Editorial

Decision making plays an important role in solving design and engineering problems. It appears on multiple levels, for instance on governmental (industry and enterprise), organizational (department and team), and individual (designer, engineer, manager) levels. Complexity of design and engineering processes has grown rapidly in recent times. Engineering decision makers have to take into account complexity and dynamic nature of engineering processes, and have to cope with the difficulty of making decisions based on varying input and output. Designers and engineers often need to frame decisions under uncertainties, i.e. based on incomplete qualitative or quantitative information. Depending on the measure of incompleteness, three distinct types of decision making are recognized, namely decision making under risk, uncertainty and ambiguity. They may occur on each of the above-mentioned levels.

Decision making interweaves with the entire process of solving engineering problems. It starts as early as during problem definition and accompanies the engineering process as long as solutions are soaked for the engineering problem at hand. Engineering decision making typically involves four major actions: aggregation of knowledge, information and factual data about the engineering problem, defining or selecting appropriate decision criteria, generating multiple alternative solutions, and selecting the most competitive alternative solutions. Computer-based tools and methods allow us to investigate the engineering processes in a detailed manner and with sufficient precision, and to integrate in-process decision making into the main-stream engineering processes. These tools assume and enforce order in decision making processes. Using computational tools increases the amount of information available for problem-solving and decision making, as well as the reliability and robustness of decisions.

This special issue concentrates on problem-solving and decision making related to concrete engineering tasks and applications. The papers were originally presented at the Sixth International Symposium on Tools and Methods of Competitive Engineering (TMCE 2006), which was held in Ljubljana, Slovenia, in April 2006. The papers have been revised substantially for this Special Issue and have gone through a two-stage peer review process. They report both on new comprehensive theories and proven development results, most of them tested through practical applications. The papers indicate that decision making related to solving complex problems is indeed a fundamental construct in engineering. They also present examples on information generation for problem-solving and multi-criteria decision making by computational techniques.

The first paper titled "Decision making in innovation processes - A concept to support small and medium sized enterprises", written by *Stefan Vorbach and Elke Perl*, proposes a systematic approach for handling high risk and uncertainties in realization of new products. A structured innovation process model is presented and the limitations of this process model are analyzed by using an application example. In addition, an innovation tool box (in other words, a set of innovation methods) is proposed which considers the overall innovation expertise of the involved designers and decision makers (beginners, experienced and professionals) of the company, the activity fields of innovation management (marketing, quality and cost), as well as the degree of innovation. Various aspects of innovation, such as information, communication, organizational, cultural and sociopsychological are analyzed and their effects on the success of product innovation are pointed out.

The second paper titled "Knowledge-based Support of Decision Making at the Example of Microtechnology", authored by *Albert Albers, Norbert Burkardt and Tobias Deigendesch*, sets the stage for further discussion by comparing various general and specific product development processes used in mechanical engineering, mechatronics, micro-electronics, mask-based micro-systems, and tool-based micro-technology. Likewise the products, which include multiple subsystems, the product development processes also show a complex structure. The authors claim that their Contact and Channel Model (C&CM) can be used in the above fields to systematize mechanical analysis and synthesis of products. C&CM combines an abstract functional description with a concrete description of technical components or systems and, by doing so, supports design decision making. The authors propose to use rule- and/or guideline-based methods for designing technology-driven micro-systems.

Hajime Mizuyama and Kenichi Ishida contributed a paper titled "Systematic decision making process for identifying the contradictions to be tackled by TRIZ to accomplish product innovation". This paper proposes a method for consideration of customers' requirements through technical innovation of the functions and structures of products in development. The proposed method is based on the concept of elementary conflicts. Actually, elementary conflicts that prevent achievement of the target quality characteristics are recognized and eliminated by a systematic analysis of the relationships between the engineering solutions and the required quality characteristics. As practical means of analysis, function trees and mechanism trees are used. Both serial and parallel relationships are taken into consideration, and the criticality of the elemental conflicts is enumerated. The method has been applied in the innovation process of a die-casting machine by using TRIZ tools.

