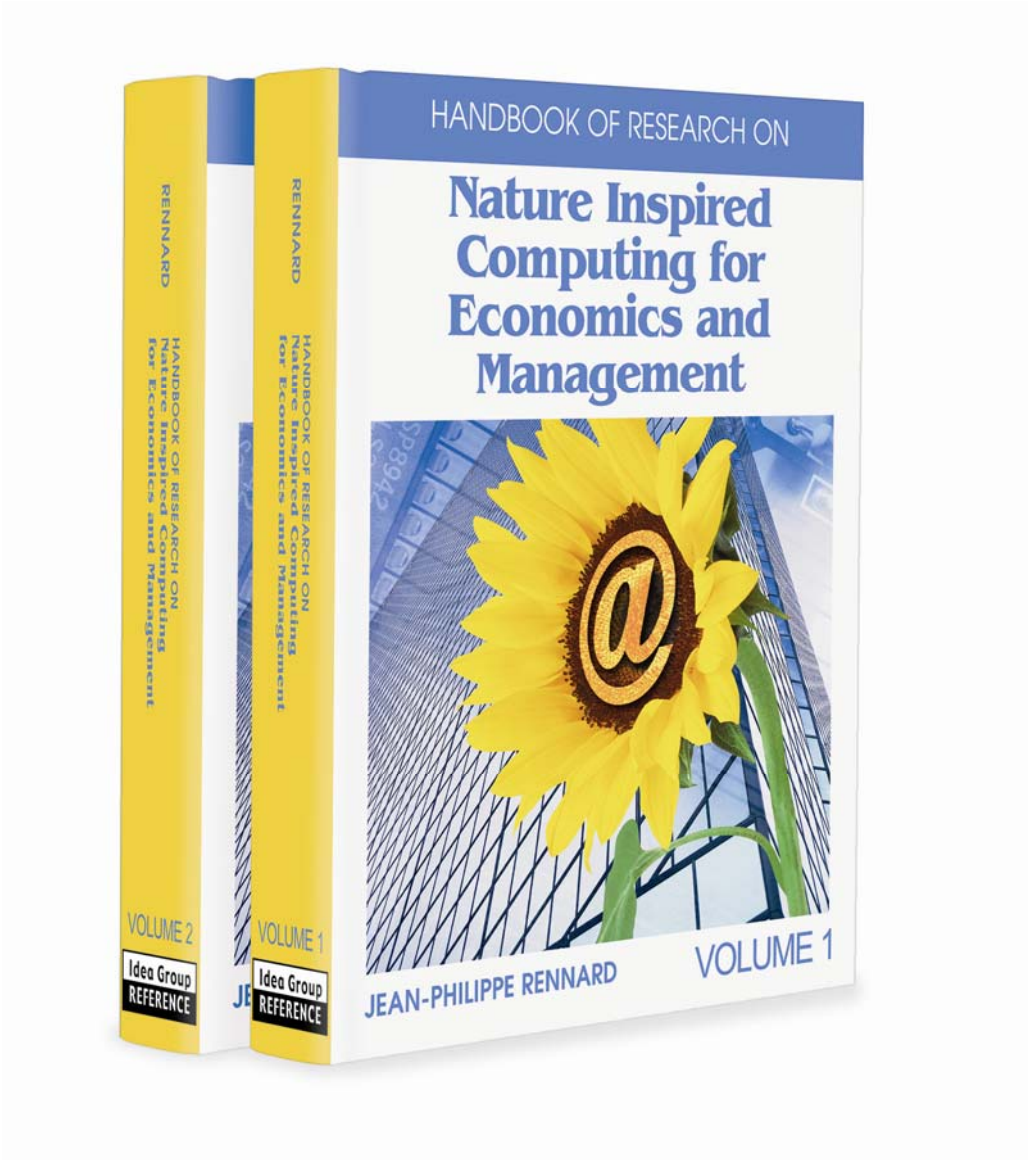
Handbook of Research on Nature Inspired Computing for Economics and Management

Rennard, Jean-Philippe (Ed.)



Foreword: A Cure for the Dismal Science

Eric Bonabeau, Icosystem Corporation

I earn a living solving real economic and strategic problems for real businesses. After a number of years of this regimen, I have lost my taste for big theories of human behavior. Especially economic theories. My version of game theory consists of playing the game and forgetting about the theory. That's because my incentive system is based not on the aesthetics of theorem proving but rather on my ability to ease the pain of suffering managers. I no longer derive any satisfaction from irrelevant elegance. The foundations of economics have for so many years ignored the realities of human behavior and decision-making that it has become a joke for business practitioners, managers and consultants. I believe that the mutual distaste of practitioners and theorists is coming to an end as a new breed of economists is emerging. These new economists embrace the complexities and subtleties of human behavior; they acknowledge the dynamic, evolving nature of the economy; they design economic experiments that involve, god forbid, real people; while they do not reject mathematics as a tool, they do not view it as a purpose; they believe that computational experiments can take them beyond confined, provable situations. The handbook that Jean-Philippe Rennard has assembled is a wonderfully diverse collection of points of view from this new breed of economists and social scientists, a vibrant cross-section of the field of economics as I hope it will evolve in the near future. (…)

1- Nature Inspired Computing and Social Sciences (volume 1)

Section 1.1-Nature Inspired Computing

1. A Brief Introduction to Artificiality in Social Sciences

Rennard, Jean-Philippe, Grenoble Graduate School of Business, France

This chapter provides with an introduction to the modern approach of artificiality and simulation in social sciences. It presents the relationship between complexity and artificiality, before introducing the field of artificial societies which greatly benefited from the computer power fast increase, gifting social sciences with formalization and experimentation tools previously owned by "hard" sciences alone. It shows that as "a new way of doing social sciences", artificial societies should undoubtedly contribute to a renewed approach in the study of sociality and should play a significant part in the elaboration of original theories of social phenomena.

