Universität Bielefeld

ZiF

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Zentrum für interdisziplinäre Forschung

SocioPhysics

June 6 - 9, 2002

ABSTRACT BOOKLET

http://ais.gmd.de/~frank/sociophysics/

AIMS AND SCOPE

SocioPhysics has become an attractive field of research over the past years, despite some controversies about its scientific eligibility and potential use for the understanding of social phenomena.

This international conference tends to reflect these discussions: It brings together scientists from various disciplines, such as physics, sociology, informatics, demography, philosophy, political sciences, economics. They will jointly discuss whether and to what extent physical models and tools can be reasonably used to enhance quantitative methods and computer simulations in the social sciences.

Ideally, this interdisciplinary dialog will result in a mutual enhancement: Social scientists may learn about the latest development in applying physical methods to the life and social sciences, physicists and other natural scientists may increase their awareness of problems, methods, and needs in the social sciences.

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Organizers: PD Dr.Dr. Frank Schweitzer (St. Augustin) and Prof. Dr. Klaus G. Troitzsch (Koblenz)

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Conference Program

Thursday – June 6, 2002	
14:00 – 14:30	Opening/Welcome Address by the Director of ZiF, Prof. Peter Jutzi
14:30 – 15:15	Nigel Gilbert **Cases and groups: almost the same or utterly different?**
15:15 – 16:00	Robert Axtell **A theory of multi-agent teams**
16:00 – 16:30	*Coffee Break*
16:30 – 17:15	Rosaria Conte **A plea for complexity: The necessity of meta-beliefs for social theory**
17:15 – 18:00	Frank Schweitzer **Coordination of decisions in multi-agent systems**
18:30	Conference Dinner at ZiF

Friday – June 7, 2002

09:00 – 09:45	Rainer Hegselmann **Opinion formation under bounded confidence**
09:45 – 10:30	Gérard Weisbuch **Continuous and binary strings opinions dynamics**
10:30 – 11:00	*Coffee Break*
11:00 – 11:45	Janusz Holyst **Phase transitions in models of opinion formation**
11:45 – 12:30	Wolfgang Weidlich **Sociodynamics: a systematic approach to mathematical modelling in the social sciences**
12:30 – 13:30	*Lunch Break*
13:30 – 15:30	**POSTER SESSION**
15:30 – 16:00	*Coffee Break*
16:00 – 16:30	Hermann Rampacher **A socio-physical ethical research program**
16:30 – 17:00	Petra Ahrweiler **Modelling conflict resolution in social systems**
17:00 – 17:30	Thierry Faure (Guillaume Deffuant, Gérard Weisbuch, Frédéric Amblard) **Modelling a population switching to extremism: the relative agreement model in a socio-physics perspective**
17:30 – 18:00	Kai Nagel (Bryan Raney) **Agent-based learning in transportation simulations**

Saturday – June 8, 2002

09:00 – 09:45	Dietrich Stauffer **Vote distributions and simulations of Sznajd models**
09:45 – 10:30	Klaus G. Troitzsch **Voters' attitude changes as a stochastic process**
10:30 – 11:00	*Coffee Break*
11:00 – 11:45	Günter Haag **Integrated models of urban and social evolution**
11:45 – 12:30	Alexia Fürnkranz-Prskawetz **Timing, sequencing and quantum of life course events: a machine learning approach**
12:30 – 14:00	*Lunch Break*
14:00 – 14:30	Jürgen Mimkes (Christian Denk, Thorsten Fründ, Geoff Willis, South Elmsall, W. Yorkshire, U.K) **The structure of complex systems: thermodynamics, socio-economics**
14:30 – 15:00	Maxi San Miguel (K. Klemm, V. M. Eguíluz and R. Toral) **Globalization, cultural drift and social networks**
15:00 – 15:30	Claudio Castellano (Matteo Marsili, Alessandro Vespignani, Daniele Vilone) **Nonequilibrium phase transition in a model for social influence**
15:30 – 16:00	*Coffee Break*
16:00 – 16:30	Jacek Miekisz **Social coordination in spatial evolutionary games**
16:30 – 17:00	Jürgen Scheffran **The complexity and stability of coalition formation**
17:00 – 17:30	Thomas Fent (Wolfgang Lutz, Warren Sanderson) **Population balance**
17:30 – 18:00	Kazimierz Pater **The random model for simulation of the growth of small populations**

Sunday – June 9, 2002

09:00 – 09:45	Dirk Helbing **Dynamic decision behavior: models and experiments**
09:45 – 10:30	György Szabó **Cyclical dominance in spatial evolutionary games**
10:30 – 11:00	*Coffee Break*
11:00 – 11:45	Frantisek Slanina **Harms and benefits from social imitation**
11:45 – 12:30	Andrzej Nowak **Order parameters of social systems**
12:30	Closing Remarks
13:00	*Lunch / Departure*

POSTER SESSION

- Moses Boudourides
  The self-organization of two coupled networks: A simulation of the co-evolution between a social and a CMC network

- Zdzislaw Burda (D. Johnston, J. Jurkiewicz, M. Kaminski, M.A. Nowak, G. Papp, I. Zahed)
  Wealth condensation in Pareto macro-economies

- Ralph Grothmann (Hans Georg Zimmermann, Christoph Tietz, Ralph Neuneier)
  Market modeling based on cognitive agents

- Erez Hatna (Itzhak Benenson)
  Dynamic of city as a human system

- Chih-ying Hsiao (Willi Semmler)
  Estimation diffusion processes based on discrete time observations

- Ondrej Hudak
  Topology and social behaviour of agents: an example from capital markets

- Jürgen Kropp (K. Eisenack)
  Modeling marine capture fisheries by means of qualitative differential equations

- Liacir Lucena (Gilberto Corso)
  The emergence of social classes as a critial phenomenon

- Fernando Pigeard de Almeida Prado (Vladimir Belitsky)
  Self-organizing market crashes resulting from agents interaction

- Tadeusz Platkowski (Michal Ramsza)
  Minority game on distributed markets

- Felix Reed-Tsochas
  Building business strategies on sandpiles: the trade-off between globally optimal and robust adaptive solutions

- Carl Reschke
  Implications of complexity for evolutionary economics

- Andreas Resetarits (Markus Knoflacher)
  Physical laws in settlement processes

- Duncan Robertson
  The use of physical and engineering frameworks to study turbulence in business environments

- Andrea Scharnhorst
  Variety and competition – the evolution of web technology

- Johannes Schneider
  The influence of opportunists and contrarians on the stability of a democracy – An investigation based on the Sznajd-model

- Dmitri Volchenkov (Philippe Blanchard)
  A toy society under attack. How to make a panic to subside

- Friedrich Wagner
  Herding behaviour in volatile financial markets

LECTURES

Cases and groups: almost the same or utterly different?

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In what ways might computational models of human groups differ in principle from models of physical particles? There are several well known examples in the literature of models developed by or for social scientists that could as well be models of physical or biological phenomena in all respects other than the particular interpretations that social scientists have chosen to place on the them (Schelling's famous segregation model is one such example). If there were no significant differences between models of particles and models of societies, then one might want to argue that sociology is merely a sub-category of physics (or, in other words, that social science consists essentially of the analysis of individual 'cases' and aggregates of them). At the other extreme, one could propose that no computational model will ever capture the essence of human societies, which are sui generis. Human groups, it could be said, are phenomena of a unique kind.

In this presentation, I shall take a middle position, arguing that models of societies are necessarily more complex than models of inanimate particles, or of non-conscious organisms, but that the nature of the additional complexity needs to be considered for each domain or target to be modelled. I shall illustrate this by developing Schelling's model (using it as a case study), considering what might be needed to take account of the effects of: residential segregation on residents and others; the social recognition of spatially segregated zones; and the construction of categories of ethnicity.

