Professur für Mechanik auf Höchstleistungsrechnern
TUM School of Engineering and Design
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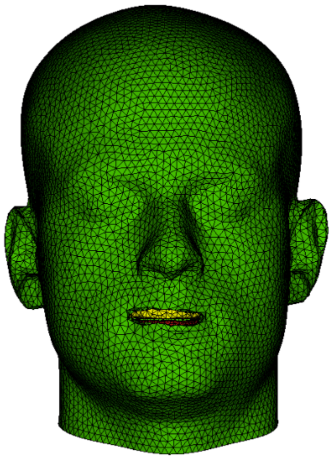
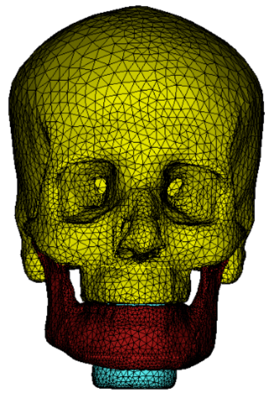
Master Thesis:

Biomechanical Head Model to Study Mechanical Interaction and Fit of Respiratory Protective Masks

Background:

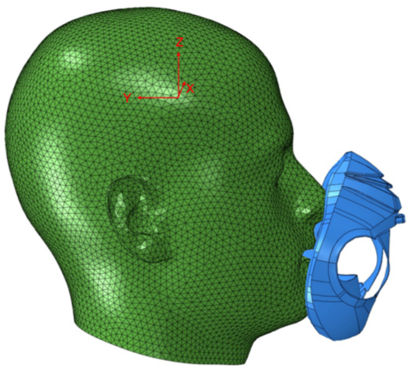
This project aims to improve models and simulations to inform product development processes for respiratory face masks by enabling an in silico quantitative evaluation of comfort and sealing performance across diverse facial geometries.

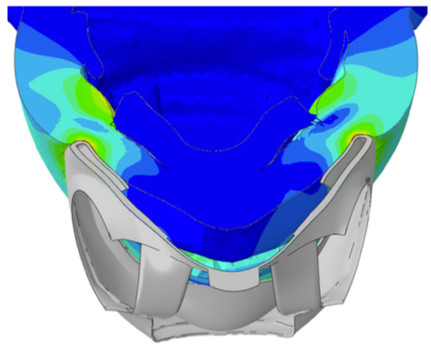




Before this research project, our industrial partner relied solely on rigid CAD design headforms. Deformable head models based on the Finite Element Method (FEM) offer strong potential to improve the analysis of mask–face interaction, enabling more realistic assessments of fit, sealing performance, and comfort across diverse users.

In previous work at the Chair of Mechanics and High Performance Computing at TUM, a high-fidelity biomechanical head model was developed from structured-light 3D surface scanning and MRI data, and contact simulations with a mask were conducted.





Motivation and objective:

Building on this, an additional MRI scan was conducted with the same volunteer wearing a mask, enabling the segmentation of the deformed configuration to support the identification of material properties and contact parameters. The fidelity of the entire FEM model will be increased to meet the required accuracy for realistic head-mask contact simulations to assess sealing and fit.

The work will be conducted in collaboration with the simulation department at Dräger (Lübeck).

Tasks:

- Familiarization with the Headform model and our C++ simulation Code
- Segmentation of the deformed configuration from MRI data
- Identification of material properties and head-mask contact parameters based on the segmented data via inverse analysis
- Additional enhancement of the existing model to meet the requirements of our industrial partner (regional mesh refinement, higher order finite elements)
- Documentation

Qualifications:

- Interest and background in continuum mechanics, finite element method, and numerical methods
- Programming in C++

Supervisors: Prof. Dr.-Ing. Michael Gee; Tahar Arjoune, M.Sc.