IMAGE PROCESSING

Mortar contains aggregates such as sand or gravel, the sizes and shapes of which determine its processing and material properties. Our 3D grain shape analysis based on volume images helps to optimize these aggregates for high-performance mortars.

MARKUS RAUHUT
HEAD OF DEPARTMENT

CUSTOMIZED IMAGE ANALYSIS FOR PRODUCTION AND THE ANALYSIS OF MICROSTRUCTURES

We develop mathematical models and image analysis algorithms and implement them in efficient, industrial-suited software, mainly for production.

The areas of application include in particular sophisticated surface inspection and the analysis of microstructures. Our large portfolio of algorithms enables the development of image processing solutions that cannot be implemented by the industry. In addition, there are many tasks for which commercially available systems cannot be used or can only be used partially. For these questions we develop tailor-made image processing solutions.

Consulting also plays an important role for us, for example, hardware decisions in the design of image processing systems (IPS) or the integration of additional components into an existing system. We also offer independent consulting in the area of optical quality controls and the development of algorithms.

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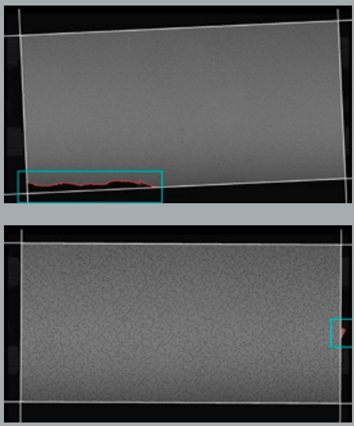
MAIN TOPICS

- Surface and Material Characterization
- Quality Assurance and Optimization
- Image Understanding and Scene Analysis



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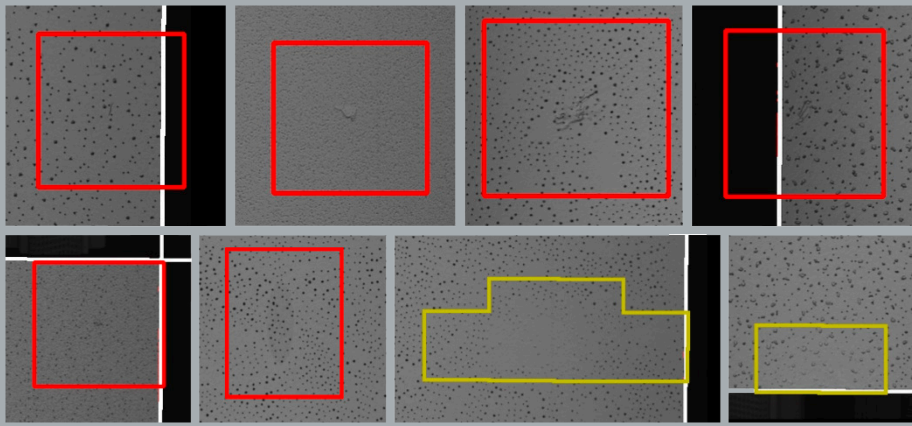

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MODEL-BASED LEARNING FOR THE INSPECTION OF MINERAL FIBER PANELS

1 Ceiling panels with detected edges: Typical geometric errors are edge break-offs (top) and overhangs (bottom).

2 Examples of surface detail defects and large area design errors in the manufacture of ceiling panels

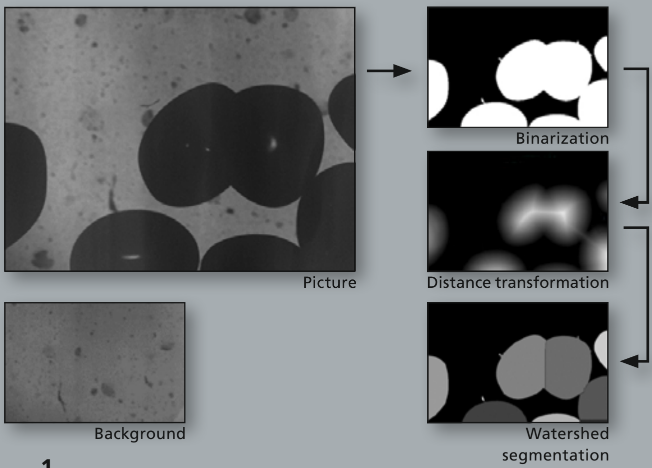
Model-based learning facilitates fast and flexible image processing solutions. We have developed and implemented such a solution for the Odenwald Faserplattenwerk GmbH (OWA) to provide fully automated testing in the manufacture of soundproofing ceiling panels. OWA mineral fiber panels come in a variety of different designs that are continuously extended. The aim of our solution is to ensure a quality inspection that is so flexible that it can be adapted to new designs and defect types with a minimum of effort.

