Segmentation of individual fibres in a uni-directional composite from 3D X-ray computed tomography data

Emerson, Monica Jane; Jespersen, Kristine Munk; Dahl, Anders Bjorholm; Conradsen, Knut; Mikkelsen, Lars Pilgaard

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

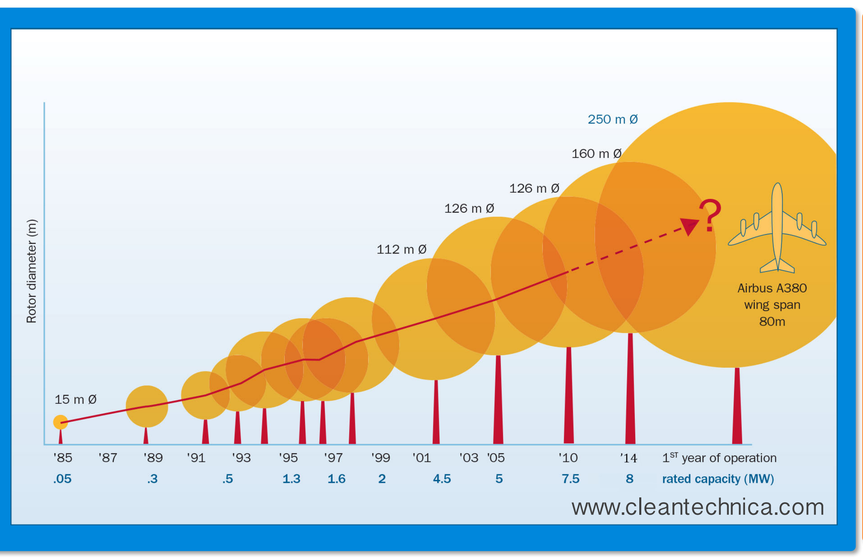
Segmentation of individual fibres in a uni-directional composite from 3D X-ray computed tomography data

Emerson M. J., Jespersen K. M., Dahl A. B., Conradsen K., Mikkelsen L. P.
monj@dtu.dk

MOTIVATION

Wind turbine blades are becoming **longer** to decrease the **cost of energy**.

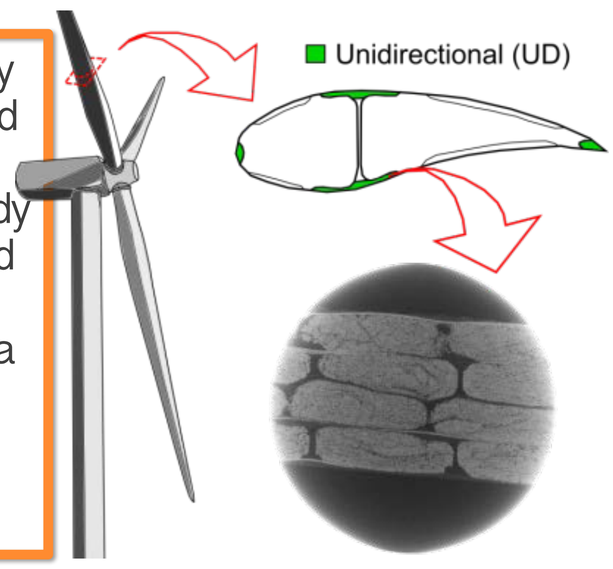
They need to stand higher stresses.



