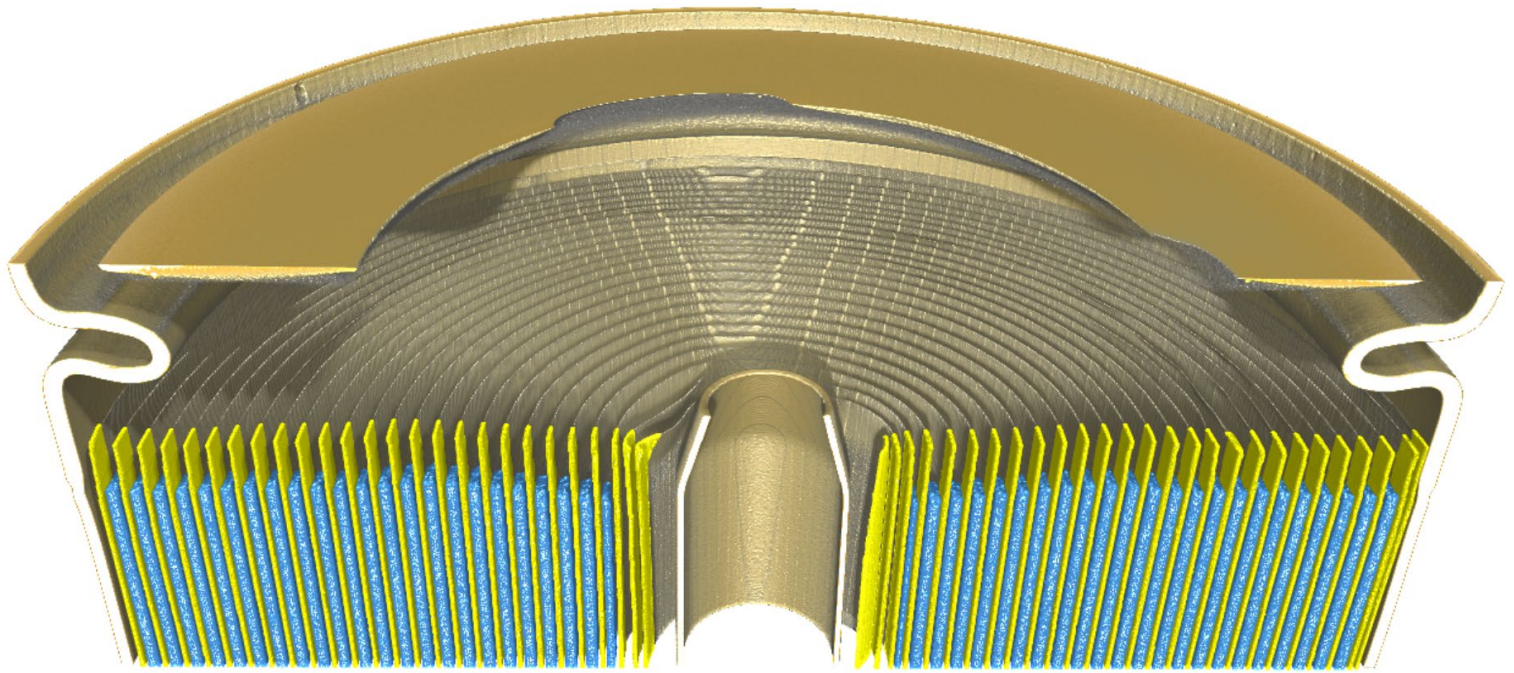




AI solutions to individual battery anode-cathode overhang analysis using Dragonfly 3D World

In this application note, we demonstrate the tools in Dragonfly 3D World that can be used to analyze high resolution X-ray CT scans of batteries. Images can be inspected and manual measurements and annotations made for any features of interest, such as overhang distance between cathodes and anodes. The segmentation of individual anode and cathode components can be achieved by deep learning, and measurements of the resulting segmented regions are also demonstrated.

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Requirements

A high resolution CT scan of a battery, the example here is from a Comet Yxlon FF35 CT system, with images acquired at 8 μm voxel size at 200 kV and with total scan time of approximately 10 minutes. A computer is needed with Dragonfly 3D World installed.

Typical outputs

- Manual measurements of overhang distances
- Manual annotations of potential defect locations / also known as indications
- Segmented cathode overhang regions and analysis of cathodes in more detail e.g. overhang length, minimum distance to nearest next anode, etc.
- Similar analysis of underlying anodes

How does it work?

When inspecting a battery in an X-ray system, you might see images as in figure 1 below. The overhang between cathodes and anodes are visible, especially at certain angles.