A theory of multi-agent teams

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The conventional game theoretic formulation of coalition formation involves rational agents with finite strategies in static environments and studies equilibrium configurations. Against this I propose a model involving adaptive behavior by heterogeneous agents having bounded rationality, who interact directly with one another out of equilibrium to form teams. Under general conditions involving super-additivity or increasing returns to scale it is shown that for any fixed population of agents the Nash equilibria of this team formation game exist and are unique. However, for sufficiently large team size the adjustment dynamics are unstable. The exact character of the instability is shown to depend on the nature of agent updating: synchronous updating is less stable than partially asynchronous updating. Permitting agents to migrate between teams, there arise stationary distributions of team size, output, growth rates, and lifetimes, despite constant adaptation and change at the agent level. No team has finite lifetime, suggesting a kind of firm-level 'turbulence.' These results are obtained computationally using agent-based modeling. The nature of these stationary distributions depends on intra-group compensation policies and the agent social network. It is demonstrated that these distributions can have certain properties in common with a variety of human groups: voluntary organizations, business firms, and cities. This is a model of multi-level selection and the implications for group selection arguments are developed. It will be argued that equilibrium theories of multi-agent teams are unlikely to ever grasp the highly skew empirical regularities that characterize human groupings.

A plea for complexity: The necessity of meta-beliefs for social theory

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PSS (Project on Multi Agent Systems and Social Simulation)
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The role of social *meta-beliefs* (i.e. beliefs about beliefs) as a fundamental component of social processes is discussed with some detail, with a special attention to the crucial distinction between Image (evaluative belief) and Reputation (belief about evaluative beliefs). Meta-beliefs are claimed to require that agents be modelled not only as intelligent, but also as *cognitive* systems. Reputation will be defined as a hybrid, multi-level object, including both agent properties and social meta-beliefs. Decisions based upon both mental objects will also be analysed.

The distinction between image and reputation will be shown to bear crucial consequences for the study of social phenomena, such as altruism, reciprocity and cooperation. In particular, a notion of reputation as merely overlapping with image is claimed to have contributed to a less than satisfactory explanation of eu-social phenomena. Existing non-cognitive approaches (such as rational theories) are not supported by experimental results about cooperation among humans, which are higher than expected by these theories. Furthermore, a failed appreciation of the utility of meta-beliefs explains why existing online reputation reporting systems (like eBay) yield unexpected under-provided and lenient reports among systems users.

Finally, further related work is re-examined and the necessity of a broader view of emergent processes that include not only bottom-up but also top-down processes is argued for.

Coordination of Decisions in Multi Agent Systems

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There are various reasons why agents at different locations make the same decision, i.e. the same choice among (two) different alternatives. In this talk, we are particularly interested in the influence of local agent interactions on their decision behavior.

In a first approach known as non-linear voter model, an agent makes a decision towards a particular alternative dependent on the number of agents in his immediate neighborhood sharing the same opinion. However, due to the non-linearity also decisions against the majority are possible. This model is investigated by means of a stochastic cellular automata approach. Using some approximations for the local interaction, we are able to derive from the microscopic interaction rules macroscopic equations for the share of agents making the same decision.

In a second approach, we focus on the spatial coordination of decisions in a agent community based on different local information. The information is generated by the agent's decision, it has a finite lifetime and is disseminated in the system with finite velocity. The spatial distribution of agents making the same decision is investigated both analytically and by means of stochastic computer simulations. In particular, we derive critical parameters for the emergence of minorities and majorities of agents making opposite decisions.

We find that dependent on two essential parameters describing the local impact and the spatial dissemination of information, either a definite stable minority/majority relation (single-attractor regime) or a broad range of possible values (multi-attractor regime) occurs. In the latter case, the outcome of the decision process becomes rather diverse and hard to predict, both with respect to the share of the majority and their spatial distribution.

We further investigate how a dissemination of information on different time scales affects the outcome of the decision process. We find that a more "efficient" information exchange within a subpopulation provides a suitable way to stabilize their majority status and to reduce "diversity" and uncertainty in the decision process.

References:

Schweitzer, F.: Brownian Agents and Active Particles (Springer Series in Synergetics), Springer, Berlin, 2002

Schweitzer, F.; Holyst, J.: Modelling Collective Opinion Formation by Means of Active Brownian Particles, European Physical Journal B 15/4 (2000) 723-732

Schweitzer, F.; Zimmermann, J., Mühlenbein, H.: Coordination of Decisions in a Spatial Agent Model, Physica A 303/1-2 (2002) 189-216

Rainer Hegselmann
Bayreuth University

Opinion formation under bounded confidence

Consider

- a group of people, for instance a *group of experts* on something;
- each expert has an *opinion* about the topic under discussion, for instance the probability of a certain type of accident;
- *nobody is totally sure* that he is totally right;
- to some degree everybody is *willing to revise* his opinion when informed about the opinions of others, especially the opinions of *'competent' others*;
- the revisions produce a new opinion situation which may lead to further revisions of opinions, and so on .... .

Such a process may lead to a consensus among the agents or to a polarization between the agents or, more general, a certain fragmentation of the patterns of opinions. An understanding of the involved processes is hardly possible without an explicit formulation of a mathematical model. In the past several such models were developed to analyse the resulting dynamics.

The talk presents and analyses a model in which individuals take into account the opinions of those others whose opinions are reasonable, i.e. whose opinions are not 'too far away' from their own opinion. The dynamics is driven by averaging over all opinions that are not to far away.

To make the basic idea a bit more precise:

- There is a set of *n individuals* ($i, j \in I$).
- Time is *discrete* ($t = 0, 1, 2, \ldots$).
- Each individual starts with a certain *opinion,* expressed by a *real number* ($u_i(t_0) \in [0,1]$) .
- Each individual i takes into account only those individuals j for which $\left|u_i - u_j\right| \leq \varepsilon$ (*confidence interval*). Thus, the set of all individuals that i takes seriously is $I(i,u) = \left\{1 \leq j \leq n \,\middle|\, \left|u_i - u_j\right| \leq \varepsilon\right\}$. (Extension: asymmetric confidence intervals $\varepsilon_{left}, \varepsilon_{right}$.)
- Individuals *update* their opinions. The next period's opinion of individual i is the *average* opinion of all those which i takes seriously, i.e.:
  $u_i(t+1) = \left|I(i,u(t))\right|^{-1} \sum_{j \in I(i,x(t))} u_j(t)$.

The talk will analyse the effects of different sizes, symmetry, and different types of asymmetry of confidence intervals.

The results presented here are based on simulations. They are the output of an ongoing research project together with Ulrich Krause (University Bremen). In that project Krause tries to get an analytical understanding via rigorous proofs, while my part is the simulation work. The model was defined in Krause (1997). Some of the results we have by now will be published in Hegselmann / Krause (2002).

Krause, Ulrich (1997), Soziale Dynamiken mit vielen Interakteuren. Eine Problemskizze: U. Krause / M. Stöckler (eds), *Modellierung und Simulation von Dynamiken mit vielen interagierenden Akteuren,* Universität Bremen. pp. 37 – 51.

Hegselmann, Rainer / Krause, Ulrich (2002), *Opinion Dynamics and Bounded Confidence – Models, Analysis, and Simulation*: Journal of Artificial Societies and Social Simulation (JASSS)

Continuous and binary strings opinions dynamics

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We present a model of opinion dynamics in which agents adjust opinions as a result of random binary encounters whenever their difference in opinionis below a given threshold.

In the case of continuous opinions and full mixing, high thresholds yield convergence of opinions towards an average opinion (consensus), whereas low thresholds result in several opinion clusters. The model is further generalised to network interactions, threshold heterogeneity, and adaptive thresholds.

In the case of binary strings of opinions, a similar transition between a consensus regime and extreme diversity is observed when the threshold is varied.

Phase transitions in models of opinion formation

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Models of cluster formation and opinion dynamics basing on active walkers approach and social impact theory in social groups with various geometry are considered. It shown that since the concentration of influence can spontaneously occur even in simple models of active walkers thus appearance of strong group leaders is also possible in this way. The presence of such leaders can cause discontinuous phase transition, i.e. rapid changes of opinion distribution in small groups. The effect occurs for several geometry of studied models: Euclidean geometry, random distribution of social distances and scale-free Barabasi-Albert networks. K. Kacperski and J.A. Holyst, Physica A, 269, 511-526 (1999), K. Kacperski and J.A. Holyst, Physica A, 287, 631-643 (2000), F. Schweitzer and J.A. Holyst, European Physical Journal B, 15, 723-732 (2000), J.A. Holyst, K. Kacperski and F. Schweitzer, Physica A, 285, 199-210 (2000), A. Aleksiejuk, J.A. Holyst and D. Stauffer, Physica A, 310, 260-266 (2002)

Sociodynamics. A systematic approach to mathematical modelling in the social sciences

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The intention of Sociodynamics is to develop a systematic approach to initiating and evaluating mathematical models for a broad class of collective dynamic social processes in different sectors of society. To achieve this, appropriate and universally applicable mathematical methods are combined with concepts from social science.

