GAMA: multi-level and complex environment for agent-based models and simulations

(Demonstration)

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ABSTRACT

Agent-based models are now used in numerous application domains (ecology, social sciences, etc.) but their use is still impeded by the lack of generic yet ready-to-use tools supporting the design and the simulation of complex models integrating multiple level of agency and realistic environments. The GAMA modeling and simulation platform is proposed to address such issues. It allows modelers to build complex models thanks to high-level modeling language, various agent architectures and advanced environment representations and built-in multi-level support.

Categories and Subject Descriptors

I.6 [**Simulation and Modelling**]: Simulation Support Systems

General Terms

Algorithms, Experimentation

Keywords

Simulation platform, Agent-based modeling, GIS data, Multi-level model

1. INTRODUCTION

In the last ten years there has been a striking increase in the use of agent-based models to study complex systems. This booming is partly due to the success of several software platforms that have reached a level of maturity supporting the development and simulation of agent-based models (Netlogo [?], Repast [?]., etc.). However, even with these platforms, the problem of the model design is still an open issue. Indeed, whereas some platforms such as Netlogo provide a dedicated modeling language to ease the model design, they are quite limited when dealing with rich models relying on GIS data. Other platforms, or toolboxes such as Repast, that allow to build more rich models are very complex to use and requires strong computer science skills. Consequently, field experts have to rely on computer scientists to develop models which slows the development and the use of realistic agent-based models.

The GAMA (GIS & Agent-based Modeling Architecture) modeling and simulation platform has been proposed to address such shortcomings. This open source platform provides field experts, modelers, and computer scientists with a complete modeling and simulation environment for building rich spatially explicit agent-based simulations. In addition, it is shipped with ready-to-use abstractions for the most common needs (e.g. decision architectures, generic agentÕs skill such as movements regardless of the representation of the environment), which are accessible through a dedicated high-level modeling language (GAML) and remains extensible by Java programmers.

A demo video can be found at http://code.google.com/p/gama-platform/wiki/VideosPresentation to illustrate both advanced features and existing applications.

2. GAMA APPLICATIONS

GAMA has already been used in various large scale applications that share a strong focus on the interactions between agents and complex environments. In natural disaster management, it has been applied to simulate evacuation organization in case of a tsunami in Nha Trang (Vietnam). This model combines detailed GIS data of the city and the coupling of agent and equation based modeling in order to upscale the number of inhabitants that can be simulated [?]. The MIRO model [?] allows geographers to conduct serious game sessions to identify cities management strategies for two mid-size cities in France : Dijon and Grenoble. This model makes also use of high resolution GIS data and large number of individuals (200.000+). GAMA can also be used as a support decision tool in natural resource management as in the MAELIA [?] project. This project aims at studying the social and ecological impact of water management in the Adour-Garonne Basin (France). GAMA has also been

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used in epidemiology. In the GAMAVI project [?], experts questioned their hypotheses about avian influenza propagation through environment or animal population. A model that includes poultry production and environment dynamics has been developed. Another application concerns the assessment of the effectiveness and impact of control policies on the recurrent invasions of insects, i.e. Brown Plant Hopper, in the Mekong delta of Vietnam.

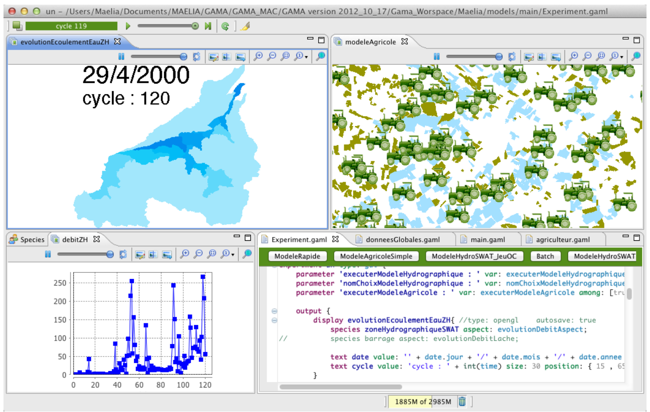

Figure 1: MAELIA simulation interface

3. GAMA FEATURES

Modeling IDE : The GAMA modeling language (GAML) is supported by an advanced modeling IDE which eases the development of complex models (multiple environments and/or multi-level for instance). This IDE features code coloration, syntax and coherency checking.

