Dagstuhl Seminar
on
Social Science Microsimulation: Tools for Modeling, Parameter Optimization, and Sensitivity Analysis

Organized by:
Klaus G. Troitzsch (Universität Koblenz)
Ramzi Suleiman (University of Haifa)
Ulrich Mueller (Universität Marburg)
G. Nigel Gilbert (University of Surrey, UK)

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Contents

1 Motivation

The Dagstuhl Seminar 9518 on Social Science Microsimulation: A Challenge for Computer Science — which all participants estimated as a very successful first attempt to bring together social scientists engaged in simulation and computer scientists interested in social science applications — resulted, among others, in unanimity in two respects: that there is still a lack in modeling tools adapted to the practice of social science modeling, and that there is a lack in experimental tools for testing simulation results against real world data, for parameter optimization and sensitivity analysis. This is why we would like to organize another seminar especially devoted to modelers' activities before and after simulation proper.

In our opinion, user friendly tools for designing simulation models (e.g. in a graphical user interface) and for evaluating results from a large number of simulation runs with varying parameters and/or initializations and/or random number generator seeds is still a challenge for computer science.

The dynamic nature of simulation and the complexity of the models relevant *to the social sciences* means that difficult problems arise for the design of appropriate human-computer interfaces, especially since some users will be rather inexperienced with the use of software tools. The user interface will need to be configurable by the user, provide easy to use diagnostics, and be capable of reacting in real or near real time. The design of graphical user interfaces with these characteristics poses a significant challenge for HCI. While a similar challenge has been successfully met with simulators for laboratory experiments, social science simulators raise a host of new problems, including the need to devise new interface metaphors.

Modeling Tools The advantages of using a special simulation toolkit are that less skill and less effort are required to build simulations, graphical interfaces are provided for the builder, so avoiding difficult and time consuming effort reconstructing common output displays such as graphs, and the resulting code can be easier for others to understand. However, all such environments limit the range of models which they can be used to build. At present, the limitations which these environments impose on researchers seem to be such that most do not use them. Those that do, tend to be the people who created the toolkits in the first place. However, this may be a temporary state of affairs, as better toolkits are developed, they are made more powerful and more flexible, and as they spread through the research community.

A prerequisite for making simulation toolkits more attractive for researchers in social sciences is that they lend themselves to an easy, intuitive and may be even informal input of the model structure which can best be achieved by a graphical user interface. While tools of this kind have long been available for the classical *System Dynamics* approach (and for discrete event simulation which does not seem to be the main field of social science simulationists), they are not available for those modelling and simulation approaches prevailing now among social science simulationists: multilevel modelling and DAI modelling, where models have still to be designed using high level formal languages like MIMOSE or SmallTalk which in most cases do not support reuse of modules, such that new models or testbeds have to be programmed from scratch each time.

Because most users of these toolkits will be social, not computer scientists, it is important to develop modelling languages which express cleanly the social science issues. This will involve the development of new formal languages, ones which focus primarily on the interaction between objects, rather than the properties of the objects themselves. Moreover, it would be desirable if these languages were compatible with being expressed visually — thus leading to a visual language which could be readily understandable by social scientists — and which had constraints 'built in' (e.g. through metaphor) to hinder the user from making syntactic and, possibly, semantic mistakes. The design of such languages is on the research edge of today's computer science. Research on the design of such languages would benefit the social science community, more generally those involved in building complex simulations in other disciplines, and those in the computer science community for whom the challenge would be a helpful spur to new ideas on the design of high level languages.

The seminar should give both social science simulationists and computer scientists an opportunity to learn about the respective needs and achievements. Participants should discuss which experience from computer science simulation (and from simulation in other realms of science more successful or less demanding in this respect) can be used for designing more powerful user interfaces for modelling needs in social science.

Model Validation Most simulations generate very large quantities of output as they are run and social science simulations (which may be simulating the actions of hundreds or thousands of agents) are no exception. New tools for displaying such output in ways which reveals 'interesting' patterns are urgently needed. Existing visualisation tools fall into two classes: those which are able to display large quantities of highly clustered or correlated data (e.g. those used to visualise the output from simulations in the physical sciences) and those which can be used for the visualisation of small quantities of data with a high error component (e.g. psychological data about a few individuals). Social science data tends to fit into neither of these categories, typically consisting of very large quantities of data that also has a large 'error' component. New ideas are needed to deal with such data.

All three levels of model validation — finding optimal parameter values for a given model, finding optimal model specification for a given set of parameters, finding the optimal set of parameters — require decision procedures and algorithms which even for the most basic models which can be solved analytically are in very limited supply.

The validation problem is that, once a simulation has been designed and run — with a large amount of output —, one needs to know whether:

- the parameters and starting configuration of the simulation are the best ones;
- the output from the simulation resembles what has been or could be observed in the world;
- the same or similar results would be obtained if the simulation were run again with slightly different parameters;
- the model is the simplest that yields the desired output and is therefore to be preferred over other, more complex models.

These are all difficult questions. One cannot look to other forms of social science research for their solution, because they have not been completely answered there either. One partial solution to determining the extent to which the output depends on the particular values of the model parameters is to engage in a sensitivity analysis. However, the number of parameters in most models and the need to check all or most combinations of values of these parameters means that a thorough sensitivity analysis is usually impracticable.

Lest it be thought that these methodological problems undermine the idea of simulation as a research method, it must be emphasised that other approaches have to deal with similar problems; it is just that simulation brings them to the fore more clearly. One strategy to overcome the methodological problems is to re-orientate the objective of simulation from that of developing models which in some sense 'fit' the social world to that of using simulation to develop conjectures and ideas that could then be applied (perhaps using some other research methodology) to the study of human societies. But if this strategy is not or cannot be taken it is worthwhile to develop tools which support both sensitivity analysis and parameter optimization — some of which have already been incorporated into simulation toolkits, but only for applications outside the social sciences. Social sciences, however, have data problems which are more difficult to solve than in most other sciences. Thus, it would be necessary to discuss the experience from the cooperation between computer science and other sciences with similar problems, and find out which achievements can be translated from successful applications in their fields into social science applications with even more complex models and with a prevailing interest in emerging structures.

1.1 Goals

Our plan is to discuss

- new tools for model specification which allow for a user-friendly — perhaps graphically supported — model design process which follows a strategy of first defining classes of objects representing real world (or "target system") entities, both elementary and aggregated, and relations between these classes, defining the objects' state spaces (by their attributes) and their state change functions, and initializing and simulating a huge number of individual objects in each class — and all this within a unified simulation and experimentation environment, which incorporates
- new algorithms and software tools for
  - sensitivity analysis allowing for a wide scope of variation of parameters and initial values, and a sophisticated analysis of the simulation results obtained during parameter and initial value variation, as well as
  - testing the goodness of fit between simulation results and empirical data if ever they are at hand and
  - optimizing simulation model parameters to real life data especially for the case where such empirical data are rather sparse (i.e. short time series) which is most often a problem in social science research practice,

  and all this for models which — for whichever reason — cannot be handled analytically, but have to be solved with efficient means of numerical treatment.

The five days from May 5 to 9, 1995, were devoted to the following subjects:

- Tools and Architectures (Monday)
- Applications (Tuesday through Thursday)
- Sensitivity Analysis and Parameter Optimization (Friday)

Participants included economists and social scientists applying microsimulation techniques of various different kinds as well as computer scientists interested in helping the former to solve their problems more elegantly and efficiently. Thus representatives of at least three different scientific communities gathered in order to discuss their problems and to help each other find solutions.