The modelling strategy takes into account the interdependence between the microlevel of individual decisions and actions driven by motivations, and the macrolevel of evolution of material and mental macrostructures within society.

Its main purpose consists in the derivation of equations of evolution for macrovariables or "orderparamters" of the social system. This is done although no "microequations" of individual behaviour are available.

Literature:

W. Weidlich: Sociodynamics - A Systematic Approach to Mathematical Modelling in the Social Sciences. Harwood Academic Publishers, 2000, ISBN 90-5823-049-X.

A Socio-physical ethical research program

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There still is no academic discipline called ethics being able to prove only the existence of categorical imperative rules, further to explain the origin of ethical conflicts and to solve them precisely without metaphysical arguments. A new scientific ethical theory including an detailed empirical ethical research program is proposed explaining ethical norms, ethical system variables and ethical conflicts. The ethical theory is based on the principle of risk minimisation, the fundamental physical concept of interaction and the measurement of ethical system variables as justice, solidarity, freedom and sustainability, the respective values of those may be observed for every existing civilisation and every existing nation. The theory can derive ethical norms as categorical imperative rules and the research program solves traditional as well as new ethical conflicts that result from scientific, technical and economic evolution. Any human interaction, universally done or undone, that destabilise each system, in which the interaction can occur, may be called ethical, every system being stabilised or destabilised by an ethical interaction may be called ethical. Technical change brings out a rapidly growing number of ethical interactions, called non-elementary, because they can be performed only by means of science and engineering. An ethical interaction may be associated with both a risk factor and a ranked ethical rule of behaviour. The rule's rank is proportional to the assigned risk factor. Ethical risk factors can be calculated for specific ethical systems, including social systems, using relevant statistical data. It is assumed that a specific final set of both done and undone high-ranking ethical interactions may stabilise a pre-set ethical system. Then the set of associated ethical rules minimises linearly the decay probability of the system and equally the ethical risks belonging to the particular rules, provided the rules are respected simultaneously (ethics of risk prevention). For that reason we identify final sets of high-ranking ethical rules of behaviour, stabilising the global society in the biosphere with sets of ranked ethical norms. Globally accepted moral and legal standards (e.g. human rights) are compatible with subsets of elementary ranked ethical norms. Prevention fails as soon as only one ethical norm is broken. For the interaction assigned to the broken norm activates correlative interactions, not all ethical norms can be observed any more simultaneously and hence an ethical conflict arises as an non-linear effect in one ethical system or even in more afflicted ethical systems. If an intervention favours higher-ranking ethical norms at the expense of lower-ranking norms harmful consequences of the conflict are limited (ethics of intervention). Non-elementary ethical norms, ethical risk factors, and demonstrable and reproducible correlation must be discovered by dedicated interdisciplinary ethical research projects as a part of a whole ethical research program. Provided this ethical research work is done, ethics as social physics is able to solve ethical problems using mathematical methods – e.g. statistics, non-linear dynamics, game theory and self-organisation – and as well methods of computer science including system simulation. Some important applications: Penal law (death penalty is prohibited) and penal justice (punishment has to be replaced by best possible compensation), peace-keeping interventions, conflicts in energy production (nuclear versus fossil combustion), medical research in human embryology. Furthermore the stability of nations can be investigated by means of simulation models using peace, justice, solidarity, sustainability and freedom as ethical system variables with actual and ideal values.

www.rampacher.de

Modelling conflict resolution in social systems

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This paper presents a multi-agent system which models and supports conflict resolution in social systems. The underlying process shows how and where actors who interpret facts in different ways can conceptually co-operate regarding a common problem (win-win situation); likewise the system finds „traps of communication“ which could lead into further conflicts. The procedure can be applied as a tool for conflict resolution in and between businesses or other institutions; it can help to fully automatise online-mediation assisting users who must rely on a successful conflict management and working communication flows.

Modelling a population switching to extremism: the relative agreement model in a socio-physics perspective

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Coauthors: Guillaume Deffuant, Gérard Weisbuch, Frédéric Amblard

We study the relative aggreement (RA) interaction model (Deffuant 2001, Deffuant et al. 2002), which extends the bounded confidence model (Deffuant et al.2000, Dittmer, 2001) by giving more influence to 8220;confident8221; agents (low uncertainty). This corresponds to the common experience in which confident people tend to convince more easily uncertain people than the opposite (whereas their range of opinions are not too far apart). We made a first study (Deffuant et al. 2002) of this model in an individual based perspective : we draw a population of individuals from a given opinion probability distribution, and then observe its evolution. We consider the RA model in the case of presence of extremists in a population of opinions uniformly drawn: we suppose that a given (low) proportion of the most extreme opinions have a much lower uncertainty than the majority. We limit the study to the case where all the agents interact with each other (total connection).

The RA model shows two antagonists dynamics : - a large part of population switch to extremism, sometimes with a balanced number on both extremes, sometimes one extreme being largely dominant – the majority resists to the influence of extremism.

In the conference, we will present a study of the RA model in a socio-dynamics approach: we consider an initial probability distribution of the opinions and make a first order approximation of its evolution using the master equation (Helbing, 1995, Weidlich, 2000).
We intend to particularly focus on the comparison between a probability distribution approach and agents based approach in particular to compare stability/instability region, and process of extremist balance, effect of distribution noise, 8230;.

References : Deffuant, G., Neau D., Amblard F. and G. Weisbuch. 2000. 8220; Mixing beliefs among interacting agents.8221; Advances in Complex Systems, 3, n°1, 87-98. Deffuant, G. 2001. 8220; Final report of project FAIR 3 CT 2092. Improving Agri-environmental Policies : A Simulation Approach to the Cognitive Properties of Farmers and Institutions.8221;
http://wwwlisc.clermont.cemagref.fr/ImagesProject/FinalReport/referenceslist.htm

Deffuant G, Amblard F., Faure T., Weisbuch G., 2002, How extremism can prevail ? A study based on the relative agreement model. 8221; To be submitted to JASSS. Dittmer, J.C. 2001. 8220; Consensus formation under bounded confidence.8221; Nonlinear Analysis, 47, 4615-4621. Helbing D., 1995, Quantitative Sociodynamics, Stochastic methods and models of social interaction processes, Kluwer Academic Publishers., 335pp. Weidlich W., 2000, Sociodynamics : A Systematic Approach to Mathematical Modelling in the social sciences, Harwood academic publishers., 380pp.

Agent-based learning in transportation simulations

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In transportation simulations, it is not only necessary to represent how travelers and vehicles move through the transportation system, but one also needs to model the decisions (plans) leading to travel, and the decisions about modes and routes. These strategic and tactical decisions interact with what happens in the transportation system. For example, plans are based on expected congestion, and congestion happens as the result of the execution of plans. This interaction is modeled by iterations between the different modules, that is, agents make plans, the plans are executed, some of the agents change their plans, the plans are executed again, etc. Agents' strategies and their scores are stored in an agent database. Strategies are usually selected according to score; from time to time, new strategies are generated and added to the agent databased. In this presentation, we show how such an approach is implemented in the context of a large scale real-world transportation simulation. Our goal is an agent-based 24-hour simulation of all of Switzerland.

Vote distributions and simulations of Sznajd models

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Euroland. Journal of Artificial Societies and Social Simulation 5, No. 1, paper 4 (2002)
http://jasss.soc.surrey.ac.uk/JASSS.html

The Sznajd model in less than two years has found followers on four continents. An isolated person does not convince others; a group of people sharing the same opinions influences the neighbours much more easily. Thus on a square lattice, with variables +1 (Democrats) and -1 (Republicans) on every lattice site, a pair (or plaquette) of neighbours convinces its six (eight) nearest neighbours of its own opinion if and only if all members of the pair (plaquette) share the same opinion. The generalization to many possible states is used to explain the distribution of votes among candidates in Brazilian local elections. If one can convince only people of similar opinions, then complete cinsensus can be reached only if the number of possible opinions is rather small.

