Preface

It is a great privilege for anyone to be part of any event with historic significance. This year the European Conference on Modelling and Simulation reaches the 30th milestone and I have the honour of being the President of the European Council for Modelling and Simulation as the scientific organization behind the conference. To mark this significant occasion, Springer Verlag is publishing this memorial book of selected high-impact articles from the keynotes and best papers of the last 5 years.

Modelling and simulation have become an integral part of every design process from the planning stages all through to the evaluation and validation of implementation and even beyond. Simulation has been the methodology used to designing vehicles for space explorations, in testing ideas for industrial processes and products and to understand human and living objects behaviour. It is not far from truth to state that every researcher in science, engineering, economics or medical science must have some involvement with modelling and/or simulation at various levels.

Simulation in Europe has long history and traditions and the modelling and simulation community has played significant role in the advancement of the modelling and simulation science and methodologies and effective application of the methodologies in numerous fields. The Modelling and Simulation community in Europe and as part of the international research community expressed its presence in various forums and conferences. One of the most important forums is the European Conference on Modelling and Simulation (ECMS) which is the international conference dedicated to help define the state of the art in the field. For the last 27 years, ECMS has proven to be an outstanding forum for researchers and practitioners from different fields involved in creating, defining and building innovative simulation systems, simulation and modelling tools and techniques, and novel applications for modelling and simulation. In the first chapter of this book, Professor Eugene Kerckhoffs, the first president of the European Council for Modelling and Simulation (known then as the Society of Computer Simulation—Europe) gives an account on the history of the council and the conference.

Over the last 29 episodes of the ECMS, generations of great scientists presented their work on modelling and simulation. Some were contributing to the advancement of the discipline itself, while other presenting significant contribution to other sciences and disciplines using simulation. In particular, the conference series witness countless significant keynote talks presenting significant and cutting-edge results in many areas that would require a multi-volume book to report on.

In this book, the editors opted to highlight a significant and exciting area in the application of modelling and simulation, namely the modelling of human brain. This is a common theme among the first three contributions in the book in Chaps. 2–4.

In the seminal talk in ECMS2014, Professor May-Britt Moser from the Norwegian University of Science and Technology and Nobel Prize Winner in 2014 in Physiology or Medicine, presented the results of her research on how the brain controls spatial navigation in mammals by activating functionally specialized cell types in the medial temporal lobe. A brief account of the content of the talk is given in Chap. 2.

Related to the topic, Professor Steve Grossberg reported on further research on medial entorhinal grid cells and hippocampal place cells are crucial elements in brain systems for spatial navigation and episodic memory. In his extended Abstract in Chap. 3, he summarizes the development of the GridPlaceMap neural model that explains many data about these cells and behaviours in a unified way. He also gives a thorough reference list to summarize and simulate these data. The chapter provides a high-level overview of the results, along with the unifying neural design principles and mechanisms that enable them to be realized.

Further account of significant advancement in the field is reported in Chap. 4 with the article by Professors Peter D. Neilson and Megan D. Neilson entitled "Modelling the Modeller". The authors explain that the Adaptive Model Theory is a computational theory of the brain processes that control purposive coordinated human movement. It sets out a feedforward–feedback optimal control system that employs both forward and inverse adaptive models of (i) muscles and their reflex systems, (ii) biomechanical loads on muscles and (iii) the external world with which the body interacts. From a computational perspective, formation of these adaptive models presents a major challenge.

Moving out of the human body but still in relation with human behaviour, Professor Alexander H. Levis from George Mason University, USA presents in Chap. 5 a detailed account of his work on the modelling of a human organization for the analysis of its behaviour in response to external stimuli is a complex problem which requires development and interoperation of a set of several models. Each model developed using different modelling languages but the same data, offers unique insights and makes specific assumptions about the organization being modelled. Prof. Levis shows that interoperation of such models can produce a more robust modelling and simulation capability to support analysis and evaluation of the organizational behaviour.