The fourth paper titled "Layout of functional modules and routing for preliminary design of automatic teller machines", also submitted by Japanese researchers, namely by *Katsumi Inoue, Tomoya Masuyama, Hayato Osaki and Tokachi Ito*, uses genetic algorithm to resolve lay-out conflicts. The design problem is formulated as a minimization problem, which is mathematically represented as a sum of weighted design parameters. For the spatial arrangement of components and for routing the Bottom-Left method and the Route-Design-Oriented Packing method, respectively, are used. The arrangement is guided by constraints and rules. The genetic algorithm is used to achieve simultaneous optimization of the module layout and the route design. This contribution is a good example of how a combination of computational methods can be used to solve complex lay-out problem to ultimately support human decision making.

The fifth paper titled "Neural network based selection of optimal tool-path in free form surface machining", co-authored by *Marjan Korosec and Janez Kopac*, is another proof of the applicability of dedicated computation methods to solving specific (non-deterministic) engineering problems. The challenge of the optimal tool-path selection originates in the relatively large number of engineering parameters and the need to achieve a multiple parameters dependent optimum. A large number of variations of five basic milling tool-path strategies are presented to the employed probabilistic neural network, having two hidden layers. The authors tested not only the efficiency of the proposed approach, but also the quality of the surface that can be achieved with the predicted optimal tool-path. They argue that human process planners are typically good in finding an efficient tool-path, but the neural network based computational approach takes the surface quality into consideration too. The computational approach allows consideration of other objectives, such as minimal tool wear and shortest machining time.

Another example of involvement of computational methods to support complex engineering decision making is presented in the paper titled "Evolutionary prediction of manufacturing costs in tool manufacturing", authored by *Mirko Ficko, Boštjan Vaupotič and Jože Balič*. It is well-known that determination of the manufacturing costs is challenging due to the large number of aspects (e.g. materials, design, machining, tools, measuring, transportation and cooperation), and due to the inherent uncertainties of product development processes. The authors analyze the problem of total cost determination and cost prediction methods. They propose a cased-based approach, which imitates the reasoning of a human expert. The basis of computational solution is genetic programming, which enables automated prediction based on a set of strongly similar source cases. The cases are described by so called case vectors, which are used as input for the genetic code. Although the results are less precise than those achievable by humans, the authors claim that they can still be considered satisfactory. Future work will focus on the improvement of predictions.

Finally, the paper titled "Specialized multi-agent search engine model for the extended manufacturing enterprise", submitted by *Ockmer L. Oosthuizen and Elizabeth M. Ehlers*, first review the advances in the field of Internet search engines. The authors claim that the major problem is that context-restricted multi-agent search engines are not yet available. They argue that search engines can be made context sensitive by personalization through user modeling and by specialization for a given knowledge domain. They introduce a reasoning model and a multi-agent architecture that serve as a functional framework for specialized search engines for virtual manufacturing enterprises. Special agents such as user role, query, partner, and result analysis agents have been defined for the proposed COPEMSA search engine. To facilitate the performance evaluation of the functional framework in virtual manufacturing enterprises, the authors propose various metrics.

There is an emerging consensus that a framework for design and engineering is decision-making, and that context-dependent decisions are the fundamental construct in these processes. Application of comprehensive reasoning, engineering and computational models, combining human intuition and heuristics with robust computational analysis and simulation techniques, and using formal risk management and error minimization methods will be the main elements of future best practices. We hope that with this special issue, we managed to provide good examples of computer oriented methods and tools that can be introduced in the industry to support engineering problem-solving. Though further work is needed, the presented methods also support fact-based decision making in various engineering processes. We also hope that by these papers, we demonstrated the best research practices for fellow researchers.

We are grateful for the efforts and willing collaboration of authors, and we appreciate their scientific contribution to this special issue. Finally, we are very grateful to reviewers who helped to improve the quality of papers and the value of this special issue.

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