. Also the known data may not be sufficient to do a desired numerical simulation.

Qualitative simulation has limitations opposite those associated with numerical simulation. Instead of precise but error-prone numerical results, qualitative simulation can produce predictions that are correct but too vague. And, instead of predicting one behavior that may turn out to be wrong, qualitative simulation returns the actual behavior but can also return a large number of other irrelevant behaviors. Also, known numerical data cannot be utilized by a purely qualitative simulation.

A unified representation and methodology for simulation can combine the best features of both techniques. Our on-going research is such a unified technique. The expected results are borne out by applying the framework to a simple model. The hybrid simulation framework will enable simulations that:

-- Are guaranteed to produce numerically correct answers, even for nonlinear systems.

-- Are guaranteed to produce a limited number of behaviors which include all behaviors
consistent with possible initial conditions.

-- Can simulate systems for which only incomplete numerical information is known.

Thus a unified technique for qualitative and numerical simulations can eliminate weaknesses inherent in either technique used alone, providing a useful new tool for reasoning about continuous systems.