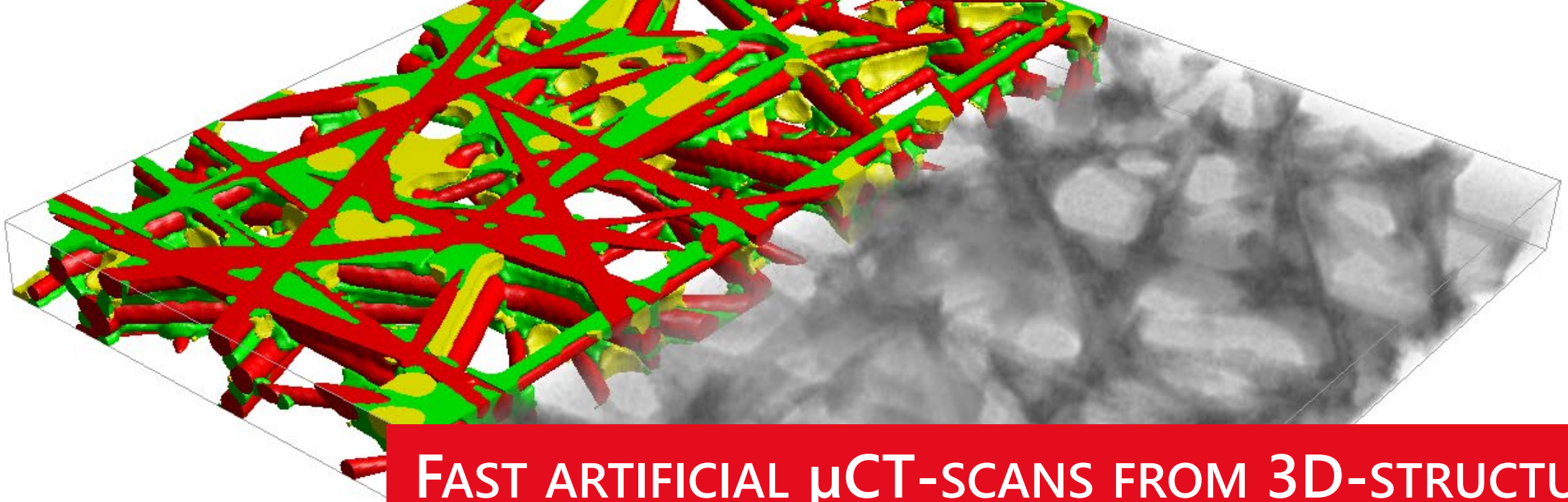


Fast artificial µCT-scans from 3D-structure models using Gaussian Random Fields

Interpore, May 6, 2019

Andreas Weber, Andreas Wiegmann, Nicolas Harttig, Christian Wagner

Who we are

MATH 2 MARKET

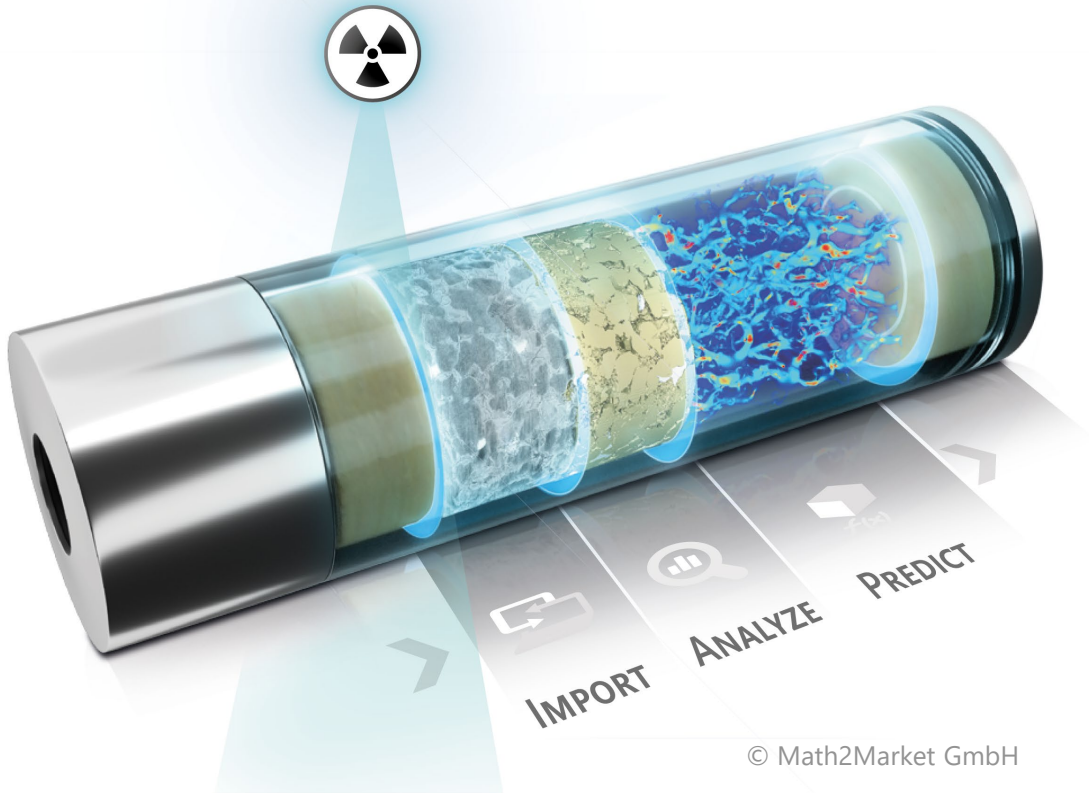
Math2Market GmbH

- creates and markets the scientific software GeoDict®.
- was spun off in 2011 from Fraunhofer ITWM in Kaiserslautern.
- is a privately owned company based in Kaiserslautern, Germany.

GeoDict® - The Digital Material Laboratory

- is a software tool to analyze and design the microstructure of porous media and composites.
- works on
  - µCT and FIB-SEM 3D images or
  - random geometric material models.

GeoDict
The Digital Material Laboratory

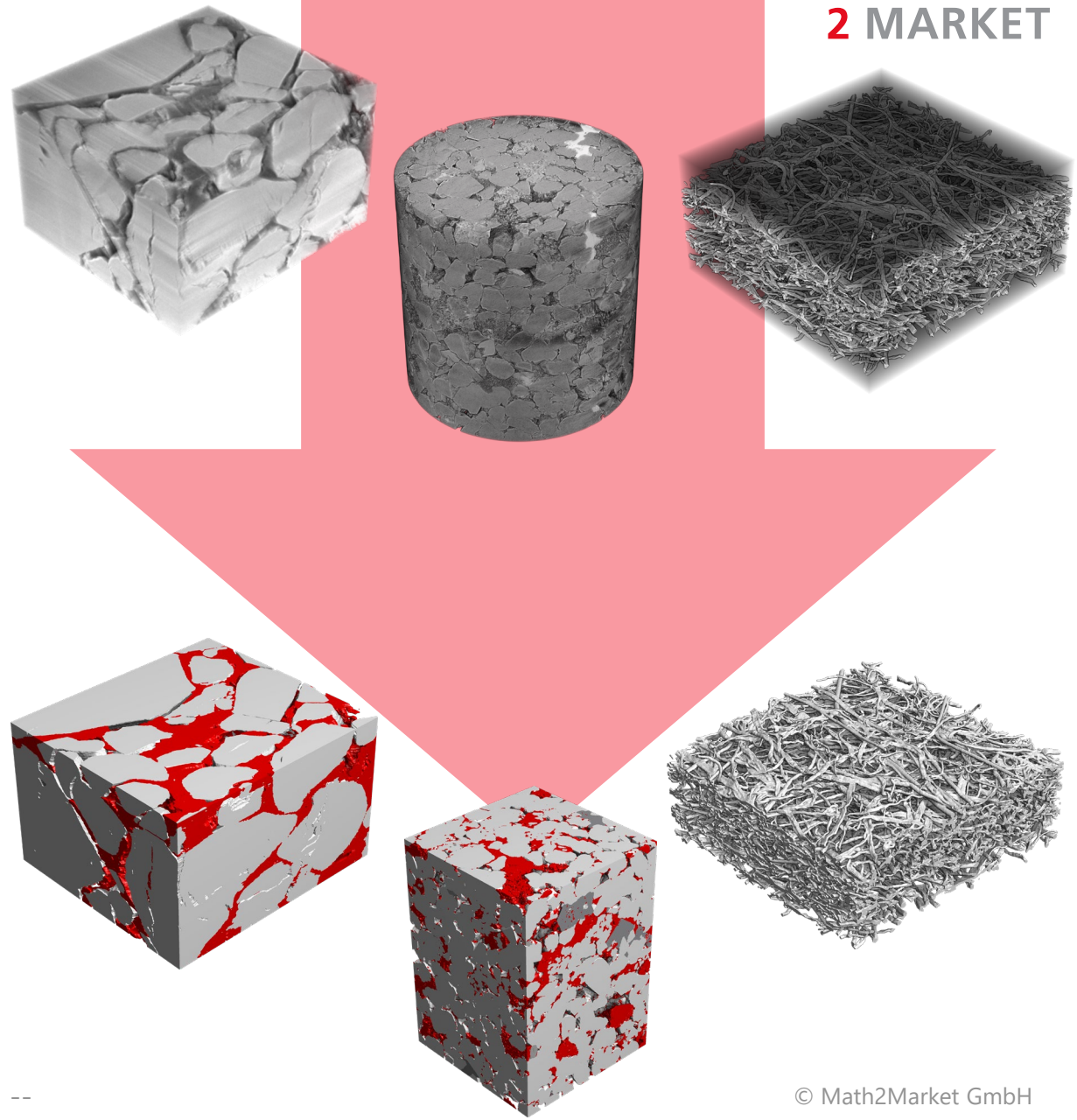


WHY DO WE NEED ARTIFICIAL µCT SCANS?

MATH
2 MARKET

Use artificial µCT scans for

- 3D image processing quality control
  - Optimize 3D image filters
  - Find suitable workflows for typical scanned structures
  - Find optimal post-processing workflow and parameters
- Artificial Intelligence learning material



WHY DO WE NEED ARTIFICIAL µCT SCANS?