Defect detection by combining a series of filter processes with morphological methods in a step by step method is difficult to adapt. We avoid this by exploiting the advantages of model-based learning. In effect, this means that we make model assumptions that generically apply to different types of products and combine them with self-learning techniques. Typical industrial applications mainly produce defect-free parts, so examples of the defects are infrequent. Instead of modeling defects, we use a so-called one-class classification of defect-free parts. Any areas whose properties cannot be assigned to this good class are then identified as defects.

Algorithm finds large-area and small-scale defects

First, we model the rectangular shape of the ceiling panels by detecting the main lines with the aid of the Hough transformation method. In this way, dimensions are determined and the first defect types can be found. To look for defects inside a panel, we model the design or even the needling. We find defects in large areas and also in small details. In the case of large-area defects, we calculate properties across the entire panel width: for small-scale defects, we use just the properties in the vicinity of the needling. For both types of defects, learning is based on a sufficiently large number of sample images classified as defect-free panels. Already a hundred images are sufficient to enable this classification to work productively with little parameterization effort.

By means of this combination of procedures, we quickly provide a good solution for the production of new product variants, which we can also iteratively improve during a running operation with the addition of more sample images.



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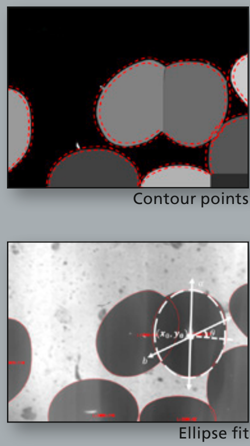

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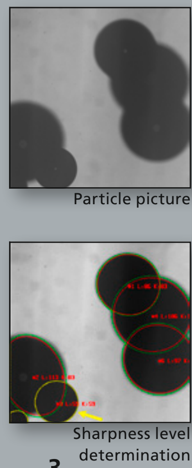

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DETECTING GRAINY AND NON-SPHERICAL PARTICLES IN THERMAL PROCESS ENGINEERING

Particulates play a major role in process engineering, for example, in agitating vessels, bubble columns, extraction columns, and crystallizers. In the AiF-ORBITRO project, we determine the geometries of the particles to enable qualitative and quantitative statements about the real processes. To this end, we have developed a multi-stage, procedurally stable method that quickly detects round and non-round particles.

The particle environment is usually not free of dust and dirt, but it is static. First, the particle foreground is separated from the background by averaging over several images. Using adaptive thresholds to binarize both the particle image and the background image, we then recombine both. We use the relative roundness of the particles to divide the resulting particle regions into individual particles. Using the Euclidean distance transformation, these help in the extraction of possible particle centers and then, with the watershed transformation, we separate the candidate particles.

Detection also functions for overlapping particles

Subsequently, the contour points on the candidate particles are used to adjust the ellipses. With these contour points, we use a so-called "general conical model" to estimate six parameters for each ellipse. The fitting step then selects the ellipse that has the smallest absolute distance to all contour points. In this way, we achieve stable detection even for overlapping particles.