As a significant contribution to the simulation methodology, Professor Martin Ihrig, University of Pennsylvania, presents new research architecture for the simulation era in Chap. 6. This chapter proposes novel research architecture for social scientists that want to employ simulation methods. The new framework gives an integrated view of a research process that involves simulation modelling. It highlights the importance of the theoretical foundation of a simulation model and shows how new theory-driven hypotheses can be derived that are empirically testable. The author describes the different aspects of the framework in detail and shows how it can help structure the research efforts of scholars interested in using simulations.

Further significant contribution to the modelling and simulation methodology is presented in Chap. 7 by Professor Witold Pedrycz from the University of Alberta with the title "Fuzzy Modeling and Fuzzy Collaborative Modeling: A Perspective of Granular Computing". The author elaborates on current developments in fuzzy modelling, especially fuzzy rule-based modelling, by positioning them in the general setting of Granular Computing. This gives rise to granular fuzzy modelling where the models built on a basis of fuzzy models are then conceptually augmented and made in rapport with experimental data. In the chapter, two main directions of granular fuzzy modelling dealing with distributed data and collaborative system modelling and transfer knowledge are formulated and the ensuing design strategies are outlined.

Staying with contributions to the methodology, Zuzana Kominkova Oplatkova and Roman Senkerik from Tomas Bata University in Zlin, Czech Republic present in Chap. 8 an article on control law and pseudo neural networks synthesized by the evolutionary symbolic regression technique. This research deals with the synthesis of final complex expressions by means of an evolutionary symbolic regression technique—analytic programming (AP)—for novel approach to classification and system control. In the first case, classification technique, a pseudo neural network is synthesized, i.e. relation between inputs and outputs are created. The inspiration came from classical artificial neural networks where such a relation between inputs and outputs is based on the mathematical transfer functions and optimized numerical weights. AP will synthesize a whole expression at once. The latter case, the AP, will create a chaotic controller that secures the stabilization of stable-state and high-periodic orbits—oscillations between several values of the discrete chaotic system. Both cases will produce a mathematical relation with several inputs; the latter case uses several historical values from the time series.

In January 2012, the world woke up on the news of a horrific accident in which a cruise liner called Costa Concordia hit a rock in the shores of Italy. This resulted is a significant loss of lives. As the investigations started, the Court was looking for methods to create better understanding of what caused the accident. It happened that the Italian group of researchers (Paolo Neri and Bruno Neri from University of Pisa and Paolo Gubian and Mario Piccinelli from University of Brescia) have developed a simple but reliable methodology for short-term prediction of a cruise ship behaviour during manoeuvres. The methodology is quite general and could be applied to any kind of ship, because it does not require the prior knowledge of any structural or mechanical parameter of the ship. It is based only on the results of manoeuvrability data contained in the Manoeuvring Booklet, which in turn is filled out after sea trials of the ship are performed before its delivery to the owner. The team developed this method to support the investigations around the Costa

Concordia shipwreck, which happened near the shores of Italy in January 2012. It was then validated against the data recorded in the “black box” of the ship, from which the authors have been able to extract an entire week of voyage data before the shipwreck. The aim was investigating the possibility of avoiding the impact by performing an evasive manoeuvre (as ordered by the Captain some seconds before the impact, but allegedly misunderstood by the helmsman). The preliminary validation step showed a good matching between simulated and real values (course and heading of the ship) for a time interval of a few minutes. Chapter 9 gives a full account of the work by the Research team as presented in ECMS conference.

