Editorial

Agostino G.Bruzzone

MISS-DIPTEM,
University of Genoa, Italy
E-mail: agostino@itim.unige.it

Biographical note: Agostino G. Bruzzone is Full Professor at DIPTEM University of Genoa, Director of M&S Net (International Network involving 34 Centres), Director of the MISS McLeod Institute of Simulation Science – Genoa Center (over 28 Centres distributed worldwide), founder member and president of the Liophant Simulation, a member of the board of MIMOS (Movimento Italiano di Simulazione) and a member of the NATO MSG. He works on innovative modelling, AI techniques, application of neural networks, GAs and fuzzy logic to industrial plant problems using simulation and chaos theory. He is a member of several international technical and organisation committees (i.e., AI Application of IASTED, AI Conference, ESS, ESM, AMS) and General Coordinator of Scientific Initiatives (i.e., General Chair of SCSC and I3M). He teaches M&S, M&S for Biomedical Systems and VV&A for the DIMS PhD Program (DIMS, Doctor ship in Integrated Mathematical M&S). He is Director of the Masters Program in Industrial Plants for the University of Genoa. His courses include Project Management and Industrial Plants at the University for Mechanical Engineering (4th year), Management Engineering (5th year) and Industrial Engineering (3rd year) degree programmes.

Nowadays, the effectiveness of simulation-based approaches is clearly established and the experience gained over the years allows to point out the continuous growth of Modelling and Simulation (M&S) as well as the potential uses of M&S in many application areas.

The historical perspective of M&S reveals not only the evolutionary path that M&S tools (currently in use) have followed but also the new directions for future evolution of M&S. Actually, the history of simulation can be written from many perspectives: uses of simulation (analysis, decision support, training, research, etc.); types of simulation models (discrete-event, continuous, combined discrete-continuous, distributed and parallel, etc.); simulation programming languages and environments (GPSS, SIMSCRIPT, SIMULA, SLAM, Arena, AutoMod, Simio, etc.); and application domains or communities of interest (industry, manufacturing, military, logistics, communications, etc.) (Bruzzone and Kerckhoffs, 1996). Generally speaking, M&S comes from the natural human desire to remove risk from the decision making process: in ancient times, rules often relied on prophets to foretell the outcome of a military action. In modern times, the same desire is manifested in sophisticated models used to closely examine and statistically anticipate the outcome of particular actions and manoeuvres. Methodologies have changed but the overarching goals remain constant: risk reduction and better decision making (McHaney, 2009, Longo, 2011).

The first applications of M&S can be traced back to the period of the Roman Empire, with the so-called ‘naumachia’, but the beginning of the modern era of simulation can be dated back in the 1950s when computer simulation was introduced. In that period, the advent of general purposes programming languages greatly benefited the simulation community. Early simulation models, mainly used in the defence industry, were built using programming languages and run on mainframes. The 1960s saw the first special purpose simulation languages, such as GPSS (Schriber 1974), SIMSCRIPT (Markowitz et al., 1963) and SIMULA (Dahl and Nygaard 1966) and the use of simulation spread out (from the military industry) to other industries, including manufacturing and finance. However simulations were just lines of computer code that allowed, by providing input data, to acquire the results of simulation runs. Amiry (1965) was among the first to provide an animation of the running simulation model providing the users with a major understanding of the model.

Meanwhile, on the theory side, researchers laid out the central problems of digital simulation, detecting two main issues namely construction and use of simulation (Conway et al., 1959; Conway, 1963). Conway showed remarkable insights into the problems and solution strategies that would shape the next years of simulation methodologies.

In the 1970s computer technology continued to advance with the introduction of the microprocessor and the microcomputer outlining the potentials for simulation that were both visual and interactive. This resulted in the development of the first Visual Interactive Simulation (VIS) language in 1979, SEE-WHY (Fiddy et al., 1981). In terms of discrete-event computer simulation modelling languages, this period recalls Pritkser and Hurst’s development of GASP IV (Pritsker and Hurst, 1973); Kiviat, Villanueva, and Markowitz’s development of SIMSCRIPT II.5 (Law and Larmey, 1984); Pritsker and Pegden’s development of SLAM (Pegden et al., 1979); Pegden’s development of SIMAN (Pegden et al., 1995) and Sargent’s contributions to formal verification and validation (Sargent, 1979). A detailed description of the history of Simulation

Programming Languages is given in Nance (1996) and Gordon (1981).

The 1980s and 1990s saw the continuous development of computing, with the introduction of the PC (personal computer) and Windows technology, both leading to further developments in the simulation marketplace. During this period a wide range of simulation languages and simulators became available (Law and Kelton, 2000), thus making simulation available to a greater number of end users; established simulation software companies continued to expand their product lines with animation packages, simulation development toolkits and enhancements of existing languages (McHaney, 1991). The use of M&S has thrived mainly thanks to the technological advances in computer science that have allowed the development of simulators that were unthinkable even few years ago. Recent developments have seen improvements in the functionalities and animation capabilities of the simulation software (3D displays and real-time simulation for training and decision making purposes, Bruzzone et al., 2009; Longo and Mirabelli, 2009), greater compatibility with other simulation software packages (e.g., spreadsheets and databases), use of simulation across the world wide web and the introduction of simulation optimisers (Robinson, 2004).

This brief overview about the simulation evolution over the years clearly outlines the key role of computing technology in shaping the progress of simulation; on this purpose, revolutions in computer hardware, advances in computer software, computer graphics, human-computer interactions, computer networks and world wide web have played a critical role. These factors as well as those generated by the communities of simulation researchers and practitioners have been deeply analysed in Nance and Sargent (2002).