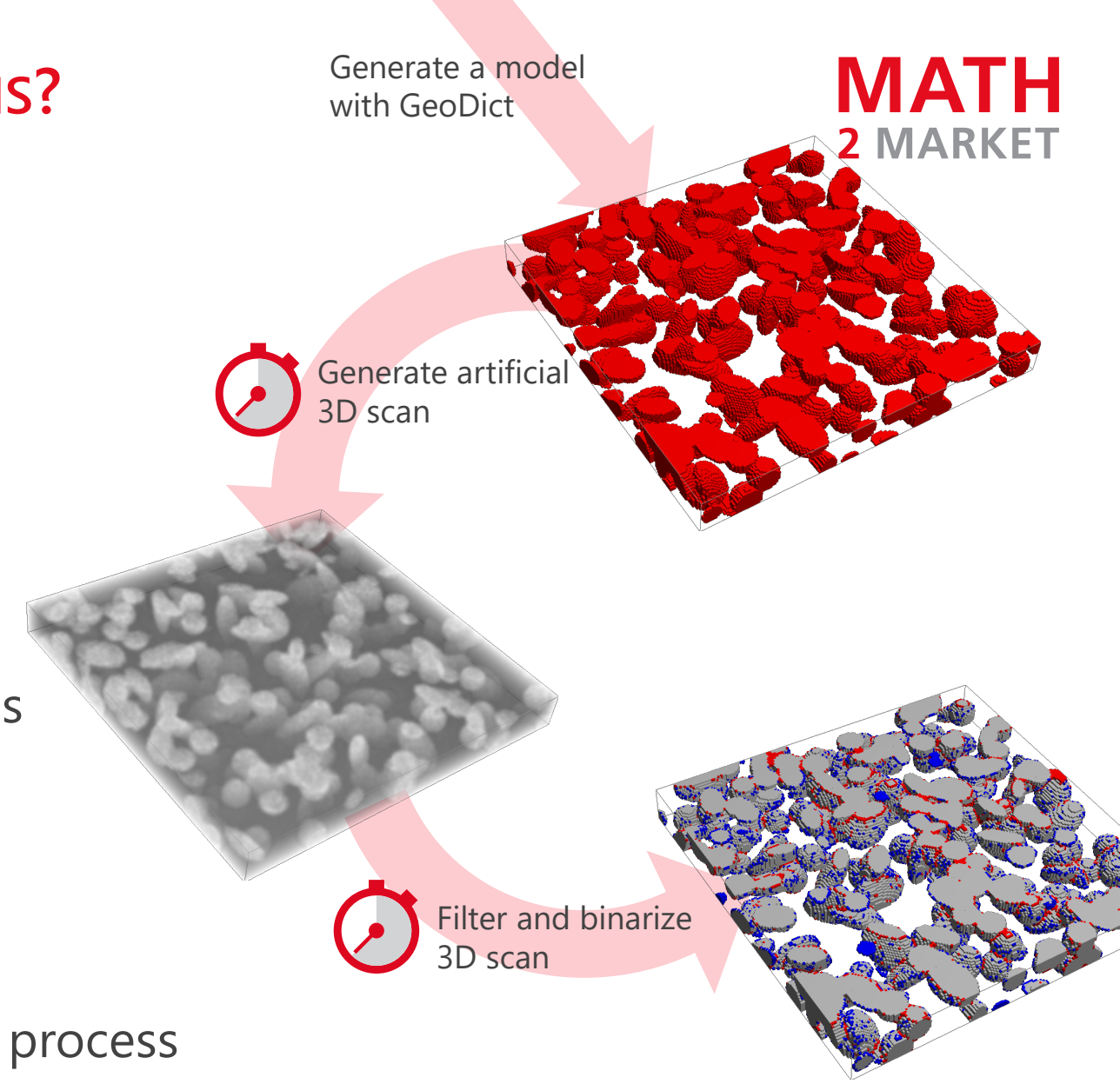
Why „fast“?

- No sinogram reconstruction
- No raytracing / beam simulation

This enables usage in fast parameter studies:

- Create a scan of a 1000^3 model in 5 minutes
- Vary image artifacts and noise
- Process image with suitable filters
- Binarize and analyze model

→ Find optimal settings for the image import process



Why do we need artificial µCT scans?

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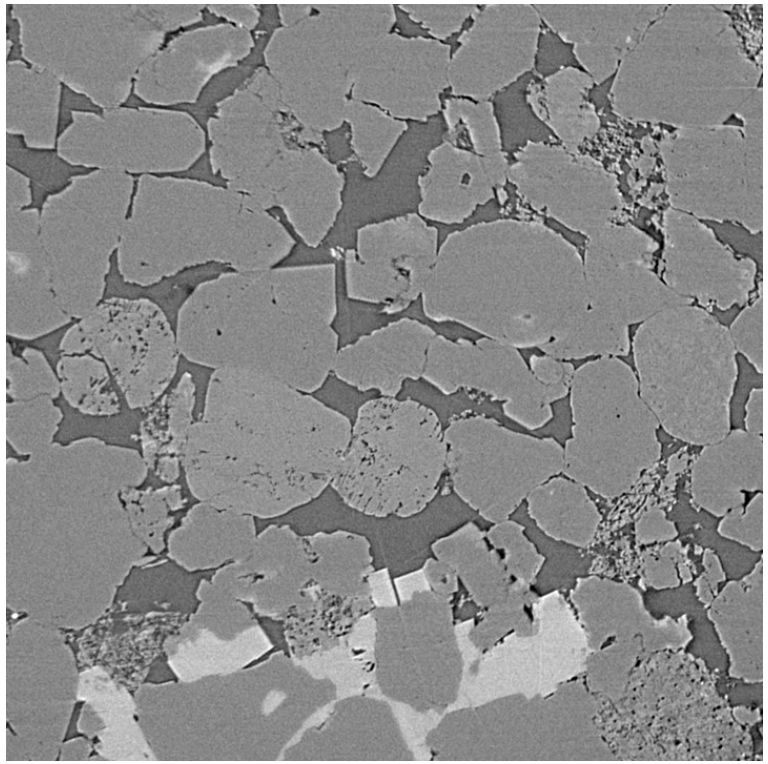
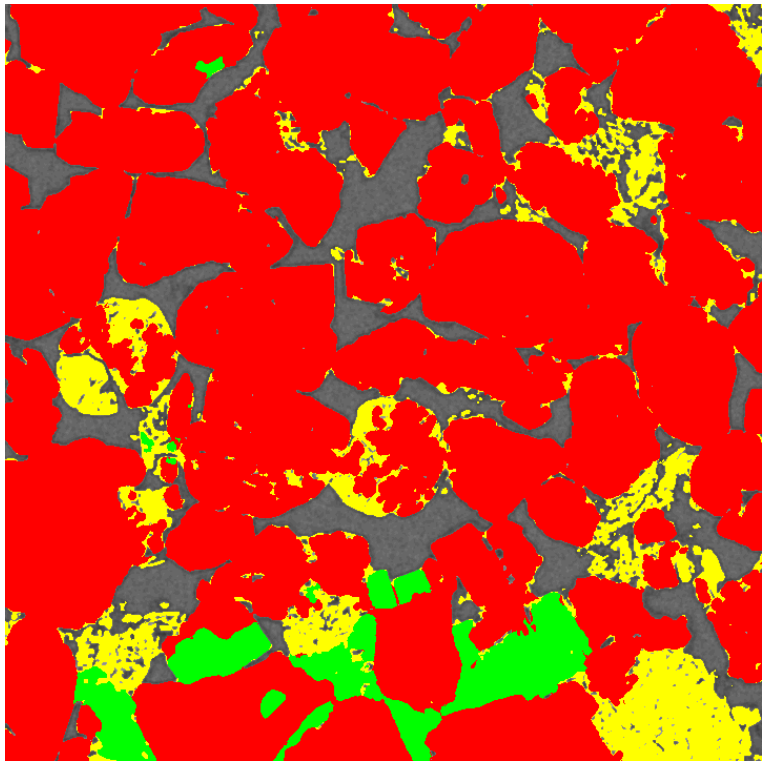
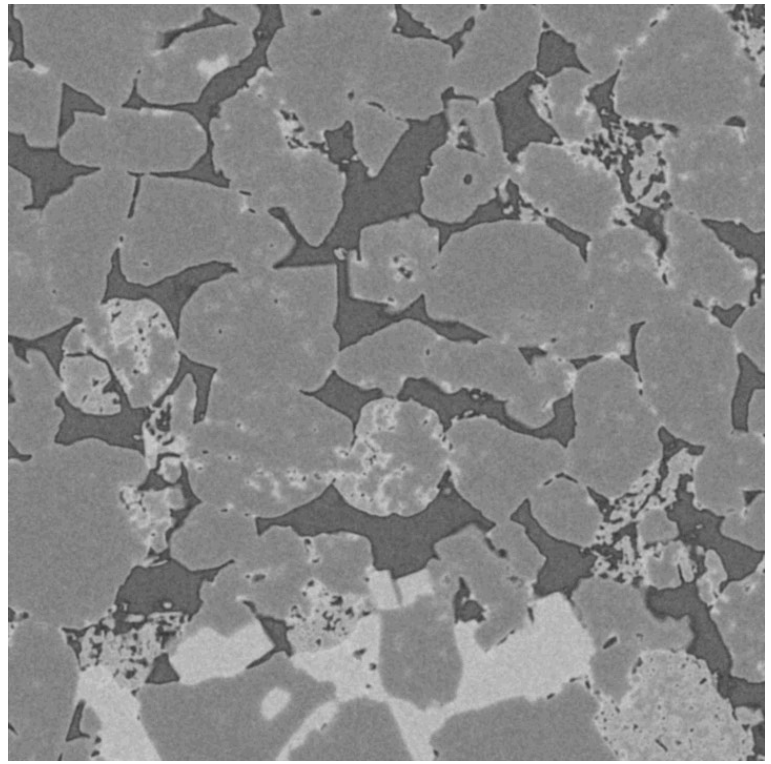
Construct artificial image from real data:



Original µCT scan



Segmented µCT scan

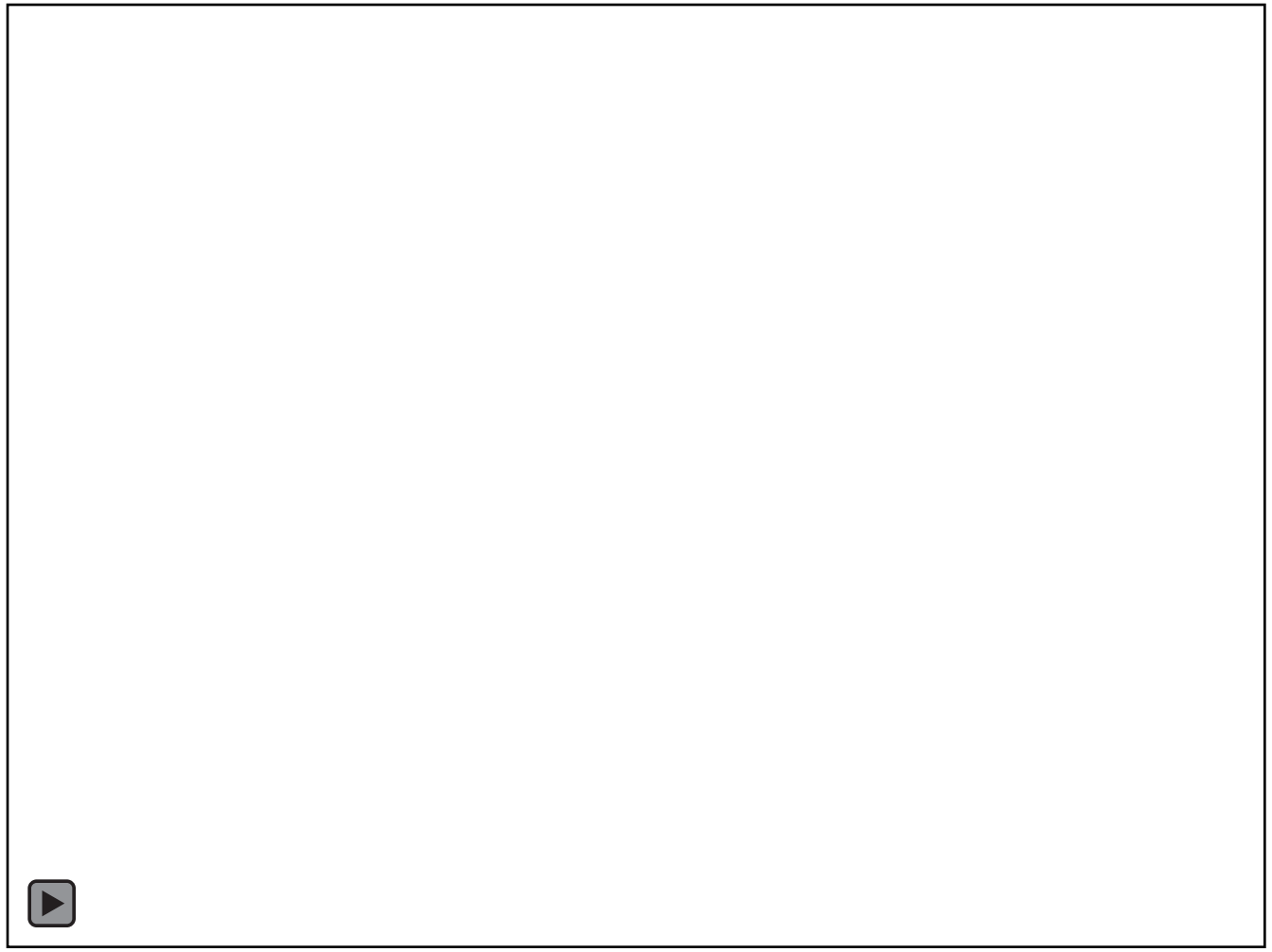


Artificial µCT scan

What are the challenges?