2. Multi-Cellular Techniques: from Social Insects to Collective Robotics

Anderson, Carl, Qbit LLC, USA

Social insects—ants, bees, wasps and termites—and the distributed problem-solving, multi-agent paradigm that they represent have been enormously influential in nature inspired computing. Insect societies have been a source of inspiration and amazement for centuries but

only in the last 25 years or so have we made significant inroads to both understanding just how various collective phenomena arise and are governed, and how we can use the lessons and insights garnered from sociobiological research for more practical purposes. In this chapter, we provide a very brief history of the field, detailing some of the key phenomena, mechanisms and lessons learned and a quick tour of some of the different types of applications to which this knowledge has been put to use, including but certainly not limited to distributed problem solving, task allocation, search and collective robotics.

3. Stochastic Optimization Algorithms

Collet, Pierre, LIL, Université du Littoral, France, Rennard, Jean-Philippe, Grenoble Graduate School of Business, France

When looking for a solution, deterministic methods have the enormous advantage that they do find a global optimum. Unfortunately, they are very CPU-consuming, and are useless on untractable NP-hard problems that would require thousands of years for cutting-edge computers to explore. In order to get some kind of result, one needs to revert to stochastic algorithms that only sample the search space without exploring it thoroughly. Such algorithms can find very good results, without any guarantee however that the global optimum has been found, but there is often no other choice than using them. Here is therefore a short introduction to the main methods used in stochastic optimization.

4. Evolutionary algorithms: A Quick Presentation

Collet, Pierre, LIL, Université du Littoral, France

Evolutionary computation is an old field of computer science, that started in the end of the 1960s nearly simultaneously in different parts of the world. Each paradigm has evolved separately, apparently without knowledge of what was happening elsewhere, until people finally got together and shared their experience. This resulted in strong trends that still survive, even though it is now possible to outline a generic structure for an evolutionary algorithm that is described in this chapter.

5. Genetic Programming

Collet, Pierre, LIL, Université du Littoral, France

The aim of Genetic Programming is to evolve programs or functions (symbolic regression) thanks to artificial evolution. This technique is now mature and can routinely yield results on par with (or even better than) human intelligence. This chapter sums up the basics of Genetic Programming and outlines the main subtleties one should be aware of in order to obtain good results.

6. An Introduction to Evolutionary Multi-Objective Optimization

Coello Coello, Carlos Artemio, CINVESTAV-IPN, Mexico

This chapter provides with a brief introduction of the use of evolutionary algorithms in the solution of multi-objective optimization problems (an area now called “evolutionary multi-objective optimization”). Besides providing some basic concepts and a brief description of the approaches that are more commonly used nowadays, the chapter also provides some of the current and future research trends in the area. In the final part of the chapter, we provide a

short description of the sort of applications that multi-objective evolutionary algorithms have found in finance, identifying some possible paths for future research.

Section 1.2- Social Modeling

7. Advancing the Art of Simulation in the Social Sciences

Axelrod, Robert, University of Michigan, USA

Advancing the state of the art of simulation in the social sciences requires appreciating the unique value of simulation as a third way of doing science, in contrast to both induction and deduction. Simulation can be an effective tool for discovering surprising consequences of simple assumptions. This essay offers advice for doing simulation research, focusing on the programming of a simulation model, analyzing the results sharing the results, and replicating other people's simulations. Finally, suggestions are offered for building of a community of social scientists who do simulation.

8. Multiagent Systems Research and Social Science Theory

Verhagen, Harko, Stockholm University & Royal Institute of Technology, Sweden

This chapter described the possible relationships between multiagent systems research and social science research, more particularly sociology. It gives examples of the consequences and possibilities of these relationships and describes some of the important issues and concepts in each of these areas. It finally points out some future directions for a bidirectional relationship between the social sciences and multiagent systems research which hopefully will help researchers in both research areas as well as researchers in management and organisation theory.

9. A Dynamic Agent-Based Model of Corruption

Chakrabarti , Rajesh, Dupree College of Management, USA

Builds an agent-based model wherein the societal corruption level is derived from individual corruption levels optimally chosen by heterogeneous agents with different risk aversion and human capital. The societal corruption level, in turn, affects the risk-return profile of corruption for the individual agents. Simulating a multi-generational economy with heterogeneous agents we show that there are locally stable equilibrium corruption levels with certain socio-economic determinants. However there are situations when corruption can rise untill it stifles all economic activity.

10. Human Nature in the Adaptation of Trust

Nooteboom , Bart, Tilberg University, Netherlands

This chapter pleads for more inspiration from human nature, in agent-based modeling. As an illustration of an effort in that direction, it summarizes and discusses an agent-based model of the build-up and adaptation of trust between multiple producers and suppliers. The central question is whether, and under what conditions, trust and loyalty are viable in markets. While the model incorporates some well known behavioral phenomena from the trust literature,

more extended modeling of human nature is called for. The chapter explores a line of further research on the basis of notions of mental framing and frame switching on the basis of relational signaling, derived from social psychology.

11. Cognitively-Based Simulation of Academic Science

Naveh, Isaac, Rensselaer Polytechnic Institute, USA, Sun Ron, Rensselaer Polytechnic Institute, USA

This work proposes a more cognitively realistic approach to social simulation. It begins with a model created by Gilbert (1997) for capturing the growth of academic science. Gilbert's model, which was equation-based, is replaced here by an agent-based model, with the cognitive architecture CLARION providing greater cognitive realism. Using this agent model, results comparable to human data are obtained. It is found that while different cognitive settings may affect the aggregate number of scientific articles produced by the model, they do not generally lead to different distributions of number of articles per author. It is argued that using more cognitively realistic models in simulations may lead to novel insights.

12. Application of Nature-Inspired Knowledge Mining Algorithms for Emergent Behavior Discovery in Economic Models

Al Dabbas, D, Nottingham Trent University, UK

Economic models exhibit a multiplicity of behavior characteristics that are nonlinear and time-varying. 'Emergent' behavior appears when reduced order models of differing characteristics are combined to give rise to new behavior dynamics. In this chapter we apply the algorithms and methodologies developed for nature-inspired intelligent systems to develop models for economic systems. Hybrid recurrent nets are proposed to deal with knowledge discovery from given trajectories of behavior patterns. Each trajectory is subjected to a knowledge mining process to determine its behavior parameters. The knowledge mining architecture consists of an extensible recurrent hybrid net hierarchy of multi-agents where the composite behavior of agents at any one level is determined by those of the level immediately below. Results are obtained using simulation to demonstrate the quality of the algorithms in dealing with the range of difficulties inherent in the problem.

