

Segmentation and characterization of fibers

Dahl, Vedrana Andersen

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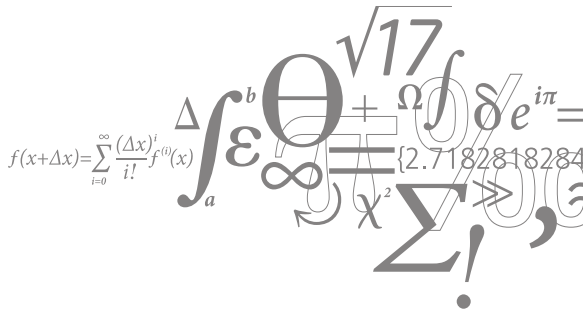
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Segmentation and characterization of fibers

Vedrana Andersen Dahl, DTU Compute

September 2015



Introduction

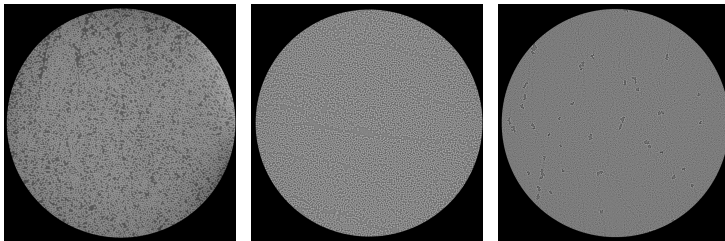
Background

- ▶ My background
- ▶ DTU imaging industry portal, industrial application, scientific advice, and research within 3D imaging
- ▶ CINEMA, the allianCe for ImagiNg of Energy MAterials, a five year DSF project with participants from both academia and the industry
- ▶ CINEMA at DTU Compute:
 - ▶ Tomographic reconstruction using movable meshes
 - ▶ Volume segmentation using movable meshes
 - ▶ Texture based volume segmentation

Presenting (mostly) the work of

- ▶ Monica Jane Emerson, PhD student, DTU Compute
- ▶ Anders BJORHOLM DAHL, associate professor, DTU Compute

Segmentation (and quantification) of fibers



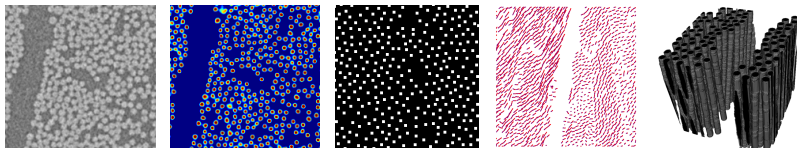
Focus areas

- ▶ Micro-CT of glass fiber, thick carbon fiber and thin carbon fiber
- ▶ Segmentation and quantification (orientation and alignment)

Motivation

- ▶ Quality control – mechanical tests for each production protocol. Time aspect.
- ▶ Quality control – quantification of fibers based on imaging, simulation using FEM.
- ▶ Our part: from images to fibers.

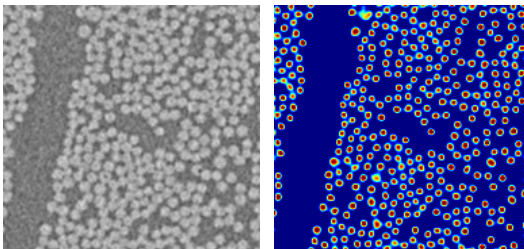
Segmentation (and quantification) of fibers



Pipeline

- ▶ Probabilistic fiber center detection. Dictionary based.
- ▶ Discretization. Treasholding or blob detection.
- ▶ Tracking. Nearest neighbour heuristics.
- ▶ Radius estimation. Back to blob detection response.

Probabilistic fiber center detection



Dictionary based approach

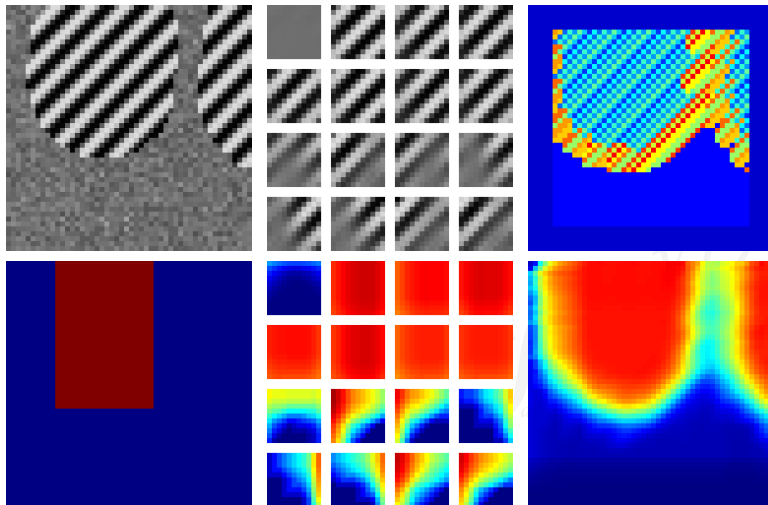
- ▶ Fiber detection vs. fiber center detection.
- ▶ Closely related to dictionary based segmentation of textured images.