TASK

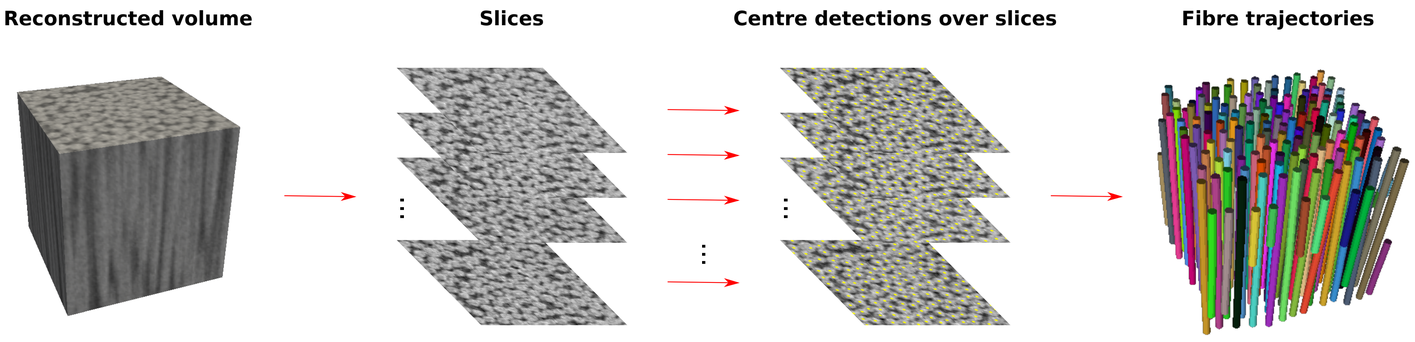
We segment individually uni-directional glass and carbon fibres from tomography data to study the **fibre orientation** and relate it to the **compression strength**, a key parameter when designing the blade's **load carrying parts***.

* green parts in the blade on the right



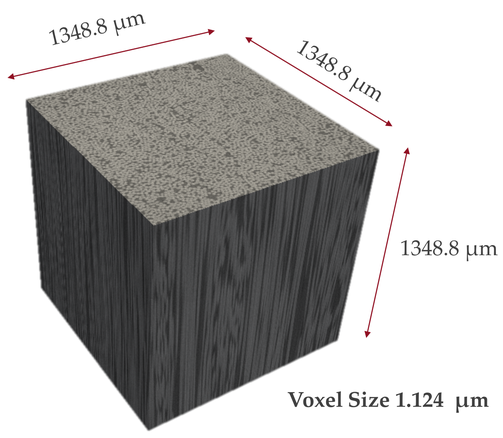
PIPELINE AND CHALLENGES

- Low quality scans to avoid a long acquisition time.
- Composite materials with high fibre volume fraction.
- Large data sets.

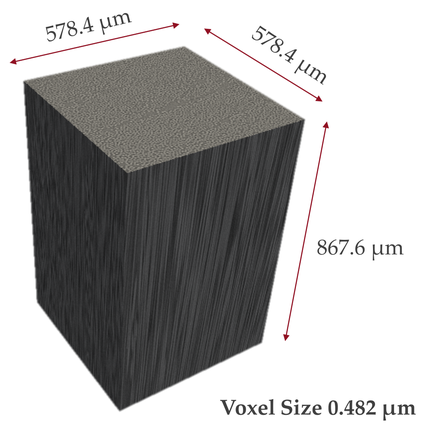


SEGMENTATION AND TRACKING

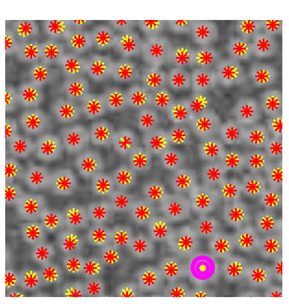
1. Glass Fibre Reinforced Polymer (GFRP)



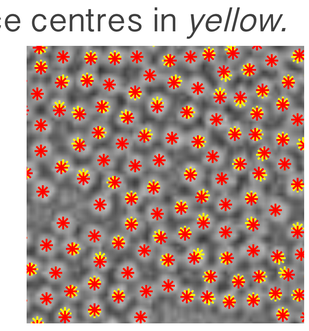
2. Carbon Fibre Reinforced Polymer (CFRP)



