Visual Analytics for Multi-Criteria Decision Analysis

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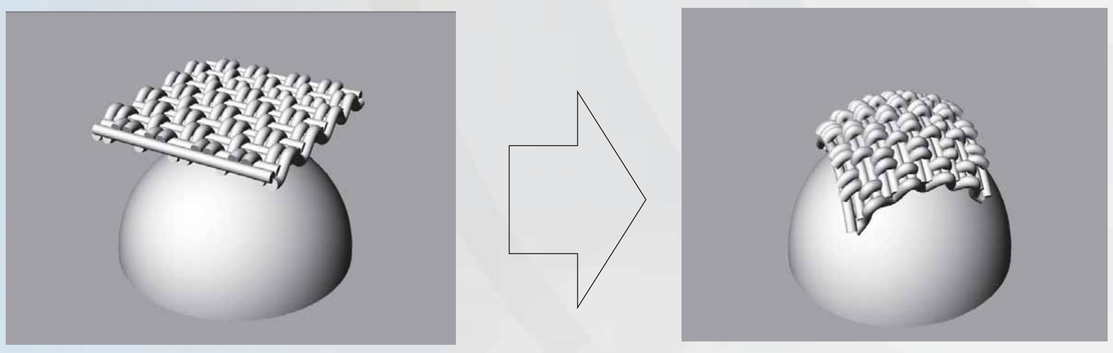
Abstract

A number of visual analytics tools has been proposed and effectively used for multiple criteria decision analysis (MCDA) problems of textile composite materials selection. The critical behavior of the woven textile composites during draping and further involved simulations and analysis are included in the process of optimal design and decision making with the aid of LIONsolver.

Draping

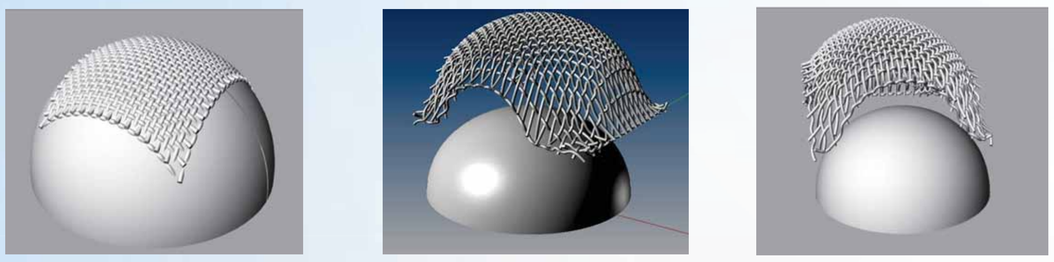
The manufacturing of woven reinforced composites requires a forming stage so called draping in which the preforms take the required shapes. The main deformation mechanisms during forming of woven reinforced composites are compression, bend, stretch, and shear which cause changes in orientation of the fibers. Since fiber reorientation influences the overall performance it would be an important factor that in the process of material selection to consider the draping along with the other criteria.



Simulation of draping process including a combined mechanical modeling of compression, bend, stretch, and shear

Geometrical Mechanical Modeling and Simulation of Draping

Beside of all presented approaches to the geometrical modeling of woven textiles so far, the Spline-based methods have been the most effective technique. In fact, the Spline-based geometrical representation of a real-life model of any type of the flat-shaped woven textile, are done with implementing the related computer aided geometrical design (CAGD) code. In order to handle the computational complexity of geometrical modeling the multiple-dome woven shapes, utilizing the NURBS-based CAGD packages are proposed. The improved version of generative algorithms provided in [1] and [2] is capable of producing the complex geometries and the whole mechanism of deformation with combining all details of compressed bended stretched and sheared properties.



Geometrical modeling of double dome

Integration the MCDM-Assisted Materials Selection with Draping Simulation

Recently a combined FEA-MCDM approach as a framework that links the capabilities of FEA tools to the MCDM approaches for composite structural materials selection problem proposed. However due do the geometrically challenging modeling of the composite product the draping simulation has not been considered in their work. In order to select the best material of a woven textile as well as the right angel of draping, the draping simulation needs to be carried out for a number of draping degrees for a particular material. The results of all the draping simulations of different drape angles are gathered as a data-set for consideration, in addition to already existed data-sets from the earlier case study including the other criteria i.e. mechanical, electrical, chemical, cost, life cycle assessment and environmental.