13. The Grid for Nature Inspired Computing and Complex Simulations: Possible Applications Allowed by the Technological State of the Art

Boero, Riccardo, University of Surrey, UK

This chapter deals with the usage of Grid technologies for nature inspired algorithms and complex simulations. After shortly introducing the Grid and its technological state of the art, some features are pointed out in order to set the boundaries of the applicability of such new technology to the matters of interest. Then two paragraphs show some possible usages of Grid technologies. The first one introduces the Master-Worker paradigm as a conceptual and technological scheme that helps in solving issues related to dynamic optimisation via nature inspired algorithms and in exploring the parameters space of complex simulations. The following paragraph concerns two other points: the possibility to distribute agents of agent based simulations using Multi Agent Systems; the boundaries, architectures and advantages in distributing parts of complex simulations which are heavy from the computational point of view. The chapter, as a whole, acts a guide presenting applicative ideas and tools to exploit Grid technological solutions for the considered purposes.

Section 1.3- Economics

14. Agent-Based Computational Economics-An Introduction

Bruun, Charlotte, Aalborg University, Denmark.

This chapter argues that the economic system is best perceived as a complex adaptive system, and as such, the traditional analytical methods of economics are not optimal for its study. Agent-based computational economics (ACE) studies the economic system from the bottom up and recognizes interaction between autonomous agents as the central mechanism in generating the self-organizing features of economic systems. Besides a discussion of this new economic methodology, a short “how-to” introduction is given, and the problem of constraining economics as a science within the ACE approach is raised. It is argued that ACE should be perceived as a new methodological approach to the study of economic systems rather than a new approach to economics, and that the use of ACE should be anchored in existing economic theory.

15. Data gathering to build and validate small-scale social models for simulation. Two ways: strict control and stake-holders involvement

Rouchier, Juliette, CNRS, Greqam, Marseille, France

This chapter discusses two different approaches that gather empirical data and link them to modeling and simulations with agent-based systems: experimental economics which built reproducible settings and quantitatively defined indicators; companion modeling which accompanies observed social groups when they negotiate over renewable resource issues. Both developed techniques have different epistemological posture which lead them to promote diverse data comparison and model validation. They both have small limitation. The paper wishes to put forward that, although both approaches have different goal, some evolutions in research protocol could enhance qualities of both. Some of these evolutions have already started to be used by researchers.

16. Modeling Qualitative Development -Agent Based Approaches in Economics

Pyka, Andreas, Universität Augsburg, Germany

This chapter introduces to Agent Based Modeling as a methodology to study qualitative change in economic systems. The need to focus on qualitative developments is derived from evolutionary economics, where the quantitative orientation of mainstream economic approaches is strongly criticized. It is shown that Agent Based Models can cope with the challenges of an evolutionary setting and fulfill the requirements of modeling qualitative change. In particular Agent Based Models allow a detailed representation of knowledge and the underlying dynamics which are considered the major driving force of economic growth and development. The chapter also gives an illustrative example of an Agent Based Model of innovation processes organized in networks of actors.

17. Agent-based Modeling with Boundedly Rational agents

Ebenhöh , Eva, University of Osnabrück, Germany, Pahl-Wostl, Claudia, University of Osnabrück, Germany

This chapter introduces an agent-based modeling framework for reproducing micro behavior in economic experiments. It gives an overview of the theoretical concept which forms the foundation of the framework as well as short descriptions of two exemplary models based on experimental data. The heterogeneous agents are endowed with a number of attributes like “cooperativeness” and employ more or less complex heuristics during their decision making processes. The attributes help to distinguish between agents and the heuristics distinguish between behavioral classes. Through this design agents can be modeled to behave like real humans and their decision making is observable and traceable, features that are important when agent-based models are to be used in collaborative planning or participatory model building processes.

18. Heterogeneous Learning Using Genetic Algorithms: Communication versus Experiments

Vallée, Thomas, Nantes University, France

The goal of this chapter is twofold. First, assuming that all agents belong to a genetic population, the evolution of inflation learning will be studied using a heterogeneous genetic learning process. Second, by using real-floating-point coding and different genetic operators, the quality of the learning tools and their possible impact on the learning process will be examined.

19. Modeling the Firm as an Artificial Neural Network

Barr, Jason, Rutgers University, USA, Saraceno, Francesco, OFCE, France

The purpose of this chapter (1) to make the case that a standard artificial neural network can be used as a general model of the information processing activities of the firm, and (2) to present a synthesis of Barr and Saraceno (2002, 2004, 2005), who offer various models of the firm as an artificial neural network.
An important motivation of this work is the desire to bridge the gap between economists, who are mainly interested in market outcomes, and management scholars, who focus on firm organization.
The first model has the firm in a price-taking situation. We show that increasing environmental complexity is associated with larger firm size and lower profits. In the second and third models, neural networks compete in a Cournot game. We demonstrate that they can learn to converge to the Cournot-Nash equilibrium and that optimal network sizes increase with complexity. In addition, we investigate the conditions that are necessary for two networks to learn to collude over time.

20. Evolutionary Modeling as an Alternative Explanation of Industrial Structure Emergence

Kwasnicka, Halina, Wroclaw University of Technology, Poland, Kwasnicki, Witold, Wroclaw University of Technology, Poland

In the first part of the paper an outline of the evolutionary model of industrial dynamics is presented. The second part deals with a simulation study of the model focused on identification of necessary conditions for emergence of different industrial strictures. Textbooks of traditional economics distinguish four typical industry structures and study

them under the names of pure competition, pure monopoly, oligopoly and monopolistic competition. Variations in behavior modes of differently concentrated industries ought to be an outcome of the cooperation of well-understood evolutionary mechanisms, and not the result of juggling differently placed curves representing supply, demand, marginal revenue, marginal cost, average costs, etc. Textbook analysis of industrial structures usually omits influence of innovation on market behavior. Evolutionary approach and simulation allow for such kind of analysis and through that allow enriching the industrial development study. One of the important conclusions from that paper is that evolutionary analysis may be considered as a very useful and complementary tool to teach economics.