This booklet summarizes the presentations and the discussions during the seminar. A collection of long versions of most of the papers given will be published by Physica, a subsidiary of Springer in early 1998.

2 Final Seminar Program

Monday, May 5, 1995

Session 1: Tools and Architectures
Chair: Klaus G. Troitzsch

Nigel Gilbert: Models, Processes, and Algorithms: Towards a Simulation Toolkit
Wolfgang Balzer: Multi-Agent Systems for Social Simulation and BDI-Architecture: A Critical Discussion
Péter Molnár: Distributed Simulator: Inter-Process Communication Instead of Linked Libraries
Christina Stoica: Interactive Networks as Tools for Modeling Social Systems

Informal Discussion: Requirements for a toolkit for social simulation
(in four groups)

After Dinner Lecture:
Rosaria Conte: Diversity in rationality.

Tuesday, May 6, 1995

Session 2: Applications I
Chair: Nigel Gilbert

Ilan Fischer and Ramzi Suleiman: The Emergence of Mutual Cooperation in a Simulated Inter-Group Conflict
Jürgen Klüver: Ordering Parameters in the Rule Spaces of Adaptive Systems
Petra Ahrweiler: Modeling a Theory Agency as a “Toolkit” for Science Studies
Paul Windrum: Assessing recent changes in UK science policy: The consequences of strategic funding on emerging scientific disciplines

Informal Discussion: Requirements for a toolkit for social simulation
(in four groups)*Chair: Klaus G. Troitzsch*

After Dinner Lecture:
Bernd Schmidt: Do Intelligent Agents Have Feelings?

Wednesday, May 7, 1995

Session 3: Applications II
Chair: Ulrich Mueller

Rainer Hegselmann, Andreas Flache, and Volker Möller: Solidarity and social impact in cellular worlds: results and sensitivity analyses
Oliver Kirchkamp: Endogenous Evolution of Learning Rules
Rolf Grützner: Individual-oriented modelling and simulation for the analysis of complex environmental systems

Afternoon Excursion

After Dinner Lecture:
Bibb Latané: Simulating Dynamic Social Impact

Thursday, May 8, 1995

Session 4: Applications III
Chair: Ramzi Suleiman

Ottmar Edenhofer: Social Conflict and Induced Technological Change in Energy Policy
Philip Kokic: Microsimulating Farm Business Performance
Serge V. Chernyshenko: Discrete effects in dynamical differential models
Matthew Rockloff: Design Considerations for Multi-Agent Models

Informal Discussion: A Simulation Toolkit for the Social Sciences
Chair: Klaus G. Troitzsch

Informal Discussion: Model Selection and Parameter Optimization
Chair: Ulrich Mueller

After Dinner Lecture:
Jim Doran: Four Questions and a Paradox

Friday, May 9, 1995

Session 5: Sensitivity Analysis and Parameter Estimation
Klaus G. Troitzsch

Nicole J. Saam: An Outline of Problems in Social Science Sensitivity Analysis
Edmund Chattoe: Sensitivity Analysis: Prospects and Problems
Mario Paolucci: What is the Use of Gossip? A Sensitivity Analysis of the Spreading of Normative Reputation
Georg Müller: Simulation Assisted Inferencing: A Practical Example
Christof Schatz: Tests of Dynamic Social Models with Time Related Surveys — an Experimental Approach

3 Abstracts of Presentations

3.1 Social Science Microsimulation: Tools and Architectures

3.1.1 Nigel Gilbert: Models, Processes, and Algorithms: Towards a Simulation Toolkit

This paper develops an initial set of requirements for a toolkit for social simulation. It begins by proposing a basic vocabulary for discussing simulation, defining the target of a simulation, that is, the social processes to be simulated, the specification, the model and the simulation itself, and proposing an ideal type for the lifecycle of a simulation project.

The potential role of toolkits is described and it is argued that toolkits present both opportunities for the researcher and a set of constraints on the possibilities of simulation models built using a toolkit.

In order to identify the constituents of a toolkit, it is first necessary to categorise the scope of social simulation. This is done in the paper by suggesting that there are a number of 'abstract social processes' which recent simulation research has identified. These include processes of hierarchical control, selection according to similarity, the 'Matthew effect', competitive exclusion, autocatalysis, percolation, structural differentiation, adaptation and co-evolution. While this list is undoubtedly incomplete, it does suggest some of the standard algorithms which a social simulation toolkit would need to make available to the modeller. These algorithms include microsimulation, cellular automata, production systems, multi-agent (and multi-level) systems, evolutionary strategies and neural nets.

However, the link between the abstract social processes and these algorithms is not yet well understood. It is certainly the case that some social processes may be modelled using any of several algorithms. It is observed that current research fails in general to make clear why particular algorithms were chosen to implement particular processes, and it is suggested that the link between process and algorithm should be made more explicit in future work.

In addition to providing these algorithms, an adequate toolkit needs to offer a range of other functionalities: good graphics facilities, including the possibility of displaying plots showing the results of simulations dynamically as the simulation runs; a facility for controlling the simulation using either a discrete event approach or a simulated clock; a parameter editor, with input from either a file or direct user input; debugging and logging aids; a validated random number generator capable of producing pseudo random numbers from a variety of standard distributions, and facilties to enable easy rapid prototyping. At the same time, the toolkit must be enable efficient processing, because many simulations are computationally intensive.

Finally, three existing simulation toolkits are reviewed and it is concluded that while each of them have some value, there is still a need to develop a toolkit which will more effectively support the researcher interested in constructing social simulations.

3.1.2 Wolfgang Balzer: Multi-Agent Systems for Social Simulation and BDI-Architecture: A Critical Discussion

I argue that the BDI-model which is widely used in DAI (for example [4], [7]) is deficient for the simulation of social systems, and that it has to be enriched by components for rule- and norm-based behavior. For this, I have four arguments, a theoretical, a methodological, a practical, and an 'internal' argument.

The theoretical argument focusses on the central ‘actor-loop’ in which input from the environment is used to produce output-behavior of an agent. In the BDI-model this loop always includes some use of the agent’s BDI (belief, desire, intention) apparatus. By contrast, one can consider an actor-loop in which output behavior is purely rule-guided and thus does not use the BDI structure. Also, a great deal of norm-guided behavior may be modelled in such a ‘direct’ way when norms can be translated into rules which can be triggered by the input. These two different kinds of loops cannot be realized simultaneously, if it is accepted that any proper use of a BDI structure includes a choice among at least two alternatives. It is not difficult to enrich the actor-loop so that both types (BDI and ‘rule/norm-guided’) can be realized by the same agent in different situations.

The methodological argument points to the well known fact that belief, desire and intention are mental predicates and not directly observable. Moreover, the theory-guided access to them also is severely restricted and can be achieved only in laboratory situations from which there is no reliable inference to behavior in other, real-life situations. Therefore, the use of BDI components yields a restriction when simulation results are to be compared with real data, for the latter do not cover the central parts of the BDI-model in a reliable way.

The practical argument consists in sketching my multi-agent simulation program, MASS, in which rule- and norm-based behavior is primary, and ‘rational’, BDI features are secondary. The system at present can reproduce most of the existing simulations of cluster- and group-formation on game theoretical or other principles [5], [6]. It is intended as a basis for a more comprehensive system which simulates the emergence and development of social institutions along the lines of the theory I developed in [2], [3].