MATH
2 MARKET

- Edge Brightening
- Noise
- Image Brightness Artifacts
- Overexposure
- Flickering
- Misalignment
- Ring Artifacts



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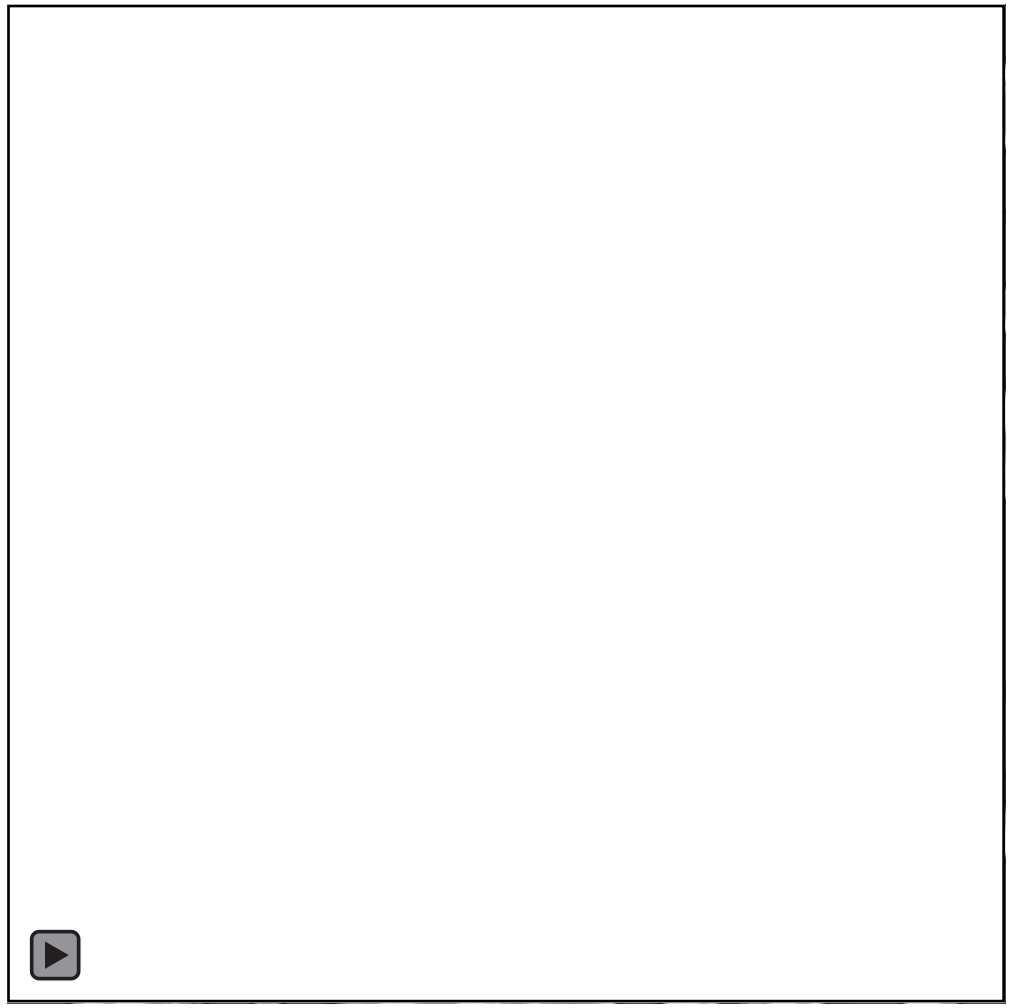

Edge Brightening

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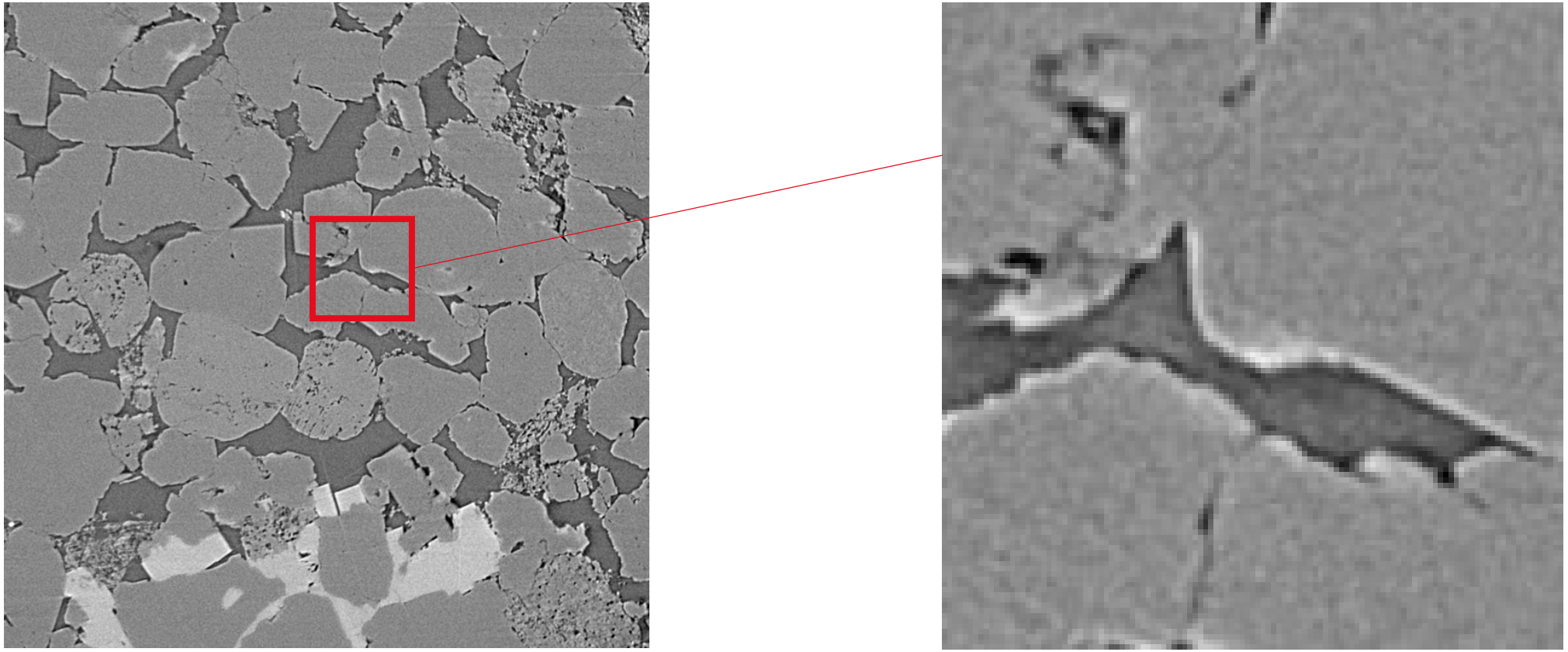
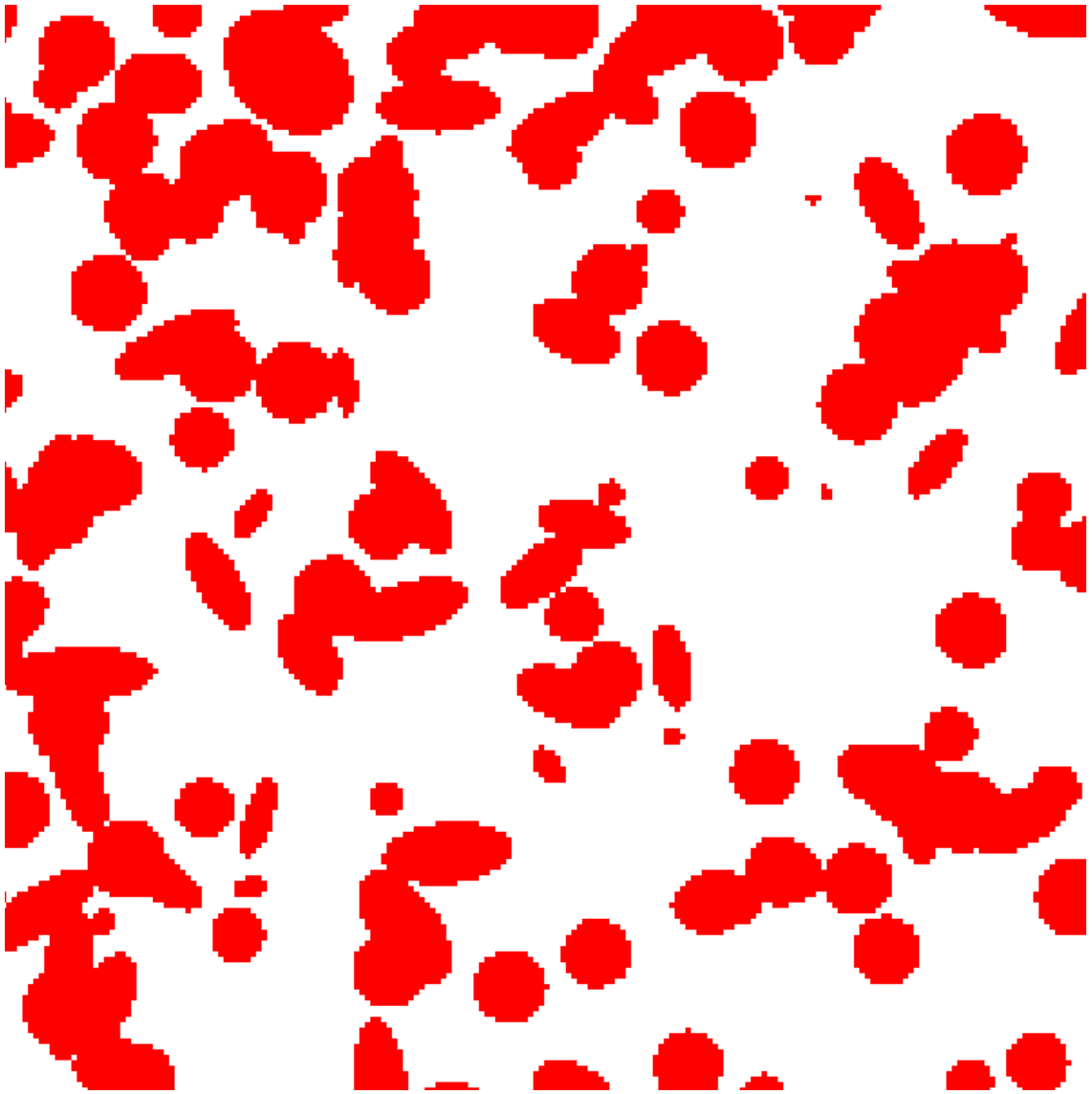


