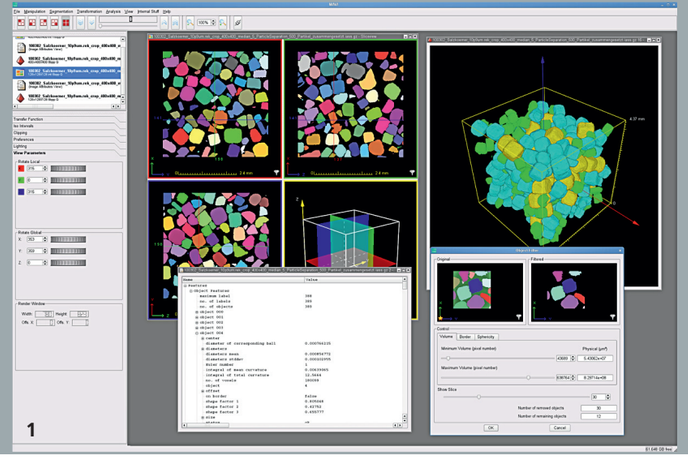


1

1 *MAVI screenshot – analysis of salt*

Features

3d image processing

- segmentation: interactive, local thresholding, hysteresis
- various filters, morphological and geodesic transforms, Fourier transform
- distance and watershed transforms, skeletonization
- fast labeling of objects, object filter
- cell reconstruction, particle separation

3d image analysis

- ObjectFeatures: volume, surface area, number of holes, diameter, shape, …
- FieldFeatures of microstructure components: volume fractions, densities of surface area, Euler number or fiber length, fractal dimension, mean chord length, …
- OpenFoamFeatures: mean cell size and strut thickness, ppi-value
- geometric tortuosity
- spectral analysis: power spectrum, covariance, Bartlett spectrum
- SubfieldFeatures: local analysis of microstructure components
- SubfieldFiberDirections: local fiber direction analysis - degree of anisotropy, principal direction, orientation tensors
- spherical granulometry: local size and thickness distributions

3d image visualization

- slice view, volume rendering

Data import and export

- native image format as well as 2d image stacks, raw volumes, AVS field data, various other volume data types
- export of analysis results as CSV files

2d images

- supported by most algorithms

Optimal system

- operating system
  - Windows 64 Bit or SuSE Linux 64 Bit
  - further OS on request
- hardware
  - 8GB RAM and 500GB disc space or more, depending on volumes to be processed
  - Intel Xeon or AMD Opteron processor
  - recent high-end Nvidia OpenGL graphics board
  - monitor resolution at least 1280x1024

License and support

- single user floating license
- update/service contract
- on-site software training and consulting
- customized software development