Dictionary based segmentation of textured images

Recent segmentation methods

- ▶ Anders L Dahl and Rasmus Larsen, *Learning dictionaries of discriminative image patches*, BMVC, 2011.
Training-testing approach. Computation based on averaging.
- ▶ Anders B Dahl and Vedrana A Dahl, *Dictionary snakes*, ICPR, 2014.
Deformable model, snakes. Requires initialization. Computation based on averaging.
- ▶ Anders B Dahl and Vedrana A Dahl, *Dictionary based image segmentation*, SCIA, 2015.
Deformable model, level sets. Requires initialization. Graph based representation.
- ▶ Monica J Emerson, Kristine M Jespersen, Peter S Jørgensen, Rasmus Larsen, and Anders B Dahl, *Dictionary based segmentation in volumes*, SCIA, 2015.
3D version. Training-testing approach.

Dictionary based texture representation



Dictionary based texture representation

Graph (matrix) based representation

- ▶ Biadjacency matrix **B** representing binary relation between image pixels and dictionary elements, given by a dictionary assignment image

$$b_{ij} = \begin{cases} 1 & \text{if } i \sim j \\ 0 & \text{otherwise} \end{cases}$$

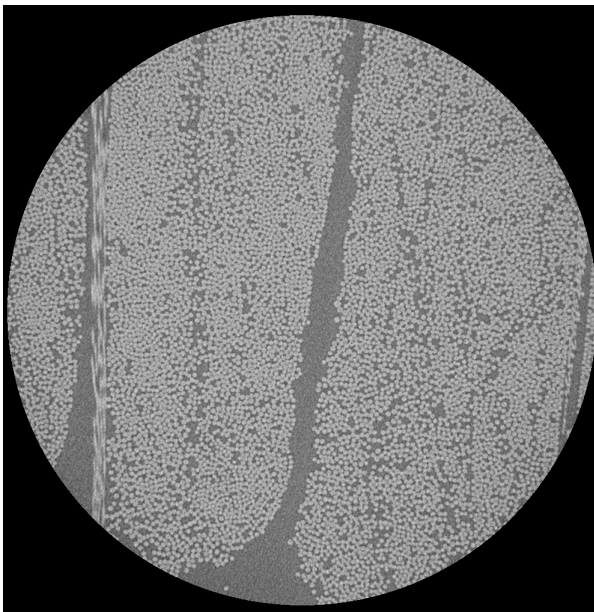
- ▶ Self similarity matrix

$$\mathbf{S} = (\mathbf{D}_B)^{-1} \mathbf{B}^T (\mathbf{D}_{B^T})^{-1} \mathbf{B}$$

- ▶ **B** is a $n \times m$ matrix, where n is the size of the image, and m is the size of the dictionary.