Figure 1: Angled and parallel views of a cylindrical battery cell in a 2D X-ray image

These 2D X-ray images allow visualization of overhang regions and might be able to successfully spot some defect types. This 2D imaging method is fast, therefore it is a good solution for large-scale inspections. However, 3D information is lost and quantitative analysis is not possible. Much better detail can be detected in 3D data acquired from CT scans. Examples of the same cell in CT is shown in figure 2 below, in both cross section and 3D views.

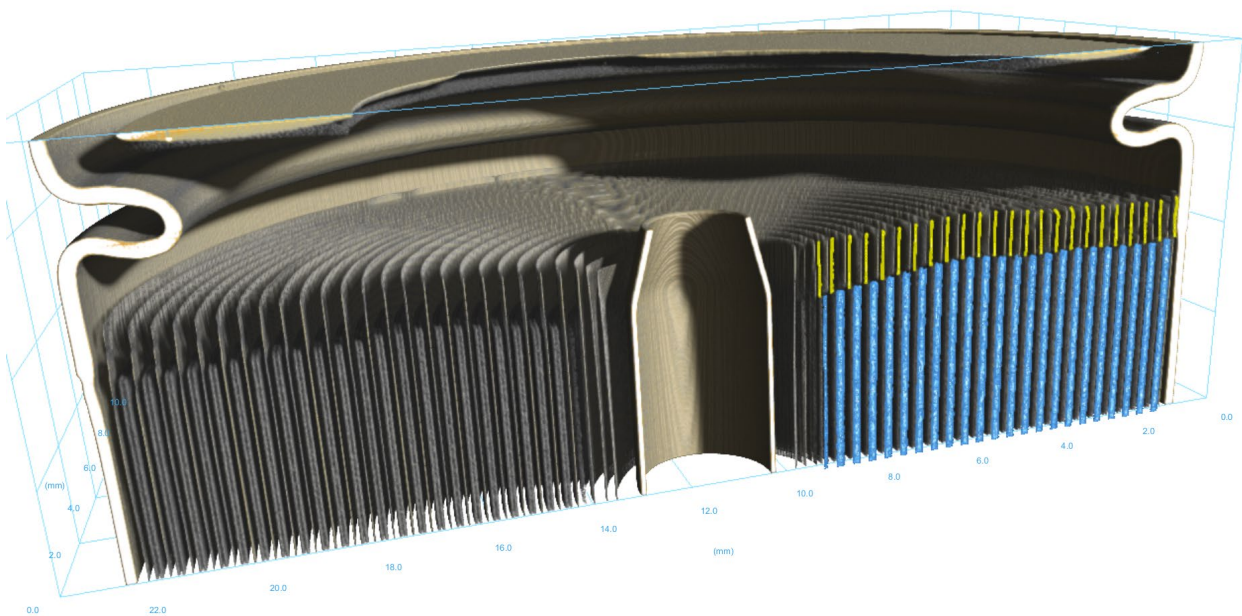
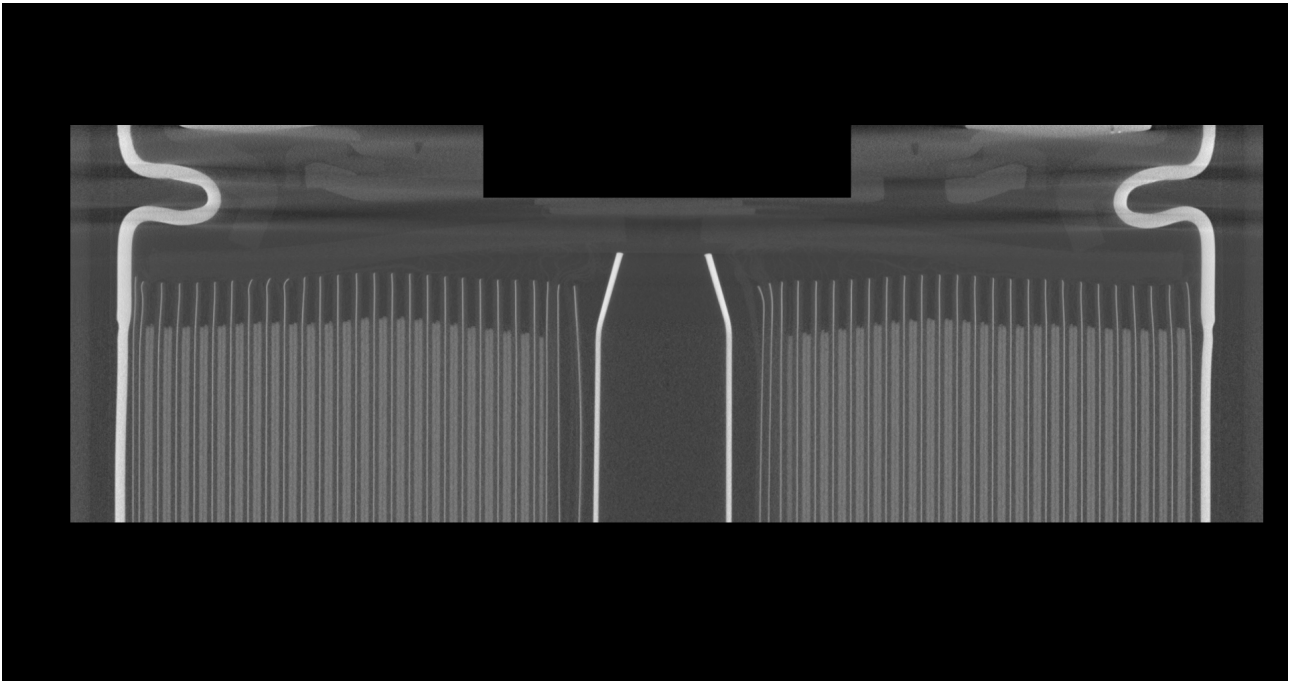


