

# Managing NetLogo Models in CLIPS

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*Abstract:* The objective of our research is to suggest and implement solutions for personalization of e-learning systems. Our motivation is to customize e-learning courses' contents to heterogeneous target groups, i.e. to users with different learning styles, preferences, previous experiences etc. In the paper we explain how NetLogo agent-based models can be described by structured facts and how these facts can be processed in rule-based system CLIPS. The rule-based solution enables managing models, update their descriptions, check consistency of descriptions and mainly search for models with respect to numerous criteria. Having search results, it is easier to integrate models into learning scenarios tailored to needs of individuals.

*Key-Words:* CLIPS, Education, Knowledge model, Knowledge management, NetLogo, Personalization, Rule-based system

## 1 Introduction

The objective of our research project “*Exploitation of constraint satisfaction problem solving techniques in e-learning*” is to suggest innovative e-learning approaches and solutions for higher education. Our motivation is to adopt e-learning courses' contents to heterogeneous target groups, i.e. to users with different learning styles, preferences, previous experiences etc. One of our intentions is to analyze particular courses from the point of view of knowledge management and knowledge engineering and to find out the description of learning materials that would enable automated creation of learning scenarios tailored to needs of individuals. We focused on constraint satisfaction techniques, which are traditionally used for automated creation of multimedia, scheduling events or for generating suitable combinations of values of interrelated variables. We expect them to be applicable in the domain of education, too.

To achieve our objectives, we chose two interdisciplinary domains with large numbers of users with non-uniform expectations: (a) digital photography and (b) agent-based modeling and programming. In the domain of photography, we focused on ontological modeling of domain concepts and online presentation of learning materials using Topic Maps technology, where the navigational structure is based on ontologies. Partial results were presented in [3,4].

In this paper we describe our effort in the area of agent-based modeling, namely in managing NetLogo models using rule-based system CLIPS.

The organization of the rest of the paper is as follows. In the second part NetLogo system is

characterized and the idea of describing models is explained. Then the CLIPS system is shortly introduced and the implementation is presented. Further steps of our research are highlighted in conclusion.

## 2 NetLogo Models

NetLogo [5] is an environment for creating agent-based models of different phenomena. The models allow us to explore macro-level patterns that emerge from micro-level behavior of individuals (called agents) and their interactions, to predict the appearance of certain events or phenomena, to demonstrate the impacts of certain initial settings etc. NetLogo is well suited for modeling complex systems developing over time where numerous agents operate independently. The principles of agent-based modeling are utilizable in areas such as biology, mathematics, chemistry, physics, social science, economics, computer science etc. The simplest models demonstrate the utilization of single NetLogo programming language command only, while the most complex models catch the functioning of real-life phenomena, produces data that can be processed statistically or even produce solutions of tasks (e.g. the NetLogo model of ant colony can be used for searching the shortest path in the graph).

The installation of NetLogo contains numerous built-in models, organized in thematic categories such as biological models, social science models etc. Hundreds of models are published online by NetLogo community on NetLogo website [5] where models are ordered simply chronologically according to the publishing date. Other models are attached to textbooks on agent systems, e.g. [7,8,9].

Therefore in this plenty of resources it is not easy for domain specialists to identify whether particular idea, hypothesis or principle was already captured in some NetLogo model, and if so, what were authors' assumptions, how does the model relates to other models, how complicated is the implementation (in sense of expected programming skills), what experiments can be performed etc.

We decided to create the repository of descriptions of NetLogo models and to implement the system for managing the repository. This application is primarily dedicated to teachers and students of agent-based modeling course at the authors' workplace, but it can help anyone who is either interested in NetLogo itself, or to domain specialists who looks for particular agent-based models. The repository is implemented in CLIPS.

### 3 Implementation of Repository

CLIPS is a productive development tool for the construction of object-based and rule-based expert systems. Its first version was developed in 1986 at NASA Johnson Space Center. The latest version of the present descendant called Jess was released in 2008 [1,2].

Rule-based programs are composed of definitions of facts and definitions of rules.

Facts are either named items only, or structured records based on the predefined template. The template defines slots and multislots (i.e. slots for multiple items), together with restrictions such as range, value types etc.

