Research theme title:
Modeling of complex humans-involved systems and control of disastrous outcomes

Description:
Many natural or human-generated systems are characterized by high complexity deriving from heterogeneity of the dynamic phenomena at play and by their interconnectedness. Examples are hydro-geological systems, financial systems, traffic networks, epidemics, etc. We all witnessed in recent times how such complex systems may evolve towards possibly disastrous outcomes: extreme weather events caused floods and destruction, the spread of viruses jeopardized the very structure of social interactions and caused enormous human and economic losses, financial defaults in a few banks spread as a contagion and sparked global financial crises, etc. The common issue in these different endeavors is that the involved phenomena can hardly be understood in isolation. Rather, it is the interaction of agents and subsystems via their networked structure which is responsible of the global behavior of the overall system.
The objective of this PhD program is to develop integrated modeling approaches for complex systems, such as agent-based modeling or activity driven networks, which make it possible to explore possible trajectories and identify bifurcations, particularly those related to emerging risks and the vulnerability of populations. Agent-based modeling approaches raise crucial challenges in computer science, AI and software engineering, as they rely on the construction and simulation of large-scale artificial worlds in which the behaviors of human societies and their environment must be represented in some detail. Dynamical network models, instead, provide simpler representations of reality, but allow for deeper theoretical analysis and understanding of the underlying phenomena. We shall address both agent-based and dynamical network models in our study. Since modeling offers freedoms that practice alone does not allow, and because it can bring out new representations capable of accompanying, or even stimulating, indispensable ruptures, it can help us to reexamine our practices and thus accompany the transition to more sustainable lifestyles.
Besides modeling and simulation of complex systems, our research objectives also include the design and test of decision strategies (both centralized and decentralized) that aim at keeping the system within a ``healthy'' functioning regime and avoid disastrous outcomes.
Our investigations will be grounded and driven by a few specific use cases such as, e.g., the COVID-19 pandemic, floods in specific regions, or traffic congestion.

References:
[1] Arthur Brugière,Doanh Nguyen-Ngoc and Alexis Drogoul, "Handling multiple levels in agent-based models of complex socio-environmental systems: A comprehensive review." Front. Appl. Math. Stat., Dec. 2022, Sec. Mathematics of Computation and Data Science.
[2] Editorial: Advances in data-driven approaches and modeling of complex systems. Front. Appl. Math. Stat., 25 May 2023 Sec. Mathematics of Computation and Data Science.
[3]N. Perra, B. Gonçalves, R. and A. Vespignani, "Activity driven modeling of time varying networks." Scientific Reports volume 2, 2012.

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