Edge Brightening



Original structure

Edge Brightening

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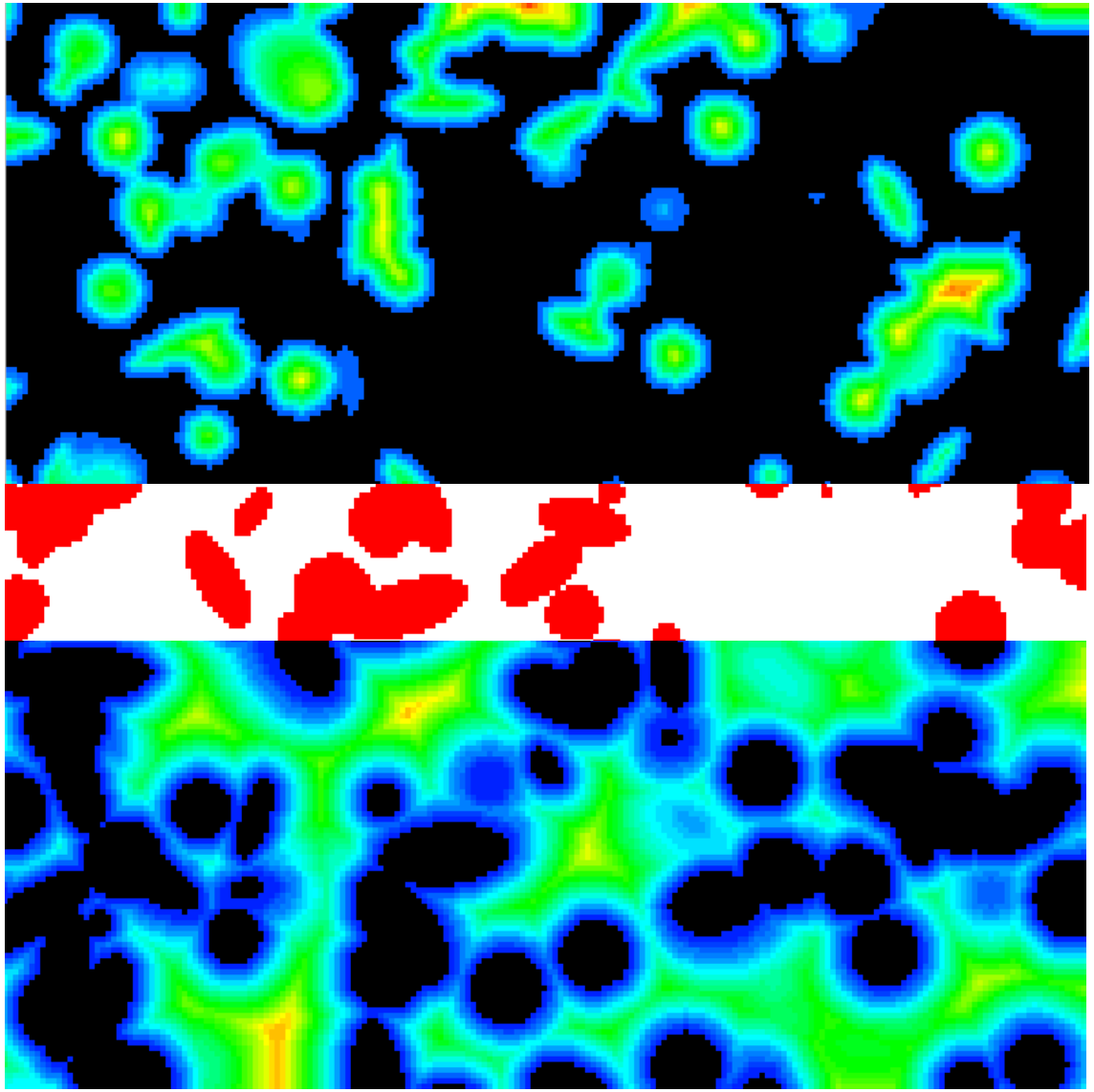
2 MARKET