21. Population Symbiotic Evolution in a model of Industrial Districts.

Merlone, Ugo, University of Torino, Italy, Terna, Pietro, University of Torino, Italy

This chapter considers a model of industrial districts where different populations interact symbiotically. The approach consists in the parallel implementation of the model with jESOF and plain C++. We consider a district decomposition where two populations, workers and firms, cooperate while behaving independently. We can find interesting effects both in terms of worker localization consequences and of the dynamic complexity of the model, with policy resistance aspects.
By using a multiple implementation strategy we compare the advantages of the two modeling techniques and highlight the benefits arising when the same model is implemented on radically different simulation environments; furthermore we discuss and examine the results of our simulations in terms of policy making effects.

22. Competitive advantage of Geographical Clusters: A Complexity Science Approach and an Agent-based Simulation Study

Giannoccaro, Ilaria, Polytechnic of Bari, Italy, Carbonara, Nunzia, Polytechnic of Bari, Italy, Vito, Albino, Polytechnic of Bari, Italy,

This chapter deals with complexity science issues in two directions: from one side, it has used complexity science concepts to give new contributions to the theoretical understanding on Geographical Clusters (GCs); from the other side, it presents an application of complexity science tools such as emergent (bottom-up) simulation, using agent-based modeling to study the sources of GC competitive advantage.
Referring to the first direction, the complexity science is used as a conceptual framework to identify the key structural conditions of GCs that give them the adaptive capacity so assuring their competitive advantage.
As regards the methodological approach, the agent-based simulation is used to analyze the dynamics of GCs. To this aim, we model the main characteristics of GCs and carry out a simulation analysis to observe that the behaviors of GCs are coherent with the propositions built up on the basis of complexity science literature.

23. A Simulation of Strategic Bargainings within Biotechnology Clusters

Berro, Alain, Social Sciences University, Toulouse, France, Leroux, Isabelle, Le Mans University, France

This chapter introduces artificial life as a means of exploring strategic relations dynamics between firms and local authorities within a local biotechnology cluster. It argues that artificial life, combined with a conception of bioclusters as complex adaptive systems, offers a significant approach to understanding the co-evolution of strategies and the potential

vulnerability of such systems. The simulation model involves firms and local government administrations which negotiate to share a quasi-rent, and which, to this end, use strategies which are to a greater or lesser extent sophisticated or opportunistic. The results show that the firms adjust their bargaining strategies according to their assessment of gains which might be collectively generated. The results also bring to light that the local authorities play a regulatory role against opportunism and that they are the key players in local coordination. Stemming from these simulations, the authors develop promising new avenues of theoretical and empirical research.

24. Knowledge Accumulation in Hayekian Market Process Theory under Limited Imitability Assumptions

Saam, Nicole J., Maximilians-Universität, Germany, Kerber, Wolfgang, Philipps-Universität Marburg, Germany

This simulation model is an example of theory-driven modeling that aims at developing new hypotheses on mechanisms that work in markets. The central aim is to model processes of knowledge accumulation in markets on the theoretical basis of Hayek's concept of "competition as a discovery procedure", in which firms experiment with innovations, which are tested in the market, and the superior innovations are imitated by other firms through mutual learning. After an overview on the structure of these simulation models and important results of previous research, we focus on the analysis of the severe negative effects that limited imitability has for this Hayekian process of knowledge accumulation. We show that limited imitability can hamper this process through the emergence of a certain kind of lock-in situations, which reduces the number of changes in the position of the leading firm.

25. On Technological Specialization in Industrial Clusters: An Agent-based Analysis

Dawid, Herbert , Universität Bielefeld, Germany, Wersching , Klaus, Universität Bielefeld, Germany

In this chapter an agent-based industry simulation model is employed to analyze the relationship between technological specialization, cluster formation and profitability in an industry where demand is characterized by love-for-variety preferences. The main focus is on the firms' decisions concerning the position of their products in the technology landscape. Different types of strategies are compared with respect to induced technological specialization of the industry and average industry profits. Furthermore, the role of technological spillovers in a cluster as a technological coordination device is highlighted and it is shown that due to competition effects such technological coordination negatively affects the profits of cluster firms.

26. Simulating Product Invention using InventSim

Brabazon, Anthony, University College Dublin, Ireland, Silva, Arlindo,Ferra de Sousa, Tiago, Matthews, Robin, Kingston University, UK, ONeill, Michael , University College Dublin, Ireland, Costa , Ernesto, University of Coimbra, Brasil.

This chapter describes a novel simulation model (*InventSim*) of the process of product invention. Invention is conceptualized as a process of directed search on a landscape of product design possibilities, by a population of profit-seeking inventors. The simulator embeds a number of real-world search heuristics of inventors, including anchoring, election, thought experiments, fitness sharing, imitation & trial and error. A series of simulation experiments are undertaken to examine the sensitivity of the populational rate of advance in product sophistication to changes in the choice of search heuristics employed by inventors.

The key finding of the experiments is that if search heuristics are confined to those which are rooted in past experience, or to heuristics which merely generate variety, limited product advance occurs. Notable advance occurs only when inventor's expectations of the relative payoffs for potential product inventions are incorporated into the model of invention. The results demonstrate the importance of human direction and expectations in invention. They also support the importance of formal product/project evaluation procedures in organizations, and the importance of market information when inventing new products.

