Domain-Specific Agent Modeling with SESM

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Enabling domain experts to visually build simulation models for human settlement activities

The MEDLAND Project

The Mediterranean Landscape Dynamics (**MEDLAND**) project aims at developing models to help understand the long-term dynamics of human land use in the Mediterranean Basin from the Neolithic through the Early Bronze Age. Researchers in archaeology, ecology, and geology – the **domain experts** – are working with **computer scientists** to build a computer simulation model of human settlements and agricultural practices.

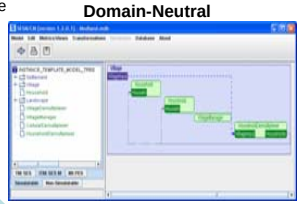
To support model development, the Scalable Entity Structural Modeler (**SESM**) has been proposed and developed. SESM is a general purpose, domain-neutral visual modeling environment used to define arbitrary model components and specify relationships between them. For simulation models as devised for the MEDLAND project, however, SESM is too general and not fully sufficient. **Simulation models are currently built and edited directly through source code by computer scientists – an approach unsuitable for domain experts.**

This research focuses on extending SESM with domain-specific modeling capabilities – functions specific to the MEDLAND project – to enable domain experts to edit simulation models themselves.

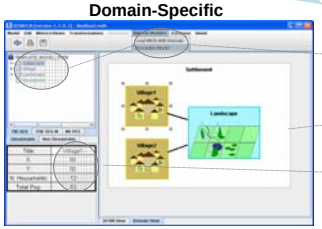
Domain-Neutral vs. Domain-Specific Modeling

- Provides a set of axioms for defining structure and behavior of hierarchical and specialized model components.
- Components can be composed through the coupling of their input and output ports.
- State variables store data about model attributes.
- Models arbitrarily are defined under a set of general-purpose rules.

Domain-Neutral



Domain-Specific



Extends domain-neutral modeling by adding:

- Models strongly defined – capability of accessing parameters in predefined, complete simulatable DEVSJAVA models.
- Visualization for improved representation & communication.
- State variables and other attributes specific to MEDLAND models are displayed and may be edited by the user.

Domain-specific modeling defines a set of components that can be synthesized to represent different kinds of household and village configurations. It provides representative knowledge that is specific to the domain.

Agent-Based Modeling and Simulation

These models are being developed using two simulation environments:

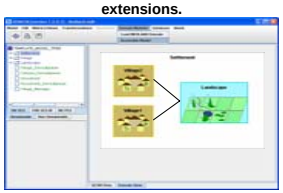
- **DEVSJAVA** – an agent-based environment for simulating human settlements and landuse practices.
- **GRASS** – a geographical information system (**GIS**) for simulating the ever-changing geology and ecology of a region over several thousand years.

Within DEVSJAVA models, human "agents" survive by exploring a landscape for fertile soil to cultivate for their subsistence, and these cultivation practices over time are fed into the GRASS simulation of that landscape to determine their cumulative long-term impact on the environment and of the environment on human land use.

Through domain-specific extensions to SESM, domain experts can easily:

- Specify household population.
- Compose households into villages and villages into settlements.
- Specify the distance of each Village model relative to the Landscape model.

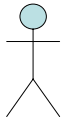
SESM with domain-specific modeling extensions.



Domain expert uses SESM to access model parameters more easily.

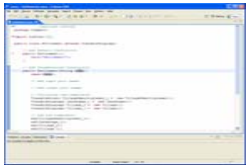
SESM modifies DEVSJAVA source code on behalf of the domain expert.

Domain expert accesses model parameters directly.

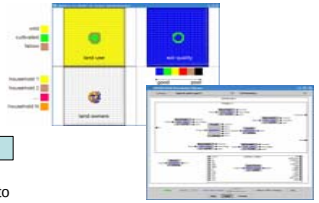


Domain Expert

DEVSJAVA Model Source Code



GRASS Landscape Simulation



Simulation results returned to domain expert.

DEVSJAVA models imported into MEDLAND simulation.

DEVSJAVA Agent Simulation

Domain experts can develop agent models that can be semi-automatically transformed to executable simulation code.

Benefits & Challenges of Domain-Specific Modeling

Relieving domain experts of the burden of developing DEVSJAVA models directly through code allows us to:

- Reduce the time & effort required to develop such models.
- Support model correctness & validation, resulting in higher-quality models.

A few of the challenges to implementing this environment on top of SESM are:

- Understanding the perspective of the domain expert, in terms of domain knowledge, technical knowledge, and user needs.
- Implementing the capability to support model correctness & validation.

Conclusions & Future Work

As the MEDLAND project matures, additional model components and parameters will be devised. SESM, therefore, will need to be further extended to support such advancements. Among these will include:

- Developing a library of agent models such as human and livestock
- Inclusion of a granary within each village to handle food storage
- Studying the short- and long-term impact of human and livestock on the landscape

The lessons learned through this research are expected to help with devising and improving domain-specific modeling capabilities in other related fields, such as modeling the growth of human population and modern urban centers and their effects on the geology and ecology of the surrounding land.

Furthermore, by helping to bridge the gap between domain knowledge and simulation studies within the MEDLAND project, this research will contribute to the project's broader impacts. Specifically, through simulation-based analysis of the long-term impacts of agropastoral landuse, we can begin to understand the potential long-term consequences of our landuse practices on the Earth's landscape and society.

Acknowledgments

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