Finally, the ‘internal’ argument can point to the fact that rule- and/or norm-based behavior has proponents both in sociology (as documented, say, by the classics of Durkheim and Parsons) and increasingly also in DAI, for instance [1], [8].

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6 N.Mark, 1996: Beyond Individual Differences: Social Differentiation from First Principles, paper read at the 1996 ASA conference, New York.

7 A.S.Rao, M.P.Georgeff, 1991: Modelling Rational Agents within a BDI-Architecture, in R.Fikes, E.Sandewall (eds.), Proceedings of Knowledge Representation and Reasoning (KR+R-91), Morgan Kaufmann, 473-84.

8 M.J.Wooldrige, N.R.Jennings (eds.), 1991: Intelligent Agents, Berlin: Springer.

3.1.3 Péter Molnár: Distributed Simulator: Inter-Process Communication Instead of Linked Libraries

Doing simulation means either to use existing simulation programs or to write the code from scratch. In the second case, usually a lot of work has to be done to equip the program with nice (and important) visualization features and facilities for convenient parameter handling. In return for this kind of effort, programs become huge and dependent on the unique characteristics of the platform they have been developed on.

In order to make programming easier, getting an implementation of the model we meight have in mind much faster, and even allow to run it on a wide range of platforms, a set of simulation helper modules is under development. Parts of the conventional simulation programs, such as the graphical user interface, work as standalone modules that make use of the mechanisms of inter-process communication (IPC). The program code can be reduced to the implementation of the model itself. A mechanism that keeps track of parameters and observables (variables) fits in almost transparently in forms os base classes (e.g. for C++ and JAVA). The helper modules can then contact the simulation part, get and request the values of parameters and observables.

3.1.4 Jürgen Klüver: Ordering Parameters in the Rule Spaces of Adaptive Systems

The central topic of sociology is the analysis of social rules. In that all theoretical sociologists agree (Weber, Marx, etc.). So the rule spaces of social systems can be investigated by mapping social systems into formal systems and looking there for general characteristics (universals) of rule systems. The technical terms for those universals are "ordering parameters". Ordering parameters are well known in cellular automata and Boolean networks: the λ-parameters (Langton), P-parameters etc. As social systems are adaptive one has to look there for "meta-parameters", i.e. parameters for hybrid systems, containing different levels of rules. At Essen, we investigated the f-parameter (frequency of rule changing) and the r-parameter (radicality of rule changing). They behave quite differently. The possibility is there that we explore this way a universal grammar (Chomsky) of social action.

3.1.5 Christina Stoica: Interactive Networks as Tools for Modeling Social Systems

Interactive Networks (IN) are a special and rather simple type of neural networks. They belong to the class of recurrent and feedback networks with the difference to most neural nets that the weights are not changed (the nets are not trained). That is why IN are very suitable tools for testing logical hypotheses and modeling social systems. The m odeling approach consists of identifying social units and their relations and mapping these structures into an IN. The dynamics of a system is captured by running the IN until it reaches an attractor state. As social systems are adaptive systems — that means that they can change their rules according to specific demands of their environment — IN are coupled in our project with a genetic algorithm (GA) which changes the IN structure according to special environmental conditions. I demonstrate these modeling techniques with several examples taken from the theory of society transformations by Eder and Habermas, and the theory of historical materialism (Marx).

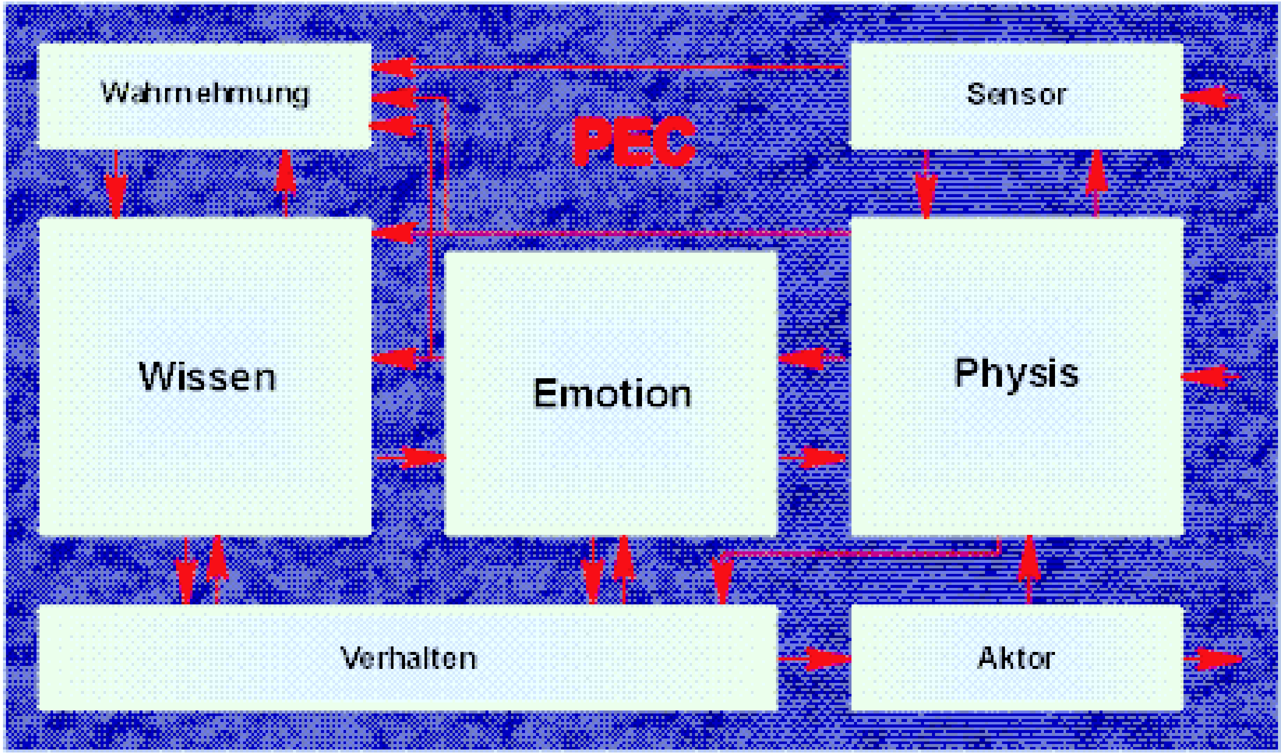
3.1.6 Bernd Schmidt: Do Intelligent Agents Have Feelings?

In general, a model claims to represent a real system, its components, its properties and its behaviour. If a model is a good and useful representation of a real system, the model can be used for explanation and prediction alike.

It is an interesting task in the social sciences to explain the observable macroscopic behaviour of a social system by means of the behaviour of the microscopic elements, which constitute the social system. One speaks of the investigation of emergent behaviour or micro-macro-simulation.

The basic elements of a social system are human beings. Therefore, it is necessary to model these with sufficient accuracy. A human being is a very complex system. Its behaviour can only be understood if physical, emotional and cognitive aspects are regarded.

The reference model PEC (Physis, Emotion, Cognition) tries to present a generally applicable architecture. The following picture gives an overview of its internal structure. The usefulness of the reference model is shown by two models belonging to different areas: ecology and economics.