Voters' attitude changes as a stochastic process

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Voters' attitude changes are modeled as a nonlinear diffusion process in attitude space. Attitude space is empirically reconstructed from panel data where voters' attitudes towards political parties and candidates were measured in three waves. The density function of attitudes was reconstructed and converted into a potential in which voters changed their positions in attitude space. This process was simulated on the individual level. In every simulation step, the density function was re-calculated. The simulated change of the density function was compared to empirical data of German national surveys in 1998. Similarities and differences between simulation results and empirical data show a way on which modeling can be continued and made even more realistic.

Integrated models of urban and social evolution

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The coming years represent a challenge for all branches of science. The nutrition and satisfaction of the further needs of the increasing world population demands more reliable planning tools. Policy advises on the base of different scenarios are useful in a planning context in the attempt to shape the future taking into account different scenario results, instead of just adapting to what may emerge. This procedure is especially important when essential parts of the system cannot be controlled by policy measures and depend on exogenous factors. The in general non-linear interactions between the agents of the socio-economic system and/or the different levels of consideration may result in a variety of possible instabilities. The simulation of uncertainties based on "measurement errors" of the data or events happening in the environment leading to "varying" exogenous parameters must be simulated in future applications of such complex models. As an outcome not only the most probable behaviour of such systems but also information about confidence intervals will be obtained.

The modelling of the spatio-temporal patterns of a system of interacting cities, consisting of different sub-models (population, transport, production, etc.) is used to demonstrate the necessity to link different theoretical frameworks in an interdisciplinary way. External shocks may sometimes require a modification of the system under consideration in the sense that new dynamic variables appear or previously useful variables disappear. The occurrence of those "structural phase transitions" can be seen as an interesting challenge for further research.

Timing, sequencing and quantum of life course events: a machine learning approach

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Billari, F.C.; Fürnkranz, J.; **Prskawetz, A.**

In this methodological paper we discuss and apply machine learning techniques, a core research area in the artificial intelligence literature, to analyse simultaneously timing, sequencing, and quantum of life course events from a comparative perspective. We outline the need for techniques which allow the adoption of a holistic approach to the analysis of life courses, illustrating the specific case of the transition to adulthood. We briefly introduce machine learning algorithms to build decision trees and rule sets and then apply such algorithms to delineate the key features which distinguish Austrian and Italian pathways to adulthood, using Fertility and Family Survey data. The key role of sequencing and synchronisation between events emerges clearly from the methodology used.

The structure of complex systems: thermodynamics, socio-economics

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The state of large stochastic systems of N objects may be calculated by the Lagrange principle L(N) = T log P(N) + E(N) ® maximum ! P is the probability, that is to be maximized under a system condition E, and T is the Lagrange ordering parameter. L is the Lagrange function of the system, that may be far away or close to stability. At equilibrium the Lagrange function is at maximum. In natural sciences E is given by the chemical bonds and the (negative) Lagrange function corresponds to the free energy, from which all thermodynamic states may be calculated. In social systems the Lagrange principle corresponds to the common benefit. The function E represents the social bonds of the system. The existence of a quasi-temperature T in social systems is demonstrated by data for binary societies (Catholics - non Catholics in Germany, black - non black in USA) and may be interpreted as tolerance of the society and is proportional to the standard of living (GNP per capita). At high standard of living a society will be integrated, at low standard of living a society will be segregated or aggressive. These results are supported by data from Bosnia and N. Ireland. Hierarchy is observed at low standard of living, democracy at high standard of living and the global phase at very high standard of living. The phases transitions correspond to revolutions, DS>0. Economics: The Lagrange principle corresponds to the common profit of an economic system, E represents the capital, the costs or the prices of a market. The existence of a quasi-temperature T in economic systems is demonstrated by data for the distribution of property in Germany and is again represented by the standard of living (GNP per capita). At low standard of living the economic structure will be in a hierarchic or feudal state, only at a higher standard of living the economy will become capitalistic. Social and economic states are closely related, this may be observed worldwide, but also in smaller socio-economic systems like companies, clubs, families. Work is defined by the 2. law of thermodynamics, economic production cycles correspond to the Carnot cycle of engines.

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Globalization, cultural drift and social networks

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We analyze Axelrod's agent-based model for the dissemination of culture [1] in two new situations: We consider the effects of cultural drift in a regular network and the consequences of social structure modeled by both small world and scale free networks of interactions. The model illustrates the mechanisms of competition between globalization and persistence of cultural diversity. In the original model, a nonequilibrium phase transition exists between a culturally polarized and a culturally fragmented phase [2].

Cultural drift is modeled as stochastic local perturbations (noise) of the set of cultural traits of the agents. We find that, for a fixed system size, the transition to a culturally fragmented phase is fixed by the rate of the stochastic perturbations, being an infinitesimally small noise rate sufficient to maintain cultural diversity in the limit of very large systems. The size of the largest culturally homogeneous domain is shown to be a universal function of the product of system size and noise rate. These results are reproduced by a simplified model in which the cultural change of an agent is independent of the cultural similarity with neighboring agents. This fact seems to invalidate, when cultural drift is at work, one of the basic premises of Axelrod´s model.

When the agents interact through a small world network, the transition occurs for a critical value of the number of cultural traits which increases with the degree of disorder of the underlying network. However, in scale-free networks the transition only exists for finite size networks, while for very large systems the culturally polarized phase prevails. Finally, in a "mass media" network in which all nodes are connected with an external source, the transition is smoothed out.

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Nonequilibrium phase transition in a model for social influence

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We present extensive numerical simulations of the model introduced by Axelrod for social influence, aimed at understanding the formation of cultural domains. This is a nonequilibrium model with short range interactions and a remarkably rich dynamical behavior. We study the phase diagram of the model and uncover a nonequilibrium phase transition separating an ordered (culturally polarized) phase from a disordered (culturally frag-mented) one. The nature of the phase transition can be continuous or discontinuous depending on the model parameters. At the transition, the size of cultural regions is power-law distributed.

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Social coordination in spatial evolutionary games

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Socio-economic systems can be viewed as systems of many interacting agents or players. We may then try to derive their macroscopic behavior from microscopic interactions between their basic entities. Such approach is fundamental in statistical physics which deals with systems of many interacting particles. We will explore similarities and differences between systems of many interacting players maximizing their individual payoffs and particles minimizing the total energy of the system. In particular, we will address the problem of equilibrium selection in games with multiple Nash equilibria. We will consider spatial games with players located on vertices of the square lattice and interacting with their nearest neighbors. In discrete moments of time, players adapt to their neighbors by choosing with a high probability the strategy which is the best response, i.e. the one which maximizes the sum of the payoffs obtained from individual games. With a small probability, representing the noise of the system, they make mistakes. A configuration of players is called stochastically stable (Foster and Young 1990) if it occurs with a positive frequency in the long run in the limit of zero noise. However, we may observe that for any arbitrarily low but fixed noise, if the number of players is big enough, then the long-run frequency of visiting any single configuration of players is practically zero. Some configurations may be stochastically stable only in the zero-noise limit. On the other hand, it may happen that in the long run, for a low but fixed noise and any big number of players, the invariant state of our dynamics is highly concentrated on an ensemble consisting of one Nash configuration and its small perturbations, i.e. configurations, where most players play the same strategy. We will call such configurations low-noise ensemble stable. We will present examples of spatial games with three strategies where concepts of stochastic stability and low-noise ensemble stability do not coincide. Such behavior is fairly generic; it exists for open sets of parameters of a payoff matrix. To show our results we use methods of statistical mechanics.

The complexity and stability of coalition formation

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Coalition formation results from the interplay between individual and collective actions that lead to the evolution of complex social networks. In the model framework a set of individual players allocate their power resources to a number of coalitions which decide on using these resources for taking collective actions. In repeated feedback cycles, the individual players adapt and coordinate their resource allocation based on the evaluation of the coalition actions while the coalitions adapt their actions to succeed in the competition for resources. The emerging dynamic process corresponds to a self-organized transition from individual actions (micro level) to the formation of larger coalitions (macro level). The complexity and stability of the social network architecture is represented by the norm and eigenvalues of the interaction matrices which are controlled by the preferences and strategies of players and coalitions. Nash-Equilibria and Pareto optima can be stabilized by cooperation and negotiation procedures on resources, actions and distribution of coalition values. The efficiency of interaction is represented by fuzzy measures which combine value-based satisfaction functions of the individual players with regard to the coalitions. The model framework is appropriate to analyse the interplay between consumers and firms in market processes, of voters and parties in election processes, and of states and state coalitions in international climate negotiations.

