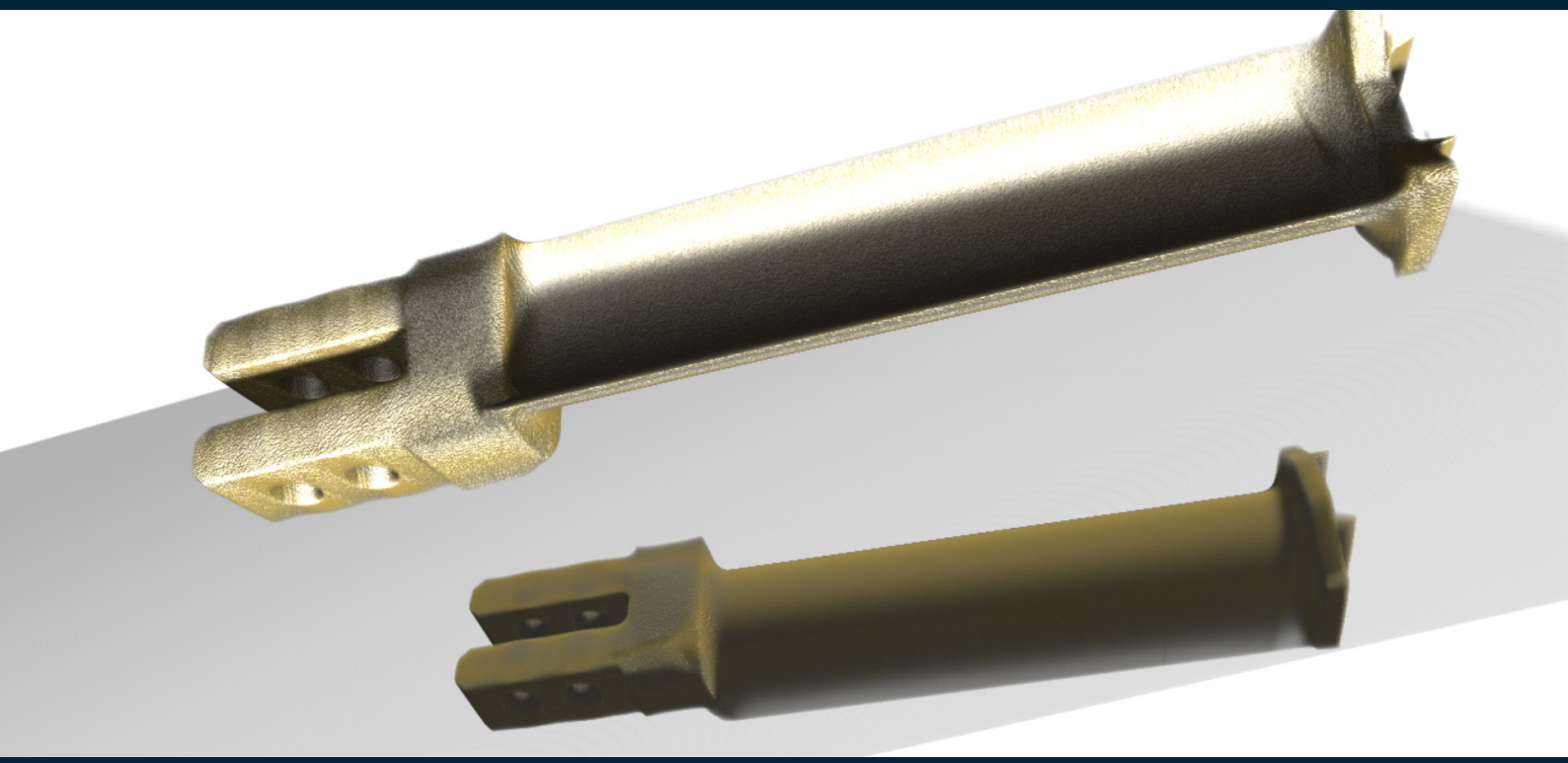
Application Note



Turbine blade segmentation using deep learning

The industrial inspection of turbine blades plays an important role in power generation and aerospace industries, either for manufacturing quality control or for evaluating wear over time. Failure of a turbine blade during operation can lead to extensive damage and potential loss of life, making their inspection of vital importance. However, turbine blades are challenging for CT-based inspection due to the density and geometry involved, which can result in image artifacts and make quantitative evaluation difficult using traditional image analysis tools.