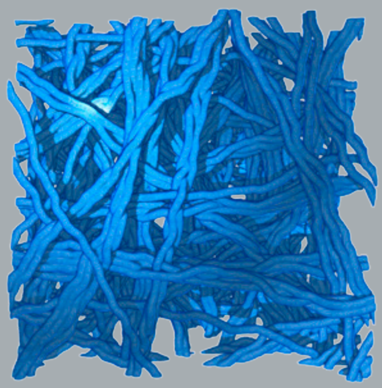
In addition to the ellipse parameters, we can set the sharpness level of the particle. This in turn is useful because the degree of sharpness – depending on the recording method – allows inferences about the position of the particle. We use different adaptive thresholds to determine the positions, followed by so-called "skeletonization." The sharpness threshold for particles can be configured by the user simply by selecting a parameter.

The processes developed with our ToolIP software is integrated in the existing LabVIEW environment and used for further statistical analysis particle processes.

1 Step by step procedure for detecting the candidate particles

2 Schematic representation of the contour points and ellipse fit after optimization

3 Determining grain sharpness by inner (red) and outer (green) circumferences of the ellipses; sharp ellipse in yellow



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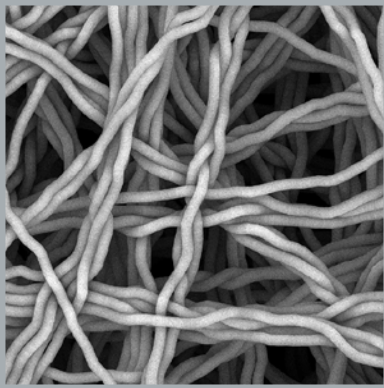

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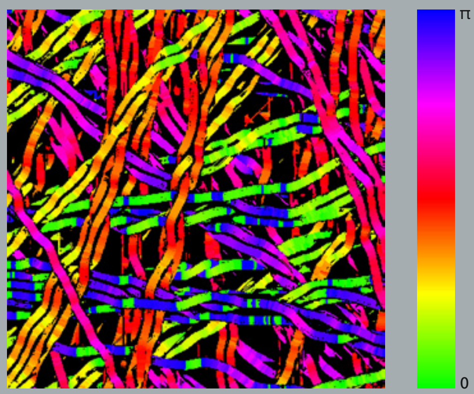

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MAVIfiber2d – MEASURING FIBER DENSITY, FIBER ORIENTATION, AND CLOUDINESS

1 Volume rendering of Altendorf-Jeulin model

2 Simulated REM image (BSE-Signal) of a random fiber system (Altendorf-Jeulin model)

3 Orientation map for the REM image in figure 2

The quality of nonwoven fabrics depends on the distribution of the fiber thickness, the fiber orientation, and the cloudiness. These properties are evaluated in the laboratory using image data. MAVIfiber2d meets the difficult challenge of automating this evaluation, while also ensuring that it is reproducible.

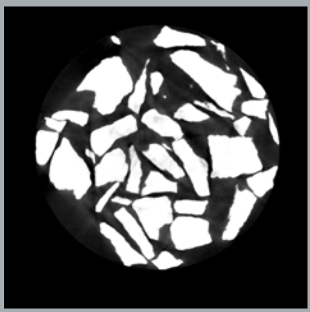
Diffusion filters have been the nucleus of image processing at ITWM and the VQC project, which measured the cloudiness of nonwovens was one of the first industry projects in the image processing department. MAVIfiber2d combines this experience with new tools of mathematical morphology and the typical point concept of stochastic geometry to create software for objective, reproducible evaluations of non-woven samples.

Local analysis without fiber separation

In a random closed set, the typical point concept makes it possible to measure the distributions of fiber thickness and fiber orientation without having to separate the fibers in the image. In ambiguous situations, it is not necessary to decide where each intersecting or looped fiber begins or ends. Rather a simple binarization suffices: for every image pixel, a decision is made as to where it belongs in the fiber system, i. e., the foreground or the background. Local thickness and orientation are defined for every foreground pixel. The result is an area-weighted distribution of thickness and orientation.

Measuring cloudiness from standardized grayscale variances

Cloudiness is mathematically not so easy to describe. MAVIfiber2d builds on the VQC project findings. The input image is smoothed step-by-step with approximated Gauss filters. The grayscale variances of the standardized filtered images reflect the cloudiness for the scale under consideration. The cloudiness index is calculated from the variances as a weighted average. The scales and weights are chosen in a manner that measuring results correspond as well as possible to the technical requirements and the subjective visual impressions.



