DESCRIPTION OF RESEARCH GROUP
(2012-14)

Research Group for
Modeling and Application of Computational Methods in Mechanical Engineering

1) Research group Info;

- **Group Leader:**
  DAMIR VUČINA, Full Professor: numerical modeling and analysis, optimization
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- **Members of the Group:**
  Gojko Magazinović, Full Professor: numerical modeling and analysis
  Zoran Milas, Associate Professor: fluid mechanics, CFD
  Igor Pehnec, PhD, Senior Assistant: numerical methods
  Milan Ćurković, Dipl.Ing. Math., PhD cand.: mathematical methods, shape modeling, 3D features
  Ivo Marinić-Kragić, Assistant, numerical methods, CFD

- **Research interests and topics**
The application of numerical methods and optimization in mechanics of deformable bodies and fluid mechanics
  3D scanning
  Parameterization
  FEM / CFD analysis
  Optimization

- **List/Description of labs**
The research Group for Modeling and Application of Computational Methods in Mechanical Engineering has its primary focus in modeling of engineering problems for computational analysis and synthesis as well as development of advanced computational procedures.
The group has established two research laboratories: Lab for Optimum Design and Rapid Prototyping, and Lab for Numerical Modeling. The group also operates the Lab for fluid dynamics.

The Lab for Optimum Design and Rapid Prototyping includes the GOM ATOS high resolution and accuracy 3D scanning system. It is an optical system based on triangulation and stereo-photogrammetry which applies structured light patterns projection and uses time-based coding for addressing the positions of individual points. It uses reference points to align and combine multiple scans into single overall point clouds. The Lab also includes a 3D printing system that builds 3D models from layered rigid plastic materials and requires no post-build curing.

The Lab for Numerical Modeling is in development and includes custom-made and workflow-integrated applications for numerical analysis, synthesis and numerical optimization.
2) The group at a glance/ activities, capacities, collaboration, applications, etc. + Highlights/main research goals of the group in the period of 2012-14

The research group has its main focus in the following:
- Development of procedures and operators in classical and evolutionary numerical optimization,
- Setting up dedicated heterogeneous numerical workflows for distributed computational numerical analysis and optimization,
- Development of advanced parameterizations of 3D shape for numerical optimization,
- Enhanced reverse re-engineering by coupling 3D shape acquisition, parameterization, simulation and shape optimization,
- Development of numerical procedures for engineering systems design, analysis and optimization.

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- In last two years the research group has implemented the national scientific project ‘Intelligent and evolutionary algorithms for optimization of materials and structures’, and participated in the national scientific project ‘Fatigue strength of materials and structures’. The research group has developed several computer codes and implementations in the fields of computer-aided analysis and synthesis, numerical optimization, and feasibility evaluation.

- The research group has developed original algorithms for the parameterization of 3D point clouds and feature detection (edges, peaks) which can are used for the adaptive parameterizations, dynamic feature-based partitioning of complex surfaces, compact representation of shape, and dynamic detection of surface deterioration and damage (gaps, impact cavities, etc.).
The group has also developed procedures for Level-set based shape based optimization using evolutionary algorithms. The group is also intensively involved in 3D scanning of engineering objects and subsequent processing including parametric surface representation, dynamic partitioning and parametric shape re-engineering and optimization.
3) Selected references/Published papers, books, monographs, etc. Some of the 2010 / 2014 publications (or currently in publication) by the group include:

**Authored papers in scientific journals:**
- Ćurković, M; Vučina, D., **3D Shape acquisition and integral compact representation using optical scanning and enhanced shape parameterization.** // Advanced engineering informatics (publishing in progress, 2014)
- Milas, Z; Vučina, D; Marinčić-Kragić, I., **Multi-regime shape optimization of fan vanes for energy conversion efficiency using CFD.** 3D optical scanning and parameterization. // Engineering Applications of Computational Fluid Mechanics. (publishing in progress, 2014)
- Vučina, D; Ćurković, M; Novković, T., **Classification of 3D shape deviation using feature recognition operating on parameterization control points.** // Computers in industry. (publishing in progress, 2014)
- Salamunićar, G; Lončarić, S; Vinković, D; Vučina, D; Gomerečić, M; Pehnec, I; Vojković, M; Hercigonja, T., **Test-field for evaluation of laboratory craters using a Crater Shape-based interpolation crater detection algorithm and comparison with Martian and Lunar impact craters.** // Planetary and space science. 71 (2012)
- Vučina, D; Lozina, Ž; Pehnec, I., **Ad-Hoc Cluster and Workflow for Parallel Implementation of Initial-Stage Evolutionary Optimum Design.** // Structural and multidisciplinary optimization. 45 (2012)
- Vučina, D; Lozina, Ž; Pehnec, I., **Computational procedure for optimum shape design based on chained Bezier surfaces parameterization.** // Engineering applications of artificial intelligence. 25 (2012)
- Vučina, D; Milas, Z; Pehnec, I., **Reverse Shape Synthesis of the Hydropump Volute using Stereo-Photogrammetry, Parameterization and Geometric Modeling.** // Journal of computing and information science in engineering. 12 (2012)
- Vlak, F; Cvitanić, V; Vučina, D., **An approach for reduction of the volume loss in the rigid-plastic FEM using two-step updating procedure.** // International journal of mechanical sciences. 53 (2011)
- Vučina, D; Lozina, Ž; Vlak, F., **NPV-based decision support in multi-objective design using evolutionary algorithms.** // Engineering applications of artificial intelligence. 23 (2010)

**Monographs (2005, 2007):**
- Damir Vučina, **Application of Computers in Engineering Analysis: with examples in program languages C and MATLAB,** FESB, Split, 2007
- Damir Vučina, **Methods of Numerical Optimization in Engineering,** FESB, Split, 2005