Content

1. Reductionism and holism (philosophy of science, success stories of the twentieth century science: quantum physics and molecular biology)

2. Systems theory, cybernetics, nonlinear science

3. NEW SCIENCE, SOCIETY and HUMANITIES
New science, society and humanities

- Modeling of Socio-Economic Systems
- Agent-Based Modeling
- Self-organization in Pedestrian Crowds

Topics
- Opinion Formation
- Cooperation in Social Dilemmas
- Evolution of Moral Behavior
- Systemic Risks in Society and Economics
New science, society and humanities

Modeling of Socio-Economic Systems

New challenges

• to predict, control and management of socio-economic crises and political insabilities
• to avoid "pathological" collective behavior: panic, extremism, breakdown of trust ...
• to understand and manage demographic changes
• to control of spreading epidemics
• to ensure security and peace
• to understand the structure and dynamics of different social networks
• to defend intellectual property rights
• to understand the relationship between individual and institutional decision making mechanism
Modeling of Socio-Economic Systems (difficulties)

- Many variables - multiple time scales - statistical variations of the measurements
- Just ONE realization (say: human history)
- Empirical studies are limited (financial, ethical) - observer interact with the observed phenomenon
- "Rule of the game" may change
- Normative and moral issues might vary over time
One of the central ideas in the article was that general well-being (that is, of the overwhelming majority of population) tends to move in the opposite direction from inequality: when inequality grows, well-being declines, and vice versa.

Figure 1: The Double Helix of Inequality and Well-Being in USA, 1800-2000: P. Turchin
New science, society and humanities

Modeling of Socio-Economic Systems (difficulties)

Figure 2: Instabilities, collective phenomena, social networks

Political instability index. Vulnerability to social and political unrest. From Economist Intelligence Unit

Panic: stadium collapses in Abidjan

Patent citation network: Chemistry: molecular biology and microbiology: from Steve Borgatti
Agent-Based Modeling

Economics focus

Agents of change

Conventional economic models failed to foresee the financial crisis. Could agent-based modelling do better?
Agent-Based Modeling

- collective phenomena
- microscopic decision -> macrostructures
- Thomas C. Schelling: Micromotives and Macrobehavior
- urban dynamics: agglomeration and segregation
- coalition formation
- standing ovation problem
- civil violence
- crowd dynamics

J. Epstein (2002); **Modeling Civil Violence: An Agent-Based Computational Approach.**
A central authority uses "cops" to arrest (remove) actively rebelling citizens from the society for a specified jail term. In each time step, each agent (cop or citizen) randomly moves to a new unoccupied site within its limited vision. A rebelling citizen’s estimated arrest probability is assumed to fall as the ratio of actively rebelling citizens to cops that the citizen perceives in its vicinity increases. Each citizen in each time step decides whether to actively rebel or not depending on this perceived ratio. Epstein shows how the complex dynamics resulting from these simple assumptions can generate empirically interesting macroscopic regularities that are difficult to analyze using more standard modeling approaches:
Agent-Based Modeling

PAYOFF:

<table>
<thead>
<tr>
<th></th>
<th>Partner</th>
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<tbody>
<tr>
<td>C</td>
<td>3</td>
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<tr>
<td>D</td>
<td>5</td>
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(C = Cooperate, D = Defect)

Average Payoff

- random
- cooperate
- defect
- tit-for-tat
- unforgiving
- unknown
Self-organization in Pedestrian Crowds

- lane formation
- panic
- evacuation dynamics

"social force" ("social field") model framework

\[ m_i \frac{d v_i}{d t} = F_a = F_p + F_{\text{int}} \]
\[ F_p = \frac{1}{\tau} (v^p - v_i) \]
Opinion Formation

From individual opinions to public opinion

Interactions of people in a group (in extreme case this may be the whole society) imply changes in their opinion about different issues and may lead to **consensus**, **fragmentation** or **polarization**. Consensus means that all players share the same opinion, fragmentation occurs when several opinions emerge, polarization is a special case of fragmentation for having two parties of people with two different opinions.
Cooperation in Social Dilemmas

- game theory (also John von Neumann)
- classical game theory; strategy, zero-sum, (non)-cooperative ...
- Prisoner Dilemma
- evolutionary game theory (connects biology to social sciences)
- evolution of cooperation
Moralists and immoralists coexist (Helbing et al). A statistical-physics-based model may shed light on the age-old question "how can morality take root in a world where everyone is out for themselves?" Computer simulations by an international team of scientists suggest that the answer lies in how people interact with their closest neighbours rather than with the population as a whole.
Systemic Risks in Society and Economics

- World wars
- Climate change
- SARs and other epidemics
- Potential collapse of the international financial market ("Greenspan Concedes Error on Regulation")
- Deviations from the Bell curve: Black Swans (N. Taleb) vs Dragon Kings (D. Sornette)

Dragons vs swans

Black swans and dragon-kings are both huge events in complex systems – but dragon-kings don’t follow a power law