Laboratory for Product Development and Lightweight Design
Department of Mechanical Engineering
Technische Universität München

We are offering a full time position as research & teaching assistant (m/f/d) in our lab at Garching/Munich for

Numerical Optimization of Solution Spaces for Complex Systems Design (PhD)

Our lab focuses on the design and optimization of complex technical systems. For this, we develop methods, tools and specific solutions to technical problems with optimal functionality, weight and cost. We are currently looking for a research & teaching assistant for a research project funded by the German Science Foundation (DFG).

Topic. Dividing large technical systems, such as airplanes or vehicles, into several smaller and more manageable parts or components is a common technique to reduce design complexity. This can be accomplished by formulating component requirements that help to align separated and independent design work towards an overall system design goal. Good component requirements guarantee – when satisfied – that the system of interacting components reaches the overall design goal. In addition, they are just as restrictive as absolutely necessary and, thus, provide maximum design freedom. This is difficult to accomplish for complex systems, where *non-linear* component interaction with *a large number of combinations* of possible component properties is to be taken into account.

Existing approaches compute so-called *solution spaces* that are the Cartesian product of permissible regions for component properties. They rely on special adaptions of numerical optimization algorithms. Approaches that can treat arbitrary non-linear systems are unfortunately limited to one-dimensional permissible regions, i.e., interval-type requirements for only one component property each. However, even when maximized, interval-type requirements may be unnecessarily restrictive. When a component possesses several relevant properties, requirements for each of them will be in total more restrictive than (or at least as restrictive as) one requirement for all of them. The goal of this project is to compute and maximize generalized component solution spaces: they are the largest high-dimensional (or possibly infinite-dimensional) permissible regions for all relevant properties of one component. If properties of all components are realized within their respective component solution spaces, the overall design goal will be reached with maximum design freedom. Numerical Tools to be used range from numerical optimization to modern machine learning algorithms.

Tasks

- Develop a new approach and a computational tool to approximate the theoretical size limit of decomposed high-dimensional solution spaces for systems consisting of several components
- Apply the results to simple and scaled-up design problems for mechanical and mechatronic systems
- Supervise student projects and support lectures
- Contribute to lab team projects

Required – please address in application

- Master degree in Engineering, Computer Science, Mathematics or similar
- Passion for numerical methods, machine learning, optimization, engineering mathematics and mechanics
- Passion for theory and analytical work
- Excellent programming skills
- German or a strong commitment to learn it

We offer

- Exciting and challenging new research area with theoretical depth and high practical relevance
- Close supervision for PhD thesis work
- Full position as research/teaching assistant with salary according to E13 TV-L in an interdisciplinary team

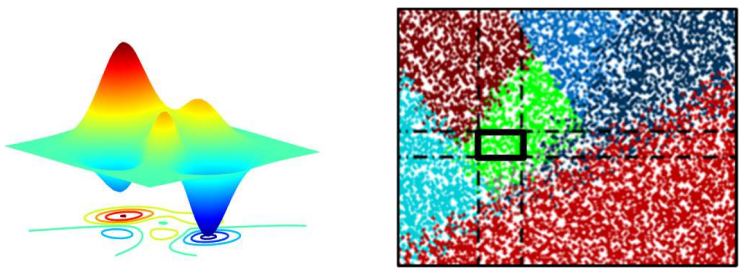

Fig. 1: Design based on classical optimization (left) and on solution space optimization (right)

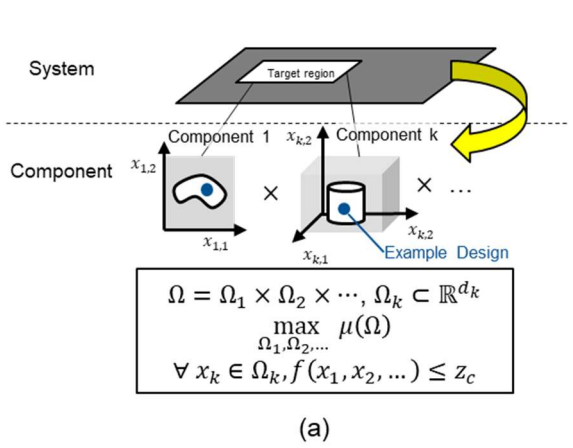

Fig. 2: Finite dimensional solution spaces for component properties.

Application. All applications received by **October 26, 2021** will be considered.
Please send your application (reference code OptSolSpaces) by email to: applications.lpl@ed.tum.de

RELATED PUBLICATIONS (for complete list check *https://www.researchgate.net/profile/Markus_Zimmermann4*, pdfs may be requested)
M. Daub, F. Duddeck, M. Zimmermann, 2020. Optimizing Component Solution Spaces for Systems Design. Structural and Multidisciplinary Optimization
M. Vogt, et al., 2018. Optimizing tolerance to uncertainty in systems design with early-and late-decision variables., IMA Journal of Management Mathematics
M. Zimmermann, J. Edler von Hoessle, 2013. Computing Solution Spaces for Robust Design. International Journal for Numerical Methods in Engineering