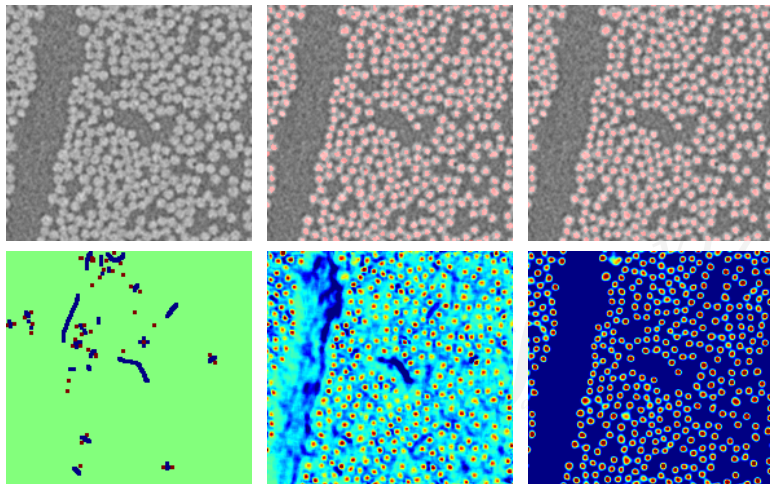
Demo

Anders' example, glass fiber

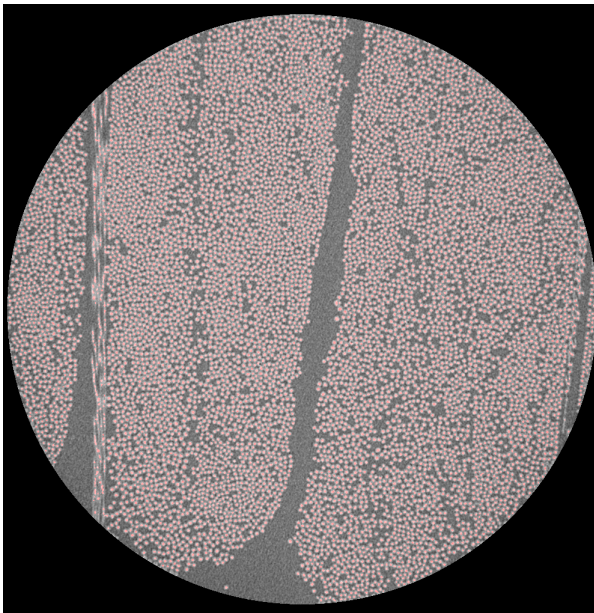


7
 $\alpha f \delta e^{i\pi} =$
2.7182818284
 Σ $\>$ \circ \circ \circ

Anders' example, glass fiber

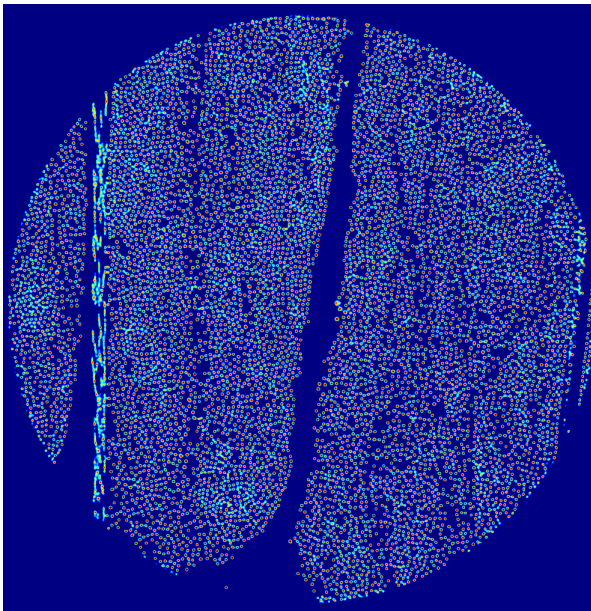


Anders' example, glass fiber

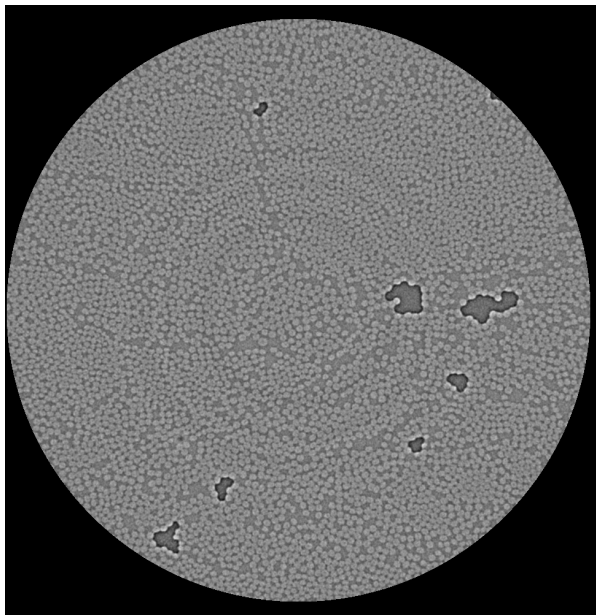


7
 $\alpha f \delta e^{i\pi} =$
2.7182818284
 Σ $>$ 0 6

Anders' example, glass fiber

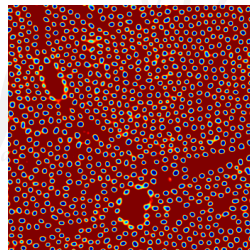
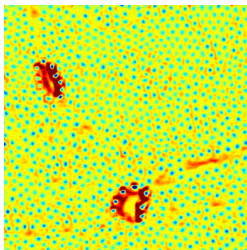
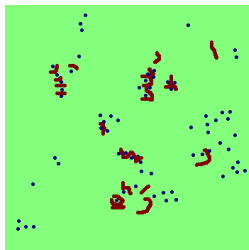
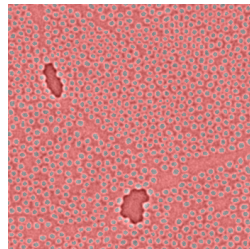
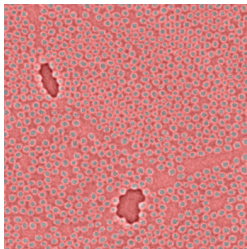
