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FIBER SEGMENTATION FROM 3D X-RAY COMPUTED TOMOGRAPHY OF COMPOSITES WITH CONTINUOUS TEXTURED GLASS FIBER YARNS

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Summary: The current study investigates the applicability of a dictionary-based fiber-detection algorithm for continuous textured glass fiber yarns in fiber-reinforced polymer composites. Additionally, the study discusses options for improving the fiber-detection algorithm so that it is applicable to continuous textured fiber yarns in fiber-reinforced polymers.

1. INTRODUCTION

In recent years, the prospects of advanced X-ray Computed Tomography (XCT) for industrial applications continue to increase. The insights into materials microstructure, delivered by XCT, are of uttermost importance for the production of high-quality composite materials, e.g. Fiber Reinforced Polymers (FRP). Hence, knowledge of the microstructure plays a vital role in optimization within manufacturing of FRPs.

The cross-sectional (2D) spatial distribution of fibers was investigated using Optical Microscopy (OM) in [1,2] and it was shown that a varying fiber distribution has a significant influence on local material behavior during the manufacturing process, i.e. thermo-chemical curing gradients. Destructive methods for 3D microstructure characterization were investigated in [3]. Non-destructive confocal laser scanning microscopy was applied in [4], but this technique is limited to sufficiently transparent samples and limited fields of view. In the study by Emerson et al. [5], unidirectional (UD) glass and carbon FRP composites were characterized using XCT in combination with a segmentation method that is robust to image quality [6]. The method is based on a probabilistic dictionary-based feature-labelling algorithm that does not require manual correction of fiber detections. The precision of the method used in [5] was validated by comparing the obtained fiber diameters and spatial distribution of fibers with similar results from OM and Scanning Electron Microscopy (SEM) in [6]. The current work studies the applicability of the method developed in [5] for fiber tracking of continuous textured fiber yarns in FRPs. Finally, options for extensions of the method will be discussed.

2. EXPERIMENTAL METHOD

The experiments were carried out on a Zeiss Xradia Versa 520 scanner at a voltage of 40kV and a power on 74 µA using 4x optical magnification. The scan was performed using 4501 projections at binning 2 with a total scan time of 20 hours. The resulting scan has 1000^3 voxels with a voxel size of 1.99µm. The fiber-center detection algorithm [5] uses a training step to set up a dictionary of corresponding image and label patches. The dictionary is then used to detect centers of fiber cross-sections in each tomographic slice. In the final tracking step, centers are connected throughout the volume to form 3D fiber trajectories.

3. RESULTS

The fiber-center detections are shown overlaid on 4 different XCT slices in Fig. 1(a). It should be noticed how the fibers with a large orientation angle are often detected as 2 or 3 individual fibers. Fig. 1(b) shows the fiber trajectories, the reader should notice how the additional fiber center detections in fibers with large orientation-

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angles cause problems for the tracking algorithm (compare red markers in Fig. 1(a) with red trajectories in Fig. 1(b)). A suggestion is to utilize the information about the estimated orientation of the fibers from the fiber tracking algorithm, to improve the precision of the fiber-center detections - this is a subject of ongoing research by the authors.

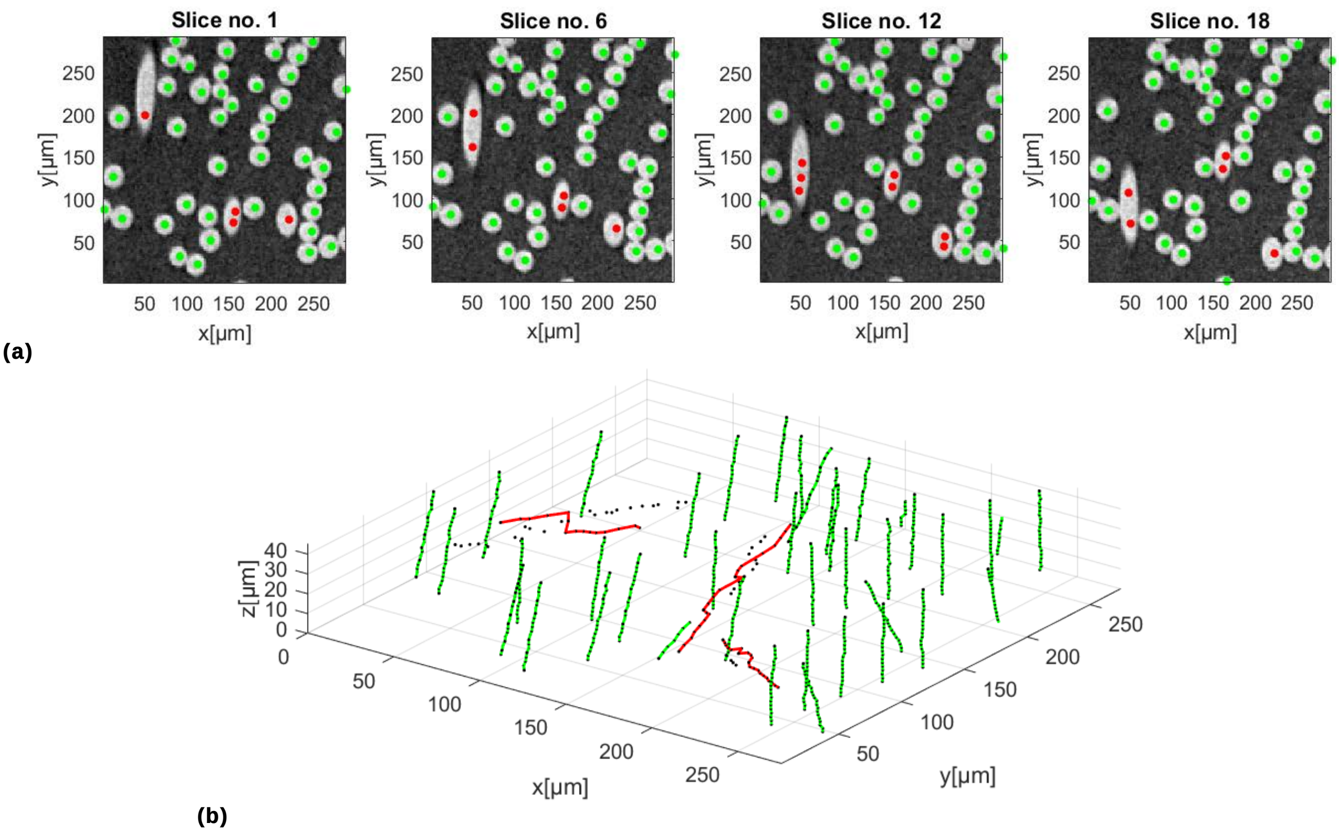

Figure 1: (a) Fiber center detection. (b) Detected centers and the corresponding tracked. The red marker/line color indicates erroneous fiber center detections and tracking.

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