Modeling and simulation at the M

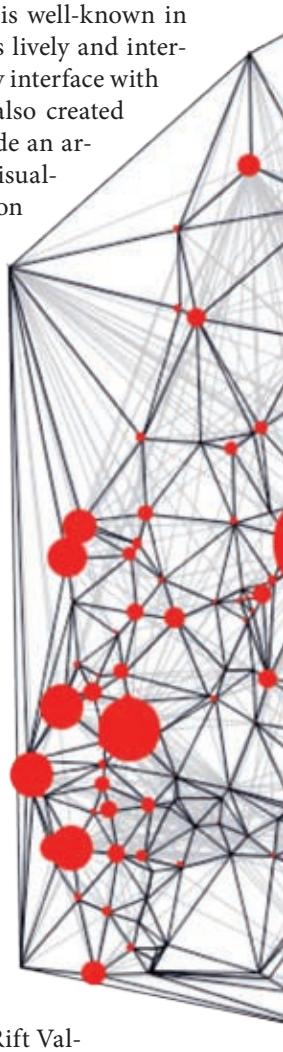
By Dr. Claudio Cioffi-Revilla, Director and Professor of C

The Center for Social Complexity at George Mason University was established in 2002 as the "main engine" of the Provost's Initiative in Computational Social Science. This unique, long-term project involves a series of innovative programs, including a full graduate program (courses, Certificate, Masters', and Ph.D.), the first of its kind in the country; and a set of interdisciplinary, multi-year, collaborative research projects funded by nearly $10 million so far from agencies such as the National Science Foundation, the Defense Advanced Projects Agency, and the Office of Naval Research.

In all, the Mason Center for Social Complexity has attracted new faculty, students, and new resources for creating a world-class program in social science modeling and simulation in Northern Virginia and the Metro DC area—a region where social complexity is evident across numerous domains, such as governance, transportation, national security, public health, and education. In 2006 the Center for Social Complexity joined Mason's Krasnow Institute for Advanced Study as a way to guarantee cross-disciplinary synergies with all fields, including computer science, mathematics, environmental science, and cognitive science. Other disciplines throughout Mason are also linked to modeling and simulation projects at the Center, including climate science, public policy, economics, and related fields and research programs at the Smithsonian Institution, Yale University, and other collaborating centers here and abroad.

Modeling and simulation are not just "alive and well" at the Mason Center for Social Complexity—in fact, M&S provide the exciting new methodology for exploring and advancing the research frontiers of computational social science in the 21st century. M&S concepts and tools enable and boost computational social science in a similar sense as the infinitesimal calculus enabled the rise of modern physics, the telescope enabled modern astronomy, or the microscope enabled microbiology. Much like those other instrument-enabled fields of science, computational social science was born with the first social applications of computing in the mid-twentieth century and has grown since to significantly expand the range of social science investigations in both theoretical and policy domains.

At Mason, scientists at the Center for Social Complexity investigate and are gaining new, fundamental understanding on a range of topics that include terrorism and conflict, humanitarian assistance and disaster relief ("HA/DR"), financial and economic market dynamics, and societal impacts of climate change. Most of these and other modeling and simulation projects lead by the Mason Center in collaboration with other research groups (at Yale, the Smithsonian, and other universities) utilize the "MASON toolkit," a multi-agent simulation system invented and maintained by our Associate Director, Professor Sean Luke of the Computer Science Department. MASON (Multi-Agent Simulator of Networks and Neighborhoods) is well-known in the multi-agent simulation community for its lively and international user community, as well as for its easy interface with the evolutionary computation system ECJ—also created by Sean Luke. Salient MASON features include an architecture that separates computation from visualization, a computational architecture based on data fields, an efficient scheduler, and RNG; replicability/reproducibility of results; and a publication-grade GIU facility for simulation graphics.



For example, in one project on humanitarian assistance and disaster relief (HA/DR), funded by the Office of Naval Research (Program Officer Dr. Rebecca Goolsby), Mason and Yale M&S partner scientists (faculty, postdocs, students) are collaborating to better understand the effects of disasters (both natural and anthropogenic) on human and social dynamics. The region of East Africa was chosen because it is both an ancient environment (the Rift Valley region where humans originated) as well as a contemporary setting for modeling and simulating disasters (natural and anthropogenic) and their effects on human societies. What if the drought in Kenya lasts a fourth year? What could be the effects on agriculture, pastoralists, the economy, and the government's capacity to mitigate such disasters? What can be learned from a scenario such as these and others like it? What if, in a more complex scenario, the resumption of rainfall causes an outbreak of Rift Valley fever at the same time as insurgency and violent instability increase in key parts of the region? Emergent patterns of population displacement, scaling in settlement patterns, and other complex phenomena are addressed by M&S tools because, typically, such problems lie beyond the realm of low-dimensionality models with closed form solution. Simulation runs "play out" complex scenarios that can be better understood by observing dynamic trajectories and investigating patterns in associated parameter spaces. The MASON system (and GeoMASON, its geospatial extension) is particularly well-suited for this kind of M&S research, because its architecture separates computation from visualization, making it possible to run many simulations faster and with guaranteed reproducibility.

GeoMASON is an extension of the MASON system to facilitate an improved computational representation of socio-natural sys-

ason Center for Social Complexity

omputational Social Science

▲ The Mason-Yale East Africa MURI project is modeling the movement of internally displaced people and international refugees in East Africa using a hybrid spatial interaction and agent-based model using GeoMASON combined with network facilities. Groups of displaced people set out for better locations based on a classic "gravity" spatial interaction model that is well known in the geography literature. To complete these movements, however, they must move through intervening towns and camps and may be forced to alter their plans. The result is a model that captures more of the dynamics of displacement and may be useful in disaster planning.

tems where "geography matters." In essence, GeoMASON provides full GIS facilities and enables the MASON system to operate more efficiently with vector and raster data for representing various landscapes. For example, in the Mason-Yale Joint Project on Eastern Africa, GeoMASON is being used to build more realistic models that include not just land-cover (which is coupled with changing weather), but also other GIS data layers representing natural, social, and built environments—all three of the dynamically coupled. GeoMASON will also be used to develop new models of societal impacts of climate change in the Mason-Smithsonian Joint Project on Climate and Society.

Growth in this field in the past decade has been particularly rapid, thanks to the application of multi-agent systems ("agent-based simulation modeling") and related advanced information technologies. Today, there is no significant area of social science that has not witnessed some interesting contribution from computational approaches—and, as some of us believe—we are just beginning to exploit M&S through advanced computing.

Today, at research institutes such as the Mason Center for Social Complexity, scientists are investigating and gaining new fundamental understanding of contemporary and earlier civilizations. MASON-based simulation models are being developed for investigating numerous complex systems and processes at the frontiers of computational social science, such as the recent refugee crises in Asia, Haiti, and Africa, financial market crashes, and societal effects of climate change in the Northern Hemisphere and developing countries.

Through these innovative and cutting-edge projects in modeling and simulation, the Mason Center for Social Complexity contributes to the scientific and technological life of Northern Virginia, by attracting and retaining "talent and treasure" in terms of human capital (faculty, student, staff) and the necessary extra-mural resources to operate a pioneering academic center with a bright future. Our Center is located on the 3rd floor of the Fairfax campus, where inquiries can be directed to complex@gmu.edu.