Editorial

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Information technology (IT) solutions are used variously to solve a wide range of data storage, retrieval, transmission, and manipulation problems in many areas of applications. Today, the application of IT is widespread, and there are many solutions used in various contexts, e.g., in business contexts, educational contexts, medical contexts, and in a wide variety of engineering application contexts, including in engineering optimisation. Entitled 'Contextualised IT solutions in engineering optimisation', this special issue intends to cast light on the challenges related to application of IT solutions in engineering optimisation through some selected application examples. It attempts to reveal the kinds of IT-related research typically conducted in various contexts of engineering optimisation. The special issue consists of six revised and extended papers that were initially presented at the 9th International Symposium on Tools and Methods of Competitive Engineering (TMCE) held in Karlsruhe, Germany from May 7–11, 2012. Obviously, the included papers are just selected examples, and the discussed challenges represent only a tiny subset of the numerous diverse engineering optimisation challenges that academic and industrial researchers typically face. The selected papers not only analyse these specific engineering optimisation challenges, but also provide new insights in contextualised engineering optimisation solutions. Six cases of optimisation challenges are discussed in this special issue, namely:

1 handling of uncertainty
2 optimisation of engineering analysis
3 testing of complex engineering products
4 extraction and reuse of knowledge
5 simulation and optimisation of engineering processes
6 performing design optimisation.

Underlying this special issue is the widely shared acknowledgement and appreciation of the power of IT solutions in solving complex research and practical optimisation problems in various professions and applications.

The processes of developing innovative products are characterised by considerable uncertainties regarding the optimal future product properties. How the product developers handle the uncertainties usually makes the difference between success and failure of a product. Reducing this uncertainty is one of the challenges that product developers often confront. In the paper titled 'Ontology-grounded validation methodology for innovative automobile development projects', M. El-Haji, T. Freudenmann, F. Gauterin and A. Albers explore this challenge with a view to develop a purposeful decision-making methodology and consequently helping to increase the chances of market success of automobile products. They introduce a methodology that aims to support product developers in sourcing, handling and exchanging the large amounts of information needed in anticipating the system behaviour of the future product when used by its customers. In using the methodology they proposed, all information used during validation should be integrated and retained in particular contexts of validation activities. They argue that this not only increases the quality of decisions by supporting the development of a common understanding in the project team; but also makes the decision taking processes become more comprehensible and repeatable. They also claim that this enables a sustainable generation and growth of an organisation's knowledge base. The work presented in this paper is written in the context of handling uncertainty in the automobile industry. They argue, however, that the proposed methodology is applicable to the processes of development of other complex, innovative products in which validation activities play central role in increasing chance of market success.

Optimisation of engineering analysis processes typically entails consideration of a wide range of aspects including, for instance, energy efficiency, manufacturing costs, life-cycle costs, and environmental impacts. Large amount of information typically need to be processed in order to come up with optimal design solutions. Contextualised computational algorithms and methods are typically needed to handle the complex underlying processes and the associated information. In their paper entitled 'An integrated approach and IT platform to optimise electric motor engineering and design', C. Favi, M. Germani, M. Marconi and M. Mengoni describe an approach to optimise the process of engineering design and engineering of electric motors. They focus specifically on optimisation of the electric motor's development process, which they argue is the most important stage in which what they dub 'green customised solutions' can be ideated, analysed and optimised. An innovative approach and software platform to configure and simulate customised electric motors is proposed. The key feature of the proposed platform is the knowledge-based system, which is central in standardisation of the electric motor's design and engineering processes. The platform integrates different software tools to support the development and verification of several electric motor design aspects, such as energy efficiency, manufacturing costs and environmental impacts. The platform also provides what they refer to as a ‘collaborative area’ to support collaboration along the whole electric motors supply chain. The authors use various case studies to illustrate the effectiveness of the platform and of the proposed approach in addressing various electric motor design aspects concurrently; as well as the applicability of the proposed platform in supporting designers and engineers in achieving high quality and innovative electric motors in a shorter time to market. The proposed innovative approach and software platform which has successfully been used to configure and simulate customised electric motors can be adapted and used to support the ideation, analysis and optimisation of other engineering products.

Testing is one of the key activities in the product development interval, which usually uses a significant proportion of the resources required in the development process. It is typically driven both by external factors (such as legislation and customer requirements) and internal factors (such company experience, affordability and organisational practice). Testing is an integral part of the product development process and is performed continuously, for instance, to identify flaws at various levels of system complexity; to learn how future users foresee new design concepts; and to find out in advance how the implemented system would behave in various practical situations. Testing a complex engineering product can be very challenging, and normally involves numerous operations and iterations, which as a result usually lengthen the development duration. K. Tahera, C. Earl and C. Eckert in their paper titled ‘Integrating virtual and physical testing to accelerate the engineering product development process’, explore the possibility of accelerating the engineering product development processes through integration of virtual and physical testing into the processes. The main objective of the reported work was to understand how testing can be integrated into the product development process and how different types of tests can be scheduled across the stages of the product development process. In their investigations, the authors used a case study from a diesel engine firm where the balance of virtual and physical testing is a key concern in reducing design time and cost. The significances of dependencies across components of the engine, its subsystems and tests were investigated by using design structure matrices. The importance of iterating physical and virtual testing with a view to facilitate task overlap and to reduce product development duration was also analysed. They argue that integrating physical and virtual testing is more than optimisation of the process, time and cost. They claim that such integration contributes to recasting the design process in response to changes in customer requirements as well as to design changes which arise during testing. The understanding obtained in the investigation presented in this paper can help the product developers to plan how to carry out testing operations and in so doing accelerate the product development process.