Therefore, M&S has matured in many ways and simulation has proved to be a day-to-day tool highly indispensable for complex system design, management and training. Starting from the military applications, M&S has made its way into diverse application domains; to name a few: science, human sciences, engineering, business and finance proving to be one of the most suitable methods for decision support, research, analysis and training. M&S has also proved to be able to provide proper responses under uncertainty, produce better results faster, saving enormous amounts of money which would otherwise be spent on pilot programmes and actual experiments. Practical examples of simulation used for decision making support in industry and manufacturing can be found in Bruzzone et al. (2007) and Cimino et al. (2009), while examples in supply chains and logistics can be found in De Sensi et al. (2008), Curcio and Longo (2009) and Bruzzone et al. (2011).

Also, new emerging fields now rely on extensive use of simulation, such as the gaming industry that places on the market futuristic games based on virtual reality and interactive simulation (see Zyda, 2005; Liarokapis, 2006; Bruzzone and Longo, 2010). Furthermore, interactive simulators are being increasingly used for training on advanced equipment (i.e., airplanes, ships, quay cranes, etc.). Application examples can be found in Zeltzer et al. (1995), Park et al. (2001), Kwon et al. (2001), Lau et al. (2007), Seron et al. (1999), Kim (2005), Bruzzone and Longo (2008).

Also, distributed simulation, virtual environments and human behavioural models, introduced in the past few decades, have been disruptive innovations in the field of M&S. Considering distributed simulation (one of the emerging paradigms in M&S) it can be seen that its current adoption in the industry is rather low. There are some research challenges that must be addressed to advance and strengthen these technologies to a level where they are ready to be applied in day-to-day business in industry (Strassburger et al, 2008):

- articulate a clear business case for the adoption of these technologies
- take into account commercial requirements to a sufficient degree, in effect the existing solutions and standards are much more focused on the needs of the defence community
- overcome the need to perform a costly integration of the needed tools.

As mentioned above, another growing area of simulation includes behavioural models: the most common computational approach to human behaviour modelling is based on multi-agent systems. Agent-based modelling allows to overcome limitations of lumped models in human behaviour simulation and also allow to study the effect of individual behavioural models on the evolutionary behaviour of populations of varying size (Sokolowski and Banks, 2009). Software agents are maturing and agent-directed simulation is gaining acceptance. However, in agent-directed simulation, there are still very challenging areas such as controlling the autonomy of agents to assure their trustworthiness (Ören, 2002).

The future of simulation is not predictable, it is not under the control of individuals or researchers but the predominant role in shaping the future of simulation will be played by world events, public demand and technological evolution. Various driving forces and implementation mechanisms can be expected to propel simulation forward: revolutionary new technologies will emerge and change the field in ways that cannot be completely foreseen. Simulations may become more invisible and begin to blend into everyday life. Perhaps products will even be designed to allow users to create their own simulations.

The current research in this area, as reported in the following includes very interesting scientific activities about experiences and challenges in the development of advanced simulation studies for complex systems, including marine ports, manufacturing systems, power plants, supply chains. In particular special results were achieved in the following papers:

- *An agent-directed multisimulation framework for simulation games management* by Galina Merkuryeva, Jana Bkovska, Tuncer Ören: an overview of agent-directed applications in management of business simulation games is presented, analysing agents and agent-based software platforms. Furthermore, the scenario-based game management concept is introduced, and an agent-directed multisimulation framework for management of simulation games is proposed with an illustrative example for a specific web-based logistic simulation game.

- *Simulating the integration of original equipment manufacturer and suppliers in fractal environment* Sameh Saad and Julian Aririguzo: this paper presents a simulation model about the integration of Original Equipment Manufacturers (OEM) and key suppliers pointing out the critical factors that affect this partnership and quantifying the related benefits. The rationale of this work can be found in the tendency of many companies, especially in the automotive industry, to establish close relationships with their key suppliers aiming at maximising flexibility and improving the general operational effectiveness through exploiting synergies and lowering inventory levels.
- *Supply chain security: an integrated framework for container terminal facilities* by Francesco Longo: this paper presents an advanced simulation framework (The Security Advances in marine PORTS, SEAPORTS) for investigating and analysing security problems within marine ports environments (with specific regard to container terminals). The SEAPORTS framework recreates the whole complexity of a real marine port through a Modelling and Simulation Infrastructure (MSI) and two additional platforms: the Key Risks Modelling Platform (KRMP) and the Sensors Technology Management Platform (STMP). The first one is a generator of virtual risks and threats (generator of virtual risk scenarios) while the second one recreates virtual sensor technologies for detecting risks and threats within the marine port. The whole SEAPORTS architecture, based on the System of Systems idea, is the integration of the three architectural components above mentioned: the MSI, the KRMP and the SMTP that allow recreating the whole port reference scenario in a synthetic environment.
- *Optimisation analysis of power limits in flow energy systems* by Stanislaw Sieniutycz: in this paper the power of energy converters has been modelled and optimised through a thermodynamic approach. Two main results have been achieved in the study: the link between the mathematics of thermal engines and fuel cells and the common formalism based on the total heat, instead of the sensible heat, for thermal, chemical and electrochemical engines.
- *Reusing model components in logistics simulation and device emulation in container terminal operation with open-source framework DESMO-J* by Philip Joschko, Bernd Page and Christopher Brandt: an open-source Java simulation framework (*DESMO-J*) to evaluate and test container terminal control systems is proposed. The paper outlines that DESMO-J allows implementing model components in a very flexible way; these components are reusable and can be applied both in logistic simulation and in test beds.

These scientific researches resulted from a two-year effort that was carried out with the aim to provide readers with the most advanced methodologies and techniques in modelling and applied simulation and useful application examples in different fields and domains.

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