BioModel Engineering

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BioModel Engineering takes place at the interface of computing science, mathematics, engineering and biology, and provides a systematic approach for designing, constructing and analyzing computational models of biological systems. Some of its central concepts are inspired by efficient software engineering strategies. BioModel Engineering does not aim at engineering biological systems per se, but rather aims at describing their structure and behaviour, in particular at the level of intracellular molecular processes, using computational tools and techniques in a principled way.

The two major application areas of BioModel Engineering are systems biology and synthetic biology. In the former, the aim is the design and construction of models of existing biological systems, which explain observed properties and predict the response to experimental interventions; in the latter, BioModel Engineering is used as part of a general strategy for designing and constructing synthetic biological systems with novel functionalities.

The overall steps in building computational models in a BioModel Engineering framework are:

- Problem Identification,
- Model Construction,
- Static and Dynamic Analysis,
- Simulation,
- Model management and development.

A major theme in BioModel Engineering is the construction of (qualitative) models, including the following common steps: (1) finding the structure, (2) obtaining an initial state, and (3) determining the kinetics by parameter fitting. In an approach that we have taken [BGHO08], the structure is obtained by piecewise construction of models from modular parts, the initial state which describes concentrations of species or numbers of molecules is obtained by analysis of the structure, see [HGD08] for a related discussion driven by a running example, and parameter fitting comprises determining the rate parameters of the kinetic equations by reference to trusted data; see [GBHD09] for more details.

Model checking can play a key role in BioModel Engineering – for example in recent work [DG08] we have shown how parameter estimation can be achieved by

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characterising the desired behaviour of a model with a temporal logic property and altering the model to make it conform to the property as determined through model checking.

References

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