2- Nature Inspired Computing and Management (volume 2)

Section 2.1- Design and Manufacturing

27. Human-centric Evolutionary Systems in Design and Decision-Making

Parmee, Ian, University of the West of England, Bristol, UK, Abraham, Johnson R., , University of the West of England, Bristol, UK, Machwe, Azahar, University of the West of England, Bristol, UK

The chapter introduces the concept of user-centric evolutionary design and decision-support systems and positions them in terms of interactive evolutionary computing. Current research results provide two examples that illustrate differing degrees of user interaction in terms of subjective criteria evaluation, the extraction, processing and presentation of high quality information and the associated improvement of machine-based problem representation. The first example relates to the inclusion of subjective aesthetic criteria to complement quantitative evaluation in the conceptual design of bridge structures. The second relates to the succinct graphical presentation of complex relationships between variable and objective space and the manner in which this can support a better understanding of a problem domain.. This improved understanding can contribute to the iterative improvement of initial machine-based representations. Both examples complement and add to earlier research relating to interactive evolutionary design systems (IEDS).

28. Double Duty: Genetic Algorithms for Organizational Design and Genetic Algorithms Inspired by Organizational Theory

Tian-Li Yu, University of Illinois at Urbana-Champaign, USA, Yassine, Ali A., University of Illinois at Urbana-Champaign, USA, Goldberg, David, University of Illinois at Urbana-Champaign, USA,

Modularity is widely used in system analysis and design such as complex engineering products and their organization, and modularity is also the key to solve optimization problems efficiently via problem decomposition. We first discover modularity in a system, and then leverage this knowledge to improve the performance of the system. In this chapter, we tackle both problems with the alliance of organizational theory and evolutionary computation. First, we cluster the dependency structure matrix (DSM) of a system using a simple genetic algorithm (GA) and an information theoretic based metric. Then we design a better GA through the decomposition of the optimization problem using the proposed DSM clustering method.

29. Autonomous Systems with Emergent Behavior

Di Marzo, Giovanna, University of Geneva, Swizerland

This chapter presents the notion of autonomous engineered systems working without central control, through self-organization and emergent behavior. It argues that future large scale applications from domains as diverse as networking systems, manufacturing control, or e-government services will benefit from being based on such systems. The goal of this chapter is to highlight engineering issues related to such systems, and to discuss some potential applications.

30. An Evolutionary Algorithm for Decisional Assistance to Project Management

Rochet, Samuel, LESIA, INSA Toulouse, France, Baron, Claude, LESIA, INSA Toulouse, France

Manufacturers have to develop products always faster and better, to satisfy their client's requirements. To help them, we have developed and experimented a methodology improving the management process by connecting it with the design process. An issue for the project manager is to select an organization among the possible ones to schedule the project tasks in order to reach the targets in terms of costs, duration, quality, etc. This constitutes a tricky operation because many options, defined during the design, can be associated to each task of the project. Choosing and optimizing the schedules is a combinatorial problem which can be solved by heuristic. This document explores the use of evolutionary algorithms to help the decision-maker. It introduces the industrial context then presents our methodology to connect the design and project management processes expressing the problem as a multiobjective optimization one, and details the scenarios selection process. Finally, it demonstrates which performances are obtained.

31. Pareto-optimality in Design and Manufacturing and how Genetic Algorithms handle it

Chakraborti, Nirupam, Indian Institute of Technology, India

An informal analysis is provided for the basic concepts associated with multi-objective optimization and the notion of Pareto-optimality, particularly in the context of Genetic Algorithms. A number of evolutionary algorithms developed for this purpose are also briefly introduced and finally, a number of paradigm examples are presented from the materials and manufacturing sectors where multi-objective genetic algorithms have been successfully utilized in the recent past.

Section 2.2- Operations and Supply Chain Management

32. Evolutionary Optimization in Production Research

Dimopoulos , Christos, Cyprus College, Cyprus

This chapter provides a short guide on the use of evolutionary computation methods in the field of production research. The application of evolutionary computation methods is explained using a number of typical examples taken from the areas of production scheduling, assembly lines and cellular manufacturing. A detailed case study on the solution of the cell-

formation problem illustrates the benefits of the proposed approach. The chapter also provides a critical review on the up-to-date use of evolutionary computation methods in the field of production research and indicates potential enhancements as well as promising application areas. The aim of the chapter is to present researchers, practitioners and managers with a basic understanding of the current use of evolutionary computation techniques and allow them to either initiate further research or employ the existing algorithms in order to optimize their production lines.

33. Ant Colony Optimization and Multiple Knapsack Problem

Fidanova, Stefka, Bulgarian Academy of Science, Bulgaria

The Ant Colony Optimization algorithms and their applications on the Multiple Knapsack Problem (MKP) are introduced. The MKP is a hard combinatorial optimization problem with wide application. Problems from different industrial fields can be interpreted as a knapsack problem including financial and other management. The MKP is represented by graph and solutions are represented by paths through the graph. Two pheromone models are compared: pheromone on nodes and pheromone on arcs of the graph. The MKP is a constraint problem which provides possibilities to use varied heuristic information. The purpose of the author is to compare a variety of heuristic and pheromone models and different variants of ACO algorithms on MKP.

34. A new way to Reorganize a Productive Department in Cells through the Help of the Ant Behavior

Brun, Alessandro, Politecnico di Milano, Italy, Zorzini, Marta, Politecnico di Milano, Italy

The authors propose an algorithm for the reorganization of a production department in cells, starting from a situation of job shop, chasing the main goal of Group Technology (GT), i.e. to gather pieces with similar technological cycles and to associate every group of items (family) to a group of machines (cell) able to realize all the necessary activities. To get this result, a behavioral pattern has been developed, having its origin in the ants' way of sorting food, larva and pupa in an anthill. As first results have shown, such an approach turns out to be interesting, provided that the algorithm parameters are adequately set.

35. Agent-Oriented Modeling and Simulation of Distributed Manufacturing

Taveter, Kuldar , University of Melbourne, Australia, Wagner, Gerd, Brandenburg University of Technology at Cottbus, Germany

This chapter proposes an agent-oriented method for modeling and simulation of distributed production environments. The proposed method views a manufacturing enterprise as consisting of active entities – agents. The method makes use of the Radical Agent-Oriented Process (RAP) methodology introduced by Taveter & Wagner (2005) which is based on Agent-Object-Relationship (AOR) modeling. The chapter first presents the AOR Modeling Language and the RAP/AOR viewpoint modeling framework of the methodology. Thereafter its lays out principles of turning the modeling constructs of the RAP/AOR methodology into the implementation constructs of a simulation environment and briefly describes the simulation environment. The method is aimed at the creation of environments for modeling and simulation of distributed manufacturing.

