A framework to specify Agent-Based Models in Geographic Sciences

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Abstract Agent-Based Modeling (ABM) and simulation have gained popularity in the Geographic Information Systems (GIS) domain. Despite the increasing number of models built by experts and users, it remains challenging for users to specify their models in a manner in which one can understand it. This constraint represents an inhibition to the development and acceptance of the ABM approach. In this paper, we raise the questions that need to be answered in order to cope with ABM specification issues. We review some of the existing solutions that have been developed. We propose a framework that includes a domain specific modeling language to respond to ABM specification problem. We finally present the first step towards its development.

Key words: Domain ontology, Agent-Based Modeling, Domain Specific Modeling Language, Geographic Information Science

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1 Introduction

In the Geographic Information Systems (GIS) domain, Spatial Modeling and Spatial Simulation are processes conducted by users of an information system in order to understand phenomenons and plan ahead.

From the different types of models used in the GIS community, Agent-Based Models (ABMs) have become a popular paradigm to perform spatial simulation. ABMS are employed to reason, experiment and extrapolate about systems. ABMs are designed and developed by representing the key decision-making entities as agents and by describing the environment in which they are interacting with a spatial model of the landscape. In the last decade, the degree of flexibility and the ability to represent social interactions induced multidisciplinary teams working in geographical sciences to develop different models based on agents. Through simulation, experts can reproduce agents' interactions over time to approach spatial problems. [11] , [8] and [1] provide a broad range of these applications.

But despite its high degree of flexibility, the agent approach presents some weaknesses when it comes to re-using, implementing and evaluating models. Experts are experiencing difficulties to specify and share this type of model. They don't have a common representation as it happens in the software community with the Unified Modeling Language (UML) for instance. Those weaknesses represent constraints and inhibitions to the development and acceptance of the ABM field. To cope with these limitations, the objective of our research project is to built a framework where experts could specify their ABM, store them and share them with the community of experts.

2 Related Work

Some authors have addressed the problem of communicating about ABM. The ODD (Overview, Design concepts, Details) protocol, described in [3] is aimed at describing individual-based models and agent-based models in scientific publications and is essentially focused on communication and reimplementation of ABM. ODD is designed to describe only one definite model version [4] and can not be directly compiled to computer code. MR POTATOHEAD [10] is another approach that tackles the design of agent-based models of land use change. It is based on an ontology tailored to a particular subset of models and enables a more detailed comparison to be made than the more generally applicable ODD. In [2], authors present an ontology defining an agent-based simulation framework and discuss the possibilities for using the Web Ontology Language's (OWL) automated reasoning capabilities. How to benefit from OWL and Semantic Web technologies for simulation is also the topic of other works. In [13] Polhill and colleagues illustrate how deploying an agent-based model on the Semantic Grid facilitates international collaboration on investigations using such a model, and contributes to establishing rigorous working practises with agent-based models as part of good science in social simulation. Polhill and Gotts

[12] presented another interesting approach to address ABM transparency issues. The authors propose to implement ABM simulations using ontologies, instead of object-oriented languages. The body of work, cited above, represents a step forward to more transparent ABM. But they individually only respond partially to the issues we want to address in our research.

3 Research Questions

In order to respond to ABM specification issues, we propose to follow an approach that will address three questions. The first question is how to represent ABM information structure in a manner in which it is decoupled from the simulation software and can be independently processed. The second question to address relates to the level of abstraction to achieve in order to represent the concepts of the domain. In fact, the abstraction should enable to represent concepts and relationships for a multidisciplinary audience who is not necessarily expert in computer science, but, at the same time be precise enough to represent all concepts of the domain. A third question to answer is which tools should be provided to users to create and explore ABM? Finally our research project should respond to a last question, which is, how can we ensure that an executable implementation conforms to a system's model?

4 Method and Expected Results

In order to respond to the questions raised above, we advocate the development of a framework (see figure 1) that would allow for specifying, exploring and exporting ABM as linked data, using the semantic web approach. This framework should integrate a domain specific language to manage models' specifications and visualise agent-based models for the GIS domain. The DSML should be supported by a domain ontology that represents the main concepts used in ABM in GIS related sciences. Those are essentially concepts related with model scheduling and initialisation.

Initial results consist in an ontology that represents not only the concepts inherent to ABM but also concepts integrated in GIS domain like the spatial environment and the concepts described in protocols such as the ODD protocol and its evolution ODD+ [9]. Since, ideally, domain ontologies should be grounded in foundational ontologies [5], our domain ontology is taking as basis the Unified Foundational Ontology (UFO) [7], [6]. To support the implementation of this language, we have designed an architecture depicted in figure 1. The architecture should allow the conversion between models' representation trough models transformation using MDE techniques. We will build a model editor that will allow to create and explore ABM. This editor will be supported, by widgets that could vary according to the type of

user. This widgets will implement visualisation of relevant aspects of the model such as maps, text and so on.

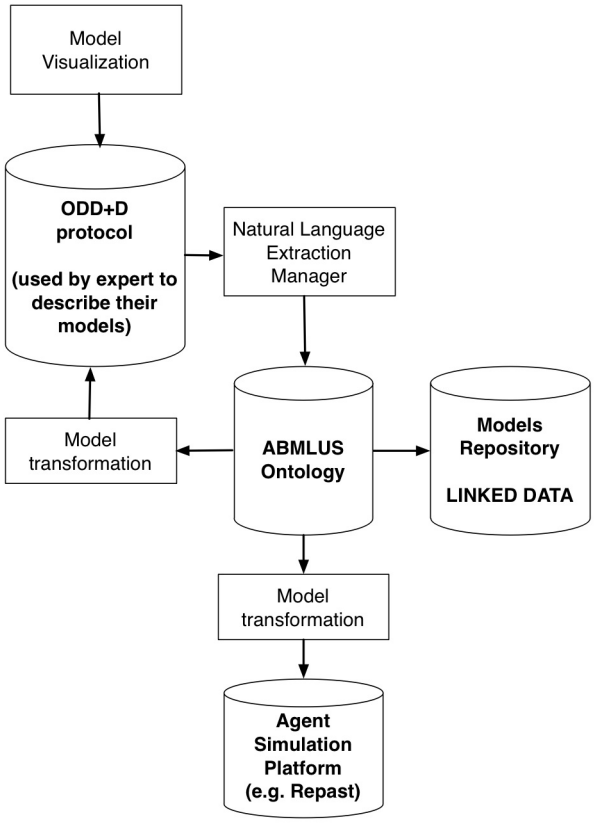

Fig. 1 Arquitecture for the proposed framework

By providing an agent-based modeling platform to the GIS community, we aim at empowering its users with a common platform to represent and communicate the systems and sub-models they are working on.

Protocols such as ODD and ODD+ describe model entities using natural language. If we can improve on these protocols by linking these descriptions to ontological entities that can easily be handled by machines, we look forward to contribute for a better validation and reuse of theses models, among the domain community. We also expect that the choice we made about using a foundational ontology as a basis for our domain ontology will facilitate the adoption and extension of our DSML to other related domains.

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