GAMA 1.6: Advancing the Art of Complex Agent-Based Modeling and Simulation

Arnaud Grignard[1], Patrick Taillandier[3], Benoit Gaudou[4], Duc An Vo[2], Nghi Quang Huynh[5], and Alexis Drogoul[2]

[1] UMI 209 UMMISCO/MSI, UPMC, France
[2] UMI 209 UMMISCO/MSI, IRD, Vietnam
[3] UMR 6266 IDEES, CNRS/University of Rouen, France
[4] UMR 5505 IRIT, CNRS/University of Toulouse, France
[5] DREAM-CTU/IRD, CICT, Can Tho University, Vietnam

Abstract. Agent-based models tend to be more and more complex. In order to cope with this increase of complexity, powerful modeling and simulation tools are required. These last years have seen the development of several platforms dedicated to the development of agent-based models. While some of them are still limited to the development of simple models, others allow to develop rich and complex models. Among them, the GAMA modeling and simulation platform is aimed at supporting the design of spatialized, multiple-paradigms and multiple-scales models. Several papers have already introduced GAMA, notably in earlier PRIMA conferences, and we would like, in this paper, to introduce the new features provided by GAMA 1.6, the latest revision to date of the platform. In particular, we present its capabilities concerning the tight combination of 3D visualization, GIS data management, and multi-level modeling. In addition, we present some examples of real projects that rely on GAMA to develop complex models.

Keywords: Agent-based modeling, simulation, GIS, multi-level, ODE, platform, visualization, complex systems.

1 Introduction

The last years have seen an important increase in the use of agent-based modeling (ABM) in various scientific and application domains. Some of these applications, that rely on large sets of data, are more and more demanding in terms of representation, simulation and interpretation of complex models. While the classical KISS [10][3] approach appeared to be well suited in the early years of ABM, this recent trend, which for instance includes developments in serious games, participatory approaches or integrated models, requires the ability to design and manage more descriptive and detailed models.

The KISS-based approach has given birth to a plethora of small-size, mostly theoretical, toy models that, although they are well suited for training purposes, have had the paradoxical effect of establishing ABM as a mainstream approach to

G. Boella et al. (Eds.): PRIMA 2013, LNAI 8291, pp. 117–131, 2013.

complex systems modeling while, at the same time, eliminating the reasons why people had wanted to adopt it in the first place. Building complex, incremental, data-driven modular models in NetLogo [28], for instance, is a difficult task. And it becomes even more difficult when different data sources, at different levels of representation, are to be used. Interpreting these models is also very tedious, given the lack of flexibility offered by the existing platforms in the visualization and parametrization of the models.

While some offers have tried to overcome these limitations (e.g. Repast [23], Mason [20]), they have failed until now to propose a credible alternative in terms of *modeling platforms*. Repast, for instance, is more a well designed *toolbox* than a *platform* as it requires modelers to be highly proficient in Java programming and Eclipse development, which is rarely the case in the scientific domains targeted by ABM. Similarly, these proposals also fall short in terms of *simulation platform*, as designing virtual experiments that combine easy parametrization and high-level interactive visualization is as complicated as building the model itself and requires the use of several external tools.

The GAMA[1] modeling and simulation platform [9] [26], developed since 2007 as an open-source project, aims at overcoming these lacks by providing modelers - which are not, most of the time, computer scientists - with tools to develop and experiment highly complex models through a well-thought integration of agent-based programming, geographical data management, flexible visualization tools and multi-level representation.

GAMA provides a complete modeling language (GAma Modeling Language) and an integrated development environment that allows modelers to build models as quickly and easily as in NetLogo while going beyond what Repast or Mason offer in terms of simulated experiments. It is currently applied in several projects in environmental decision-support systems, urban design, water management, biological invasions, climate change adaptation or disaster mitigation. This paper aims at presenting the new features developed in the latest version of GAMA. We will focus in particular on the following features: the evolution of the GAML language for specifying models using multiple paradigms (especially combinations of mathematical and computer approaches), the seamless integration of geographical data and other spatial data, the tools offered to support high-level visualization of simulations and the multi-level description of models.

2 GAMA Meta-Model

The concepts and the operational semantic of GAML are completely described in a meta-model (see Figure 1) from which every model written in the language derives. This meta-model supports the development of multi-level agent-based models by considering three main sets of abstract classes that represent, respectively, the *entities*, the *space* and the *time* of a model.

[1] `http://gama-platform.googlecode.com`