36. Application of RAP/AOR to the Modeling and Simulation of a Ceramic Factory

Taveter, Kuldar, University of Melbourne, Australia.

This chapter describes the application of the RAP/AOR methodology proposed by Taveter & Wagner (2005a, 2005b) to the modeling and simulation of a real ceramic factory. The chapter addresses the modeling of the ceramic factory from the interaction, information and behavior aspects of the framework. The chapter also discusses simulation of business and manufacturing processes of the ceramic factory by executing the process models developed using the RAP/AOR methodology. The method is aimed at the creation of simulation environments and automation systems of distributed manufacturing.

37. Building Distribution Networks Using Cooperating Agents

Urquhart, Neil, Napier University, UK

This chapter examines the use of emergent computing to optimize solutions to logistics problems. The chapter initially explores the use of agents and evolutionary algorithms to optimize postal distribution networks. The structure of the agent community and the means of interaction between agents is based on social interactions previously used to solve these problems. The techniques developed are then adapted for use in a dynamic environment planning the dispatch of goods from a supermarket. These problems are based on real-world data, in terms of geography and constraints. The author hopes that this will inform researchers as to the suitability of emergent computing in real-world scenarios and the abilities of agent based systems to mimic social systems.

38. Games, Supply chains and Automatic Strategy Discovery using Evolutionary Computation

Gosling, Tim, University of Essex, UK, Nanlin, Jin, University of Essex, UK, Tsang, Edward, University of Essex, UK

The use of Evolutionary Computation is significant for the development and optimization of strategies for dynamic and uncertain situations. This chapter introduces three cases in which Evolutionary Computation has already been used successfully for strategy generation in the form of work on the Iterated Prisoners Dilemma, Rubinstein's Alternating Offers Bargaining Model and the Simple Supply Chain Model. The first two of these show how Evolutionary Computation has been applied to extensively studied, well known problems. The last of these demonstrates how recent statistical approaches to Evolutionary Computation have been applied to more complex supply chain situations that traditional game-theoretical analysis has been unable to tackle. The authors hope that the chapter will promote this approach, motivate further work in this area and provide a guide to some of the subtleties involved in applying Evolutionary Computation to different problems.

39. Applications of Neural Networks in Supply Chain Management

Minis, Ioannis, University of the Aegean, Greece, Ampazis, Nikolaos, University of the Aegean, Greece

This chapter focuses on significant applications of Self Organizing Maps (SOMs), i.e. unsupervised learning neural networks, in two supply chain applications: Cellular manufacturing, and real time management of a delayed delivery vehicle. Both problems require drastic complexity reduction, which is addressed effectively by clustering using SOMs. In the first problem, we cluster machines into cells and we use Latent Semantic

Indexing for effective training of the network. In the second problem, we group the distribution sites into clusters based on their geographical location. The available vehicle time is distributed to each cluster by solving an appropriate non-linear optimization problem. Within each cluster an established Orienteering heuristic is used to determine the clients to be served and the vehicle route. Extensive experimental results indicate that in terms of solution quality our approach outperforms, in general, previously proposed methods. Furthermore, the proposed techniques are more efficient, especially in cases involving large numbers of data points. Neural networks have and will continue to play a significant role in solving effectively complex problems in supply chain applications, some of which are also highlighted in this Chapter.

40. JGA: An Object-Oriented Framework for Rapid Development of Genetic Algorithms

Medaglia, Andrès L., Universidad de los Andes, Colombia, Gutiérrez, Eliécer, Universidad de los Andes, Colombia

JGA, acronym for Java Genetic Algorithm, is a computational object-oriented framework for rapid development of evolutionary algorithms for solving complex optimization problems. This chapter describes the JGA framework and illustrates its use on the dynamic inventory lot-sizing problem. Using this problem as benchmark, JGA is compared against three other tools, namely, GAlib, an open C++ implementation; GADS, a commercial Matlab® toolbox; and PROC GA, a commercial (yet experimental) SAS® procedure. JGA has proved to be a flexible and extensible object-oriented framework for the fast development of single (and multiobjective) genetic algorithms by providing a collection of ready-to-use modules (Java classes) that comprise the nucleus of any genetic algorithm. Furthermore, JGA has also been designed to be embedded in larger applications that solve complex business problems.

41. Applications of JGA to Operations Management and Vehicle Routing

Medaglia, Andrès L., , Universidad de los Andes, Colombia, Gutiérrez, Eliécer, , Universidad de los Andes, Colombia

Two of the most complex activities in Productions and Operations Management (POM) are inventory planning and operations scheduling. This chapter presents two problems related to these activities, namely, the Capacitated Lot-Sizing and Scheduling Problem and the Capacitated Vehicle Routing Problem. For each of these problems, the authors discuss several solution methods, present a competitive genetic algorithm, and describe its implementation in the Java Genetic Algorithm (JGA) framework. The purpose of this chapter is to illustrate how to use JGA to model and solve complex business problems arising in POM. The authors show that JGA-based solutions are quite competitive and easier to implement than widely-used methods found in the literature.

42. Solving Facility Location Problems using a Tool for Rapid Development of Multi-Objective Evolutionary Algorithms (MOEAs)

Medaglia, Andrès L., , Universidad de los Andes, Colombia, Gutiérrez, Eliécer, , Universidad de los Andes, Colombia, Villegas, Juan G., Universidad de Antioquia, Colombia

The low price of coffee in the international markets has forced the Federación Nacional de Cafeteros de Colombia (FNCC) to look for cost-cutting opportunities. An alternative that has been considered is the reduction of the operating infrastructure by closing some of the FNCC-

owned depots. This new proposal of the coffee supplier network is supported by (uncapacitated and capacitated) facility location models that minimize operating costs while maximizing service level (coverage). These bi-objective optimization models are solved by means of NSGA II, a multiobjective evolutionary algorithm (MOEA). From a computational perspective, this chapter presents the Multi-Objective Java Genetic Algorithm (MO-JGA) framework, a new tool for the rapid development of MOEAs built in top of the Java Genetic Algorithm (JGA). We illustrate MO-JGA by implementing NSGA II-based solutions for the bi-objective location models.