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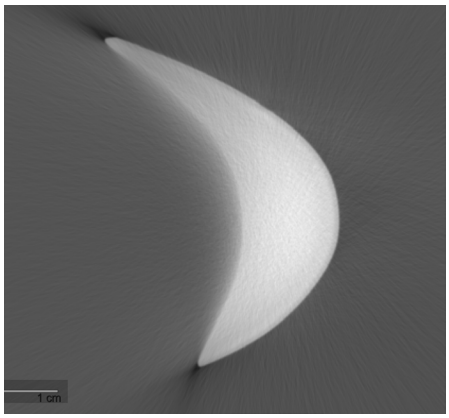
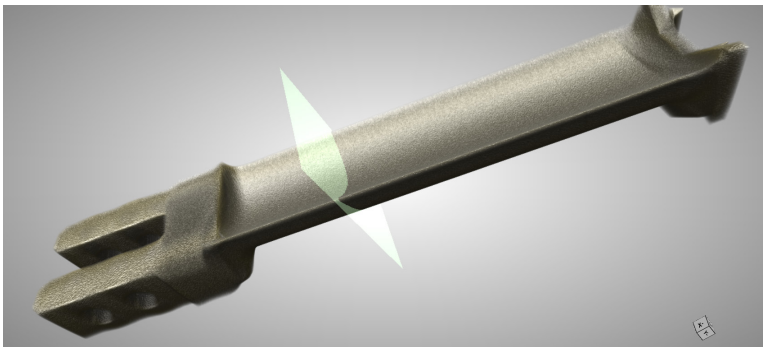
dragonfly

Why deep learning for this application?

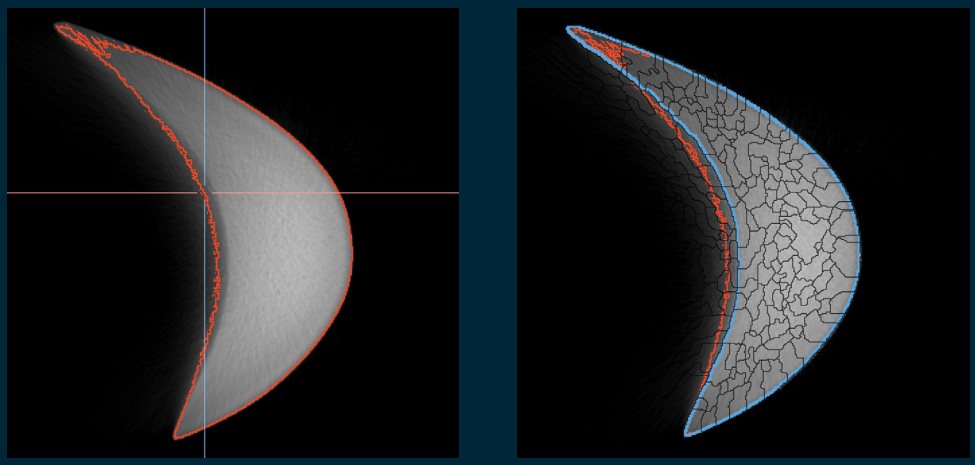
Typical laboratory X-ray micro-CT instruments generate images with bright and dark regions, related to local X-ray density. This allows imaging of greyscale cross-sectional images, as shown below, making the inspection for possible cracks, porosity, or other unexpected deviations from the design possible.





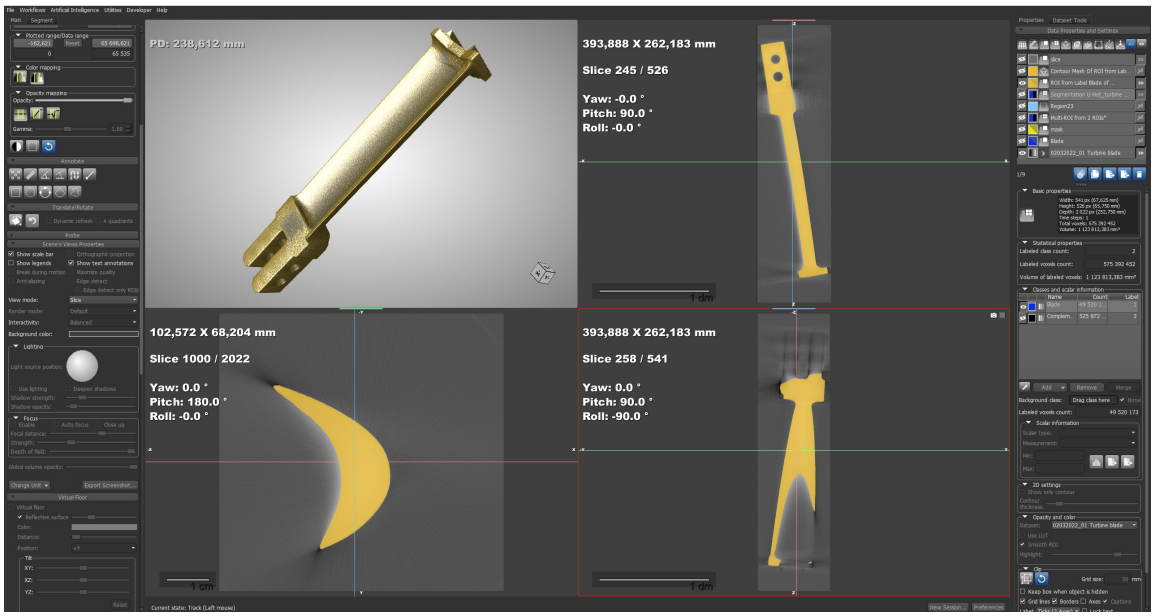
Cross-sectional slices images allow inspection of blade for defects.