Graphical user interface : The simulator graphical interface allows to keep track of the simulation dynamics from multiple point of views. Environment visualizations (2d or 3d), monitors and (agent) inspectors allow to view the instantaneous state of the simulation whereas various charts keep track of the simulation dynamics.

Multiple environment : GAMA is particularly powerful concerning the management of complex environments. It allows to define several environments that can have different topologies (grid, graph or continuous). One continuous environment is used as reference to synchronize all of them. Each GAMA agent has a shape, that is a 3D simple (point, polyline or polygon) or complex (composed of several subgeometries) vector geometry.

Seamless GIS integration : A particularly interesting feature of GAMA is the possibility to create agents and to define their attributes (in particular their shape) from real data using shapefiles. Conversely, this allows the modeler to integrate geographical data into models under the form of active agents (one agents is created by geometry of a shapefile). In addition, GAMA manages the spatial projection of the data (to get a spatially coherent model) and the reading of attribute values. In order to ease the manipulation of vector geometries, GAMA integrates different GIS features that are directly available through the GAML language (geometry buffer, convex-hull, intersection, difference, etc.). In the same way, the GAML language provides many complex primitives to manage the movement of agents in a specific environment (shortest path computation, movement constrained by a geometry, etc.).

Multi-Level agent-based modeling : Multi-level agent-based modeling requires to manipulate agents at different levels of representation w.r.t. to time, space and behavior. Our approach of multi-level modeling is based on three principles. (1) An agent represents a level of organization which is associated with a spatial and temporal scale. (2) Levels are hierarchically organized to define privileged interactions between embedded levels. (3) Organizations can be dynamic: some agents can move from an organization to another in order to dynamically adapt their representation level. We have implemented these principles in GAMA which offers the modeler a straightforward way to write multi-level agent-based model in GAML [?].

Mathematical model integration : GAMA integrates a built-in numerical solver for ordinary differential equations such as prey-predator models (Lokta-Volterra) or compartmental models in epidemiology (e.g. classic SIR models). This allows to define agent behavior according to differential equations and study coupling (or simply compare) with agent-based models.

Advanced visualization : GAMA provides a high-level graphic library (based on OpenGL) that allows user to define their own custom multi-layer displays. Each of these displays can show different information and represent the agents in different ways. The multi-layer rendering feature allows to superpose different layers of information on the same screen. For example, GIS data and DEM (Digital Model Elevation - grid) can be mixed to represent height information.

4. CONCLUSION

The platform website (http://gama-platform.googlecode.com) provides modelers with numerous tutorials and a GAML language reference. It provides developers with a guide on how to extend the platform with their own plugins (GAMA is under GPL) while the code is accessible on the projectÕs SVN. The GAMA executable for the 3 major OS can also be downloaded from this website.

5. ADDITIONAL AUTHORS

6. REFERENCES

[1] Banos, A., Marilleau, N. and MIRO team: Improving individual accessibility to the city: an agent-based modelling approach. Proc. of ECCS, Bruxelles. (2012)

[2] North, M., Howe, T., Collier, N., Vos, J.: A declarative model assembly infrastructure for verification and validation. Proc. of Advancing Social Simulation: 1st World Congress. (2007)

[3] Taillandier, P., Therond, O., Gaudou B.: A new BDI agent architecture based on the belief theory. Application to the modelling of cropping plan decision-making. Proc. of IEMs pp. 107-116. (2012)

[4] Taillandier, P., Vo, D-A., Amouroux, E., Drogoul, A.: GAMA: a simulation platform that integrates geographical information data, agent-based modeling and multi-scale control. Proc. PRIMA'12 (2012)

[5] Vo, D-A.: An operational architecture to handle multiple levels of representation in agent-based models. PhD thesis. Université P&M Curie, Paris. (2012)

[6] Wilensky, U.: Netlogo. Technical report, Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL. (1999)
[7] N. T. N. Anh, J.-D. Zucker, N. H. Du, A. Drogoul, and V. O. D. An, ÒHybrid Equation-based and Agent-based Modeling of Crowd Evacuation on Road NetworkÓ Proc. ICCS pp. 456-466 (2012).
[8] E. Amouroux, S. Desvaux, and A. Drogoul, "Towards virtual epidemiology: an agent-based approach to the modeling of H5N1 propagation and persistence in North-Vietnam" LNCS, vol. 5357, pp. 26-33, 2008.