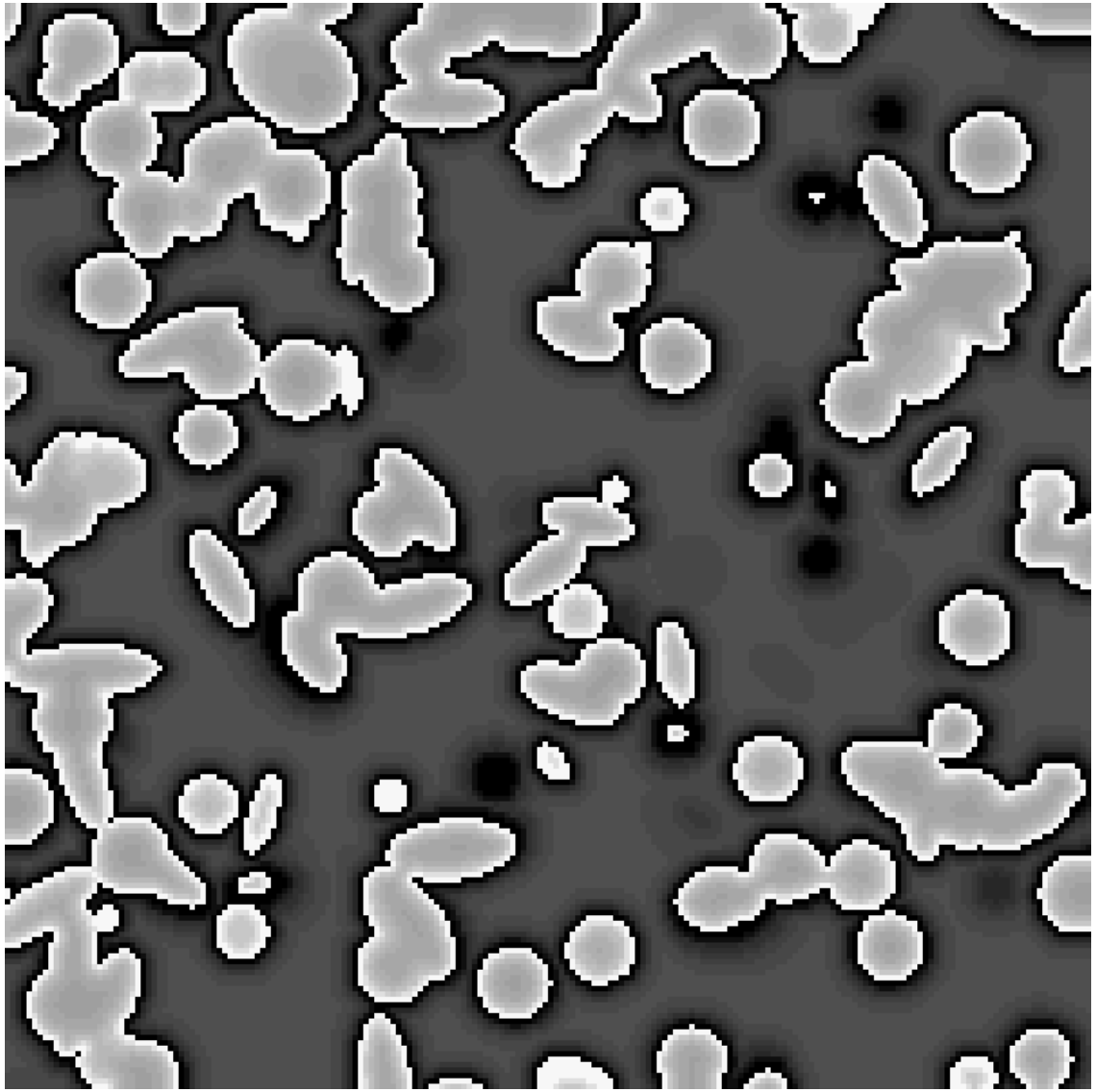


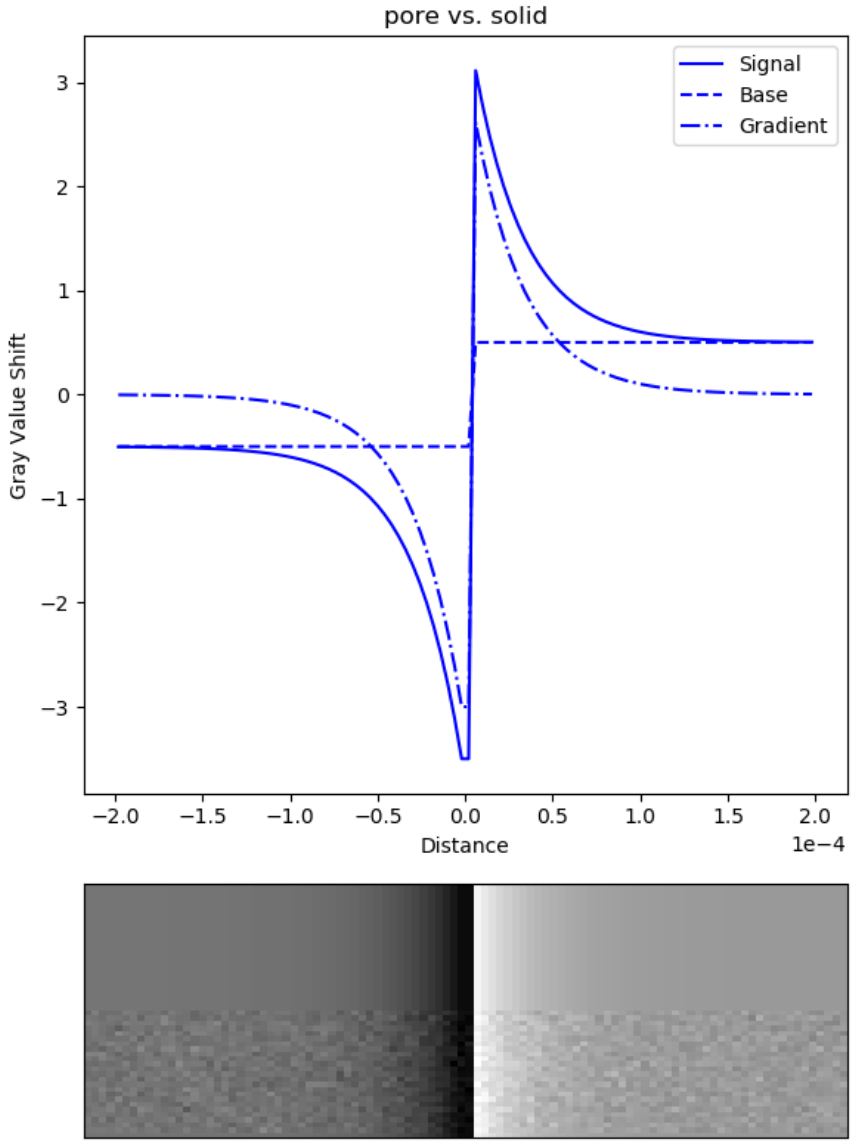
Distance map in solid space

Original structure

Distance map in pore space

Edge Brightening





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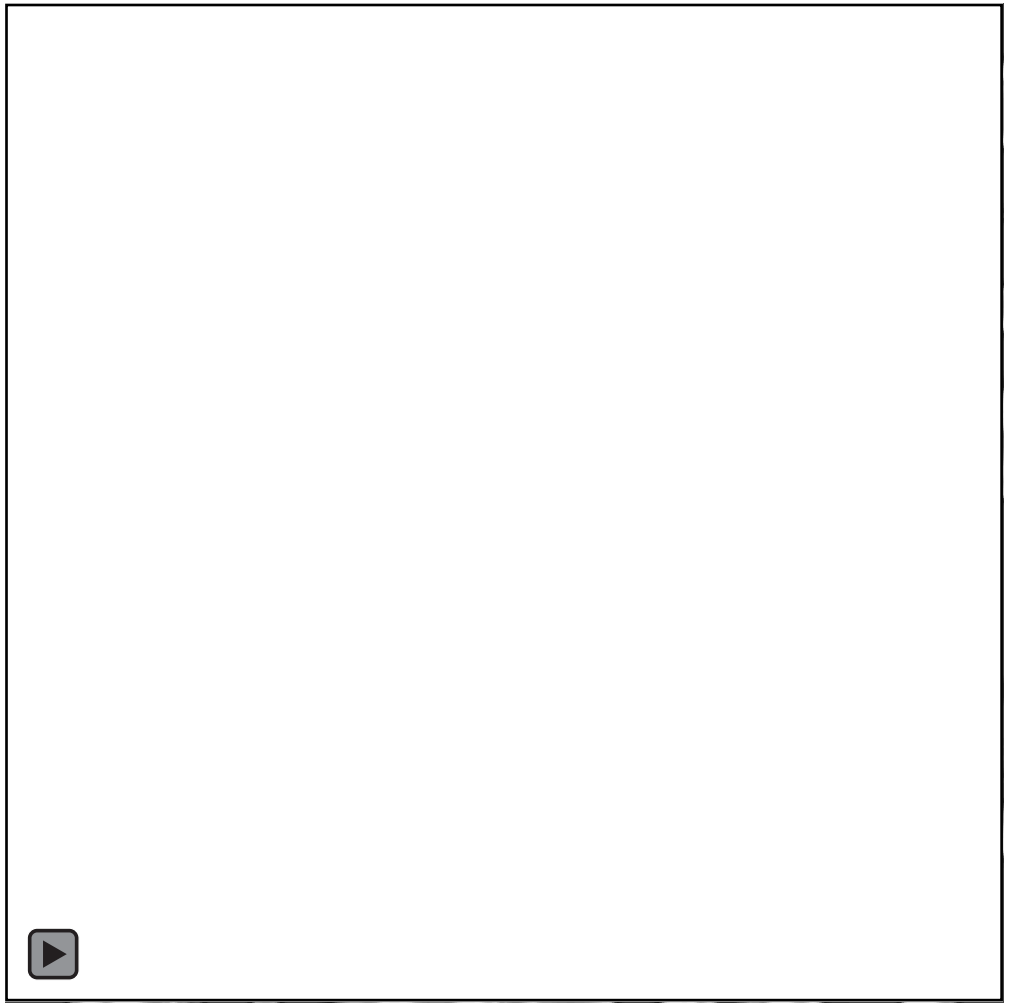

Noise

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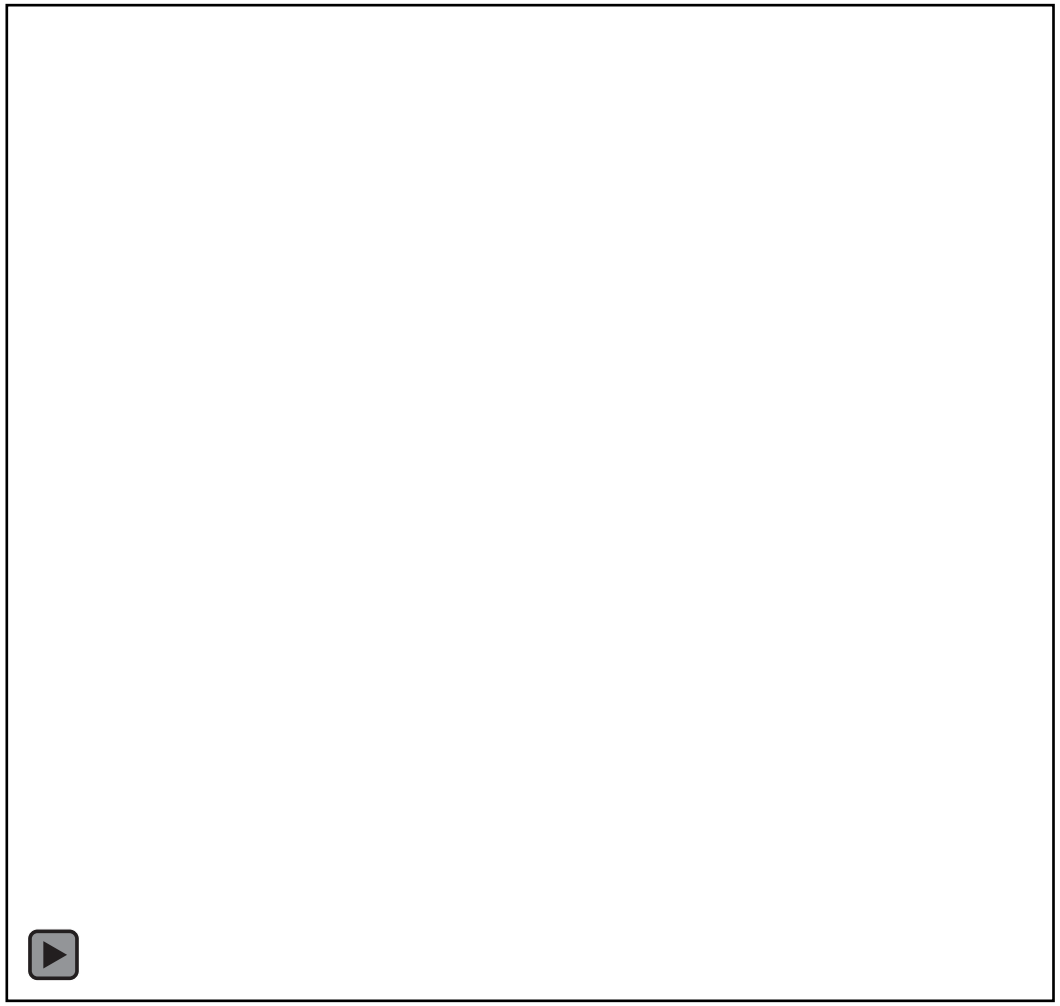
Gaussian Random Field:

- A 3D field filled with random gradients forming blobs
- Size and amplitude of the random blobs can be adjusted
- Multilevel randomness possible
- Resembles the noise that can be seen in µCT scans



Noise

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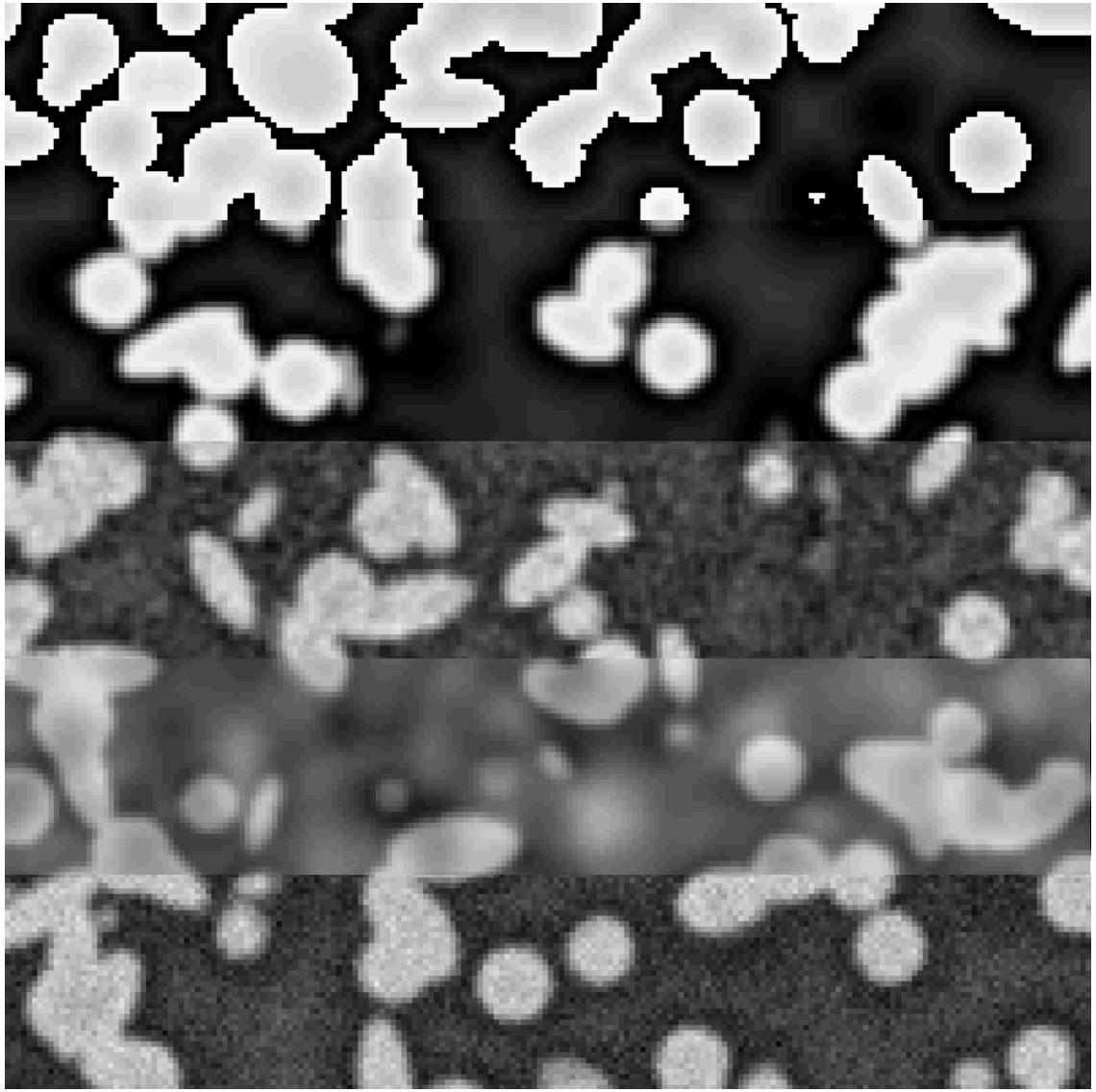
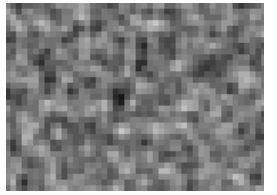
2 MARKET



Untreated

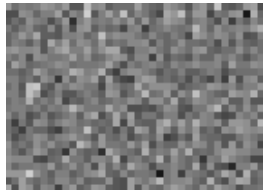
Gaussian Blur

Gaussian Random Field (fine)



Gaussian Random Field (coarse)