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3.1.7 Rolf Grützner: Individual-oriented modelling and simulation for the analysis of complex environmental systems

Environmental systems are quite complex: they have many attributes with complex interdependencies and rules of interaction which are not always obvious. They are usually non-linear and they have non-deterministic dynamics. Models can help understand and better explain environmental systems and the phenomena associated with them. Computer simulation models involve the creation of an artificial system on a computer which displays behaviour close to that of the real system.

This paper treats such systems which can be broken down into independent interacting entities. The basic entities of such models are individuals which possess an extendible behavioural repertoire. This repertoire includes sensing their local environment, changing the environment locally, changing their own state (e.g., position in space and other characteristic values) and learning from the effects of actions on the environment (for example, for the purpose of realising optimal behaviour).

Each of the individuals is characterised by its inherent dynamic behaviour. The dynamic behaviour of the entire system results from the dynamics of each of the independent individuals. Individual-oriented modelling and simulation is an approach which has attained increasing importance in recent years in the analysis of environmetal systems (Drogoul, 1992), (Wissel, 1990).

An important example is the investigation of time-dependent volume of source traffic on a new road in a settlement, with the traffic originating from the people who live in this settlement. The individuals of the model represent car drivers living in the settlement and using the new road. Initially, the car driver will find very little traffic there. But, after some experience and some time, they will encounter queues of vehicles or traffic jams on the new road. Car drivers will learn to take another route or to avoid these peak times to reach their destination in the shortest possible time. Using this model, simulation experiments may lead to following results:

- Determination of air pollution and noise levels associated with time-dependent traffic.
- Determination of time-dependent traffic loads on main roads.
- Generation of data for decisions in city planning (e.g., as data base for the extension of a traffic network, support of public or private transportation, or site selection for a public facility).

The main application fields of individual-oriented approaches are the ecological domain, for solution of eco-toxicological questions, and the field of regional and urban planning. Models of these application fields demand great amounts of environmental and geographical data, other input information, and model parameters. All of these are stored and managed by geographical information systems (GIS).

Classical modelling approaches are based on equations (e.g., on system dynamic methods with Lotka-Volterra models). These are characterised by several attributes:

- Classical models describe features of an average individual.
- Classical models describe a very simple life cycle of this individual.
- The density (rather than the number) of individuals, combined with further values for these individuals, is a variable of state.
- Spatial distributed resources and environmental properties are not included directly by the model.

It is commonly held that individual-based models begin where the life cycle or the behaviour of an individual is described in more details than in classical models.

A great number of simulation experiments are necessary to obtain significant statistical results. Each of these experiments is realised on the basis of different probability start conditions. There are some similarities with observation of a natural systems such as ant colonies or schools of fish. The selection of sensitive parameters for such models is an important research field today.

3.2 Applications: General

3.2.1 Rosaria Conte: Diversity in rationality. A multi-agent perspective

Limits of rationality The marriage between AI, on one hand, and economic and strategic rationality, on the other, is unavoidable: there are too strong "elective affinities". For many purposes and domains, the AI adoption of the economic paradigm ([10]) or of the game-theoretic apparatus ([7]), is both motivated and productive. However, these paradigms are often imported a-critically, as mere techniques or instruments. The debate occurring in the original disciplines about the foundations of these approaches has been ignored. One should import from other disciplines not only the solutions but also the related background problems. This should be true also within AI, if this is considered as a science rather than a mere technology (engineering).

Here, the merits of the economic theory of rationality will only be re-stated. Indeed, in the first section of the paper, the merits of Game-Theory (GT) will be shown to be particularly relevant for DAI and MAS. Afterwards, a number of criticisms to economic decision theory that have an impact on its significance for modelling intelligent social/individual action, will be examined. These criticisms differ from both the most classical ones (no computational limitations, completely specified preferences, complete knowledge) and others more recent developed in decision theory ([1]). The interpretation of rationality allowed by economics will be challenged. Economic rationality will be argued to differ from rationality tout court and be unnecessary for artificial agents.

Merits of Game Theory In general

- the introduction of a very synthetic, meaningful, and formal prototypical social situations ("games") that allows heuristic and clear-cut experiments;
- the use of formal and sound notions, welcome in disciplines frequently based on vague notions and informal reasoning;
- the fact that those formal notions and scenarios are particularly apt for computer simulation; GT gave a significant contribution to the success of simulation in the social sciences that now can be considered as the ”experimental method” within those sciences;
- its heuristic character: i.e. the identification of a host of crucial problems for social theory (social dilemmas; free-riding and cheating; reciprocation; coalition formation; reputation; emergence of norms);

- its attempt to solve the micro-macro relation founding social and collective phenomena on individual interests, choices and behaviors (although this ”individualistic” and reductionist solution may be found insufficient, see [4]);
- its explanatory and predictive power, which is particularly remarkable when compared with the greet majority of descriptive models and post-hoc explanations.
- In some sense GT has been foundational for MAS. In fact, true MAS have to be defined as systems that allow both cooperation and competition among autonomous and possibly heterogeneous agents ([8]). Now agents are really socially autonomous when they have “their own goals” and subordinate the adoption of others’ goals to their own achievements. In other words, socially autonomous agents are self-interested, they pursue their own (local) utility (although, one should not mix up “self-interested” and “selfish”! ([4]).
- One of the main contributions of GT to DAI consisted of
  1. eliminating the presumption of “benevolence” among the agents, the assumption of a “common problem”, a “social goal”, a “global utility”, while
  2. deriving cooperation from the agents’ local utilities.

This has also applicative follow-outs: the analysis of the agent’s costs and benefits in coalition, communication, exchange, etc., which will be absolutely necessary in future real applications to a free market of agents belonging to different companies and institutions.

Drawbacks Aside the problems already addressed in the relevant literature (no computational limitations, multiple equilibria, etc.) , other aspects of rationality theory need reconsideration:

- Economic reductionism: economic rationality is equalized to rationality.
- Unsituatedness: a context-unsensitive notion of rationality is proposed
- A monarchic view of rationality: rationality is seen as a monarchic” notion (profit) indifferent to the various qualitatively different motives of the agents.

Crucial limits of GT for modelling MAS are examined:

- the absence of a specific notion of cooperation: GT is an essentially ”behaviorist” approach, while a satisfactory notion of cooperation needs the modelling of the agent’s cognition, especially of its goals (rather than its knowledge only!);
- the absence of a general model of social influence: the utilitarian assumption that the ability to influence other agents (in order to change their behavior) can be fully explained in terms of ”incentive engineering” is questioned: the study of mind disclosed several ways of influencing and getting agents to cooperate.

Amendments: diversity in rationality Quite on the contrary, a notion of rationality is called for which does not rule out diversity.

There are many senses in which diversity must and can be integrated with a theory of rationality:

- by introducing substantial differentiation: qualitative heterogeneity among individual agents' goals; to do this, a goal-based rather than preference-based, view of endogenous motivations should be provided. The difference between goals and preferences is fundamental in agent theories and architectures (for a for a discussion about the difference between goals and preferences and the advantages of the former notion over the latter, see also [8]). The essential difference between them is o,n the qualitative vs quantitative characterization: while preferences are quantitatively defined, goals are symbolic, qualitative notions. Unlike the former, they allow for agents to be heterogeneous.