Population Balance

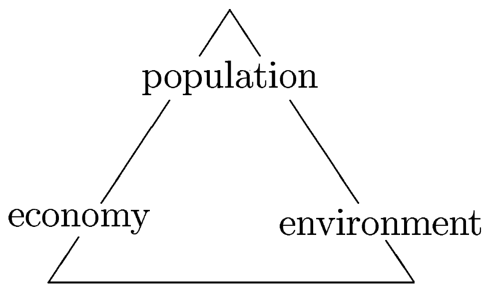
Thomas Fent, Wolfgang Lutz, Warren Sanderson

Abstract

This paper provides a unified theoretical treatment of the relationship between population growth and economic growth taking age structure, education, and the environment into account. The framework allows us to analyze consistently the effects of rapid population growth and rapid aging in a consistent fashion. The model separates the long–run effects of demographic and educational changes from their transitional effects. We conclude that sustainable development requires population balance.

At the beginning of the 21st century we are confronted with two major trends in fertility. On one hand, in the developing countries even after many years of several efforts to educate the individuals in family planning techniques and convince them that a high number of children is not something desirable per se, there still persists a rapid growth of the population with all its negative impacts. On the other hand, people in the industrialized countries seem to refuse having children although their chances to raise children within a healthy and protected environment are much better.

In contrast to the popular stereotype that in the long run fertility must tend close to replacement fertility to ensure sustainable development we postulate that the development of population, economy, and environment should be harmonized. Keeping a balance among these three interacting processes may be the solution in taking up the challenge of a growing or shrinking (aging) population.



In this paper we present a simulation model taking into account the interdependencies of the age–structure of the population, expenditures for education, economic growth, individual welfare, and the environment. Various settings are being compared to allow for meaningful conclusions about the threat of low or high fertility rates and possible solutions.

The random model for simulation of the growth of small populations

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The numerical model for simulation of the evolution of small populations has been proposed where the dependence on the mature age, procreation rate and stability of social structure was factorised. In the model, a population community is composed of the individuals between zero year age to the dead age, which was taken the same for all individuals. Zero age individuals represent empty spaces in the population structure. The position of the population member in the linear social structure results from population history or is random or is ordered to conserve an age hierarchy. The population growth is possible only as a result of the couple appearance in the structure, which is composed of the different gender individuals in the mature age adjacent in the structure. It is a mediate element of the structure and needs not to be durable in all history of the population. The couple could procreate only one offspring in the given time steep of the evolution. The newborn baby appears in the empty space of the social structure or at the end of it in the one-year age.

The probability of the survival of the population of given mature age, procreation rate and structure stability has been searched in the numerical experiment. For the given social parameters one hundred primary populations were selected at random and next their evolution were monitored. Primary age structure of the all populations was random and contains also empty spaces. It is accepted that the population survived if the number of their individuals increases ten times over the initial number. Thus, the number of survived populations gives the procent of survival probability.

The results are compatible with the expectations. The populations with long period of reproduction and the high rate of procreation and without social mobility have the most chance to survive. The populations with the late mature age and high mobility dies out in principle. But if in the model an age hierarchy is forced, a probability of survival goes to 100% for the populations without social mobility. The time stability of the population is most for the groups composed with not mobile individuals and under threshold procreation rate depended on the matural age.

Dynamic Decision Behavior: Models and Experiments

by Dirk Helbing

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We will present dynamical models for decision making with and without temporal constraints [1,2]. These models take into account the non-transitive and probabilistic aspects of decisions, i.e. they reflect the observation that not always the decision with the highest utility or payoff is taken. The theory is compared with recent results of experimental games relevant to the route choice behavior of drivers. The adaptivity ("group intelligence") with respect to changing environmental conditions and unreliable information is quite astonishing. Nevertheless, we find an intermittent dynamical reaction to aggregate information similar to volatility clustering in stock market data, which leads to considerable losses in the average payoffs. It turns out that the decision behavior is not just driven by the potential gains in payoffs. To understand these findings, one has to consider individual learning. Our results are highly significant for predicting decision behavior and reaching the optimal distribution of behaviors by means of decision support systems. These results are practically relevant for any information service provider, although the test persons were found to be more or less resistant against manipulation through biased information. Participants followed recommendations just as much as they helped them to reach their personal goals.

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Cyclical dominance in spatial evolutionary games

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We study the emergency of cooperation in spatial evolutionary prisoner's dilemma games with players who can follow three strategies. The players are located on the sites of a square lattice or a random regular graph whose sites have four neighbors. For each player the total income comes from prisoner's dilemma games with the four nearest neighbors. A Darwinian evolutionary rule is introduced by allowing the players to modify their strategy. Namely, a randomly chosen player adopts one of its neighboring strategies with a probability dependent on the payoff difference. Using Monte Carlo simulations and dynamical pair approximations two models are considered systematically.

In the first model [1], the players can choose one of the three strategies: cooperation (C), defection (D), or "tit for tat" (T). The cyclical dominance (T beats D beats C beats T) is maintained by an external constraint that enforces the cooperative behavior by the adoption of C with some probability.

In the second model, the individuals can follow C or D strategies or they can refuse the participation. This former choice is called loner (L) strategy. The loners avoid the risk of possible exploitation and rely on a smaller but fixed income. The introduction of loners leads to a cyclical dominance of these strategies and promotes substantial level of cooperation where otherwise defectors would dominate [2].

The above systems exhibit different stationary states, namely, the uniform distribution, and the coexistence of two or three strategies. Phase transitions can be observed when tuning the model parameters characterizing the temptation to defect, the noise, the loner's income, etc. On the square lattice, the coexistence of all the three strategies (exhibiting a self-organizing polydomain structure) is maintained by the mentioned cyclical invasion processes. In general, good agreement is found between the results of MC simulations and pair approximation. In some cases, however, the pair approximation predicts oscillating strategy concentrations (limit cycle) characteristic to Lotka-Volterra systems. These oscillations can be observed by MC simulations on random regular graphs where the pair approximation coincides with that of a square lattice.

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Harms and benefits from social imitation

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We consider a model market composed of heterogeneous agents playing a frustrated evolutionary game. We show that their overall parformance can be increased by spontaneous formation of groups, homogeneously acting under leadership of an agent which is imitated by the rst of the group. Generally, the local social tension is also decreased by the formation of groups, but high cost of information transfer may invert the trend, creating higher tensions instead. Finally, we investigate the possibility of individual agents leaving the group and starting independent life again. We find that this effect results in decrease of the overall performance of the system, but simultaneously supresses the spread of gain among individual agents.

Order parameters of social systems

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One of the key aspects in modeling social systems concerns the validity of the model – that is, does the model correctly represent the key properties of system it is supposed to represent. The crucial question, then, is what variables describe the key properties of the system. In statistical physics and thermodynamics (Landau & Lifsthitz, 1964), order parameters refer to global properties of a system that emerge from the interactions among system elements. The values of these emergent properties distinguish between qualitatively different states of the system (e.g., gas vs. liquid). In the approach of nonlinear dynamical systems (e.g., Haken, 1978), the notion of order parameter has been generalized to capture collective variables that provide characterization of the system's evolution on a macroscopic scale. Finding appropriate order parameters thus involves identifying the most important features of a system's state or dynamics. Hence, one of the crucial questions in building models of social systems is "what are the order parameters of social systems?" Finding order parameters would not only establish common dimensions on which to compare models and real systems, but would be helpful in indicating what properties of a social system are most important for the prediction of future states of the system. Theoretical considerations, analytical work, and computer simulations may be useful in finding order parameters of social systems.