Fraunhofer-Institut für Techno- und Wirtschaftsmathematik ITWM

Fraunhofer-Platz 1
67663 Kaiserslautern
GERMANY

Contact
Michael Godehardt
Phone: +49 631 31600-4430

Dr. Katja Schladitz
Phone: +49 631 31600-4625

mavi@itwm.fraunhofer.de

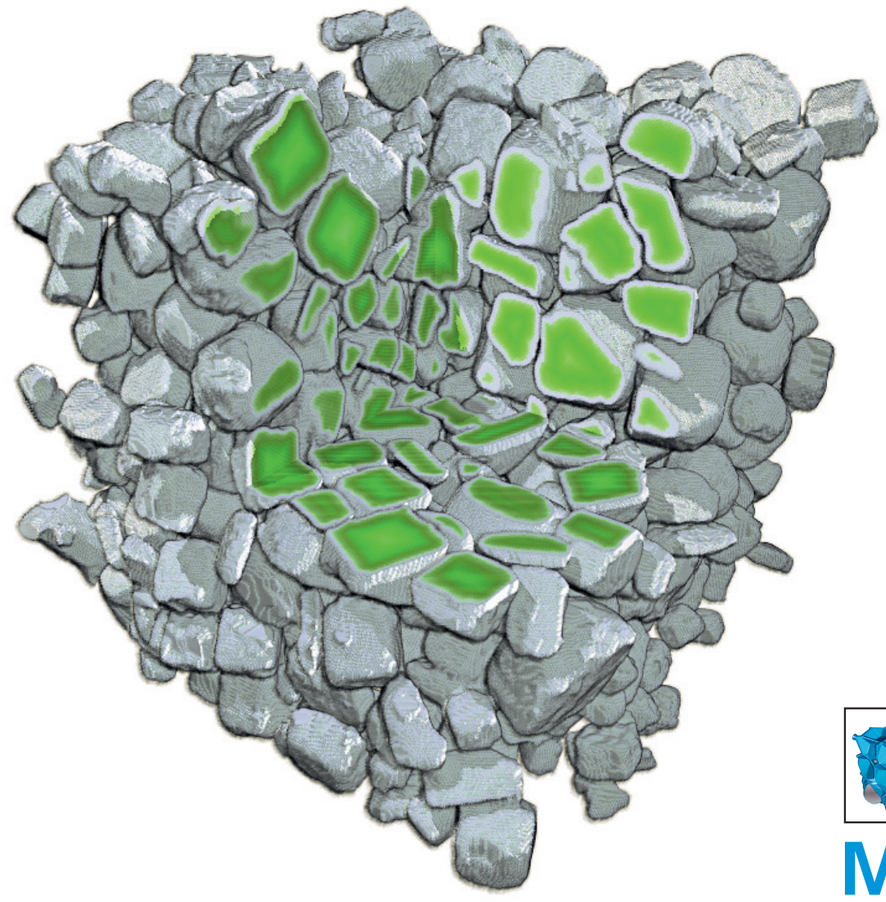
www.mavi-3d.de
3d-analyse.itwm.fraunhofer.de
www.itwm.fraunhofer.de

BV_Flyer_Mavi_EN_neuesCD

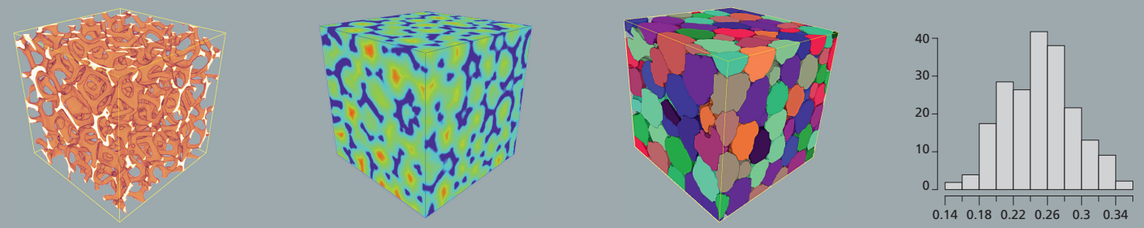
Fraunhofer
ITWM

FRAUNHOFER INSTITUTE FOR INDUSTRIAL MATHEMATICS

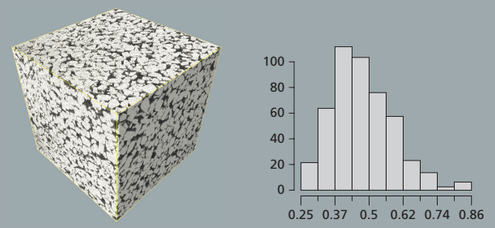
MAVI – MODULAR ALGORITHMS FOR VOLUME IMAGES



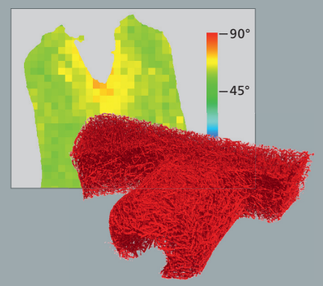
MAVI



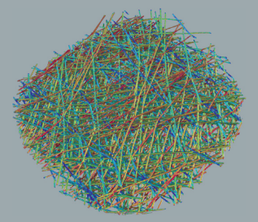
1



2



3



4

Overview

MAVI is a software tool for 3d image processing developed especially for the analysis of volume images of microstructures.

MAVI is particularly suited for quantitative analysis of microstructures of materials.

MAVI is easy to use. The graphical user interface allows fast progress, also for the non-expert user.