43. Worker Performance Modeling in Manufacturing. Simulation: Proposition of an Agent-Based Approach

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Discrete event simulation is generally recognized as a valuable aid to the strategic and tactical decision making that is required in the evaluation stage of the manufacturing systems design and redesign processes. It is common practice to represent workers within these simulation models as simple resources, often using deterministic performance values derived from time studies. This form of representing the factory worker ignores the potentially large effect that human performance variation can have on system performance and it particularly affects the predictive capability of simulation models with a high proportion of manual tasks. The intentions of the chapter are twofold: firstly, to raise awareness of the importance of considering human performance variation in such simulation models and secondly, to present some conceptual ideas for developing a multi-agent based approach for representing worker performance in manufacturing systems simulation models.

Section 2.3- Information Systems

44. Towards An Agent-Oriented Paradigm of Information Systems

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This chapter presents a meta-model of information systems as a foundation for the methodology of caste-centric agent-oriented software development, which is suitable for applications on the Internet/Web platform and the utilization of mobile computing devices. In the model, the basic elements are agents classified into a number of castes. Agents are defined as active computational entities that encapsulate (a) a set of state variables, (b) a set of actions that the agents are capable of performing, (c) a set of behavior rules that determine when the agents will change their states and when to take actions, and (d) a definition of their environments in which they operate. Caste is the classifier of agents and the modular unit of the systems. It serves as the template that defines the structure and behavior properties of agents as class does for objects. Agents can be declared statically or created dynamically at runtime as instances of castes. This chapter also illustrates the advantages of agent-oriented information systems by an example.

45. Caste-centric Development of Agent Oriented Information

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Based on the meta-model of information systems presented in (Zhu, 2006), this chapter presents a caste-centric agent-oriented methodology for evolutionary and collaborative development of information systems. It consists of a process model called growth model and a set of agent-oriented languages and software tools that support various development activities in the process. At the requirements analysis phase, a modeling language and environment CAMLE supports the analysis and design of information systems. The semi-formal models in CAMLE can be automatically transformed into formal specifications in SLABS, which is a formal specification language designed for formal engineering of multi-agent systems. At implementation stage, agent-oriented information systems are implemented directly in an agent-oriented programming language called SLABSp. The features of agent-oriented information systems in general and our methodology in particular are illustrated by an example throughout the chapter.

46. Evolving Learning Ecologies

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This chapter describes the application of self-organizing principles to the field of e-learning. It argues that traditional managed approaches to e-learning suffer from deficiencies both in cost and adaptativity that are addressed through the application of nature-inspired processes such as stigmergy and evolution. Such systems, primarily those employing social navigation, are built to generate structure through the dialogue-like interactions of individual learners within them. The result is emergent control of the learning process, adapting dynamically to learner needs, with limited teacher involvement. The chapter describes some example applications and explores some of the remaining challenges in the field, most notably in encouraging pedagogically useful structures to evolve.

47. Efficient Searching in Peer-to-Peer Networks using Agent Enabled Ant Algorithms

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In this chapter we describe a mechanism to search for resources in unstructured peer-to- peer (P2P) networks using ant algorithms implemented through software agents. Traditional resource search algorithms in P2P networks use an uninformed or blind search among the various nodes of the network. In contrast, the resource search algorithm described in this chapter performs an informed search using the ant-based heuristic. In our algorithm, ants, implemented as software agents, are created in response to a user’s resource search query. An ant reinforces the route that yields a successful search for directing ants in the future towards nodes with higher probability of locating resources. We describe and compare different reinforcement strategies used by ants to perform efficient resource search in P2P networks.

Section 2.4- Commerce and Negotiation

48. An Annealing Protocol for Negotiating Complex Contracts

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Work to date on negotiation protocols has focused almost exclusively on defining contracts consisting of one or a few independent issues and relatively small number of possible contracts. Many real-world contracts, by contrast, are much more complex, consisting of multiple interdependent issues and intractably large contract spaces. This chapter describes a simulated annealing based approach appropriate for negotiating such complex contracts that achieves near-optimal social welfare for negotiations with binary issue dependencies.

49. Agents for Multi-Issue Negotiation

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This chapter describes a generic multi-issue negotiating agent that is designed for a dynamic information-rich environment. The agent strives to make informed decisions by observing signals in the marketplace and by observing general information sources including news feeds. The agent assumes that the integrity of some of its information decays with time, and that a negotiation may break down under certain conditions. The agent makes no assumptions about the internals of its opponent — it focuses only on the signals that it receives. Two agents are described. The first agent conducts multi-issue bilateral bargaining. It constructs two probability distributions over the set of all deals: the probability that its opponent will accept a deal, and the probability that a deal should be accepted by the agent. The second agent bids in multi-issue auctions — as for the bargaining agent, this agent constructs probability distributions using entropy-based inference.

50. An introduction to Evolutionary Computation in Auctions: the Ausubel Format

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The increasing use of auctions as a selling mechanism has led to a growing interest in the subject. Thus both auction theory and experimental examinations of these theories are being developed. A recent method used for carrying out examinations on auctions has been the design of computational simulations. The aim of this chapter is to give a background about auction theory and to present how Evolutionary Computation techniques can be applied to auctions. Besides, a complete review to the related literature is also made. Finally, an explained example shows how a genetic algorithm can help finding automatically bidders´ optimal strategies for a specific dynamic multi-unit auction: the Ausubel auction, with private values, drop-out information and with several rationing rules implemented. The method provides the bidding strategy (defined as the action to be taken under different auction conditions) that maximizes the bidder’s payoff. The algorithm is tested under several experimental environments that differ in the elasticity of their demand curves, number of bidders and quantity of lots auctioned. The results suggest that the approach leads to strategies that outperform sincere bidding when rationing is needed.