Knowledge extraction and reuse of knowledge is common in some daily life activities. It typically involves creation of knowledge from existing structured and unstructured sources such as databases, knowledge bases, text and images. IT solutions such as advanced simulation tools effectively facilitate extraction and reuse of knowledge from existing data in many areas of applications, including in healthcare. S. Bartesaghi and G. Colombo in their paper titled ‘Knowledge extraction to automate CFD analysis in abdominal aneurysm diagnosis and treatment’ attempt to address the challenges of using CFD simulations to develop a tool for the diagnosis and treatment of aneurism. The authors specifically considered that although many studies on the state and the evolution of abdominal aortic aneurysm (AAA) by using numerical tools have been conducted, these studies have not had a significant impact on patient treatment. They assert that an important issue for a successful application of simulation tools for AAA diagnosis is the possibility to automate the process of risk indicators evaluation. A way to achieve this is to develop knowledge-based procedures to automate all CFD simulation tasks, i.e., pre-processing, setting up numerical analysis and post-processing. In particular, they explored how and what parameters of the numerical simulations influence the evaluation of hemodynamic properties and the diagnosis of the disease. Since the geometry of the aorta and aneurysm varies from a patient to another one, they considered a simplified geometric model of the arteries and the aneurysm. They introduce procedures and parameters required to perform an automatic CFD simulation of an AAA. They claim that the results obtained can be used as the basis for designing an application that can be used to determine the useful risk factors. The obtained research results suggest that domain knowledge extraction can be used as the basis for developing other knowledge-based solutions for other comparable applications.

Simulation is widely used in the analysis, design and optimisation of various engineering processes, including chemical processes. Modelling and representation of a chemical process and obtaining accurate simulation results is the challenge that the developers of the simulation software often face. This is partly attributed to the fact that model development is typically a multi-disciplinary exercise that brings together multiple areas of expertise, such as chemical engineering, computer science and mathematics. Many multi-disciplinary attempts are continuously being made to develop new and improved models for simulation of complex chemical processes. Y. Zhu, E. Schnack and G. Iancu, in the work described in their paper titled 'Microstructure simulation in isothermal chemical vapour infiltration of SiC composites', contribute to these efforts. They developed a multiphase field model for isothermal chemical vapour infiltration (ICVI) process of SiC composites from methyltrichlorosilane (MTS). The model they developed consists of a set of non-linear partial differential equations by coupling Ginzburg-Landau type phase field equations with convection diffusion type mass balance equations and Navier-Stokes equations for fluid flow. In their work, a reduced chemical reaction mechanism was adopted to allow for the incorporation of the thermodynamics of the pyrolysis of MTS into phase field model framework. They simulated the microstructure of preferential deposition of Si, SiC under high ratio of H_2 to MTS. Furthermore, the potential risk of blockage of the premature pores during ICVI process was also predicted. They claim that the results they obtained were in good agreement with experiments investigation. The proposed model, which has successfully been used for microstructure simulation, can be adapted and used to simulate other comparable complex chemical processes.

Finally, the advances in computing have led to creation of various types of design optimisation support solutions, including structured repositories of previously successful designs of components. J.A. Feldman, B.J. Hicks and G. Mullineux in their paper titled 'Mechanism synthesis: a comparison of adaptive and traditional approaches' deal with the challenges of synthesising a mechanism to output a prescribed path, which they argue is important in mechanism design. Specifically, given an output path, specified normally as a collection of discrete precision points, the challenge they dealt with was how to find a mechanism whose output traverses these points exactly or, at least, closely as far as possible. They formulated the synthesis task as an optimisation problem, in which a variety of different numerical techniques such as the 'traditional' direct search and gradient methods, as well as adaptive computing methods such as genetic algorithms and methods based around constraint programming can be applied. The interest here was to investigate the performance of readily available numerical optimisation methods, which are broadly classified as the 'traditional' methods (i.e., methods that are essentially direct search in nature, or that merge into Newtonian methods when they use numerical approximations for the required derivatives) or 'evolutionary' or 'adaptive' methods (such as genetic algorithms and their variations). The task was to investigate whether the 'evolutionary' or 'adaptive' methods offer advantages over 'traditional' methods. A comparison which involved a number of case study examples and which was based on four bar mechanisms was made. They found that the traditional methods perform at least as well as the others, and arguably involve a more simple and intuitive problem formulation. They claim that all methods benefit from a good starting point for the search process. They also argue that the provision of catalogues of suitable mechanisms allows the designer to be involved in the selection of a suitable starting point.

In conclusion, the selected papers dealt with several varieties of engineering optimisation challenges. Each of the developed optimisation solution described above is tied to a specific application domain and context. Overall, on one hand, it is imperative that in developing an IT solution for solving or managing a particular engineering optimisation problem, the developer should carefully analyse the problem and understand the context in which the designers and engineers would eventually use the intended solution. And on the other hand, the end-users (i.e., designers and engineers) should carefully analyse the needs and sensibly select IT engineering optimisation solutions for the applications and contexts at hand.

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