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Garp3 - Workbench for Qualitative Modelling and Simulation

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Abstract

Garp3 is a domain independent, multi-platform, qualitative modelling and simulation environment. It allows modellers to articulate and refine their conceptual domain knowledge and analyse this knowledge through simulation. Garp3 has been successfully applied in Ecology and Sustainable Development (SD) and is freely available via (http://www.garp3.org).

Garp3 and the NaturNet-Redime Project

Ecologists in the NaturNet-Redime project (http://www.naturnet.org) are building qualitative models about sustainable development issues through several case studies. For this purpose the Garp3 workbench for building, simulating, and inspecting qualitative models was developed (Bredeweg e al, 2006). The main goals of the development was making qualitative reasoning technology usable for non-computer scientists by creating a uniform user interface, a diagrammatic visual language for representing model content, and graphical buttons to communicate the available user options and manipulations. Garp3 is implemented in SWI-Prolog (http://www.swi-prolog.org) and seamlessly integrates three previously developed software components: Garp2 for simulating models, Homer for building models, and VisiGarp for inspecting simulation results.

To further support the ecologists in their modelling efforts a structured approach to modelling was developed. This framework helps modellers refine their initial ideas, represented in concept maps, into detailed conceptualisations, such as structural models, causal models, and expected model behaviour. The diagrams in the final steps of the framework are close to the actual modelling primitives used to implement qualitative models. The Sketch environment in Garp3 supports modellers with tools to create the required diagrams. These Sketches not only help modellers in creating a model, but also serve as a more general description of the final model for other users of the model.

One of the main goals of the NaturNet-Redime project is to create a sustainable development curriculum that allows students to learn about specific issues through qualitative modelling and simulation. To advance this goal the case study models developed in project are being integrated into a single library of sustainability concepts. Students can run and adapt different scenarios, let Garp3 automatically gather the correct knowledge relevant to the simulation and predict the possible outcomes, and analyse the results. To support the integration of the different case study models multiple model support and copy/paste functionality have been added to Garp3. The copying functionality assures that models remain syntactically correct, avoids adding redundant knowledge, preserves existing knowledge, and merges conceptual knowledge in a semantically correct manner as much as possible. The copy functionality also allows modellers to reuse parts of
already existing models. Furthermore, a qualitative model repository was developed to allow modellers to share and search for potentially reusable models. The copying functionality is currently actively used in the project.

**Modelling and Simulation**

The model implementation process starts with creating model ingredient definitions, e.g. the objects (entities), relations (configurations), quantities, external influences on the system (agents) and the different assumptions made by the modeller. Secondly, modellers create different scenarios (initial situations of the system) (Figure 1) using the defined modelling primitives. Thirdly, the modeller represents the different processes that can happen in the system in different model fragments (Figure 2). These model fragments represent the causal dependencies that exists between different quantities by representing a part of the structure of the system as conditions and the causal dependencies as consequences.

The simulation starts by selecting a specific scenario. The reasoning engine (Garp3) tries to find matching model fragments, i.e. model fragments that have conditions that are fulfilled by the scenario. The consequences of the model fragment are added to the scenario, which potentially allows more model fragments to match. When no more matching model fragments can be found, the derivatives of the quantities are calculated using the derived causal dependencies. Using these derivatives the next possible states of behaviour are determined (possibly multiple due to ambiguity). For each of the new states the same algorithm is used to derive new states. The result is a state graph describing the complete behaviour of a system given the initial scenario (Figure 3). Modellers can inspect the value history and/or the derived inequalities for sets of states (Figure 4), and the dependencies of the system in specific states (Figure 4).
Figure 3: State graph after simulating scenario with selected cycle.

(a) Value history of selected states.  
(b) Dependencies in state 7.

Figure 4: Value history (a) and Causal model (b).

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