Editorial

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Computer simulation as well as numerical modelling and optimisation play an increasing role in contemporary engineering and science. The complexity of the systems considered in various fields has been constantly growing over the years and the theoretical models offer more and more accurate description of the physical phenomena, structures and devices. However, most of these models are far too complicated to be handled through analytical solutions: a computer simulation is required for majority of real-world applications, not only to evaluate the model, but also to exploit it in the design process. Advanced state-of-the-art commercial simulation software packages are available and used in everyday design work in mechanical engineering, civil engineering, aerospace industry, electrical engineering, and many others.

Computational optimisation has become an essential, and, in many cases, critical component of the design process. In almost all applications in engineering and industry it is necessary to maximise performance and efficiency, while at the same time, minimising the cost, size, weight, or energy consumption. This is usually a complex task that involves manipulation of available design parameters in order to find satisfactory values of one or more objectives that are evaluated through – often computationally expensive – computer simulations. In many cases, a number of constraints have to be satisfied in the optimisation process.

There are several factors due to which the search for optimal design can be complicated further. One of them is the presence of uncertainties that is common for most real-world systems. In particular, material properties and geometry of the manufactured device may differ from their nominal values as a result fabrication tolerances. Or, the actual operating conditions are different from the design conditions. Therefore, the optimisation process may seek the robust design which ensures the highest probability of satisfying the performance requirements under the presence of uncertainties, rather than just for the optimal design. Many optimisation problems are non-linear and NP-hard, that is, the solution time for finding optimal design grows exponentially with the problem size. In some cases the designer may face multiple local optima and the global search procedures are necessary. On the other hand, a number of practical problems have multiple and competing objectives where the optimum is obtained through a decision making process based on a set of Pareto-optimal solutions.

The fact that contemporary engineering design is heavily based on computer simulations introduces additional difficulties to optimisation. Growing demand for

accuracy and ever-increasing complexity of structures and systems results in the simulation process becoming increasingly time consuming. In many engineering fields, evaluation of a single design can take as long as several days, or even weeks, so that straightforward approaches by employing high-fidelity simulator directly in the optimisation loop are prohibitive. Interestingly, the increasing computational power of today's computers does not alleviate this problem because the availability of faster computers is compromised by the tendency of simulating more and more complex structures and systems with higher and higher accuracy. Furthermore, simulation-based objective functions are inherently noisy, which makes the optimisation process even more difficult. Still, simulation-driven design becomes a must for growing number of areas, which creates a need for robust and efficient optimisation methodologies that can yield satisfactory designs, even at the presence of analytically intractable objectives and limited computational resources.

Extensive research conducted in the area of computational optimisation and modelling has resulted in numerous techniques that alleviate the difficulties of traditional design optimisation methodologies. Many of these techniques address particular issues, such as multiple local optima, multiple objectives, or handling computationally expensive cost functions. Substantial progress has been observed in the development of derivative-free optimisation techniques, the use of adjoint sensitivities, as well as methods exploiting surrogate models, both function-approximation- and physically-based.

Despite substantial progress in the development of efficient design optimisation and modelling techniques there are still a number of issues that need to be solved. The workshop Computational Optimisation, Modelling and Simulation, COMS 2010, held during International Conference on Computational Science, ICCS 2010, spanned a wide range of applications and reflected the state-of-the-art developments in computational optimisation, modelling and simulations. This post-conference special issue of *International Journal of Mathematical Modelling and Numerical Optimisation* includes extended versions of the selected papers presented at COMS 2010 that cover various aspects of the field, including new algorithms, simulation and modelling techniques, as well as applications in various areas of science and engineering.

The special issue opens with the paper by G.A. Gray et al. discussing hybrid optimisation schemes for black-box optimisation problems. They describe several derivative-free optimisation approaches as well as their advantages and disadvantages. They also explain how these techniques can be used to form the hybrid algorithms which exploit the strengths and overcome the drawbacks of the underlying methods.

In the second paper, D.E. Ciaurri et al. discuss the application of derivative-free methodologies to generally constrained oil production optimisation problems. They exploit a few approaches including generalised pattern search and Hooke-Jeeves direct search as well as a genetic algorithm. They also utilise penalty functions and filter methods to handle non-linear constraints. The paper presents numerical results for the three oil production optimisation problems of various complexities.

The following paper, by D. Lozovanu, addresses the game-theoretical approach to Markov decision problems. In particular, a new class of stochastic positional games, that extend the well known deterministic and stochastic positional games, is studied. The results show that the problem considered can be reduced to a continuous problem for which classical numerical methods can be applied.

The next paper, by P. Domschke et al., deals with simulation and optimisation of gas transport in networks. The authors consider a hierarchy of models describing the flow of gas through a pipe so that models of different fidelity can be used in different parts of the network depending on the prescribed tolerances for the model errors. The errors are estimated using adjoint techniques.

The multi-fidelity aerodynamic shape optimisation of airfoils at high-lift conditions is presented in the paper by L. Leifsson and S. Koziel. The direct optimisation of computationally expensive airfoil model is replaced by iterative updating and re-optimisation of the fast surrogate model. The surrogate exploits a low-fidelity model and appropriate correction that aim at aligning its corresponding airfoil surface pressure distribution and skin friction distribution with that of the high-fidelity model using a shape-preserving response prediction technique. A substantial reduction of the computational cost is observed when compared to direct high-fidelity model optimisation.

In the last paper, M. Simsek et al. give an overview and recent developments in microwave modelling and design using knowledge based neural modelling techniques. The knowledge based networks are constructed by incorporating the existing knowledge such as empirical formulas, equivalent circuit models and semi-analytical equations in neural network structures. Such techniques require less training data and have better extrapolation performance than classical neural networks, which is demonstrated through microwave device modelling applications.

The guest co-editors would like to acknowledge our outstanding authors and contributors to this special issue. We should also take this opportunity to acknowledge the effort of many reviewers who helped us shape the content of this volume.