Normal Distributed Noise



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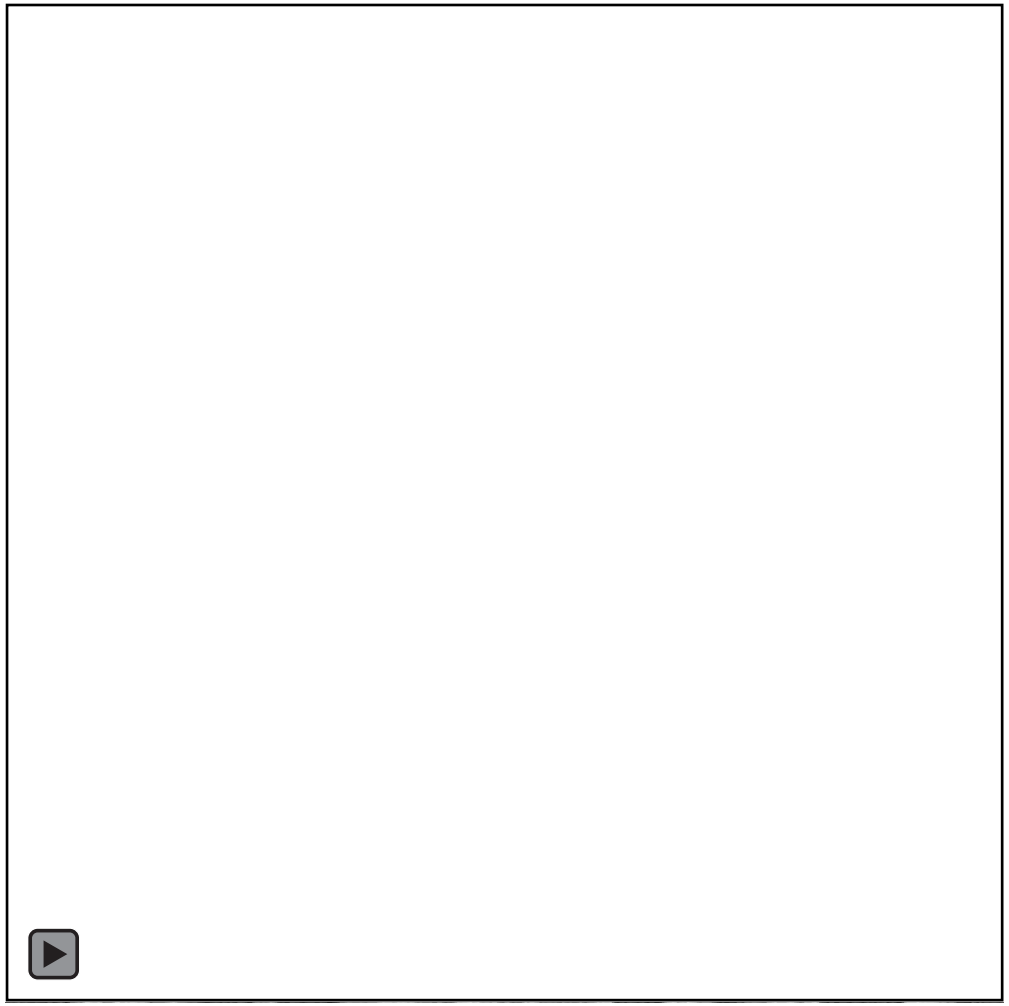

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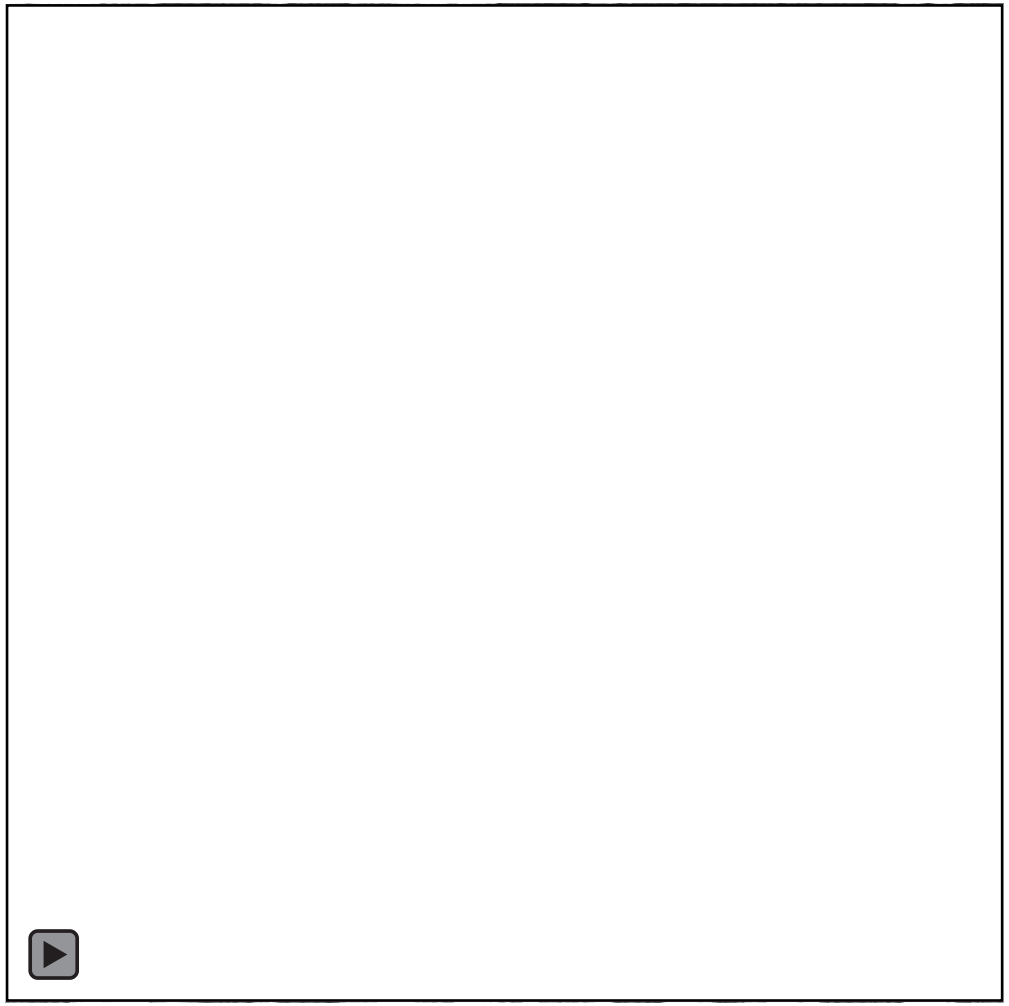

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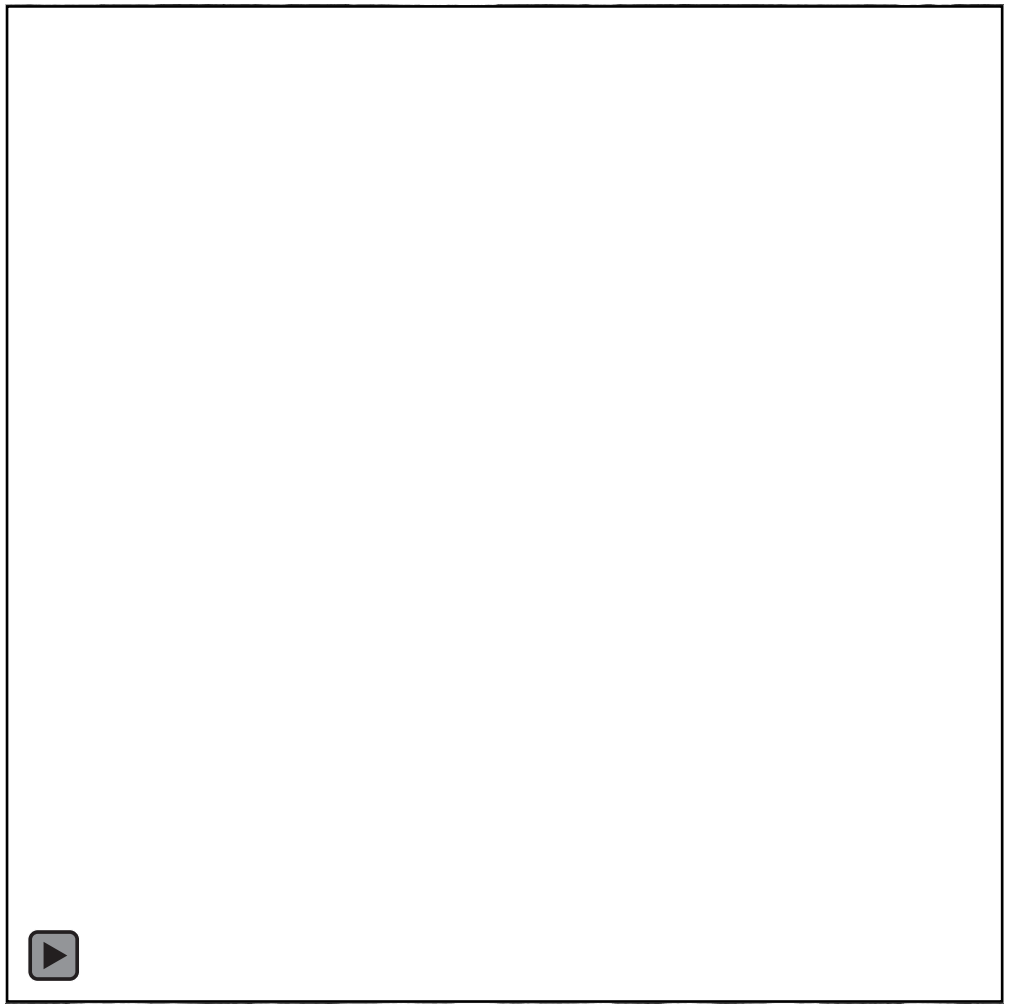

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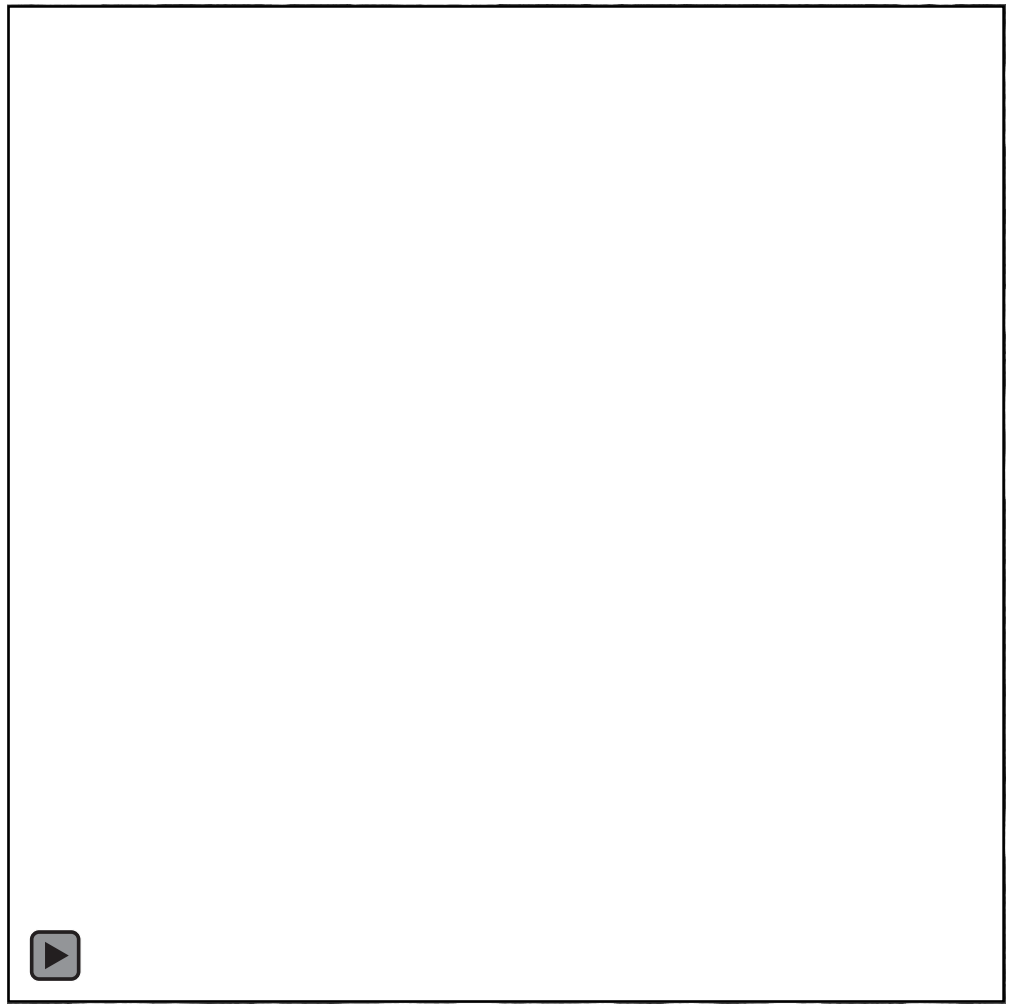

