Editorial

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The engineering design and production methodologies change and evolve as new tools are developed and became available for constructing mathematical models of the real working environment for design and production synthesis and analysis. The progress in new methodologies promotes the research and development phases taking place in virtual environments. Advanced methods for virtual machine design and production have their purpose set to streamline the design and production process in order to meet the shorter turn-around times in a cost-effective fashion. The outcomes of the studies towards these advanced methods have been presented and discussed in many international events including the International Conference on Machine Design and Production (UMTIK) which was held in 2008 and 2010. The 3rd International Conference on Advanced Design and Manufacture (ADM 2010) was yet another international meeting place for the researchers who have put much work on virtual machine design and production techniques. The interest and the progress observed in these two established conferences led towards compilation of articles of this special issue that reflect the state-of-the-art. The articles in this special issue span around virtual design of machines and production.

The first paper presents a study on general framework for constructing a virtual environment for robotic applications. The key technologies of virtual reality for the application in robotic machining and manipulation are discussed. Material removal model, collision detection model, and collision response model in virtual environment are investigated through case studies. Finally, some practical application examples, which are developed using the proposed virtual reality methodology, are presented.

A general numerical model for five-axis machining is proposed covering all possible tool geometries in the second paper. The proposed process model predicts total cutting forces acting on the tool given the cutter profile geometry, process conditions and material specifications without preliminary cutting operations. Tool envelope is extracted from CAD data, and helical flutes points are represented in cylindrical coordinates. Equal parallel slicing method is utilised to find cutter engagement boundaries (CEB) determining cutting region of the tool surface for each axial level in the tool axis

direction. Uncut chip thickness value is found for each level, and total forces are calculated by summing force values for each point along the cutting flutes. Forces are simulated, and obtained results are experimentally verified for arbitrary cases.

The third paper is focused on reliability-based design optimisation of a simple aircraft wing based on performance measure approach using various computer aided design and analysis tools. Catia is used as a parametric solid modeller while Abaqus is used to compute the structural response of the wing system. As an optimisation driver, Modefrontier is used with sequential quadratic programming method. The core of the problem leans on the structural optimisation of a statically loaded wing. Weights and modal frequencies of that wing are optimised with stochastic parameters. The uncertainties concerning both yield strength and Young's modulus of the aluminium material is finally analysed by the reliability analysis code developed in MATLAB®.

The study presented on the fourth paper aims to generate a haptic-based cutting force model, and to develop a virtual cutting operation application in which the user is able to feel the deformable object by probing and then to physically deform the object. In this model, it is aimed to have the flexibility of different cutting tool head shapes, sizes and rotation speeds in real-time. A cutting force model that depends on the spring-damper method is proposed for interacting with volumetric data for both cutting force and torque calculations to enhance the realism of the force-rendering for medical and CAD/CAM applications. To compare the realism of the model, tooth data are implemented in the application. A novel 6DOF multi-contact method is introduced for reducing the computational load. One of the objectives of this study is to use high level design tools to model a virtual environment, and high level graphical rendering packages to visualise the virtual environment. In order to have a realistic multi-contact force model, a voxel-based representation of deformable data is used for voxel-based collision checks. For deformation of an object, 'L' shaped tool handles and different tool heads (spherical, conical and flat) with different cutting speeds and sizes are used. Conical and flat tool heads are physically modelled and applied.

Production of a new mechanism involves design, manufacturing and testing phases. In order to achieve shorter turn-around times, researchers have studied methods of shortening these phases. Today, structural tests and simulations conducted in virtual environments prior to manufacturing are a part of most of the standard production processes. However, in robot production not only the structural aspect of the mechanism but also its controller is required to be tested. The fifth paper summarises a versatile method to rapid prototype the robots in virtual environments to conduct controller tests. The verified controllers are then employed in actual robot prototype. The procedure is implemented in a gimbal-based joystick production process.

The sixth paper presents new capabilities of a versatile software tool named Surface Constructor for gear investigations, development and innovation. Reaching model conjugate surface generating theory as the core of the kinematical modelling and simulation software application is explained. This explanation is followed by a short description that summarises the structure and the capabilities of the tool. Finally, concrete examples are provided to demonstrate the versatility of the application in modelling the meshing of gears. The introduced cases include special grinding wheel generation, double modified worm gearing, generating gear pairs by an intermediary generating surface like hypoid bevel gear pair and a novel worm gearing type characterised by continuous meshing in a point.

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The guest editors would like to thank all authors and reviewers along with the journal editors, who all largely contributed to this special issue. It was a pleasant and memorable task for us to assemble all the research papers presented in this special issue. We hope the readers will find the articles both interesting and useful.