- By introducing architectural, or formal differentiation: agents do not only differ in the contents of their goals but also in their architectural properties. Therefore, they do not only have different goals, but also different decision-making rules. (Notice that in evolutionary game-theory, different strategies for interaction are allowed but the principle of utility maximization in decision-making is never questioned!) In our view, a further principle (goal-based rationality) exists, in which utility is subordinated to goal-satisfaction. rather than vice versa.

- By allowing for a variety of social action to be described and predicted: in terms of rational decision theory applied to social settings only the alternative between defection or cooperation is possible. But social life is interspersed with different types of pro-social action, from influencing, to exchange, to cooperation. It is argued that utility cannot actually account fro such a variety, while a qualitative notion can.

- By admitting for a context-bounded notion of rationality, such that different contexts call for different rational strategies.

In the remaining of the paper, our preliminary contribution to these objectives — especially to the first three — will be illustrated. Some aspects of a model of intelligent (social) action will be described, and applied to partially different computational tools developed within the framework of Multi-Agent Systems and Social Simulation.

A Multi-Agent approach In our view, a (social) action is defined in terms of (social) goals (cf. [4]). A goal is a symbolic representation of the world, which the agent wants to be true. A goal is not yet an action. Goals are ordered according to precedence or preference relations; but a goal is not primarily defined by its order position. A social action is aimed to modify another agent's mind.

A (social) agent, in a quite elementary sense, is defined as characterized by goals, actions, (planning) knowledge and resources. The notion of agent here referred to is defined as:

- (a) an ideal-type construct – not to be confused with the subjective, idiosyncratic individual of differential psychology; and

- (b) an AI-based notion, where the attention is drawn on the whole process that leads a system to acting, and on its internal makeup, i.e., the internal regulatory mechanisms and representations allowing a system to act adaptively in its environment.

Substantial diversity and interaction variety In ([9]), a computational instrument (DEPNET), calculating the network of dependence relations among agents in a common environment, has been developed, based on a very simple agent architecture, consisting of agents' goals, actions, and resources. In ([3]; [5]) DEPNET has been applied to allow a complex structure of agents' interdependencies to emerge, and as a consequence, a variety of rational social (inter)actions to be predicted (influencing, exchange, and cooperation).

Formal diversity In another study ([6]), the preceding tool (substantial diversity) was applied to a computer-simulation study of partnership formation. A computational system, MICROdep, has been developed on the tracks of DEPNET. MICROdep was employed to

- (a) describe social agents as endowed with
  - different goals and actions (substantial diversity), and
  - different principles of decision-making (formal diversity), based on either utility-maximization (aiming at maximizing the overall utility independent of the values of the single goals) or goal-satisfaction (aiming at achieving goals with the highest values);
- (b) calculate a general matrix including all the agents' preference lists of possible partners, as determined by pre-existing dependence relations;
- (c) form real partnerships thanks to successive pruning and updating of this initial matrix, up to completion of the list.

The computer simulation-based comparison between the two modalities of partnership formation, the goal-oriented and the utility-oriented shows both similarities and differences between them. Generally speaking, in all markets, the two modalities show significant correlations. The two strategies show quite similar behaviors, and seem to predict each other to a considerable extent.

But our findings show interesting differences also: for example, agents which are socially useful to satisfy others' goals may be depending from them to a high degree (they may need much more than what they can give). On the contrary, a utilitaristically useful agent is one whose "price", so to speak, must be lower than what she has to offer.

Our findings seem also to encourage the exploration through computer-simulation of different strategies of decision-making. So far, in our opinion, an essentially monarchic view of this phenomenon has prevailed in decision theory, namely the idea that it is rational for self-interested agents to maximize their utility, whatever the content of such utility may happen to be. In our study, we have endeavored to show that self-interested agents can apply a somewhat different, although related, criterion for decision-making, namely goal-satisfaction. Of course, comparisons between these criteria, especially between their relative effects on the agents applying them, are still to be made. However, such a comparison should be made on a variety of measures, including but not reduced to those analytically consistent with the utility principle (accumulation, capitalization, and the like). This is one of the objectives which MICROdep will be applied to in the future.

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3.2.2 Ilan Fischer and Ramzi Suleiman: The Emergence of Mutual Cooperation in a Simulated Inter-Group Conflict

The simulation expands the modeling of an intergroup conflict by introducing a sub- level of a simulated society. In the study, an enduring intergroup conflict is modeled by two representatives, each elected for a given constituency period. The conflict between the two groups is modeled as an iterated Prisoner's Dilemma game played by the groups' representatives. However, we assume that the performance of each representative influences her constituents and that this, in turn, affects her prospects for being reelected. At the end of a constituency period, new elections are called for, and their results determine whether the delegate remains in her position or is replaced by another representative. Our study explores the effect of this common democratic procedure, namely, the periodic election of group representatives, as well as the influence of different constituency periods, on the evolution of cooperation between the groups. Outcomes of 360 simulations yielded the following main results:

1. the dynamics of the intergroup conflict evolved into five phases of well-defined patterns.
2. The probability of emergence of each of the five patterns depended upon the election frequencies in the underlying societies.
3. For all election frequencies, mutual defection was not an enduring pattern while mutual cooperation evolved as an enduring one.

3.3 Applications: Science and Technology Studies

3.3.1 Petra Ahrweiler: Modeling a Theory Agency as a "Toolkit" for Science Studies

Science Studies is an interdisciplinary enterprise of philosophy, sociology and history of science, which tries to investigate the genesis and the development of scientific knowledge both with respect to "internal" epistemic factors and to "external", mainly social and historical factors. Due to the fact that the participating disciplines follow heterogeneous concepts, the various theories of Science Studies are not only supplementary but partly competing. What is the respective explanation power of participating theories? Where are possible links, opportunities for cooperation and integration between them? These questions should be answered in order to formulate concrete interdisciplinary projects.

SiSiFOS is a multiagent system for testing, evaluating, combining and integrating theories from the field of Science Studies. The theories act as "agents", all engaged in explanations concerning the same field — for example in the task to explain particular scientific discovery processes during a specific period in as many aspects as possible. The interests lies in the process the theory agents are involved in, to learn about the theory agents their capacities, their dependencies, their respective advantages etc. Communication between agents is possible via a shared memory, the "blackboard". In the end the content of the blackboard (front and back) contains information not only about the explanations and the competing chains of explanations that have been found by the community of agents, It also gives information about: which agents have suggested equivalent explanations for certain aspects, which agents offer alternative explanations, which agents contribute to which aspects of the explanations, and which agents have cooperated.

From a technical point of view, SiSiFOS bears two particularities: first the perspective to evaluate the participating agents through the procedures of the system instead of finding an optimal solution for a defined problem (the normal application of multiagent systems). Second, although the blackboard methodology seems to claim for deliberative agents, the theory agents of SiSiFOS act as "reactive" agents regarding aspects of agency and environment. Programs like SiSiFOS can instruct empirical research in Science Studies by producing reasonable hypotheses and can evaluate the performance of existing theories.

3.3.2 Paul Windrum: Assessing recent changes in UK science policy: The consequences of strategic funding on emerging scientific disciplines

In developing simulation models that have practical application we need to identify the characteristics of the system we wish to consider (social groups, institutional structures etc.), their dynamical relationships, and be able to say something about the relationship between the output of our models and the real world system being simulated.