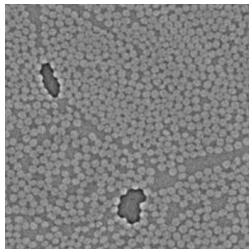


Anders' example, carbon fiber

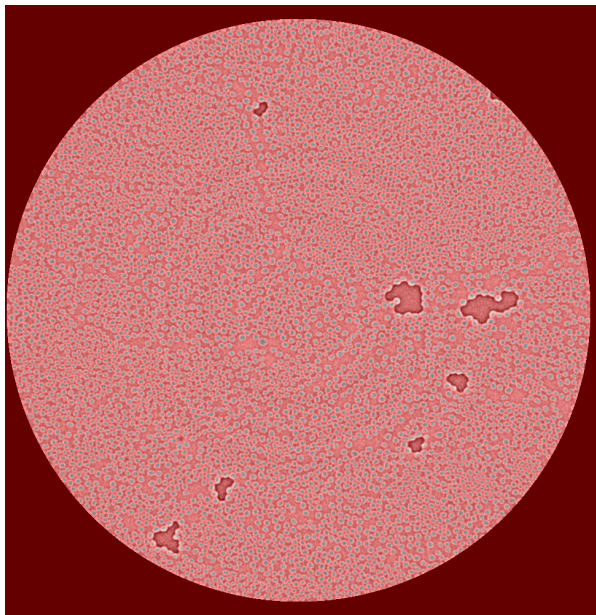


7
 $\alpha \int \delta e^{i\pi} =$
2.7182818284
 Σ $>$ 0 6
 $!$ $'$

Anders' example, carbon fiber

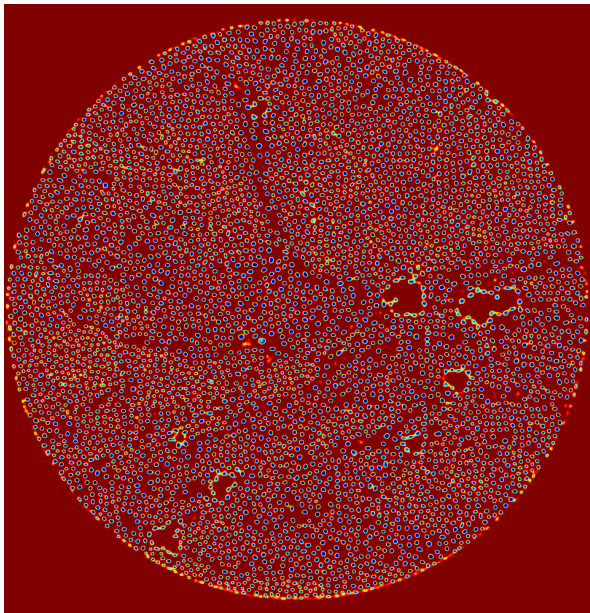


Anders' example, carbon fiber



7
 $\Omega \int \delta e^{i\pi} =$
2.7182818284
 $\Sigma / > 0$
 $\Sigma !$

Anders' example, carbon fiber



7
 $\alpha f \delta e^{i\pi} =$
2.7182818284
 $\Sigma ! > 0, 6$

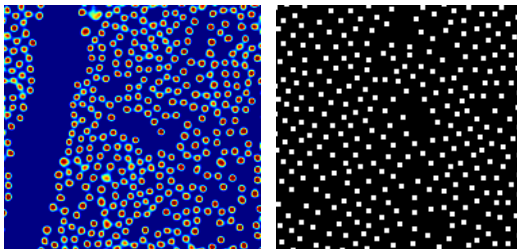
Research topics

Current research topics

- ▶ Generalization to 3D
- ▶ User input, small and easy
- ▶ Dictionary, when and how
- ▶ Handling big data