Detected centres in *red* and reference centres in *yellow.*

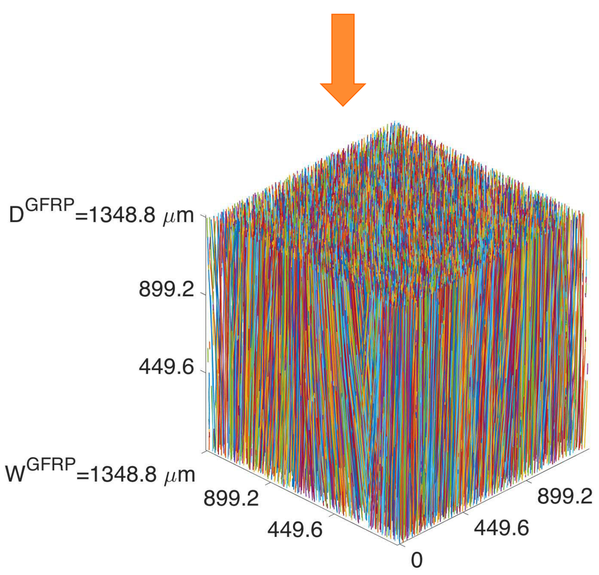


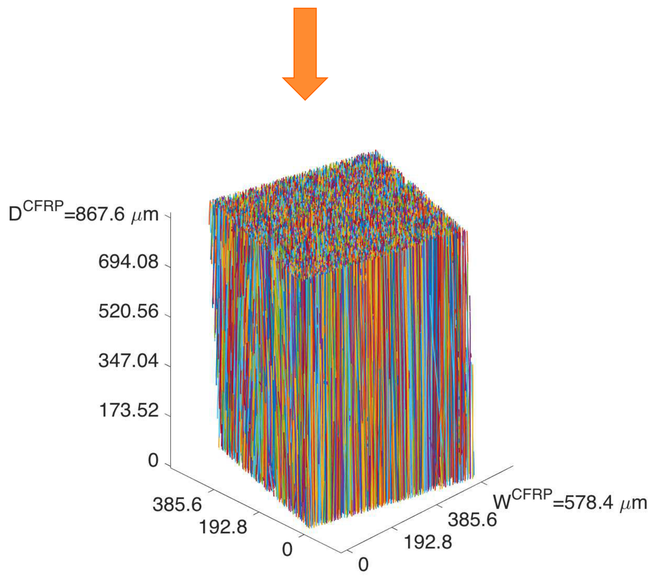
Accuracy** 99.1%



Accuracy** 100%

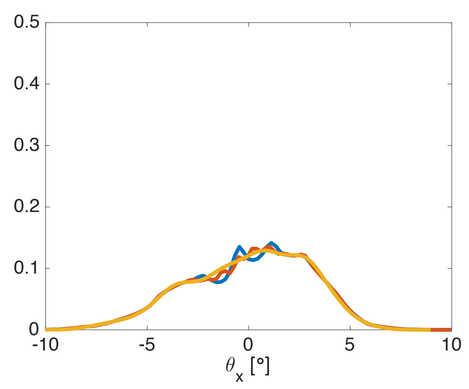
**Accuracy measured as correctly found centres in a test image, of size half of a slice.