Based on previous research employing cellular automata, we suggest that the likely order parameters of social systems include some properties that are generic for a large class of systems:

1. The proportion of individuals in different states (e.g., holding a specific attitude).
2. The degree to which individuals in similar states (e.g., holding similar attitudes) form clusters.
3.The average size of these clusters (as measured by the length of correlation function) and the extent to which the clusters are connected are important "cluster" properties.
4. The average frequency with which individuals change their state
5. The degree to which different properties of individuals (i.e., different attitudes) are correlated.
7. The coherence of influences an average element receives from other elements.
8. The degree of temporal synchronization of dynamics of elements, locality of the synchronization, and character of the synchronization (e.g. in phase, anti-phase)

Evaluation and certainty, on the other hand, are likely order parameters that are specific for both cognitive and social systems. However, for social systems defined in more specific terms, the order parameters may have a correspondingly unique identity. In economics, for example, the average stock market price represents a likely order parameter.

Order parameters are informative of the properties of mechanisms operating in the system in question and therefore may be useful in building models of specific phenomena. For example, the length of the correlation function indicates the effective distance over which elements influence each other, while the frequency of changes may indicate how far from equilibrium the system is, the noise level in the system, or the strength of the intrinsic dynamics of system element.

The order and control parameters that are crucial for characterizing a system's state and dynamics correspond to highly meaningful theoretically variables in the social sciences.

POSTER SESSION

The self-organization of two coupled networks: A simulation of the co-evolution between a social and a CMC network

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With special contributions by
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Our purpose is to simulate the co-evolution of two dynamic networks, which are sustained by the same population of actors: a **social network** S and a **computer-mediated communication network** (from now on referred as a '**CMC network**') C. In our simulation, the co-evolution of the two networks is driven by a small number of simple rules and the simulated dynamic networks converge to two 'equilibrium' static networks. As we will see, the assumed simulation rules are completely endogenous to the coupled dynamics of the two networks and they do not depend on any external parameters or mechanisms. In this sense, the two coupled networks are **self-organized** in order to attain their equilibrium configurations. Our fundamental assumption is that the distribution of degrees d_{Si}, d_{Ci} of the social and the CMC network can be diffused through the corresponding network by the mechanism of **social contagion** in order to transform d_{Si}, d_{Ci} to $\ddot{a}_{Si}$, $\ddot{a}_{Ci}$, respectively. Then our simulation proceeds as follows: Initially we start with two random networks, a social network S_0 having density $\tilde{n}_{So}$ and a CMC network C_0 having density $\tilde{n}_{Co}$. At the end of the first step of the simulation, the two networks S_0 and C_0 will be transformed to two new networks S_1 and C_1, which are obtained by checking all pairs of actors (i,j) and either connecting them or disconnecting them in order to build the two networks S_1 and C_1 according to certain simple rules, which involve $\ddot{a}_{Soi}$, $\ddot{a}_{Coi}$ and $<\ddot{a}_{So}>$, $<\ddot{a}_{Co}>$ (where by $<D>$ we denote the median of the vector $\{D_1, D_2, \ldots, D_N\}$). Similarly, in the second step of the simulation, the networks S_1 and C_1 are transformed into the networks S_2 and C_2, which subsequently are transformed into the networks S_3 and C_3 and so on. But, for certain selections of the simulation parameters ($\tilde{n}_{So}$, $\tilde{n}_{Co}$, $\hat{e}_S$, $\ddot{e}_S$, p_{S+}, p_{S-}, p_{C+} and p_{C-}), we observe that there are two 'equilibrium' networks, a social network S_e and a CMC network C_e, towards which the initial random networks and their subsequent transformations converge. In this sense, we could say that the co-evolution of the above dynamics of the coupled network transformations is *self-organized* through the emergence of the two 'equilibrium' networks S_e and C_e.

Wealth condensation in Pareto macro-economies

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We discuss a Pareto macro-economy (a) in a closed system with fixed total wealth and (b) in an open system with average mean wealth and compare our results to a similar analysis in a super-open system (c) with unbounded wealth. Wealth condensation takes place in the social phase for closed and open economies, while it occurs in the liberal phase for super-open economies. In the first two cases, the condensation is related to a mechanism known from the balls-in-boxes model, while in the last case to the non-integrable tails of the Pareto distribution. For a closed macro-economy in the social phase, we point to the emergence of a "corruption" phenomenon: a sizeable fraction of the total wealth is always amassed by a single individual.

Market modeling based on cognitive agents

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In this talk we present an explanatory multi-agent model. The agents decision making is based on cognitive systems with three basic features (perception, internal processing and action). The interaction of the agents allows us to capture the market dynamics.

The three features are derived deductively from the assumption of homeostasis and constitute necessary conditions of a cognitive system. Given a changing environment, homeostasis can be seen as the attempt of a cognitive agent to maintain an internal equilibrium. We model the cognitive system with a time-delay recurrent neural network.

We apply our approach to the DEM / USD FX-Market. Fitting real-world data, our approach is superior to a preset benchmark (MLP).

Dynamic of city as a human system

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City is an *artificial* complex system (Portugali, 2000) in a sense that its elementary objects - land units, households, householders, firms – are created and governed by humans. City is also a *spatial* system. For example, householder choice depends both on the properties of the real estate and the family's economic abilities, and on the properties of the physical and human environments at current and potential locations. For landowner, the vicinity and wider neighborhoods of the location are important for making commercial decision regarding the price and the usage of the land units. Humans define the characteristics of both mobile and immobile urban objects of all kinds; however, as opposed to non-living objects, the standard reaction of humans to unsatisfactory conditions is a decision to ***relocate*** themselves or their activity in a City.

As it is intensively discussed in the psychological literature (Gigerenzer, Goldstein, 1996), the spatial (as well as non-spatial) behavior and choice of humans does not follow assumptions of chemical dynamics. Serious experimental and analytic arguments in favor of the ***bounded rationality*** and ***satisfycing behavior*** have been provided. We propose the agent-based model of urban spatial development, which is based on this principle.

The analysis of the several versions of the model demonstrates, that satisficing spatial behavior of human agents both enables likely simulation of the real-world population dynamics and makes the model results ***robust*** to infrastructure changes. It is shown that "human-based" urban system exhibits long periods of stable development interrupted by abrupt changes, caused by essential qualitative changes in the infrastructure, such as new building construction over extended areas, major changes in road network, and so on. The model provides, thus, an explanation for "strange" super-stability of urban systems.

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Estimation diffusion processes based on discrete time observations

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We estimate diffusion processes based on discrete time data. In order to obtain a discrete time model for maximum likelihood estimations and data predictions we apply three discretization methods for the simulations of diffusion processes : the Milstein method, the Euler method and the Osaki-Shoji method (the new local linearization method). The three discrete time models are employed to estimate stochastic processes for short term interest rates for several countries. Specifications of the models are discussed. The performances of the models are compared by using Monte Carlo simulations.