For further quantitative analysis, image segmentation is necessary – i.e., the definition of what is the part and what is the background. The problem with manual (thresholding) segmentation methods for 3D volumes of turbine blades are the image artifacts, which can lead to bright and dark areas with over and under estimation of surface locations. The image below left shows a traditional thresholding approach (red). This typical thresholding approach results in regions near the tip being under-estimated and regions in the middle over-estimated, in this case manual correction is usually needed, which is time consuming and prone to human error. The image to the right shows a 2D watershed segmentation (blue). In this case the watershed is incorporated into a thresholding function called the “Smart Grid tool” and works well on 2D images of the blade.



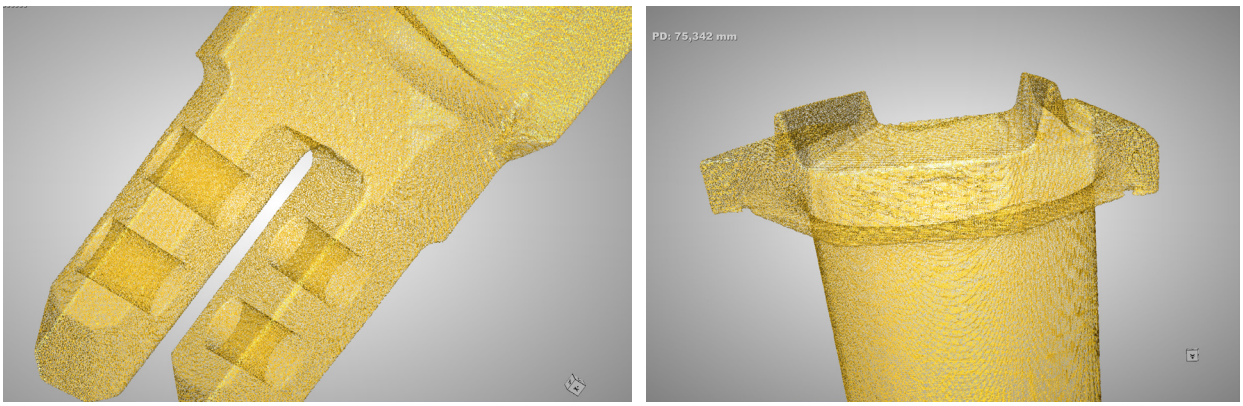
The problem with manual global thresholding (red) and the solution in 2D space using watershed segmentation (blue).

In contrast to traditional methods, such as thresholding, deep learning models can be trained to fully segment the whole blade without any further human interaction. In the example shown below, a model was trained on three segmented slices of the original data with U-Net, an all-purpose deep-learning architecture designed especially for image segmentation. Dragonfly 3D World's deep learning-based algorithms are optimized for real-world image analysis, typically require small datasets, short training periods, and can 'learn' to distinguish anomalies and features while tolerating variations in complex patterns.



The deep learning model segmented the whole blade based on the training data consisting of only 3 slices.

As shown below, close-up images of a mesh extracted from voxels classified as 'blade' by the trained deep-learning model demonstrate the quality of the segmentation. In addition, meshes generated from a scan of the manufactured part can be used for comparison to a mesh of the designed part, or for digital record keeping of geometries (digital twin).



The mesh output is clean and directly useful for downstream processing as shown in the above close-up images.

Deep learning segmentation of industrial parts

Dragonfly 3D World's deep learning solutions for segmentation, denoising, and super-resolution are bundled with pre-built neural networks that implement powerful architectures such as U-Net, U-Net 3D, Sensor3D, FC-DenseNet, and many others. Even Even novice users find it easy to apply Dragonfly 3D World's powerful segmentation features on select reference slices and then use those results to train existing neural networks. Trained neural networks can, in turn, segment the rest of the same image stack and subsequent ones, thereby saving countless hours of demanding work.

- Any material
- Also for defects
- Multi-phase materials
- AI manufactured parts needing quality control

Advanced

This application note describes a workflow for segmenting a turbine blade with deep learning. The model training data was generated on only 3 slices, which required only a minimal amount of time. Once trained, the same model can be applied to all scans of similar parts with no human interaction or bias possible, with a similar output as shown. To view a video of the process described in this application note, please see the "how to video" link below.

The benefits

The benefits of this for your process is knowledge of the quality of your parts, using a reliable software for data analysis, minimizing user interaction, and maximizing throughput of large numbers of parts. The workflows in Dragonfly 3D World are fully customizable and open to the user, there are no hidden algorithms or question marks surrounding data analysis. For deep learning, the more data is provided to training, the better the model becomes. All results are fully open to be checked and training can be improved based on this feedback. Customization and reporting tools allow faster and better decisions to be made for improving manufacturing processes and in quality control and qualification efforts. Unlock a new world of quality control in your industrial inspection using Dragonfly 3D World!

For a video workflow demonstration of the above case:
https://www.youtube.com/watch?v=81bDOI8Np_8

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