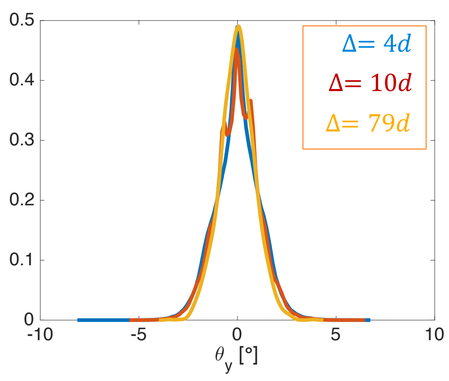




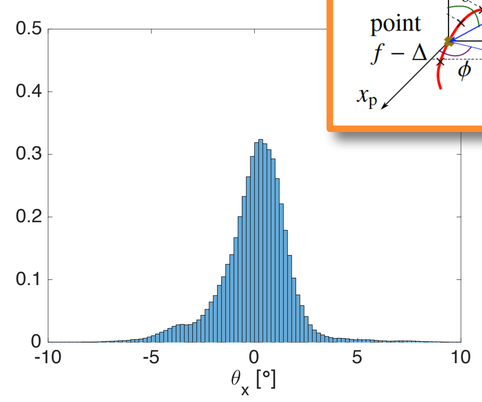
FIBRE ORIENTATION

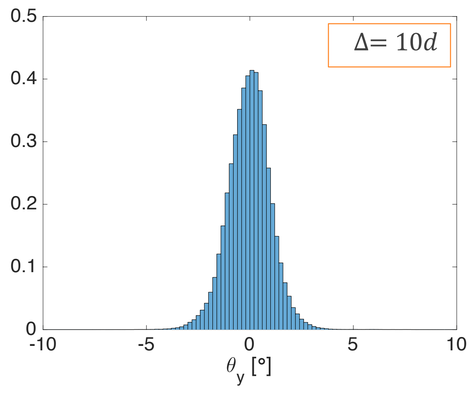
1. GFRP

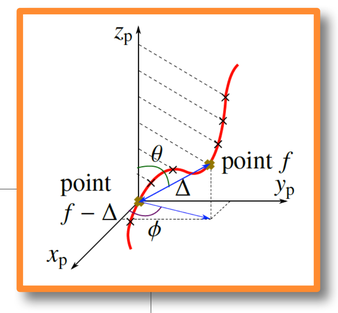




2. CFRP







COMPRESSION STRENGTH

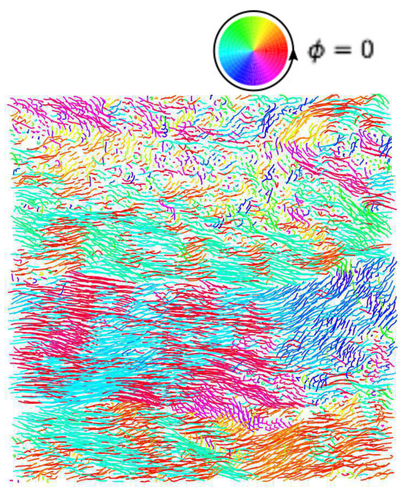
$$\hat{\sigma}_c = \frac{G}{1 + \hat{\theta}/\gamma_y}$$

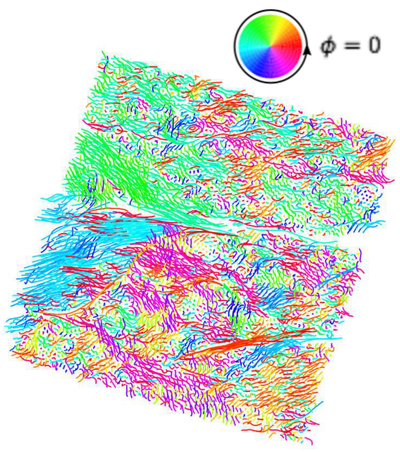
(Budiansky et al., 1993)

Material	GFRP	CFRP
$< \theta >$	2.75°	1.61°
$< \lvert\theta_x\rvert >$	2.45°	1.23°
$< \lvert\theta_y\rvert >$	0.86°	0.79°
$\hat{\sigma}$	0.44 GPa	0.70 GPa
$\hat{\sigma}_x$	0.49 GPa	0.87 GPa
$\hat{\sigma}_y$	1.14 GPa	1.21 GPa
σ_m	(0.82 ± 0.07) GPa	(0.90 ± 0.06) GPa

Estimated compression strength $\hat{\sigma}$ compared to measured σ_m by Markussen et al., 2013

For a more precise estimate...





...add the spatial distribution

Financial support from CINEMA: the allianCe for ImagiNg of Energy MAterials, DSF-grant no. 1305-00032B under The Danish Council for Strategic Research is gratefully acknowledged.

Individual fibre segmentation from 3D X-ray computed tomography for characterising the fibre orientation in unidirectional composite materials. Emerson et al., under submission.