Figure 2: Examples of cross-section and 3D view of CT data of the same cell.

Typical work with CT cross sectional images would involve individual measurements or annotations which are made in 2D cross sectional images as shown below for example in figure 3. In the same way the engineer can inspect all slices through the object to search for major flaws such as inclusions, porosity, cracks, or missing regions e.g. a missing anode or cathode.

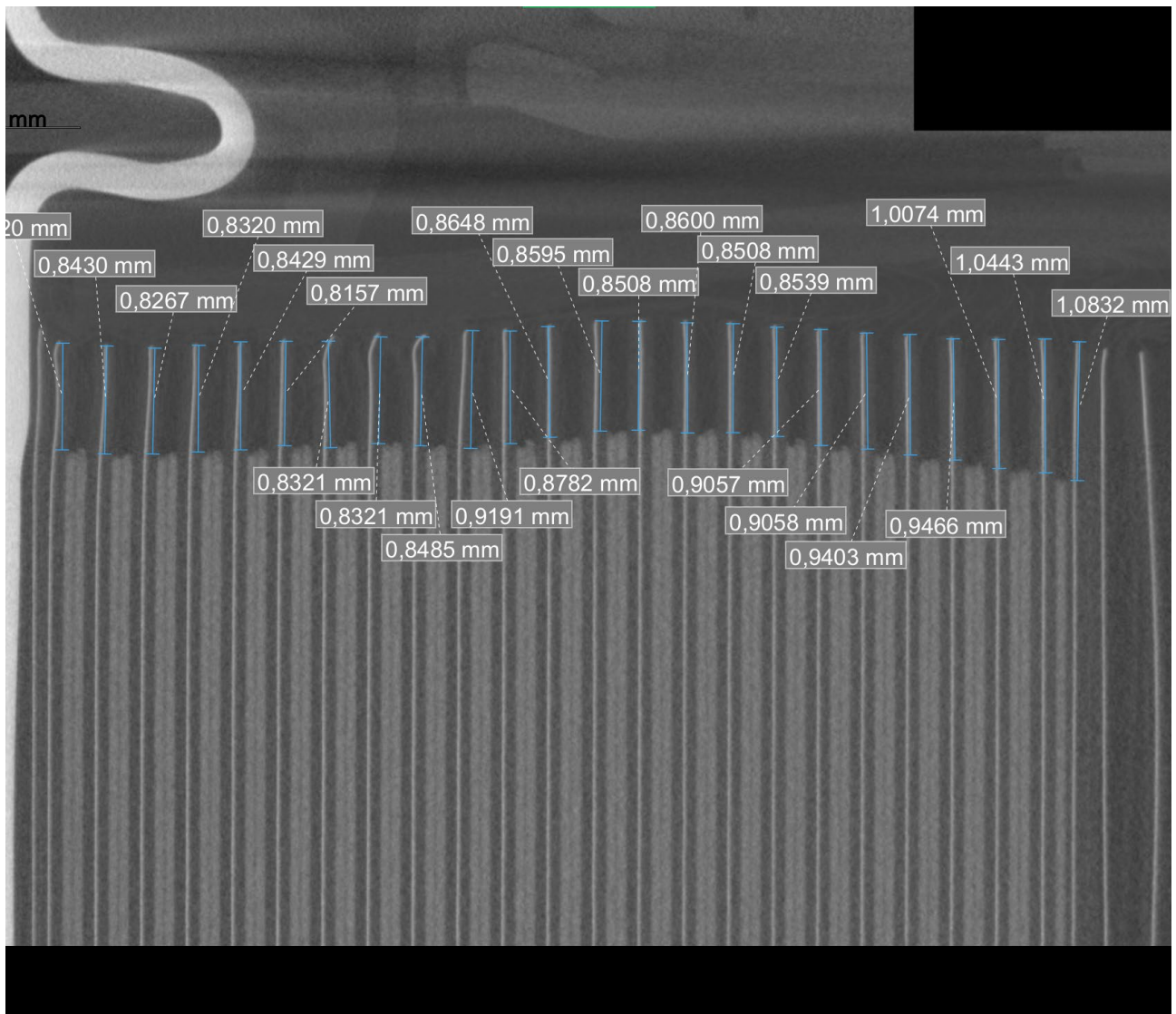


Figure 3: Examples of individual overhang measurements done manually in Dragonfly 3D World

The manual measurement approach can be slow over the long run, especially when you need to do this repeatedly 100s of times a day. It would be much better to use AI tools to identify or segment the regions of interest and then make automatic analysis, as shown below in Figure 4 for the overhang regions.