$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

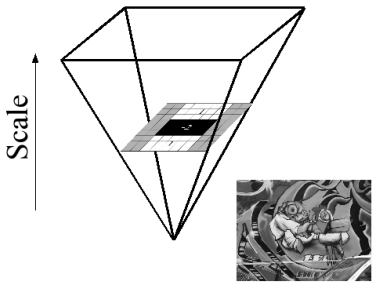
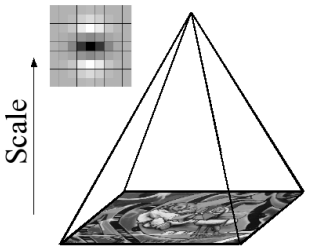
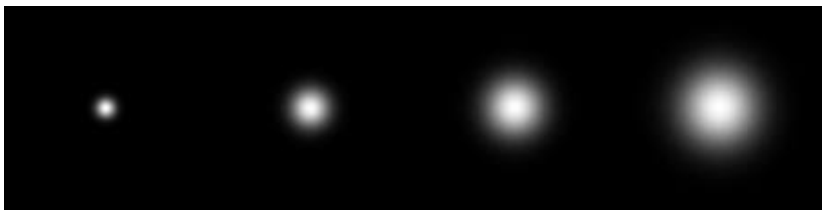
Discretization



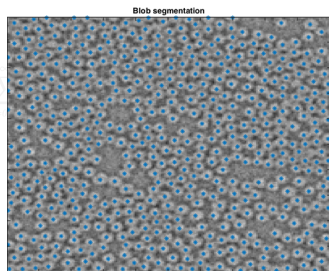
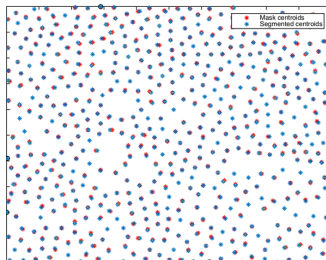
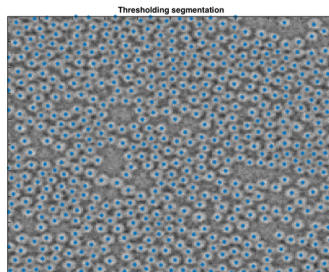
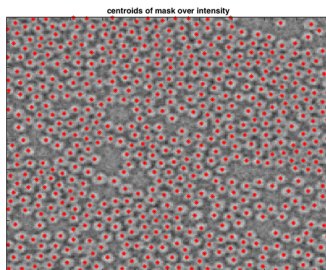
Tested options

- ▶ Treasholding
- ▶ Scake space blob detection

Discretization, scale space blob detection



Discretization, Monicas results



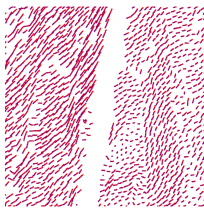
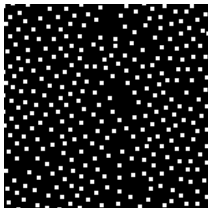
Discretization, Monicas results

True positive ratio depending on discretization, in percentages

	thresholding	blob detection
glass fiber	99.1	93.4
thick carbon fibre	100	98.9
thin carbon fibre	95.5	100

