THE FUTURE OF SCIENCE AND TECHNOLOGY

Forecast: Geosimulation will infiltrate mainstream modeling and geoprocessing on the Web

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Description:

Geosimulation is a novel approach to model-building and application in the geographical sciences and geocomputing. It is predominantly focused on generation of methods and tools for constructing very realistic and extensible models of complex dynamic geographic processes. It offers distinct advantages over conventional approaches in spatial modeling, a field that has been developed for the last sixty to seventy years in one form or another.

First, the traditional consideration of average and spatially-modifiable geographical units or (statistically) mean individuals is replaced in geosimulation. Instead, units are regarded as spatially non-modifiable entities, with individual descriptions and independent functionality. Where aggregates are considered, they are formulated generatively, built from the bottom up by assembling individual entities for the purposes of accomplishing an aggregate task or amassing an aggregate structure. This allows for very small-scale geographies at the real genesis of complex phenomena to be represented at their atomic scale, but also allows flexibility in scaling those phenomena up to holistic levels, or any stage in between.

Second, simulated entities are independent and autonomous in their behavior. The independence is significant; attention in model-building turns to the specification of individual-level behaviors. Also, entity behavior is not necessarily treated as homogenous across the system being considered or static over the lifetime of a phenomenon. Geosimulation is relatively agnostic toward the sorts of behaviors, phenomena, agency, or processes that it can handle.

Third, models are commonly designed as event-driven, rather than time-driven, where events are cast as discrete packets of change, based on the independent internal clocks of simulated components. Events may be ascribed heterogeneously across entities, actions, transactions, and interactions, and represented at the characteristic timing of a process, dynamically, in cross-section, or longitudinally as needed. When put together to form a system, update of modeled entities' clocks may be flexibly-defined and the methodology can reconcile diverse temporal scales.

Fourth, geosimulation has a natural and symbiotic alliance with Geographic Information Science, Geographic Information Systems, and related geospatial technologies, as well as a diverse range of data models: entity-relationship, object-oriented, hierarchical and so on. It is relatively straightforward, therefore, to form dataware partnerships with an array of data types.

Fifth, geosimulation is comfortably allied with computer science theory, such that most—if not all—approaches to computational modeling can be supported within a geosimulation framework, largely because automata are the tool of choice in geosimulation development.

Sixth, because of the flexible treatment of space, time, space-time, and spatio-temporal scaling, geosimulation is well-suited to handling complex systems and associated phenomena of non-linearity, positive and negative feedback, path-dependency, emergence of novel space-time ensembles, self-organization and autopoiesis, fractality, and so on.

Geosimulation will move into mainstream modeling

The idea of geosimulation has already caught-on, particularly as an approach to agent-based modeling, thanks in part to development of operational toolkits that allow people to build their own geosimulation models [1], or to use of geosimulation as an interfacing mechanism [2]. In addition to its use in dynamic Geographic Information Science [3], agent-based modelers in computer animation [4, 5], social geography [6], location-allocation modeling [7], machine learning and data-mining [8], human-computer interaction [9, 10], criminology [11], and medical epidemiology [12] have developed geosimulation models. Geosimulation has also been used to extend neighborhood functionality in cellular automata methodology [13]. These developments represent early in-roads for geosimulation into the broader science of simulation, fueled in large part by an emerging and broad fascination with geospatial technology and spatial thinking in the physical, social, and life sciences. The future fusion of geosimulation with existing modeling toolkits and applications will open-up new territories for exploration through simulation.

Geosimulation will become Web-enabled, fueling next-generation semantic systems
The basic building blocks of geosimulation have an affinity with object-based models and entity-relationship database schemes. Geosimulation also has a natural alliance with geospatial technology. These synergies align geosimulation for seamless inter-operability with semantic applications or Web search, as well as performing predestination work-horse crunching for location-based services. Already, groups are using geosimulation-like algorithms and heuristics to extract space-time activity trajectories from geospatial data [14]. Much of the future development of geosimulation and related technology will be shaped by development of Web-enabled geosimulation processing services and new applications of the technology to a stready stream of newly-emerging geodata.

Geosimulation will power dynamic entities in virtual worlds
Geosimulation is already being used to power dynamic graphics [4, 5, 15, 16] and it is a logical choice for driving non-player characters (NPCs) in gaming engines and avatars in virtual worlds. Indeed, much of the intelligence in the AI for such characters is spatial intelligence. To date, AI for game engines and virtual worlds has been dominated by cursory behavioral geographies based on simple topology-derived look-up tables (Pontevia decries the behavioral implementation of class game engine AIs on the inadequacies of their geography, for example [17]), and there remains much potential for geosimulation in developing more sophisticated, realistic, and entertaining synthetic behaviors for virtual characters. Gaming and MMORPG worlds are not the only environments that could benefit from such developments; much potential exists for designing effective "serious games" and VR-based training environments, particularly where such environments require culture-specific activities and behaviors from their NPCs.

Geosimulation + geodemographics = well-informed expert systems for business intelligence
Geodemographics--the science of classifying consumer profiles based on position and activity in space and spatial clusters--is now a dominant force in marketing and business intelligence, serving as the bedrock for unsolicited advertising-by-mail campaigns, political polling, and actuarial analyses. The dataware for garnering positional details for individuals and groups, as well as independent and collective actions and transactions has swelled to unprecedented volumes. New techniques will be required to data-mine and ultimately to data-farm this information. Geosimulation is an obvious candidate for processing such data-sets and extracting what-if scenarios.

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Signals:
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