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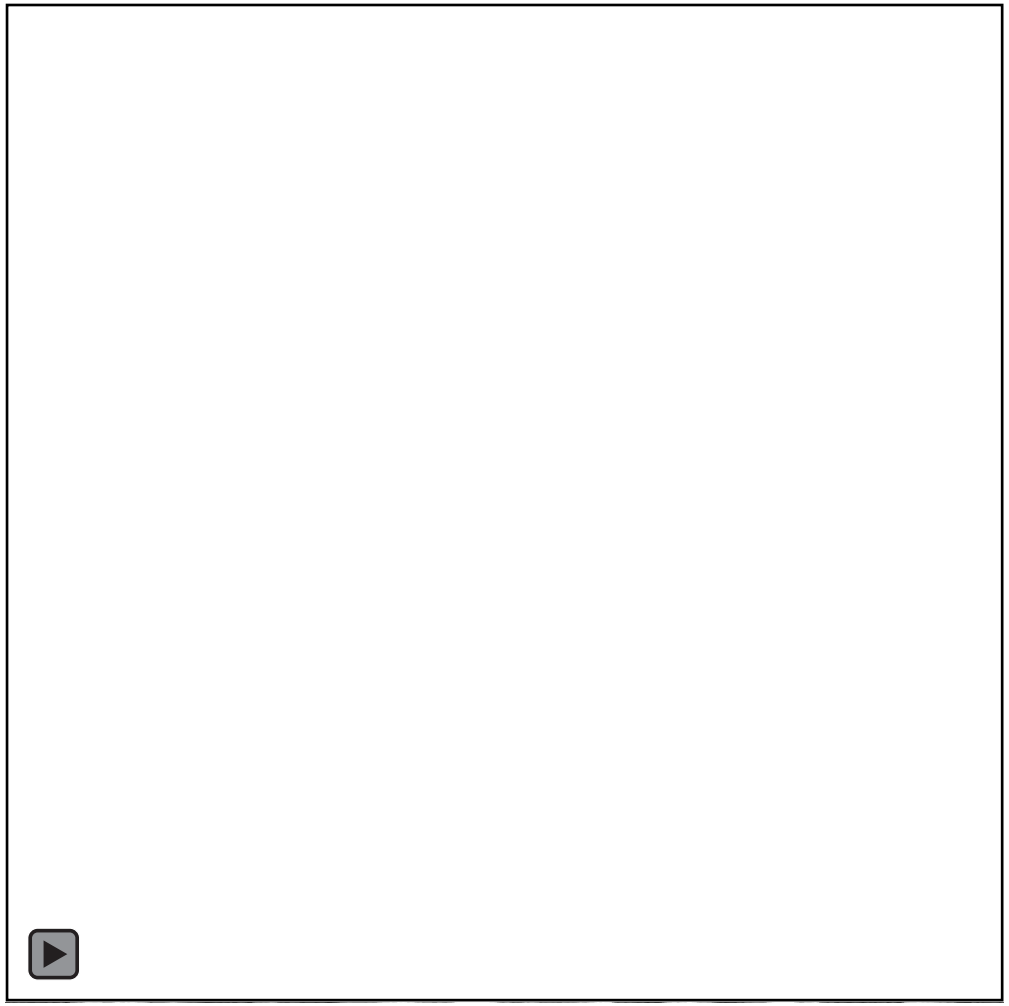

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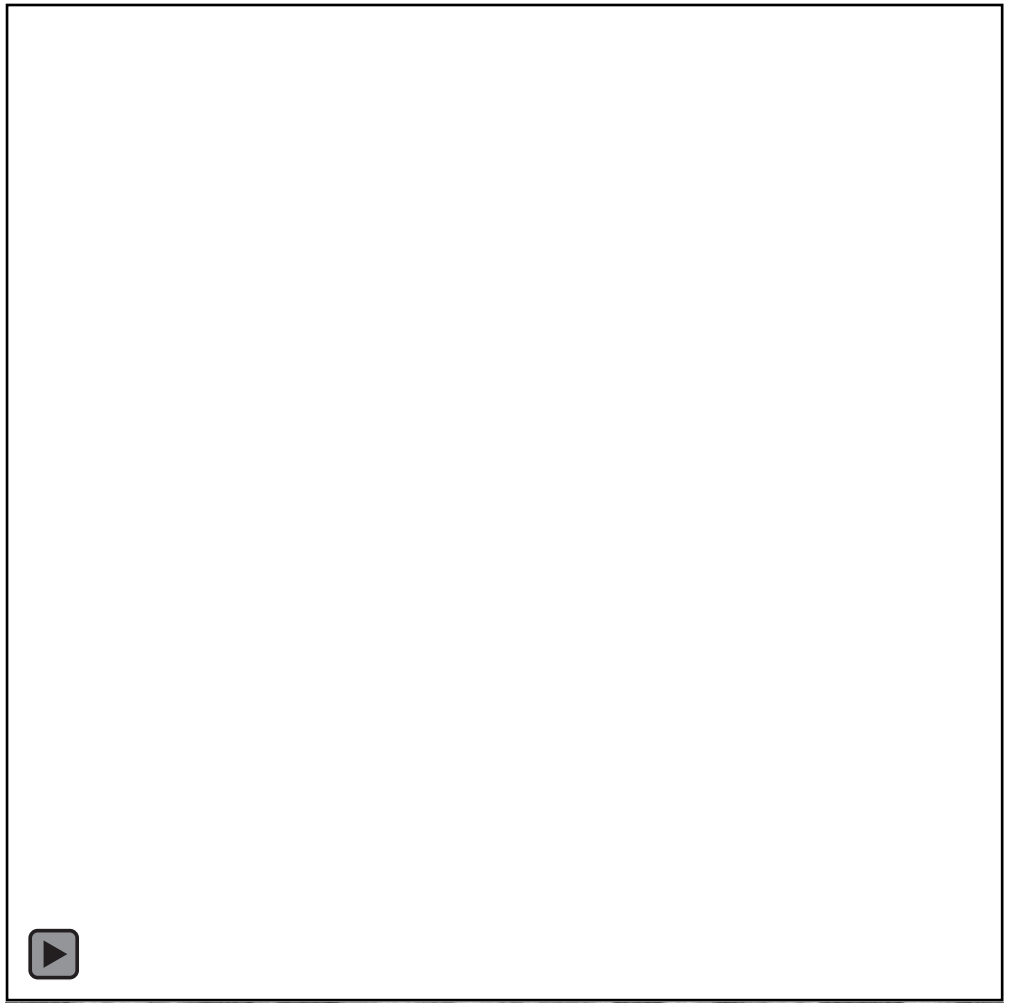


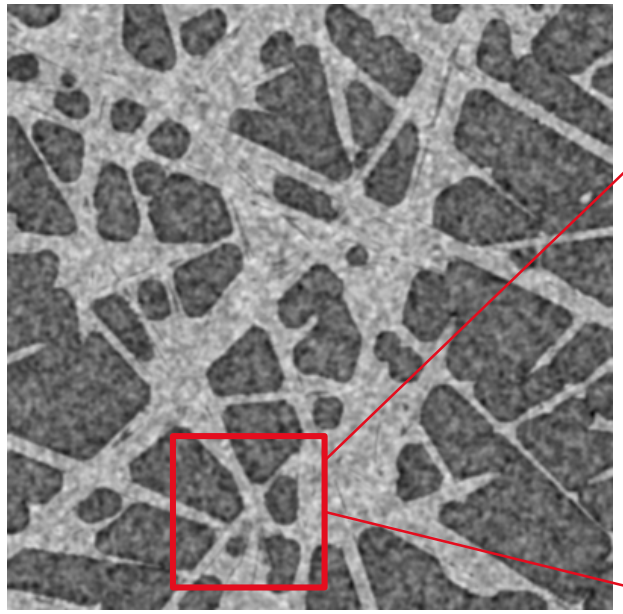
Example Study

MATH
2 MARKET

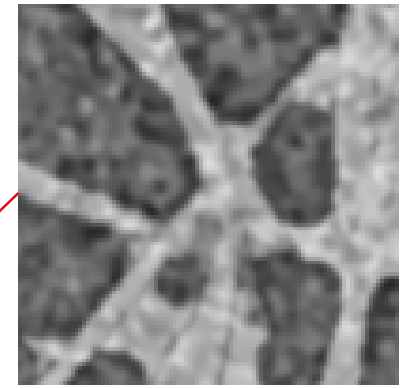
Start: µCT image with low signal to noise ratio

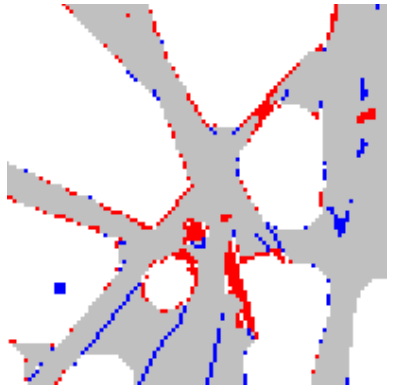
Improve image with non-local means filtering