MAVI focuses on the characterization of the complex geometry of microstructures:

- Volume, surface area, integrals of curvature and Euler number are determined for the whole structure or isolated objects.
- Anisotropies and preferred directions are not only found but their strength is measured, too.

MAVI's design is modular. Therefore, it can easily be extended to special applications by incorporating additional functionality.

MAVI can be customized to meet your own special requirements. If your applicational needs lie beyond **MAVI's** standard or extended functionality, do not hesitate to contact us. We will be glad to provide modules tailored to your needs.

Analysis of Microstructures

Microstructures

MAVI is not restricted to a certain range of materials. So far, 3d images of the microstructure of the following materials have been investigated using MAVI:

- metals, ceramics
- sinter materials
- composites
- fiber reinforced polymers
- metal, ceramic, and polymer foams
- non-wovens, felts, paper
- building materials, e. g. concrete or cement
- sandstone, soil, snow
- biological materials, medical objects, food

Image data

- micro computed tomography
- FIB tomography
- electron tomography
- serial sectioning
- confocal laser scanning microscopy

MAVIlib

The wealth of algorithms used by MAVI is available as a C++-library, too. MAVIlib is complemented by MAVImini offering slice view, interactive cropping and thresholding only.

MAVImesh

This latest addition to the MAVI family bridges the gap between your tomographic image data and your simulation framework. MAVI mesh generates a triangular meshing of the surface of the foreground component, allows to simplify the mesh to a user defined degree and exports the mesh in STL format.

Service

We provide service analyses as well. If you are interested in an analysis and do not have equipment for acquiring 3d images, we will help you with image acquisition.

- X-ray micro-CT
- sample preparation
- image processing and analysis
- fixed prices

For further information on our service offer, please refer to our separate brochure "3d-Microtomography".

Analysis of an open metal foam – OpenFoamFeatures and Cell Reconstruction

For open cell foams MAVI offers a variety of analysis methods. As a first step, mean characteristics are obtained just based on a segmentation of the strut system, that is a simple binarization of the 3d image. Results are

- volume fraction/porosity
- specific surface area
- mean strut length per volume
- mean cell volume

Image analytic reconstruction of the cells based on distance and watershed transforms allows to determine empirical distributions of cell characteristics like volume or shape. For an illustration of the reconstruction procedure see Example 1.

The strut thickness distribution can be obtained by spherical granulometry. Tortuosity and percolation analysis yield alternative descriptions of the pore system.

Analysis of a GRFP part – SubfieldFeatures and SubfieldFiberDirections

Global analysis using MAVI's FieldFeatures yields a global direction analysis as well as the global fiber volume fraction. However, these characteristics are not suitable to describe local behavior or to detect local defects.

The SubfieldFeatures divide the image into 2d or 3d tiles of user-defined size and compute characteristics such as the volume fraction, the specific surface or the Euler number density within these tiles. This allows the user to detect local irregularities of a microstructure. Furthermore, the resulting local measurements can be mapped to images for visualization.

The SubfieldFiberDirections, which operate on gray value images, quantify fiber directions from image data of e. g. glass and carbon fiber-reinforced polymers. This analysis, which can be applied both globally and locally, yields e. g. orientation tensors, the mean fiber direction and a scalar anisotropy measure. This allows to validate simulations of composite production processes, and reveals local deviations from the desired direction(s).

Examples: Volume renderings of reconstructed tomographic images along with selected analysis results. All images taken by ITWM's in house CT.

1 *Open nickel-chrome foam Sample: Recemat International (RCM-NC-1723.13); Result of distance transform. Blue – strut system, from green to red – increasing distance to strut system. Reconstructed cells (colored, each color represents one cell). Histogram of cell volumes.*

2 *Sugar Particle size histogram – diameters of the equal volume ball; Particles separated using distance and watershed transforms*

3 *Part made of glass fiber reinforced polymer SubfieldFiberDirections – colors of tiles represent deviation of principal direction in the 3d tile from principal direction in the whole part*

4 *Silica gel fibers Sample: Fraunhofer ISC; SubfieldFiberDirections – colors of fibers represent their local directions in the colored pixels*