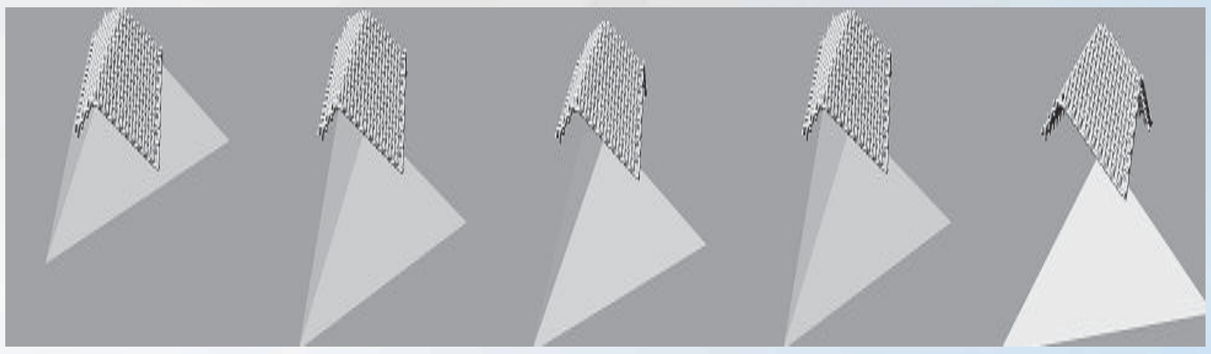
Visual Analytics

Visualization; Effective Approach to MCDM and Materials Selection

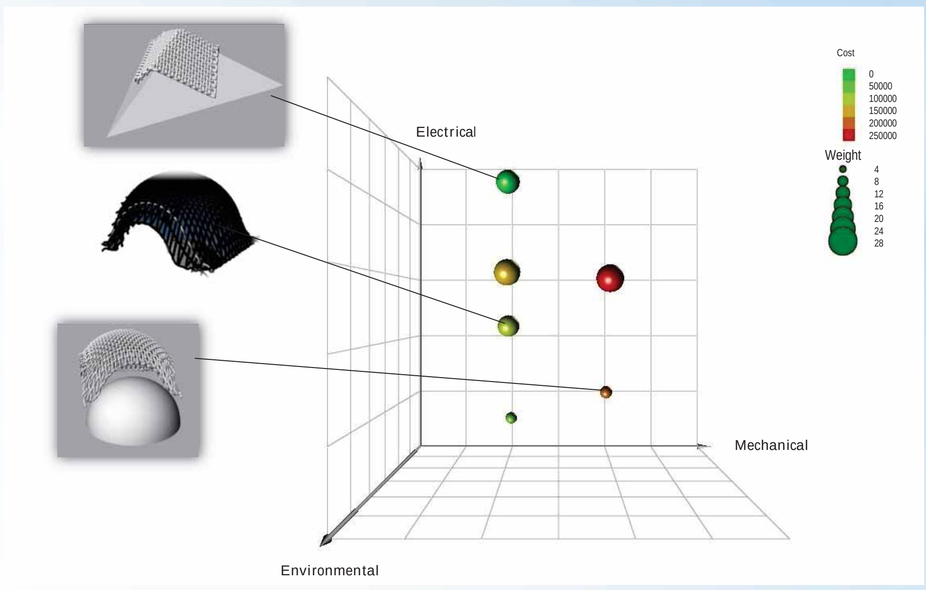
Visualization is an effective approach in operations research and mathematical programming applications to explore optimal solutions, and to summarize the results into an insight, instead of numbers. Fortunately during past few years, it has been a huge development in combinatorial optimization, machine learning, intelligent optimization, and RSO, which have moved the research in advanced visualization methods forward.

Software Architecture of the Reactive and Interactive MCDM Visualization Environment

The proposed software is based on a three-tier model, independent from the optimization package which is an effective and flexible software architecture for integrating problem-solving and optimization schemes into the integrated engineering design processes and optimal design, modeling, and decision-making well suited for optimal design of textile composites. The software is implemented a strong interface between the generic optimization algorithm and DM. While optimization systems produce different solutions, the DM is pursuing conflicting goals and tradeoff policies represented on the multi-dimensional graphs.



Mechanical modeling of draping process for a number of draping degrees



7D Visualization graph of LIONsolver

Conclusion

The new set of powerful integrated data mining, modeling, visualization and learning tools via a handy procedure stretches beyond a decision-making task and attempts to discover new optimal designs relating to decision variables and objectives, so that a deeper understanding of the underlying problem can be obtained. The applicability of software can be easily customized for different problems and usage contexts. The preliminary tests of the software environment in the concrete context of designing a multiple dome shapes have shown the effectiveness of the approach in rapidly reaching a design preferred by the decision-maker.

References

[1] A. Mosavi, "Multiple criteria decision making for material selection of composites; utilizing advanced data mining visualizations and learning/intelligent optimization tools," Proceedings of 15th European Conference on Composite Materials, Italy, 2012.

[2] A. Mosavi, et al. "Multiple criteria decision making integrated with mechanical modeling of draping for material selection of textile composites." Proceedings of 15TH European Conference on Composite Materials, Italy. 2012.

[3] R. Battiti, and B. Mauro "Reactive search optimization: learning while optimizing." Handbook of Metaheuristics. Springer US, 2010. 543-571.