Automated Scientific Computing

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Increasingly complex mathematical models are being solved in large computer simulations to answer questions of scientific and industrial relevance. Often, these models come in the form of differential equations that may be solved by means of standard numerical methods such as the finite element method.

However, the implementation of a numerical method to solve a given differential equation is a both difficult and time-consuming task. Furthermore, the output of a computer simulation is an approximate numerical solution that may or may not be close to the exact solution. Mathematical techniques exist for assessing the accuracy of a computed numerical solution, but this too is a difficult and time-consuming task that requires manual labor.

In this talk, I demonstrate how one may automate the solution of differential equations and remove the need for any manual labor. The key to this automation is automated code generation, where computer code is automatically generated to solve a given problem with a prescribed accuracy.

Examples are presented that range from simple model problems like the Poisson equation to complex nonlinear fluid-structure interaction problems.

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