Implementing Mathematics: Domain Specific Languages and Automated Computing

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Abstract

Computer simulation is today an indispensable tool for scientists and engineers in modeling, understanding and predicting nature. Having emerged as a complement to theory and experimentation, it is becoming increasingly more important as a result of advancements in hardware, software and algorithms.

However, in spite of its success and ever increasing importance, simulation software is still largely written by hand, following a primitive, outdated and unsustainable pipeline: first express a model in the language of mathematics, then translate this model - using pen and paper - to a complex system of data structures and algorithms, then express those data structures and algorithms in a programming language. Even if those algorithms can today be expressed in high level programming languages, the pipeline still involves the translation (obfuscation) of the mathematical model to computer code.

In this talk, I will argue that we should not strive to translate mathematical models or methods to computer code. Instead, we should strive to develop exact computer representations of mathematics that make the original mathematical model or method native to the mathematical / programming language.

I will give several examples of ongoing work in this direction based on the FEniCS Project software. [1]

References

1. A. Logg and K.-A. Mardal and G. N. Wells et al.. Automated Solution of Differential Equations by the Finite Element Method. Springer 2012.