In engineering it is usually necessary to design systems as cheap as possible whilst ensuring that certain constraints are satisfied. Computational optimization methods can help to find optimal designs automatically. However, the team of Lars Nolle (Jade University of Applied Science), Ralph Krause (Siemens AG) and Richard J. Cant (Nottingham Trent University) demonstrated in the work in Chap. 10 that an optimal design is often not robust against variations caused by the manufacturing process, which would result in unsatisfactory product quality. In order to avoid this, a meta-method is used in here, which can guide arbitrary optimization algorithms towards more robust solutions. This was demonstrated on a standard benchmark problem, the pressure vessel design problem, for which a robust design was found using the proposed method together with self-adaptive step-size search, an optimization algorithm with only one control parameter to tune. The drop-out rate of a simulated manufacturing process was reduced by 30 % whilst maintaining near minimal production costs, demonstrating the potential of the proposed method.

The last three chapters of the book comprise significant contributions to the analytical and stochastic modelling which were presented as part of the International Conference on Analytical and Stochastic Modelling and Applications that have been collocated with the ECMS conference.

In Chap. 11, Dieter Fiems, Stijn De Vuyst, and Herwig Bruneel, all from Ghent University discuss in Chap. 5 the packet loss problem which is an important and fundamental problem in queueing systems and their applications in modelling communications networks. Buffer overflow in intermediate network routers is the prime cause of packet loss in wired communication networks. Packet loss is usually quantified by the packet loss ratio, the fraction of packets that are lost in a buffer. While this measure captures part of the loss performance of the buffer, the authors show that it is insufficient to quantify the effect of loss on user-perceived quality of service for multimedia streaming applications.

Approximating various real-world observations with stochastic processes is an essential modelling step in several fields of applied sciences. In Chap. 12, Gabor Horvath and Miklos Telek from Budapest University of Technology and Economics, present fitting methods based on distance measures of marked Markov arrival processes. They focus on the family of Markov-modulated point processes, and propose some fitting methods. The core of these methods is the computation of the distance between elements of the model family. They first introduce a methodology for computing the squared distance between the density functions of two phase-type (PH) distributions. Later, they generalize this methodology for computing the distance between the joint density functions of k-successive inter-arrival times of Markovian arrival processes (MAPs) and marked Markovian arrival processes (MMAPs).

Chapter 13 of the book presents a very interesting modelling concept called "Markovian Agent Models". A Markovian Agent Model (MAM) is an agent-based spatiotemporal analytical formalism aimed to model a collection of interacting entities guided by stochastic behaviours. An MA is characterized by a finite number of states over which a transition kernel is defined. Transitions can either be local, or induced by the state of other agents in the system. Agents operate in a space that can be either continuous or composed by a discrete number of locations. MAs may belong to different classes and each class can be parameterized depending on the location in the geographical (or abstract) space. In this chapter, Andrea Bobbio, Davide Cerotti, Marco Gribaudo, Mauro Iacono and Daniele Manini (Italy) provide a very general analytical formulation of a MAM that encompasses many kinds of forms of physical dependencies among objects and many ways in which the spatial density may change in time.

As stated at the beginning of the Preface, the field of modelling and simulation cover huge range of theoretical and application areas that cannot be covered in one book. The articles selected in this volume represent a small sample of the contributions over 29 conference and they meant to mark the 30th ECMS conference. On this occasion it is important to mention few people whose contributions (scientific or organizational) allowed the conference and the council to reach this significant milestone. The list will definitely not be comprehensive but I would like to mention Professor Eugene Kerckhoffs, first President of the Council, Professor Andrzej Bargiela, Past President, Dr. Evtim Petychev, Past President and Mrs Martina-Maria Seidel, ECMS Officer Manager and the tireless driving force behind the organization of all ECMS conference. Specifically, for the help in editing this book, I would like to thank Professor Robin Bye from Norwegian University of Science and Technology and General Chair of ECMS2014 for his help in getting several contributions.

Finally, the European Council for Modelling and Simulation is very grateful to the Simon Rees, Associate Editor, Computer Science, in Springer Verlag for the initiative to publish this book and for the help provided all through the process.

Prof. Khalid Al-Begain
President of the European Council of Modelling and Simulation

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