Announcement for the course
Digital Microstructure Characterization and Modeling

Microstructures: inorganically bound sand core (left), polycrystalline structure typical for metals and alloys (center) and short-fiber reinforced thermoplastic (right)

Topic

Microstructured materials, like metals, fiber-reinforced composites, concrete, foams etc., serve as a driving force for technological advances for industrial applications and for the energy change. Due to their intrinsic heterogeneity and the associated anisotropy, characterizing such materials experimentally may be prohibitively expensive.

Modern imaging techniques, in-situ measuring devices and computational homogenization methods permit gaining detailed insights into microstructures and their effective material behavior.

This course provides an introduction to the theory of heterogeneous materials, discusses their characterization (e.g., based on $\mu$CT data), presents computationally efficient methods for generating digital microstructure models, and elaborates on specific material classes like porous materials, fiber-reinforced composites and polycrystalline materials.

A variety of different topics will be touched - aspects of materials science, computer science, optimization and statistics play a role.

Programming-based exercise sessions associated to this course are scheduled. They will start with an introduction to the programming/scripting language python. Due to the coronavirus situation, the course will take place purely online (until further notice). Lecture notes will be provided on a weekly basis via ILIAS. Then, open questions and issues will be addressed via MS Teams.

Literature


Schedules and exams

<table>
<thead>
<tr>
<th>Courses &amp; Exercises</th>
<th>starting April 20th</th>
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<tbody>
<tr>
<td>Location</td>
<td>online via ILIAS, question sessions via MS Teams</td>
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<tr>
<td>Exams</td>
<td>oral</td>
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<tr>
<td>Volume</td>
<td>C 2 SWS, E 2 SWS, 6 LP</td>
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<tr>
<td>Lecture notes</td>
<td>will be provided</td>
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<tr>
<td>Contact</td>
<td>JProf M. Schneider, MSc J. Görthofer</td>
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Target audience

This course addresses bachelor and master students with an engineering, mathematical or more general scientific background with an interest in materials. This course is complementary to other events offered at the Institute of Engineering mechanics.

Prerequisites:

All relevant results will be developed during the course.

Content

- **Laminate microstructures:**
  Analytical solutions for multi-phase laminates; provides a specific example for an interesting class of microstructures

- **Digital microstructure characterization:**
  intrinsic volumes; \( n \)-point correlation functions; reconstruction of \( \mu \)CT data and segmentation; Euclidean distance transform and single-particle segmentation; further geometric invariants

- **Generating digital microstructure:**
  Why the fuss?; Influence of boundary conditions; pseudo- and quasirandom numbers; sphere-packing algorithms; morphological operations

- **Fiber-reinforced composites:**
  Fiber-orientation tensors and Folgar-Tucker dynamics; closure approximations; microstructure generation of fiber systems

- **Polycrystalline materials:**
  Voronoi and Laguerre tessellations; connection to semi-discrete optimal transport; priority queues and descriptions by level-set functions; spatial tree structures in computer science