Topology and social behaviour of agents: an example from capital markets

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We call in a social group its members as agents. On a capital market the social group is formed from those who are buying and selling shares. In general the social group we characterise in accordance with T. Plummer / The Psychology of Technical Analysis, rev.ed., Probus Pub.Comp., Chicago, 1993/. We assume that individual behaviour of agents is influenced to some degree by the need to associate with other agents and to obtain the approval of other agents in the group. The group is characterised by a very large nonrational and emotional element to decisions of agents. It is due to the fact that making decisions an individual equates own needs with those of the other agents from the group. Any two agents from the group may interact. The interaction consists of the exchange of information and it costs some energy. The information is well defined, and we assume that agents interact in such a way that they give reference to the origin of the information if asked by other agents. Thus the agent may verify obtained information. It is natural then that there exits a subroup of interacting agents the interaction of which has the following property: it is nonreducible in the sense that in this subgroup there exists the interaction of a given agent with another one, this another one agent again interacts with another agent, and because it has no sense to exchange the information with the first one to verify the information, this last mentioned agent is different from the first one. This third agent can thus always verify the information from two sources either interacting with the first one, either he/she is interacting with the fourth agent. In the first case we have a minimal subgroup of interacting agents, which form a closed subroup in which every agent verifies information from two sources - agents. In the second case the fourth agent either interacts with the first one and verifies exchanged information, either with the second one and verifies information. He of course can interact with the third one agent, however to verifiy information he needs again to interact with different agent from that interacting with which he obtained the new information. This is the reason why he interacts either with the first one agent, either with the second one. In the first case we have a closed subgroup of four agents in which every agent interacts with two agents. In the second case the closed subgroup reduces to the group of three interacting agents /last three agents/. This process can continue futher, because the fourth agent may also verify information interacting with the fifth agent. Then by the same procedure as in previous case we may obtain nonreducibile subgroups of three, of four and of five agents, or the fifth agent interacts with the sixth one. And so on. Thus we obtain closed subroups of interacting agents in which every agent interacts with two other agents, and in which the process of verification of information leads to closed linear structure. If any of agents from such an subgroup exchange and thus verifies information with any third one agent from the subroup, the structure of the subgroup changes, the subgroup becomes reducibile to two new nonreducibile subgroups. This is the process of differentiation of the first nonreducibile subgroup to two new ones. This is an example of an elementary transformation between two configurations of nonreducibile subroups. An vice versa: if the interaction between two agents which interact with three agents in the configuration of two nonreducibile subgroups vanishes, a new one nonreducibile subgroup creates and information is still verifiable. When the configuration in which an agent was interacting with three agents which were not interacting between themselves transform to a configuration in which two of the mentioned three agents interact, then we may observe the process of mitosis: a new nonreducibile group appears.Thus the transformation between this two configurations is reversibile. A cell is such a configuration of a given number of nonreducible subroups in which every two interacting agents belongs to two nonreducibile subgroups /subgroups are connected in this sense/ and which is closed . Such a cell may disappear and may be created, may change number of nonreducible subroups in a reversible way. Becasue the structure – configuration of interactions between agents in the group forms a macroscopic structure, we say that it is a microreversible process any process within a nonreducibile subgroup and within a cell. Statistical equilibrium of the whole group is characterized by a set of different subroups of the type mentioned above, and by a probability that such a subroup occurs. Thus we have probability distribution which characterizes the group. Moreover there exists an equation of state which enables to compare different macroscopic states of the group.The statistical equilibrium due to microreversibility is characterised by the maximum of entropy and by the minumum of energy /costs of information exchange/. There exist constrains, such as a fixed number V of agents in the group, a number E of interactions within the group, a number F of subgroups which are nonreducibile, and a number C of cells. Thus we have a structure which is equivalent to random cellular networks. Such networks and their evolution were described by N. Rivier /Physica 23D (1986) pp. 129-137/. He applied methods of statistical mechanics to study these structures. We will use methods described by Rivier to study social behaviour of agents, mainly the presence of topological structure of interactions between agents and its changes, which is the most important property of the group of agents. One can define an area of nonreducible subgroup and a volume of the cell. The area may be formed for example by a sum of areas. We assume homogeneity, thus it is one third part of the agent's characteristic, for example personal, area by which the agent contributes to this sum of areas which form the area of the nonreducibile group. The volume of a cell may be in the case of a capital market defined by the sum of corresponding amounts of financial volume of agents which form a cell in the above sense. The area of a nonreducibile group which belongs to those nonreducibile groups which form the cell may be formed again for example by a sum of areas of agents characteristic areas. Note that area of the nonreducibile group and volume of a cell may be also some other characteristics of the group of agents depending on studied social relations between agents. Thus we are able to study topology properties of interactions of agents, their evolution, and evolution of financial volumes of cells and characteristic areas corresponding to some characteristic diameters for nonreducibile groups. Social behaviour of agents is discussed in general, and for the capital market case as a special case. It can be shown that the equilibrium number of agents with which a given agent interacts is three for a group without cellls /the group forms a single cell/, and it is four for a group in which more than one cell exist. Then the corresponding amount of financial volume is fourth part of the whole agent's financial volume invested on the capital market. We studied Aboav's law concerning number of agents in the neighbouring nonreducibile subgroups which is connected to a given nonreducibile group with a given number of agents, distribution of nonreducibile cells which maximises entropy /informational/, Lewis' law concerning the financial volume of cells, and Von Neuman law of time development of financial volume of average cell.

which an agent was interacting with three agents which were not interacting between themselves transform to a configuration in which two of the mentioned three agents interact, then we may observe the process of mitosis: a new nonreducibile group appears.Thus the transformation between this two configurations is reversibile. A cell is such a configuration of a given number of nonreducible subroups in which every two interacting agents belongs to two nonreducibile subgroups /subgroups are connected in this sense/ and which is closed . Such a cell may disappear and may be created, may change number of nonreducible subroups in a reversible way. Becasue the structure – configuration of interactions between agents in the group forms a macroscopic structure, we say that it is a microreversible process any process within a nonreducibile subgroup and within a cell. Statistical equilibrium of the whole group is characterized by a set of different subroups of the type mentioned above, and by a probability that such a subroup occurs. Thus we have probability distribution which characterizes the group. Moreover there exists an equation of state which enables to compare different macroscopic states of the group.The statistical equilibrium due to microreversibility is characterised by the maximum of entropy and by the minumum of energy /costs of information exchange/. There exist constrains, such as a fixed number V of agents in the group, a number E of interactions within the group, a number F of subgroups which are nonreducibile, and a number C of cells. Thus we have a structure which is equivalent to random cellular networks. Such networks and their evolution were described by N. Rivier /Physica 23D (1986) pp. 129-137/. He applied methods of statistical mechanics to study these structures. We will use methods described by Rivier to study social behaviour of agents, mainly the presence of topological structure of interactions between agents and its changes, which is the most important property of the group of agents. One can define an area of nonreducible subgroup and a volume of the cell. The area may be formed for example by a sum of areas. We assume homogeneity, thus it is one third part of the agent's characteristic, for example personal, area by which the agent contributes to this sum of areas which form the area of the nonreducibile group. The volume of a cell may be in the case of a capital market defined by the sum of corresponding amounts of financial volume of agents which form a cell in the above sense. The area of a nonreducibile group which belongs to those nonreducibile groups which form the cell may be formed again for example by a sum of areas of agents characteristic areas. Note that area of the nonreducibile group and volume of a cell may be also some other characteristics of the group of agents depending on studied social relations between agents. Thus we are able to study topology properties of interactions of agents, their evolution, and evolution of financial volumes of cells and characteristic areas corresponding to some characteristic diameters for nonreducibile groups. Social behaviour of agents is discussed in general, and for the capital market case as a special case. It can be shown that the equilibrium number of agents with which a given agent interacts is three for a group without cellls /the group forms a single cell/, and it is four for a group in which more than one cell exist. Then the corresponding amount of financial volume is fourth part of the whole agent's financial volume invested on the capital market. We studied Aboav's law concerning number of agents in the neighbouring nonreducibile subgroups which is connected to a given nonreducibile group with a given number of agents, distribution of nonreducibile cells which maximises entropy /informational/, Lewis' law concerning the financial volume of cells, and Von Neuman law of time development of financial volume of average cell.

The emergence of social classes as a critical phenomenon

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We propose a model in which a set of individuals get the income in accordance to a given probability distribution. These individuals invest their money among them earning interest. We simulate how the system evolves in time. At the begin all the individuals live in an equalitarian society having roughly the same amount of money. At a critical time the society experiences a second order phase transition.

After this time it splits in two classes characterized by different average wealth, generating a gap between the rich and the poor. This means that part of the society becomes rich and the other part poor, which we interpret as an eruption of social classes. The phenomenon leads to a stable situation after a long time. We also investigate the scaling laws relating the critical time and the interest rates.

Self-organizing market crashes resulting from agents interaction

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We present a model of market's agents behavior that we have built using the ideas of the Brock and Durlauf ("Discrete Choice with Social Interactions", 1995, University of Wissconsin at Madison.) and of the Kaizoji model ("Speculative Bubbles and Crashes in Stock Markets: An Interacting-Agent model of of Speculative activity", 2000, University of Kiel - Germany). Kaizoji used a ferromagnetic Ising model to explain market crashes by classical phase transitions; market's price variation is interpreted by the magnetization in Kaizoji model. We observed that the analogue of magnetization in the Brock and Durlauf model would exhibit the same behaviour as the magnetization does in the Kaizoji model, if appropriated adjustments are made. The adjustments has the advantages of a well defined time evolution rules that mimics market's agent decisions. We have derived certain rigorous results concerning the emerging stochastic price process.