$$f(x+\Delta x) = \sum_{l=0}^{\infty} \frac{(\Delta x)^l}{l!} f^{(l)}(x)$$

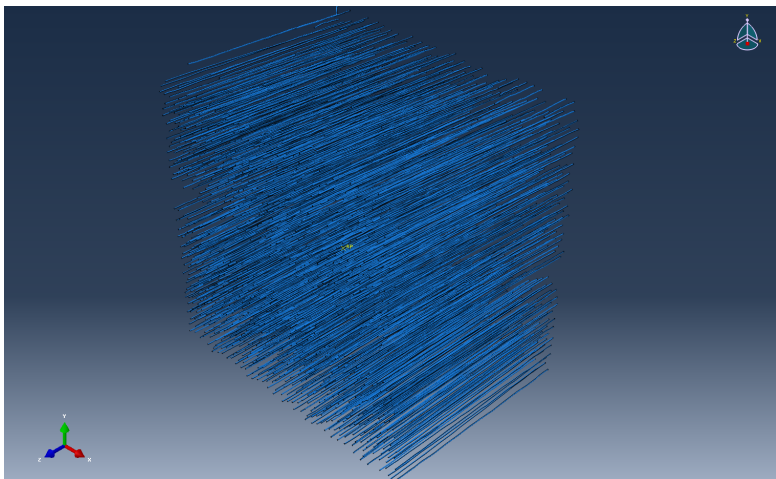
Tracking



Tested options

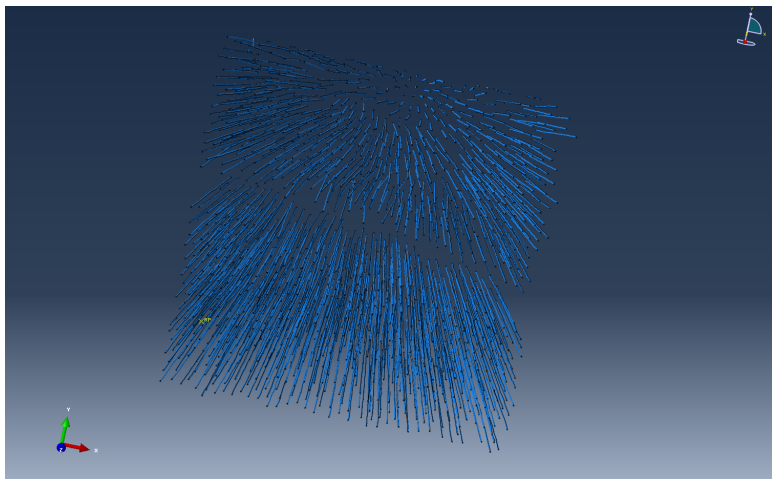
- ▶ Nearest neighbor heuristics

Fibers in abaqus



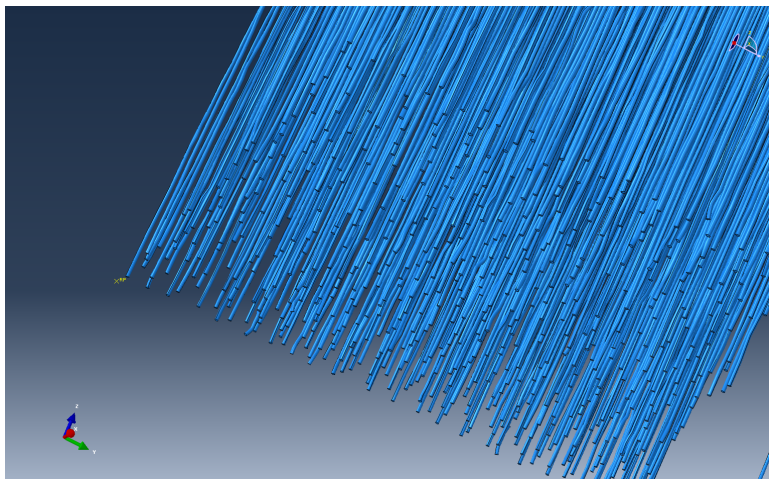
Visualization of fiber centers by Kristine Munk Jespersen, DTU Wind Energy.

Fibers in abaqus



Visualization of fiber centers by Kristine Munk Jespersen, DTU Wind Energy.

Fibers in abaqus

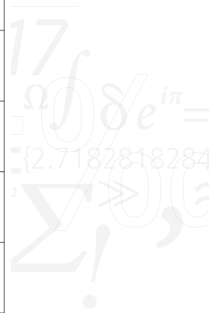
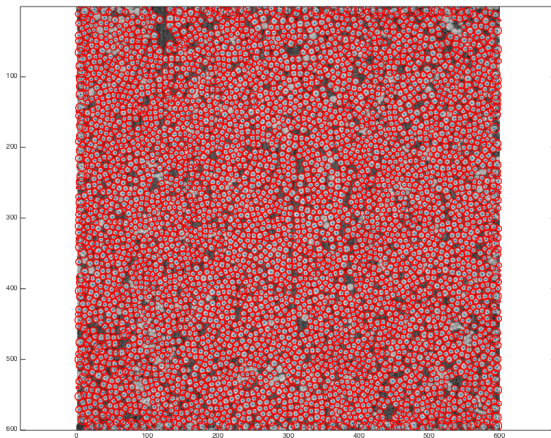


Visualization of fiber centers by Kristine Munk Jespersen, DTU Wind Energy.

Radius estimation

Tested options

- ▶ Blob detection response



Monicas results, visualization of fiber radii.

Thank you!

Questions?

$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$