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3D ANALYSIS OF PARTICLE SHAPE FOR HIGH PERFORMANCE MORTAR

Construction mortar contains aggregates like sand or gravel, where size and shape determine the processing parameters and material properties. Standardized test sieves are used to control grain sizes. By using bar sieves instead of perforated sieves, rough statements about grain shapes can be deduced. In the past, to determine the grain shape more accurately, it was necessary to measure manually with sliding calipers.

The shape distribution is also important because, besides the size distribution, it determines the packing density and the mechanical properties of the aggregate. Computed tomography was used for the first time to spatially image the shape of several thousand grains simultaneously in the ZIM project "Developing innovative high performance mortars based on conformity criteria through the use of new 3D measuring and evaluating techniques in computer tomography." In the 3D images generated, however, the individual grains touch each other. The grains must be separated via image analysis before their shapes can be measured.

Standard morphological algorithms for particle separation cannot solve this problem – even with the ideal choice of parameters - because the particles are too flat and too pointed. In particular, grains split in the image if their shape deviates too far from the spherical. In the project, fragments were first interactively assembled and then we tried to distinguish real grains and fragments based on their spatial geometry. However, this method of classification does not work because the grain shapes vary too much.

Correcting the particle separation

Consequently, instead of focusing on the grains or the resulting fragments, we now study the separation areas as spatial geometric objects. Their expansion and rippling are well suited to distinguish real from false separation areas. This approach is currently being tested for subsequent implementation as a separation algorithm.

Successfully separated grains can be measured far more accurately by image analysis today than by the mechanical methods required previously. In addition to volume and surface content, the length, width, thickness, isoperimetric shape factors, elongation, and maximal thickness as well as a number of other parameters can now be determined.

1 *Cross sectional view of the reconstructed tomographic image of a grain packing*

2 *Left: Same slice after automatic particle separation. Clearly, some particles are erroneously separated. Right: Results of interactive post processing*

3 *Volume rendering of a particle that is separated too strongly.*

NEWS

12. EUROPEAN CONGRESS FOR STEREOLOGY AND IMAGE ANALYSIS 2017

International research scientists met at the ITWM for the Stereology Symposium on processing, segmentation and analysis of FIB-SEM image data: A special focus was on highly porous structures. The agenda highlighted Annick de Backer for her doctoral thesis “Quantitative Atomic Resolution Electron Microscopy Using Advanced Statistical Techniques.”

OPEN HOUSE WITH THE MOUSE

The department once again participated in the institute’s “Open Doors” program inspired by the German children’s TV show “Sendung mit der Maus” and presented its own amusing facts and stories in the atrium. Approximately 30 boys and girls learned about the field of surface inspection and used a computer game to detect and classify various irregularities on a cow hide, for example, insect bites, injury from barbed wire, and stretch marks. The focus topic of microstructure analysis was experienced by the young guests by analyzing different types of lady finger biscuits and blasting dirt particles using compressed air at a greatly enlarged model of a vacuum cleaner filter.

DIGITAL TECHNOLOGIES WORKSHOP FOR FIBERS, NON-WOVENS, AND TECHNICAL TEXTILES

Two-day exchange for experts in industrial development and application-oriented research: The lecture topics were as wide ranging as the application areas of simulation technology and included fiber spinners, technical textiles, fiber processes, nonwoven fabrics, filtration, and textile composites. The workshop participants, for example, worked on the development of new ceramic fibers, a simulation and optimization of needling processes, and the virtual development of filter methods and media. The computer-aided characterization of the microstructure of fiber composites and the virtual design of textile-reinforced composites also played a role.

Front, left to right: Petra Gospodnetic, Bess, Dr. Katja Schladitz, Yuli Afrianti, Annika Schwarz, Nikita Nobel, Franz Schreiber, Dascha Dobrovolskij, Markus Rauhut, Mark Maasland, Sonja Föhst, Diego Roldán, Dr. Xiaoyin Cheng, Konstantin Hauch, Dr. Thomas Weibel, Dr. Ali Mogiseh, Martin Braun, Dennis Mosbach