This paper sets aspects of sociology of scientific knowledge (SSK) literature within an evolutionary model of disciplinary development. The three key aspects of this evolutionary model are selection : in science this is traditionally effected through a process of peer review (self-selection); variety : alternative research schools may foster alternative research programmes; competition : a multi-layered competition exists with both intra- and inter-school competition for intellectual leadership, and resources (financial, human, and instrumental). The model captures two principle dynamic features of the system. The first is the Latour-Woolgar 'credibility cycle', a positive feedback mechanism linking funding, research capacity, publications and peer status. The second is population learning through the use of a 'Learning algorithm' that is based on a GA. This captures the dynamics of emulation and mutation within populations of adaptive, learning agents.

Two outcomes of the model are explored. The first is the emergence of research niches within complex search spaces under a regime of peer-review funding. These are associated with a lock-in of financial and intellectual capital within a (relatively) few research institutions. Not only are these findings are useful in reflecting on the Kuhn-Lakatos debate of disciplinary emergence but they highlight certain characteristics of the traditional UK system of academic funding.

A second set of experiments have particular significance given recent policy changes in UK science funding. The original set of experiments are re-run under an alternative funding regime, comprising a combination of responsive mode (peer review) and strategic mode (targeted). The experiments show increasing levels of strategic funding alters the research activities of agents in the model but that there are diminishing returns to this type of funding. The paper concludes by reflecting on the dynamics of the model in order to explain this (ex ante) surprising behaviour.

3.4 Applications: Cellular Automata

3.4.1 Rainer Hegselmann, Andreas Flache, and Volker Möller: Solidarity and social impact in cellular worlds: results and sensitivity analyses

In social science modelling, the cellular automata framework is increasingly applied to incorporate the dimension of social space in the analysis of social dynamics. In our paper we explore the robustness of results derived from cellular automata modelling. In particular, we concentrate on effects of the discreteness of cellular automata, and on effects of the micro foundation underlying cellular models of macro phenomena.

To explore discreteness, we analyse a model of social impact in opinion formation. We depart from Abelson's (1964) model, where it is assumed that both time and actors' opinion are continuous variables. This model predicts that in a fully connected network opinion formation always converges on ubiquitous agreement. We then make Abelson's model discrete in time and opinion space. It turns out that polarisation in opinion clusters can emerge, even under conditions that seem to make cluster formation highly unlikely (homogeneity in actor's persuasive strength, no opinion bias etc.). Whether polarisation occurs depends, however, sensitively on the number of different opinions that actors can adopt. These results clearly contradict with Latane and Nowak's simulation analyses of social impact. They argue that the crucial conditions for cluster formation are heterogeneity and non linearity in opinion change. We found that only making opinions discrete suffices to obtain the result of clustering.

We furthermore show that the way how space is made discrete may be crucial. Using an irregular rather than a regular cell grid may turn ubiquitous agreement into polarisation, all other things being equal. To explore micro foundations, we use Hegselmann's (1996) analysis of solidarity networks. Hegselmann demonstrated that networks of solidarity relations may arise even between self-interested rational actors. In the cellular world, actors search attractive solidarity partners by migration. This typically results in a core-periphery structure of solidarity clusters, where actors who are least needy are in the core, while those who need most help are at the periphery.

In the present paper, we replace the assumption of 'forward-looking' rational decision making by a model of 'backward-looking' adaptive learners. Our results suggest that between adaptive egoists solidarity networks may still arise, but these networks show a much higher degree of class segregation. The reason is that adaptive actors are less successful in discovering potentially profitable solidarity relations than are rational actors. As a consequence, adaptive actors have only a small range of potential partners to choose from, resulting in a highly segregated pattern of solidarity relations.

3.4.2 Oliver Kirchkamp: Endogenous Evolution of Learning Rules

We study a model of local evolution. Players are located on a network and play games agains their neighbors. Players are characterized by three properties: (1) The stage game strategies they use agains their neighbors. (2) The repeated game strategy that determines the former. (3) A learning rule that selects the repeated game strategy, on the basis of the player's own and the neighbors' payoff and repeated game strategy.

The dynamics that specifies learning rules is given exogenously. Players sample their neighbors' learning rules and their respective payoff. Then they construct a model that related parameters of the learning rules to payoffs. Given this model they choose an optimal learning rule.

We find that under this dynamics learning rules emerge in the long run which behave deterministically but which are asymmetric in the sense that while learning they put more weight on the learning players experience then on the observed players one. Nevertheless stage game behavior under these learning rules is similar to behavior using symmetric learning rules.

3.4.3 Bibb Latané: Simulating Dynamic Social Impact

An extensive program of social simulation has resulted in 30 recent articles and chapters reporting the emergence of four group-level phenomena as very general consequences of social influence among spatially distributed individuals. These phenomena are consolidation, or a reduction in diversity as minorities are exposed to more adverse influence than majorities; clustering, as neighbors come to resemble one another; correlation, as clusters on originally independent issues increasingly overlap; and continuing diversity as clustering allows minorities to survive by forming local majorities.

These conclusions hold for simulations using three platforms- a mixed human/computer system, computers alone, and humans alone; three social spaces- a 1D Ribbon, a 2D Torus, and a ?D Family; three scales- 12-24 actors, 400 actors, and 196,000 actors; and three levels of prediction to data from the real world- the existence and magnitude of several counterintuitive phenomena, differences among groups, and differences among individuals.

The Hegselmann group's finding of continuing diversity under some unusual circumstances provides unexpected support for social impact theory, although their primitive four-neighbor cellular model does not constitute a fair test of Latane & Nowak (1997), whose inverse square distance models have richer and somewhat different dynamics. Hegselmann's claim that making opinions discrete suffices is consistent with but not as informative as Latane & Nowak's stronger claim that nonlinearity is critical, since discrete opinions are by nature nonlinear and continuous nonlinear opinions also show the effects. Please see Latane & Nowak, one of the most extensive sensitivity analyses done on a social simulation, for a more exact statement of the crucial conditions for the formation and survival of clusters. (Latane, B., & Nowak, A. (1997). Self-organizing social systems: Necessary and sufficient conditions for the emergence of consolidation, clustering, and continuing diversity. In G. Barnett & F. Boster (Eds.), Progress in communication sciences: Persuasion (v. 13, pp. 43-74). Norwood, NJ: Ablex.) Finally, everyone was invited to participate in an international multi-platform human/computer simulation involving a large group of people spending half an hour a week at their own convenience exchanging messages on topics of mutual interest over the Internet. All interested in participating or in reprints of Latane & Nowak should contact latane@fau.edu

3.4.4 Matthew Rockloff: Design Considerations for Multi-Agent Models

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A set of suggested design principles are advanced for the construction of multi-agent simulation environments. Models should include the properties of both the agents and their agency (relationships with one another) in each dimension of the simulation including: Data representation, Manipulation, Visualization, Validation. Data representation is the means by which data is stored either on a physical medium or in memory. Manipulation is the methods by which the data is transformed in the simulation. Visualization is the translation of simulation and actual results to a coherent display. Validation is calculation of order parameters of the global system, as well as statistics that compare actual results with simulated. Compact, efficient and encapsulated code is generated by following these heuristics.