51. Supporting Virtual Organizations through Electronic Institutions and Normative Multi-Agent Systems

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The Multi-Agent Systems (MAS) paradigm has become a prominent approach in distributed artificial intelligence. Many real-world applications of MAS require ensuring cooperative outcomes in scenarios populated with self-interested agents. Following this concern, a strong research emphasis has been given recently to normative MAS. A major application area of MAS technology is e-business automation, including the establishment and operation of business relationships and the formation of Virtual Organizations (VOs). One of the key factors influencing the adoption of agent-based approaches in real-world business scenarios is trust. The concept of an Electronic Institution (EI) has been proposed as a means to provide a regulated and trustable environment, by enforcing norms of behavior and by providing specific services for smooth inter-operability. This chapter exposes our work towards the development of an agent-based EI providing a virtual normative environment that assists and regulates the creation and operation of VOs, through contract-related services. It includes a presentation of the EI framework, knowledge representation structures for norms in contracts, and a description of two main institutional services, namely negotiation mediation and contract monitoring.

Section 2.5-Marketing

52. Co-evolving Better Strategies in Oligopolistic Price Wars

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Using empirical market data from brand rivalry in a retail ground-coffee market, we model each idiosyncratic brand’s pricing behavior using the restriction that marketing strategies depend only on profit-relevant state variables, and use the Genetic Algorithm to search for co-evolved equilibria, where each profit-maximizing brand manager is a stimulus-response automaton, responding to past prices in the asymmetric oligopolistic market. It is part of a growing study of repeated interactions and oligopolistic behavior using the GA.

53. Social Anti-Percolation, Resistance and Negative Word-of-Mouth

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Many new products fail, despite preliminary market surveys having determined considerable potential market share. This effect is too systematic to be attributed to bad luck. We suggest an explanation by presenting a new percolation theory model for product propagation, where agents interact over a social network. In our model, agents who do not adopt the product spread negative word of mouth to their neighbors, and so their neighborhood becomes less susceptible to the product. The result is a dramatic increase in the percolation threshold. When the effect of negative word of mouth is strong enough, it is shown to block any product from spreading to a significant fraction of the network. So, rather than being rejected by a large fraction of the agents, the product gets blocked by the rejection of a negligible fraction

of the potential market. The rest of the potential buyers do not adopt the product because they are never exposed to it: the negative word of mouth spread by initial rejectors suffocates the diffusion by negatively affecting the immediate neighborhood of the propagation front.

54. Complexity Based Modeling Approaches for Commercial Applications

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Understanding complex socio-economic systems is a key problem for commercial organizations. In this chapter we discuss the use of Agent Based Modeling to produce decision support tools to enhance this understanding. We consider the important aspects of the model creation process, which include the facilitation of dialogue necessary to extract knowledge, the building of understanding, and the identification of model limitations. It is these aspects that are crucial in the establishment of trust in a model. We use the example of modeling opinion diffusion within a customer population and its effect on product adoption to illustrate how the Agent Based Modeling technique can be an ideal tool to create models of complex socioeconomic systems. We consider the advantages compared to alternative, more conventional approaches available to analysts and management decision makers.

Section 2.6-Finance

55. Spatiotemporal Forecasting of Housing Prices by Use of Genetic Programming

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This chapter compares forecasts of the median neighborhood prices of residential single-family homes in Cambridge, Massachusetts, using parametric and nonparametric techniques. Prices are measured over time (annually) and over space (by neighborhood). Modeling variables characterized by space and time dynamics is challenging. Multi-dimensional complexities - due to specification, aggregation, and measurement errors – thwart use of parametric modeling; and nonparametric computational techniques (specifically genetic programming and neural networks) may have the advantage. To demonstrate their efficacy, forecasts of the median prices are first obtained using a standard statistical method: weighted least squares. Genetic programming and neural networks are then used to produce two other forecasts. Variables used in modeling neighborhood median home prices include economic variables such as neighborhood median income and mortgage rate as well as spatial variables that quantify location. Two years out-of-sample forecasts comparisons of median prices suggest that genetic programming may have the edge.

56. Multiattribute Methodologies in Financial Decision Aid

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This chapter introduces the capability of the numerical Multi Dimensional Approach to solve complex problems in Finance. It is well known how with the growth of computational resource, the scientists have developed numerical algorithms for the resolution of complex systems, in order to find the relations between the different components. One important field in this research is focused on the mimic of Nature behavior to solve problems. In this chapter

two technologies based on these techniques, Self Organizing Maps and Multi Objectives Genetic Algorithm, have been used to solve two important fields in the Finance: the Country Risk assessment and the time series forecasting. The authors with the examples in the chapter would like to demonstrate how a Multi Dimensional Approach based on the mimic of Nature could be useful to solve modern complex problems in Finance.

57. Multiobjective Optimization Evolutionary Algorithms for Mathematical Models of underlying catastrophic loss index of Insurance-Linked Derivatives

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This work addresses a real-world adjustment of economic models where the application of robust and global optimization techniques is required. The problem dealt is the search of a set of parameters to calculate the reported claim amount. Several functions are proposed to obtain the reported claim amount and a multi-objective optimization procedure is used to obtain parameters using real data and decide the best function to approximate the reported claim amount. Using this function, insurance companies negotiate the contract underlying that is the catastrophic loss ratio defined from the total reported claim amount. They are associated to occurred catastrophes during the loss period and declared until the development period expired. The suitability of different techniques coming from Evolutionary Computation (EC) to solve this problem is explored, contrasting the performance achieved with recent proposals of Multi-Objective Evolutionary Algorithms (MOEAs). Results show the advantages of MOEAs in the proposal in terms of effectiveness and completeness in searching solutions, compared with particular solutions of classical EC approaches (using an aggregation operator) in problems with real data.

58. Modeling an Artificial Stock market: When Information Influence Market Dynamics

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This chapter presents an artificial stock market created to analyze market dynamics from the behavior of investors. It argues that information – delivered by financial intermediaries as rating agencies and considered as cognitive institution – directs the decisions of investors who are heterogeneous agents endowed with capabilities of learning in a changing environment. The objective is to demonstrate that information influences market dynamics as it allows the co-ordination of the decisions of investment in the same direction: information is a focal point for investors and contributes to generate a speculative dynamic on the market.