Binarize image and compare with original model



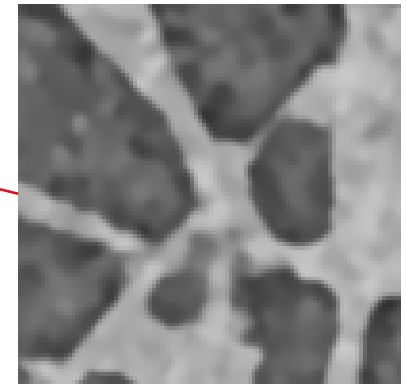
Low
filter strength

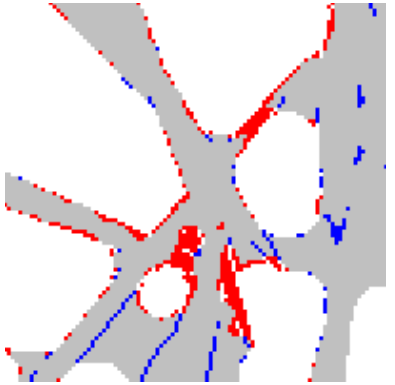




underestimated voxels
overestimated voxels

High
filter strength





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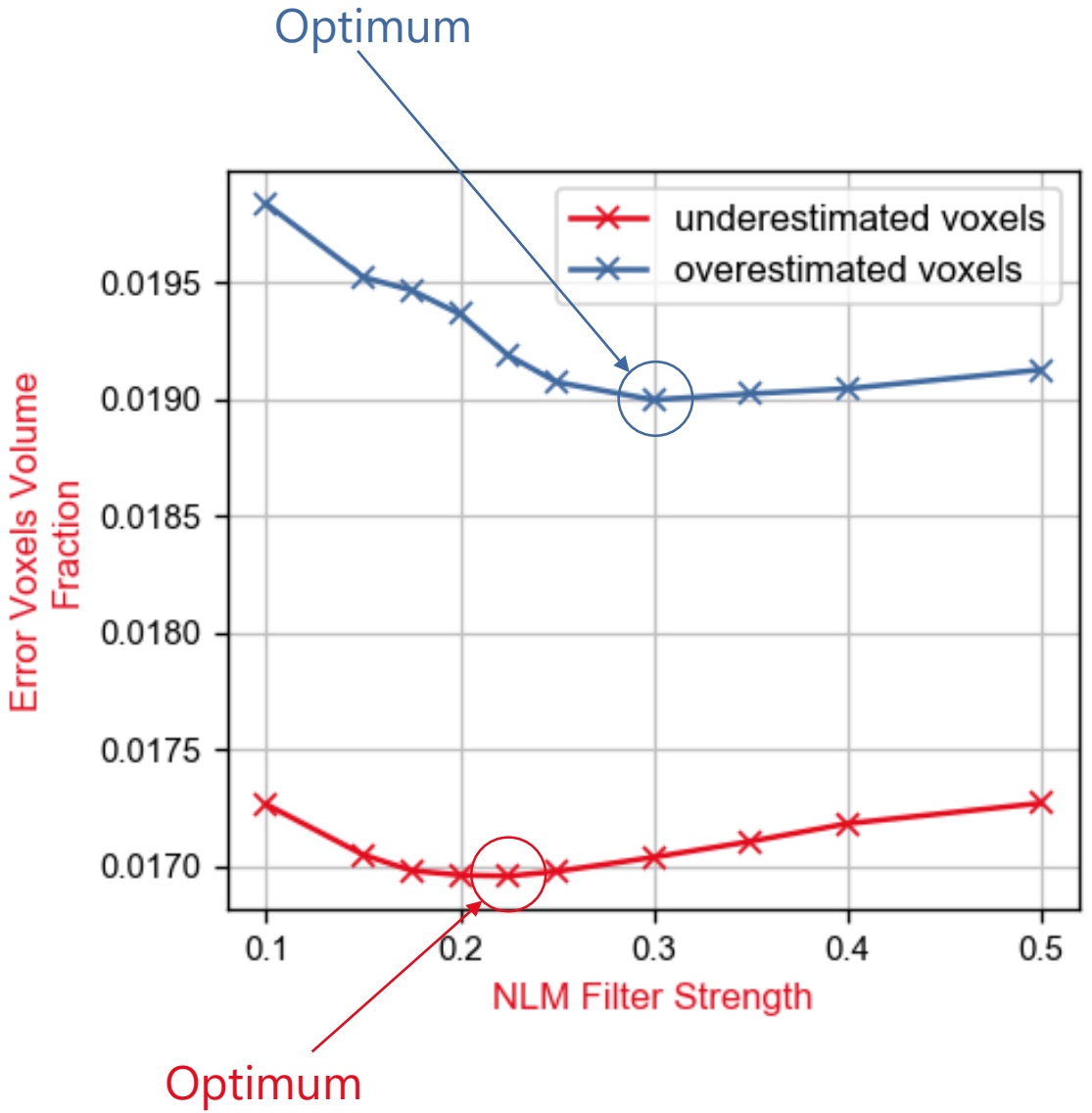
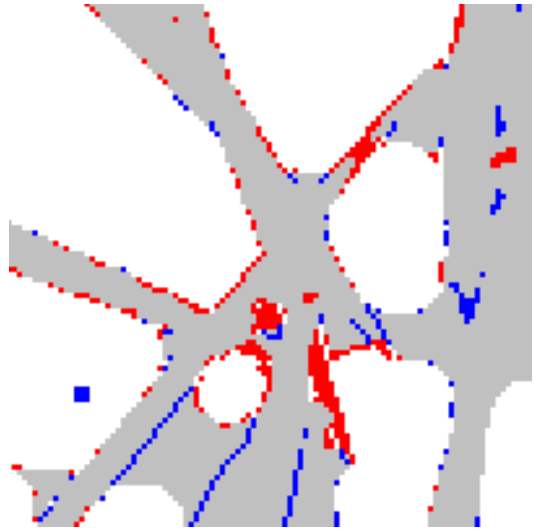
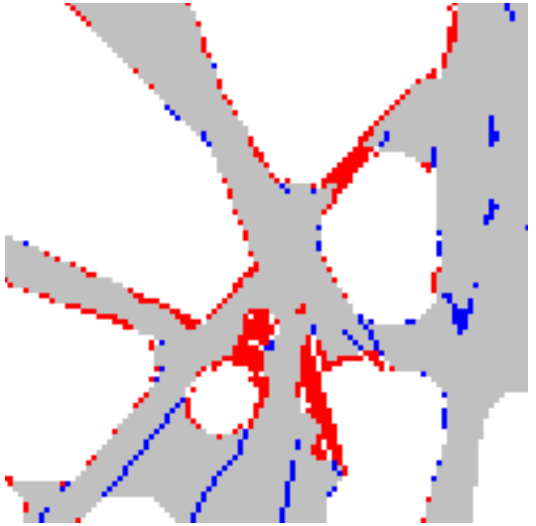


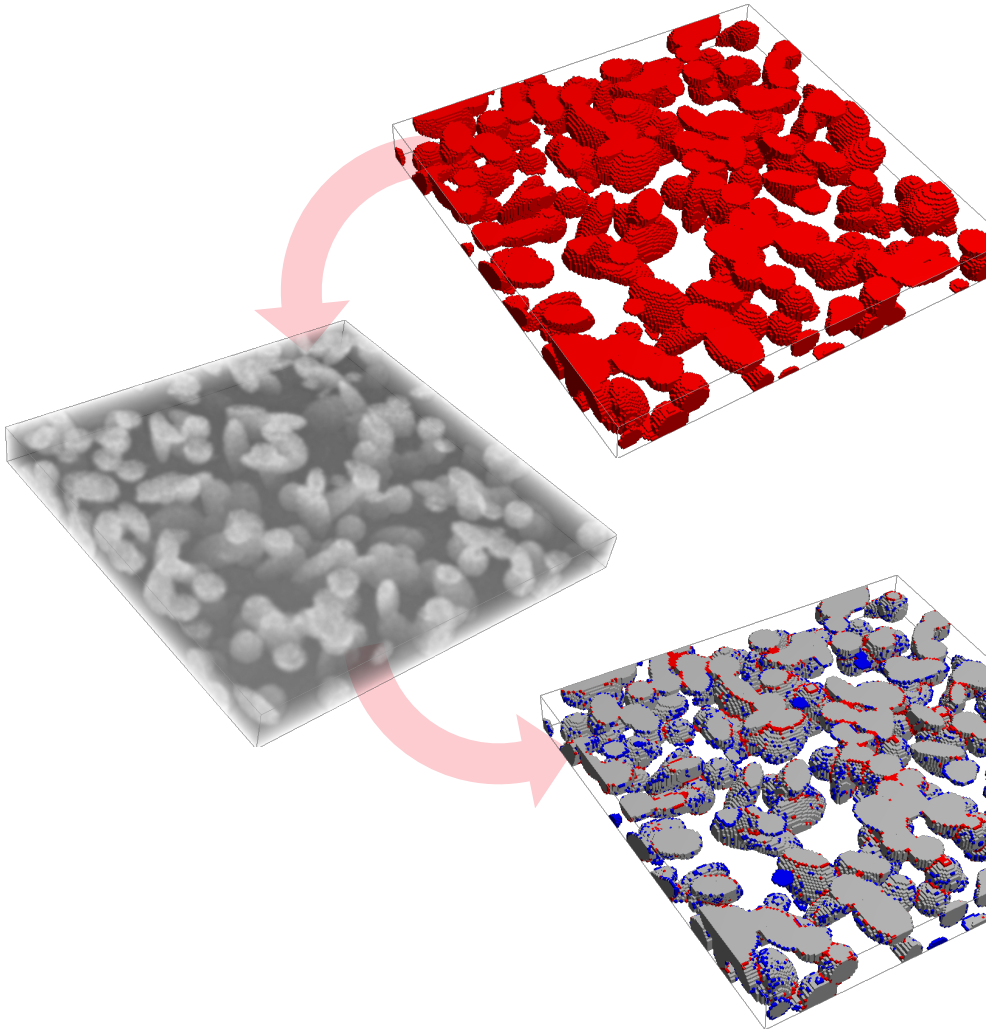




Conclusions

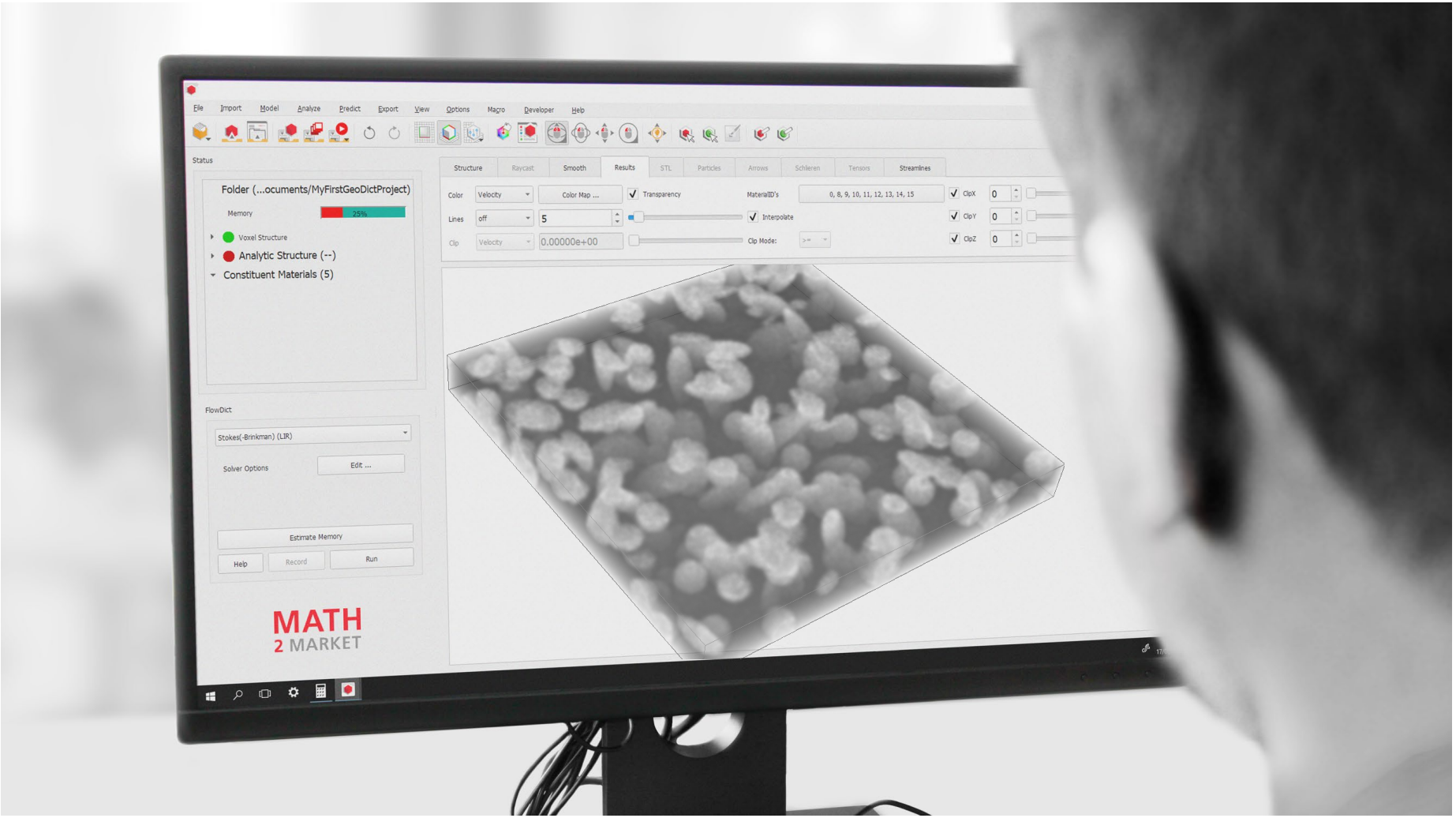
MATH
2 MARKET

- Create artificial µCT images from GeoDict models
  - add imaging artifacts
- Compare artificial µCT images and models
  - to validate filters
    - find optimal filter parameters
    - use models as ground truth
  - to train Artificial Intelligence labeling



THANK YOU!

MATH
2 MARKET



More information on AI:

Session MS 15, Room 1
Wednesday 11:20

Meet us at BOOTH #6