3.5 Applications in Economics

3.5.1 Ottmar Edenhofer: Social Conflict and Induced Technological Change in Energy Policy

It has been widely argued in neoclassical environmental economics that social costs should trigger an internalisation strategy by the state in order to avoid emissions of greenhouse gases. Most economic models to assess internalisation policies, however, neglect two important phenomena: induced technological change and social conflict about internalizing social costs. Economists in the neoclassical tradition assume that the government has the power to coerce a pareto-optimal strategy. It seems more realistic to assume that the government is embedded in an interdependent network of firms, consumers, workers and suppliers of energy. In such a network it should be checked whether the government has the ability to impose its will on the actors despite resistance. Therefore, in this paper we try to conceptualize power in a non-linear model with social conflict and induced technological change. The model illustrates basic factors which determine energy productivity as well as labor productivity. It shows what happens if internalising social costs is a highly conflictual issue which induces struggles between enterprises, workers and suppliers for energy.

We offer a mathematical description of the model without any government control and we assess how ecological innovations affect profits, wages and energy prices. Subsequently, we assess two different styles of government control: an energy tax and an energy cap. With the energy cap the government tries to control the network through social norms. If government cannot predict the business cycle correctly or time lags occur in implementing the program, the whole economy could be destabilized by a tax. Paradoxically, the stronger the intended stabilizing effect the stronger will be the distortions of the economy.

In contrast to an energy tax, an energy cap doesn't need any correct prediction of the business cycle. The state limits the property rights of the firms, for example through tradeable permits, and induces the introduction of technologies which improve energy productivity.

3.5.2 Philip Kokic, Ray Chambers and Steve Beare: Microsimulating Farm Business Performance

Over the last ten years the Australian Bureau of Agricultural and Resource Economics (ABARE) has developed a set of computational tools to forecast farm business performance at the individual farm level which account for the dynamic response of individual farms to macro level price expectations. The methods presented in this paper extend these techniques to simulation of these microdata.

Recent research in ABARE has partly focused on building a set of analytic tools which could be used to predict the distribution of farm outputs and incomes under a variety of alternative policy and price scenarios, as well as under a variety of climatic scenarios, particularly those associated with drought.

The purpose of this paper is to describe the statistical methodology underlying these tools and how they can be used in the microsimulation of farm business performance.

These tools are illustrated by applying them to data collected in the Australian Agricultural and Grazing Industries Survey; an annual survey carried out by ABARE since 1978 which covers farms with a significant involvement in one or more of the enterprises cereal, beef, sheep meat or wool production.

At the core of these tools is a dynamic supply model. This model predicts an individual farm's response, in terms of the amounts of various products produced, to output price changes according to a profit maximisation criterion and subject to a fixed operating area constraint. The two key stochastic elements in the simulation model are (a) temporal yield variation, which in the Australian context is highly dependent on geographic location, and (b) temporal price variation, which is largely exogenous since Australia is a price taker rather than a price setter in global commodities markets.

3.6 Sensitivity Analysis and Parameter Optimization

3.6.1 Jim Doran: Four Questions and a Paradox

The methodology of ”artificial societies” is first reviewed. Then a series of questions is considered of which the most important are:

- What is an agent (in computational terms)?

- How may agents be recognised?
- How may experiments with artificial societies be used to characterise the set of possible trajectories from simple to complex social organisation?
- Under what conditions does foreknowledge in artificial societies have negative evolutionary impact?

Some computer-based experimental work relating to these questions is described. ”Edmund’s Paradox”, which arises in the assessment of the social impact of foreknowledge, is examined and possibly resolved.

3.6.2 Nicole J. Saam: An Outline of Problems in Social Science Sensitivity Analysis

The presentation takes a toolkit perspective on sensitivity analysis. A walk through the literature shows that the field is basically unstructured and the state of the art is that sensitivity analysis is more a kind of art than a scientific method. Therefore some fundamentals that the field seems to agree upon are presented first: definition, purposes, importance and requirements upon results of sensitivity analysis. After sketching the prevailing methods in sensitivity analysis we give an outline of two problems:

1. the robustness of results request, and
2. the complexity of results.

We request (1) an operational definition of robustness, and (2) complexity reducing algorithms, the standardization of sensitivity measures, standard sensitivity software, or standard sensitivity procedures, or user supportive sensitivity tools that support the user in defining and runing user specified application dependent sensitivity tests.

3.6.3 Edmund Chattoe: Sensitivity Analysis: Prospects and Problems

A very general definition of sensitivity analysis is that it involves investigating changes in the behaviour (variable components) of some system in response to changes in its “fixed components”. This talk considers what it might mean to do sensitivity analysis for systems other than simple mathematical ones. It identifies four outstanding difficulties:

1. That changes in behaviour need not be comparable with changes in fixed components.
2. That changes in behaviour need not be simple to identify or characterise.
3. That changes in fixed components may be hard to interpret consistently. (For example, if parameters are varied away from a model of “best fit”, what value does observed behavioural stability have when connected with parameter values of *different* fit quality?)
4. The technical challenge of ensuring that changing certain kinds of fixed values does not induce inadvertent changes elsewhere in the system. (For example, ensuring full modularisation in simulation programs.)

The paper concludes that one task of a simulation toolkit (and perhaps one measure of its success) might be to begin a resolution of these difficulties:

1. The "ceteris paribus" requirement is ensured by good design of the program architecture.
2. The problem of identifying behaviours is facilitated by, for example, offering a wide range of visualisation tools.
3. The problem of computability may be approached by offering a more unified representation of social processes within the toolkit.

3.6.4 Mario Paolucci, Mario Marsero, Rosaria Conte: What is the Use of Gossip? A Sensitivity Analysis of the Spreading of Normative Reputation

The authors investigate the problem of social order in multiagent systems, examining the performance of simple property norms. In the model, respectful and non-respectful agents (cheaters) compete for scarce food in a two-dimensional square grid. The performance of agents is judged by final strength and by distribution of final strength.

From previous tests two paramaters are found to be critical: first, the (different) reaction of a respectful agent towards a cheater (called sub-behaviour); second, the timing of recognition of cheaters, or the speed of knowdledge spreading, obtained by information exchange (gossip).

The model is marked from the presence of a large parameter space, even if choices are often suggested from plausibility. In the current work, an extensive exploration of the parameter space has been carried on in regard to the parameters of ending time, global agent density and relative agent density. The analisys has been repeated for the various kinds of sub-behaviours.

From the results we see that the experiment is indeed stable in respect to ending time. In respect to global density variations, previous results are again confirmed, except that the respectful agents seem to step over the cheaters in high density (lower per-agent food) settings. Varying relative density we see a crossover when the population with higher density takes control. It is intersting to note that punitive sub-behaviours obtain better results in this area, while in the "classical" settings non-punitive behaviours had been superior.

In every setting, information exchange as a tool to haste knowledge diffusion is indispensable for the respectful agents to be competitive. This makes us say that gossip may have an important, overlooked role in the establishing of normative behaviours. At last, the validity of main instances whitin the extended range of experimental condition reassure us about the stability of the model.

3.6.5 Georg Müller: Simulation Assisted Inferencing: A Practical Example

Simulation assisted theory building generally has three separate facets: Formalization of already existing theories, empirical testing by comparing the output of a model with observational data, inferencing by looking for generalizable theoretical conclusions of a model. The focus of this paper is mainly on the latter facet of theory building. It is in so far problematic as there is always only a finite number of simulation experiments in order to prove the general validity of a hypothesis referring to an infinity of actors or situations. Consequently, it is argued that the validity of general hypotheses cannot be proved by simulation experiments. Instead, it is suggested to search for model parameters and initial conditions for which the model output falsifies the hypothetical inference. If this search is successful a counter-example has been found and the hypothetical inference has to be discarded. Otherwise the hypothesis under consideration can provisionally be accepted as a logical implication of the model.