Each rule has got two parts: condition and action. If the condition part was satisfied, action part could be performed. Typically, the condition part of the rule defines the combination of facts, and action part consists in manipulating these facts, e.g. the following rule prints the value of the variable *?n*.

```
(defrule show-model-name
  (netlogo-model (model-name ?n))
  =>
  (printout t ?n crlf))
```

If several facts matched the condition part of the rule, the rule is applied several times.

The efficient pattern matching mechanism of CLIPS is based on Rete algorithm [2]. Several searching strategies for managing agenda of activated rules can be applied.

Our main template *NetLogo-model* defines the structured fact for catching characteristics of NetLogo models. For each model, following items are stored:

- name of the model,

- its location (Models Library, Community web, Other location),
- original source (journal article, book chapter etc. – if exists) where the idea of the model is presented in details,
- category of the model (biology, economics, game theory, physics, social science etc.),
- topics from the domain (e.g. “two players’ game” for the model from the domain of the game theory, or ”stigmergy” for the domain of biology etc. ); topics correspond to important concepts from the domain,
- minimum and maximum number of agents in the model,
- number of different populations of agents in the model,
- type of agents (reactive, rational, social),
- properties of the agents’ environment (static or dynamic, deterministic or stochastic, fully or partially observable, for details see [6]),
- number of sliders and switches in the interface of the model (this informs about variability of initial settings of the model, or experiments respectively),
- names of related models,
- version of NetLogo (due to changes in syntax, some older models are not executable in newer versions of the NetLogo system),
- level of complexity (three categories were defined for differentiating among (a) trivial models that demonstrates using NetLogo commands, (b) medium models that enable experimenting and (c) complex models based on serious hypotheses about functioning real-systems such as economy or ecosystems),
- special, uncommon NetLogo commands used in the code (the list of frequently used commands is defined, too).

Most items are defined as multislot, i.e. it can contain multiple values, or it can be empty. The following sample fact written in CLIPS syntax describes *Ants*, the model of indirect insects’ coordination based on the mechanism called stigmergy:

```
(NetLogo-model
  (model-name ants)
  (source ModelLibrary)
  (category biology)
  (topics stigmergy coordination)
  (num-of-agents 0 200)
  (num-of-populations 1)
  (type-of-agents reactive)
  (environment static deterministic)
  (num-of-input-parameters 5))
```

(related-models ant-lines)  
 (NetLogo-version 4.1.1)  
 (level 2)  
 (commands diffuse distancexy uphill))

Except the main template, other facts are defined such as:

- A list of frequent and a list of uncommon NetLogo commands, i.e those commands that appear in NetLogo language tutorials and are used in most models without respect to the application domain, and those commands that are used rarely. Both lists have no shared elements and were defined by skilled NetLogo programmer. The items in lists of special commands inside the description of models are elements of the second list. Models with a lot of uncommon commands in the code are seen to be difficult for beginning programmers. Here we have to notice that biological models of models of economics are expected to be used by non-programmers who are interested in performing experiments with the model, but not changing the code.
- List of application domains and lists of topics from each application domain. These lists should contain domain concepts, keywords, words from textbook indices and glossaries, important terms from the given branch of science etc. The lists should be consulted with domain experts, as well as binding of topics to each model. For our purpose, keywords from descriptions inside models were extracts. The more models from the given domain are available, the more important the list of topics would be.

All the previously mentioned lists are reused in case of consistency checking of the repository.

Rules for manipulating the repository are separated into modules –it makes the application better organized. Modules for these actions are available:

- Adding a new model to the repository – it involves filling all slots and multislots, including the consistency check and optional linking a new model name with current models.
- Deleting the model from the repository – it involves deleting the name of the model from all relevant lists of related models.
- Browsing all models and browsing models from the given category, with printing the summary information.
- Searching for models that satisfy various combinations of criteria (types of agents, properties of environment, number of agents

and number of populations, number of interface elements, version of NetLogo etc.). For each combination of parameters, there are two rules – one for reading parameters from the input and the next for searching itself.

- Searching for sequences of models with the same or ascending complexity, and same or similar topics, and same or different category. These models can become part of the curriculum of agent-based modeling courses.

## 4 Conclusion

The repository of structured descriptions of NetLogo models simplifies the process of searching for relevant models. It can be enhanced in different directions. We plan adding the descriptions of experiments that can be performed on particular models, and the description of other learning materials on agent-based modeling. Then it will be possible to generate more complex sequences of studying materials.

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