GESIS Fall Seminar in Computational Social Science 2024
“Agent-based Computational Modeling”

Lecturers: Michael Mäs
Affiliation: Karlsruhe Institute of Technology
Email: michael.maeskit.edu

Fabio Sartori
Affiliation: Karlsruhe Institute of Technology
Email: fabio.sartori@kit.edu

Date: September 16-20, 2024
Time: 09:00-16:00

About the Lecturers
Michael Mäs is full professor of Sociology and Computational Social Science at the KIT. He serves as the scientific director of the methods laboratory at KIT’s House of Competence and as the dean of the KIT-Faculty of Humanities and Social Sciences. His background is in sociology and economics. Inspired by complexity science, Michael is fascinated by formal models explaining the emergence of complex sociological phenomena like opinion polarization, the spreading of fake news, collective democratic decision-making, discriminatory behavior, and social norms in networks. To test critical model assumptions and model predictions, Michael gathers data with surveys, in laboratory experiments, and on the web.

Fabio Sartori is post-doc at the Chair of Sociology and Computational Social Science at the KIT and guest scientist at the MPI for Dynamic and Self-organization in Göttingen. His background is in complex systems and neuroscience. He completed his Ph.D. at the MPI for Brain Research, Frankfurt, using tools developed to describe random walks on graph to model protein diffusion. Fabio is fascinated by how the spread of misinformation thrive even when it directly influences the life of those believing in them, like during epidemic outbreaks.

Course Description
Deliberate actions can lead to unintended and even undesired consequences. For example, cities may exhibit ethnic segregation in their neighborhoods, despite high levels of citizen tolerance. Polarization of opinions amongst political actors as well as citizens can occur even when individuals do not actively promote differences. Online social bots with numerous followers might be less successful in disseminating content than those with only a few followers. Grassroot social movements can arise spontaneously and gain immense political power although they are much less organized, centralized, and coherent than political parties and interest groups. Arising from complex interactions between individuals, these intriguing collective phenomena are emergent and often go unnoticed by individuals. Explaining them is an intriguing scientific challenge. This seminar aims to familiarize participants with agent-based modeling, a rigorous methodology for investigating emergent phenomena. Participants will delve into the principles of complexity science, a multidisciplinary field exploring similar phenomena across physics, computer science, and biology. The focus will be on seminal agent-based models from the social sciences, teaching students to implement models using NetLogo or Python, depending on their programming experience. Special emphasis will be placed on employing simulation methods to analyze agent-based models, identifying the underlying mechanisms driving emergence, and developing tests to validate the responsible mechanisms. Participants are given the opportunity to present their agent-based modeling projects and receive feedback.

Organizational Structure of the Course
On Day 1, the seminar starts with an introduction to complexity science and examples of complex phenomena from fields as diverse as biology, physics, computer science, economics, mathematics, and, of course, the social sciences. Applying basic principles of complexity science, participants learn to implement the Sakoda-Schelling Segregation model in NetLogo.
On the remaining days, participants are introduced to a seminal model of a complex social phenomenon in the mornings. In this way, students get an overview over famous models from different social-scientific fields, and
develop an understanding for the critical ingredients of social complexity and alternative ways to formally represent critical aspects of reality in a computer model.

In the afternoons, students implement and experiment with the respective model under the supervision of the lecturers. To this end, the seminar will be split into a lab group of starters working with NetLogo and a lab group of more experienced programmers who will work with Python. During the week, models of ethnic segregation, opinion polarization, the dissemination of fake news and social bots, and the emergence of social classes will be covered.

Keywords
Agent-based modeling; Emergence; Complexity; Simulation; NetLogo; Python; Computational Social Science

Target Group
- Participants with diverse disciplinary backgrounds are welcome to join but participation always requires a strong interest in social phenomena.
- Participants with programming experiences as well as starters are welcome.

Course and Learning Objectives
By the end of the course you will:
- Understand the core concepts of complexity science
- Know and understand emerging phenomena from various scientific disciplines
- Know seminal agent-based models of opinion polarization, social order, the dissemination of fake news, and the emergence of classes
- Be able to reflect on the strengths and weaknesses of agent-based modeling.
- Be able to develop agent-based models.
- Be able to reflect on the complementary advantages of toy models and “realistic” models (e.g. digital twins)
- Have practiced implementing and analyzing agent-based models either in NetLogo or Python
- Will have learned how to develop expectations about the mechanism generating emergent phenomena and how to challenge these expectations with agent-based models.

Course Prerequisites
- Strong interest in social phenomena
- Motivation to expose yourself to mathematical methods.

Software and Hardware Requirements
Participants should bring their own laptops for use in the course. Participants who want to work with Python should have it installed on their own machines. We will inform these participants that they need to install Igraph. NetLogo can be installed in a few moments and does not require any planning in advance.

Recommended Literature to Look at in Advance
Day-to-day Schedule and Literature

**Day 1: Complexity research, Emergence in social systems, Ethnic segregation**

*Literature:*

**Day 2: The emergence of social order**

*Literature:*

**Day 3: Opinion Polarization and online social networks**

*Literature:*

**Day 4: The spreading of fake-news and the effects of social bots**

*Literature:*

**Day 5: The emergence of social classes**

*Literature:*

**Additional Recommended Literature**