In order to systematize this search process the paper suggests the use of numerical optimization for finding a worst case set of model parameters which minimize the correspondence between the results of the computer simulation and the hypothetical inference under consideration. The choice of a target function describing this correspondence depends on the type of hypothesis to be proven. For the most important types of inferences from system dynamics models the paper suggests the following target functions and optimization procedures:

1. For hypotheses about positive (or negative) causal relations between variables: The minimization of the positive (or negative) Pearson- or Spearman-correlation between the simulated values of these variables.

2. For hypotheses about the existence of equilibria of dynamic variables: The minimization of the simulated negative absolute growth rates of these equilibrium variables for a relatively distant time-point.

The numerical optimization processes which are at base of the proposed method of inferencing have several well-known disadvantages:

1. They identify local instead of global minima.

2. They accumulate rounding errors and are thus numerically instable.

3. They entail numerically intensive computing and thus require powerful hardware.

These disadvantages tend to question the viability of the proposed method of inferencing. In order to assess the real weight of these problems the author has tried to apply the methodology to the Richardson arms race model which has the advantage that inferences by simulation can be cross-checked by analytical reasoning. The optimizations were done on a relatively small Macintosh Performa-475 computer by using the nonlinear regression module CNLR of SPSS-4. Several practical experiments with the Richardson model have confirmed the existence of the mentioned numerical stability problem. However, there were no problems with computation time and local minima: With the proposed simulation methodology it was possible to make correct inferences about causal relations and equilibria within a few minutes of computation time.

3.6.6 Christof Schatz: Tests of Dynamic Social Models with Time Related Surveys — an Experimental Approach

In Social Science Modeling Theory the integration of empirical aspects seems to be weak. One reason may be the paralyzing effect of highly complex and unsolved methodological problems. To avoid them, I just tried to test a non-linear formal model explaining job-keeping expectations of employed people.

In the model each actor is described by one ordinary differential equation (Kernel Model). The additional Network Model couples the actors together in such a way that the total number of open parameters per actor is seven. In the test, panel data of six points in time are used. Complexity Problem: because of the convergence properties of the model, the parameter sets of the actors ought not to be chosen identically. So tenths of open parameters have to be determined by fitting them to the data.

Micro-Macro-Link: In order to avoid a simultanous fit, I applied an iterated approximation of the coupling, which permits a fit actor by actor.

Ambiguousness Problem: The non-convex optimization problem gives ambiguous results due to the existence of hundreds of local fit optima (OLS-minima). To represent as much as possible minima, for each actor a cluster analysis calculates the biggest cluster of minima as such as the center of this cluster represents about one half of all minima found.

Result: The test gives a positive falsification result. The sociopsychological constraints indicate an insufficiency of either the data analysis method or the model itself. There are various ways to proceed: By modification of the model, by testing the data analysis method or by comparison with standard time series regression methods. Hence this falsification is an example for tests, which lead to systematic ways for developing empirically founded formal models and theories.

3.6.7 Serge V. Chernyshenko: Discrete effects in dynamical differential models

Two approaches of investigation of discrete effects on the base of differential models are represented.

The first approach is based on the comparative analysis of differential equations and stochastic flows. A differential system is approximated by Poisson stochastic flow. A comparative analysis of this two models allows to propose a special method of stochastic flow composing.

The results of the method application to a social-economic model of the Lotka-Volterra type are represented. The schematic model describes dynamic of the supply and demand in the course of corresponding social-economic processes. The first co-ordinate describes intensity of demand and may be measured by number of peoples which are ready to buy goods. The second one describes the intensity of supply and can be measured by number of goods available for sale.

The figures show the differences between continuous solution of the differential equation and the discrete time series, which are obtained on the base of the proposed method. In accordance with general rules, the discreteness increases a system instability. For the supply, as for the more unstable variable, we observe even same kind of pseudo-stochastic behaviour, especially in oscillatory mode, which corresponds to a focal equilibrium point.

The second approach is connected with a usage of senergetic ideas for modelling dynamic discrete effects. The problem of modelling the process of forming society stratification is considered. Different strata (or populations) are related by two main types of interactions: cooperation and competition. It is shown that a modification of the famous Eigen's hypercycle model is applicable, if the competition oppresses all population equally, i.e. a some kind of third Newton's law is true. They determine a close dependence of the next population from previous one. As an example of such consequence of populations, we may consider social groups, connected with different economic branches: agricultural production (the background population); industrial production (the second stage); information production, etc.

For the n-dimensional model only n+1 equilibrium points can be stable. Some number of their first co-ordinates have non-zero values, others are equal to zero. We can interpret this fact as a possibility to obtain different dimensions of the system in the steady-state. The dimension of the steady-state is determined by the system parameters and, particularly, it increases with the grows of the parameter C, which determines the total size of all populations in the steady-state, and can be considered as a “total capacity of society”. The system “can” chose its dimension depending on “capacity” of social space. The model can be considered as a model of social self-organization.

4 Summaries of Informal Discussions

4.1 A Simulation Toolkit for the Social Sciences

4.1.1 Target Users and User Levels

Reasons for a general toolkit (What?)

- Market: Needs to be adequate. (Not just simulations for people who can already write their own.) (Commercial, standardisation etc.)
- Competition/Complexity: Can't compete with specialist packages already in existence. (Social simulation doesn't require it normally.)
- Practical Agreement: Expert simulators will never agree on a specialist package.
- Unification, simplicity of learning, sharing models.

Possibilities for a general toolkit (How?)

- Programming Level: Chosen language (OOP).
- Module Level: Script Language.
- Scheme Level: GGUI.
- Application Level: Menu Driven.

Uses (Why?)

- AL: End Users, Lay Persons, Politicians, Decision Makers. (Parameter investigation.)
- SL: Teaching, Preparing Applications, Packaging Models for others.
- ML: New research, Standardisation of Models.
- PL: Most of the above, Tool Development.

New Users

- Example models
- Tutorials.
- Documentation.

Specification Types of modelling technique to be supported

- Neural Networks
- Evolutionary Algorithms (GA, GP, EA)
- Multi-Agent Simulation
- Hierarchical and Multilevel Modelling
- Hybrid Models
- Equation Based
- Stochastic Processes
- Finite Automata
- Cellular Automata
- Social Networks
- Microsimulation
- Discrete Event Modelling

Data Analysis and Input

- Numerical Statistical Processing
- Non Numerical Visualisation (Clustering, detecting emergence etc.)
- Sensitivity Analysis
- Parameter Optimization
- Databases for input
- Dumping of Input and Output
- Parameter Generator/Editor
- Structure Generator/Editor
- Random Number Generation
- Runtime Tracing

Kernel Features

- Platform Independence
- Integration of User Levels
- Integration of Parts of the Modelling Cycle
- Visual Representation in terms of clickable nodes, “controllers” and links.
- Integration of Timescales
- Aggregation
- Overlapping Group Membership
- Birth and Death Processes: Agents as controllers?

Plan

- Comparison with Existing Products/Projects (Market Research).
- Specification (High level: specialisation in modules.): Designing a GGUI and prototyping it using Modelling Techniques above as examples.

Future Extensions

- Distributed Simulation.
- WEB Version.
- Persistence: For crashes and errors.
- Explanation Feature