Minority game on distributed markets

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One of the simplest paradigms in modelling complex adaptive systems of heterogeneous agents is the Minority Game (MG) [1]. In the original MG the agents operate on one (global) market, and have to play with all the other agents at each time step of the game. In reality the agents often undertake some actions to change their economical environment in order to improve their performances. We consider a generalization of the MG in which we allow the agents to play on several markets, choosing the market on which they play according to some optimization strategies on the local markets, cf. [2]. The markets have their local histories. Any agent at any time can play only on one local market, but over time they may change the market according to certain rules - optimization strategies, e.g. to their expected performance, measured e.g. by the wealth accumulated on the markets or by the virtual scores of their strategies on the markets. Since - in general - the agents possess different sets of strategies, such an option of choosing various economical environment might contribute to their better performance and/or to a better performance of the system as a whole. The groups of agents with suitably correlated (anticorrelated) strategies could choose the markets on which they would perform better, avoiding the agents with "improperly correlated" strategies, cf. e.g. [3].

In general, various measures of the agents performance can be considered. We discuss the influence of the chosen optimization strategy on the overall performance of the system of agents. In particular we study the fluctuations of the prices and the attendance, average wealth of the agents and volatility for various strategies of the choice of the local market. We also compare the performance of the system of agents acting on local markets with the performance of the the same system on the global market.

Implications of complexity for evolutionary economics

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I review approaches to complexity from physics, computer science and biology. Special attention is given to the tension between "reductionism" and complexity.

Each of these disciplines offers a specific way of dealing with complex phenomena, with distinctive advantages and disadvantages. Physics measures potentially relevant characteristics. Computer science aims at algorithmic accounts of how complex systems can be artificially constructed. Biology harbors sometimes more holistic views besides - of course - evolutionary theory. Holistic approaches are a somewhat tricky issue, since they may serve to replace scientific investigation into the "proof" of hypotheses with veils of beautiful concepts that prove in the end to be merely of a "shamanist" or marketing function. This notwithstanding they may serve a limited but useful purpose in the hypotheses generation phase of the scientific process. Evolutionary thinking finally offers the question after the adaptive value of specific characteristics. This is an important point, since it shifts attention from the standard optimality criterion to a differentiated account of selection criteria in social systems.

Building business strategies on sandpiles: the trade-off between globally optimal and robust adaptive solutions

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It has been widely suggested that firms operate in an increasingly complex and volatile competitive environment, and consequently need to rethink their approaches to business strategy. In this paper I concern myself with the trade-offs which are implicit in the choice between globally optimal strategies and robust adaptive strategies, and characterise some of the environmental conditions under which each broad class of strategies is likely to prove more appropriate. The conceptual framework for this analysis derives from models of complex adaptive systems, and the search for optimisation algorithms which are suited to highly degenerate and dynamic fitness landscapes.

For a firm to choose whether highly optimised or robust types of strategies are most appropriate, it must be able to assess whether the competitive environment which it inhabits is complex, or merely complicated. Here traditional analytic tools based on measures such as the competitive structure of an industry sector are unlikely to prove helpful, since they typically fail to capture the collective dynamic properties of the system under consideration. I propose that a good measure of the complexity of the competitive environment can be derived from the strength and extent of interactions between the firm and other relevant agents (e.g. competitors, suppliers, customers etc), and the timescale on which the nature of competition changes. In a relatively static competitive environment which is largely dominated by the aggregate behaviour of weakly interacting agents and exogenous macroeconomic variables, maximising global competitive fitness is a desirable and achievable aim, and any other approach will be sub-optimal.

However, once competitors and other agents interact strongly, attempts by any agent to improve its own fitness can moderate the fitness landscape all other agents face, in a process reminiscent of the dynamics associated with co-evolution in biological systems. In such a context no stable globally optimal strategy can generally be located, and each agent is best off modifying competitive strategies according to a local adaptive algorithm. Indeed, under such circumstances a firm which optimises its business strategy in order to maximise certain performance metrics (such as economic value creation) might well be reducing its longer term viability.

Physical laws in settlement processes

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The description and the prediction of settlement sprawling is essential for the political instrument of landuse regulation. Therefore it is important to create adequate applications of known theories and methods for a deep insight of the processes of landuse and settlement. It is empirically evident, that the application of common models and traditional political instruments is insufficient in regulation of landuse development processes at the regional scale. One important question in this context is, how far the observed processes can be explained by application of physical theories.

After an introduction in the problems and requirements to a qualitative description of landuse and settlement processes in time and space follows a discussion of eligible physical theories (like diffusion, thermodynamics in non-equilibrium systems). The validity of the application of these theories will be discussed under consideration of scales in time and space. A comparison to other modelling methods like Cellular Automata and Multi Agent Systems is focussed on the degree of usability of physical theories and methods in the context of landuse and settlement.

The use of physical and engineering frameworks to study turbulence in business environments

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Complexity theory, network analysis, statistical analysis, and measures of volatility, can all be used to study the level of turbulence within a business organisation. However, until recently these methods have not been used or even considered, with authors in strategic management preferring to rely on qualitative accounts of the level of turbulence in an industry.

This paper sets out a critical evaluation of the methods, frameworks, and models that can and have been used to introduce rigour into the measurement of turbulence in the business environment, from the point of view of a physicist and a social scientist. It introduces a new framework for studying turbulence in industries based on a Reynolds Number formulation. The problems with transferring the models of physics and engineering to the specific discipline of strategic management are discussed. Whilst physical models have been developed, which may have merit in their own right, this paper examines the acceptance of these models and frameworks from the point of view of the practitioners who are expected to implement strategies based on the results of these frameworks and models 8211; a community that is, for the most part, not trained in physics or engineering, and very often sceptical of such import of scientific models. An examination is further undertaken of the reasons why certain models are accepted and certain models are not.

Variety and competition - the evolution of web technology

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The evolution of new branches of technology seems often to follow a particular pattern. Starting with a pioneer (a product, a process, a device etc.) in a first phase a variety of different types can be observed. Later, one technology may dominate the whole market ("lock-in"). (Bruckner et al. 1996, Ebeling et al. 2001) Also, the development of web technologies seems to follow this pattern. In this paper we consider the case of web browser development. We will apply a population dynamical approach to described the competition between different browser types. Unlike the model of Maurer Huberman about the competition of web sites we will not take an economic perspective but a user oriented-one to identify processes which are relevant for the diffusion of a certain browser type. In particular, we will analyze to which extent non-linear properties of the Internet network change the condition for diffusion of an innovation.

The influence of opportunists and contrarians on the stability of a democracy -- An investigation based on the Sznajd-model

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Sznajd-Weron and Sznajd introduced a model investigating the democratic development in a closed community. This model is based on the USDF-principle ("united we stand, divided we fall"). However, it faces the problem that the system tends either to a dictatorship (i.e. 100 pro or 100 contra) or to a stalemate state (i.e. exactly 50 pro, 50 contra). Based on their model, I will show that a democratic system keeps alive if there are both persons with an opportunistic attitude and with a contrarian behavior.

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A toy society under attack. How to make a panic to subside

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We use a discrete time extended dynamical system (a randomly coupled map network) for describing the emergence, spread, and subside of panic in a "toy" community constituting of a large number of interacting identical agents exhibiting a simple behavior. Being enforced in a panic, the isolated agent inevitably regains her composure in a few time steps. It is the mutual interaction between agents that induces the emergency of sustained panic in the community.

The collective behavior observed in such a community is spanned by three parameters: the density of social network, the mutual confidence between agents, and the fraction of initially attacked agents. Extensive numerical simulations show that if more then a half of agents initially set into panic and they are perfectly confident in each other, a sustained panic would suddenly sweeps through a considerable fraction of the "toy" society as the density of social network is not very high. Otherwise, for rather dense social networks, the perfect confidence between community members makes the panic to subside.

Within the sustained panic state, we observed an interesting pattern of periodic collective behavior when the fraction of community members affected with panic swings.

Herding behaviour in volatile financial markets

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A simple herding model can explain the following stylized facts.

(i) The volatility distribution including either fat tails or an exponential decay depending on the herding parameters.

(ii) Presence and time structure of volatility clusters

(iii) 1/f Noise It is important that there exist at least three types of agents with different strategies.

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http://ais.gmd.de/~frank/sociophysics/

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