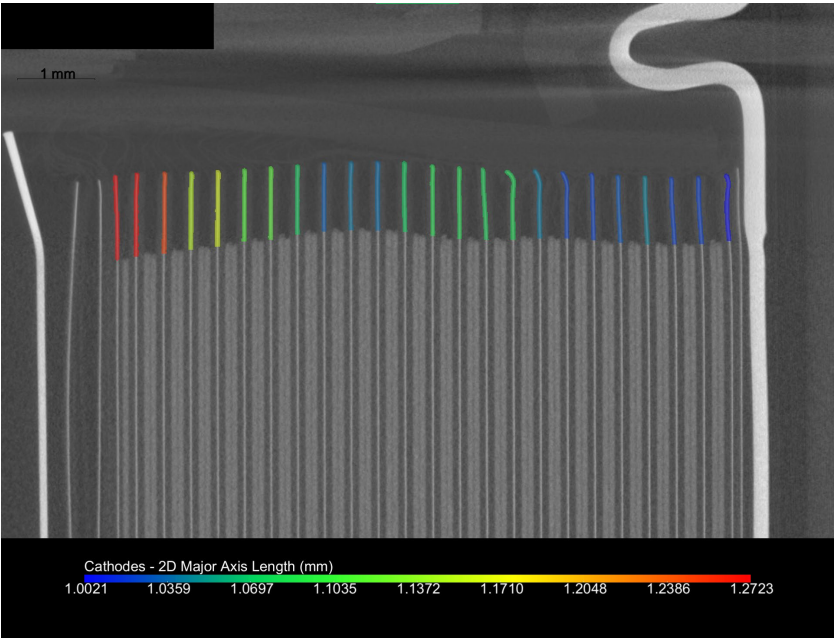


Figure 4: Cathode overhang distances segmented by Dragonfly deep learning and color coded by length.

The deep learning segmentation approach allows to train Dragonfly to correctly segment the regions you want to measure, in a way that is faster than doing it manually. In this case the model was trained to segment the overhang regions specifically, so that individual measurements can be made for each. The training is done in the Dragonfly Segmentation Wizard, using a pretrained Unet neural network. Some of the ground truth data and the training progression is shown in Figure 5, as is the segmentation result.

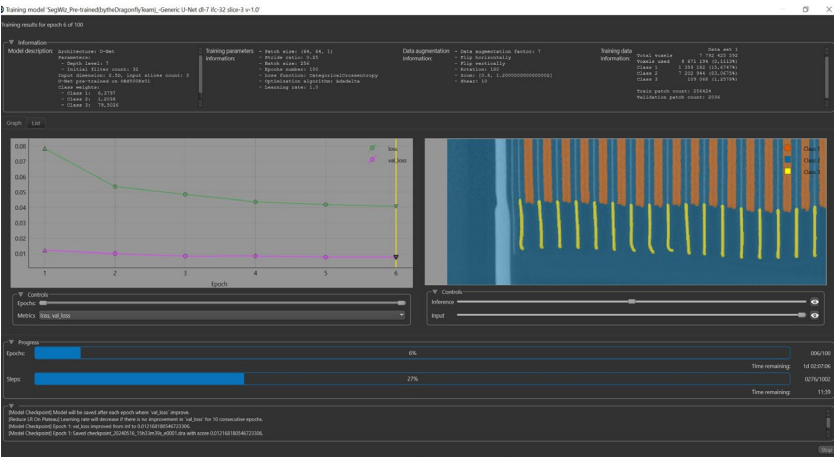


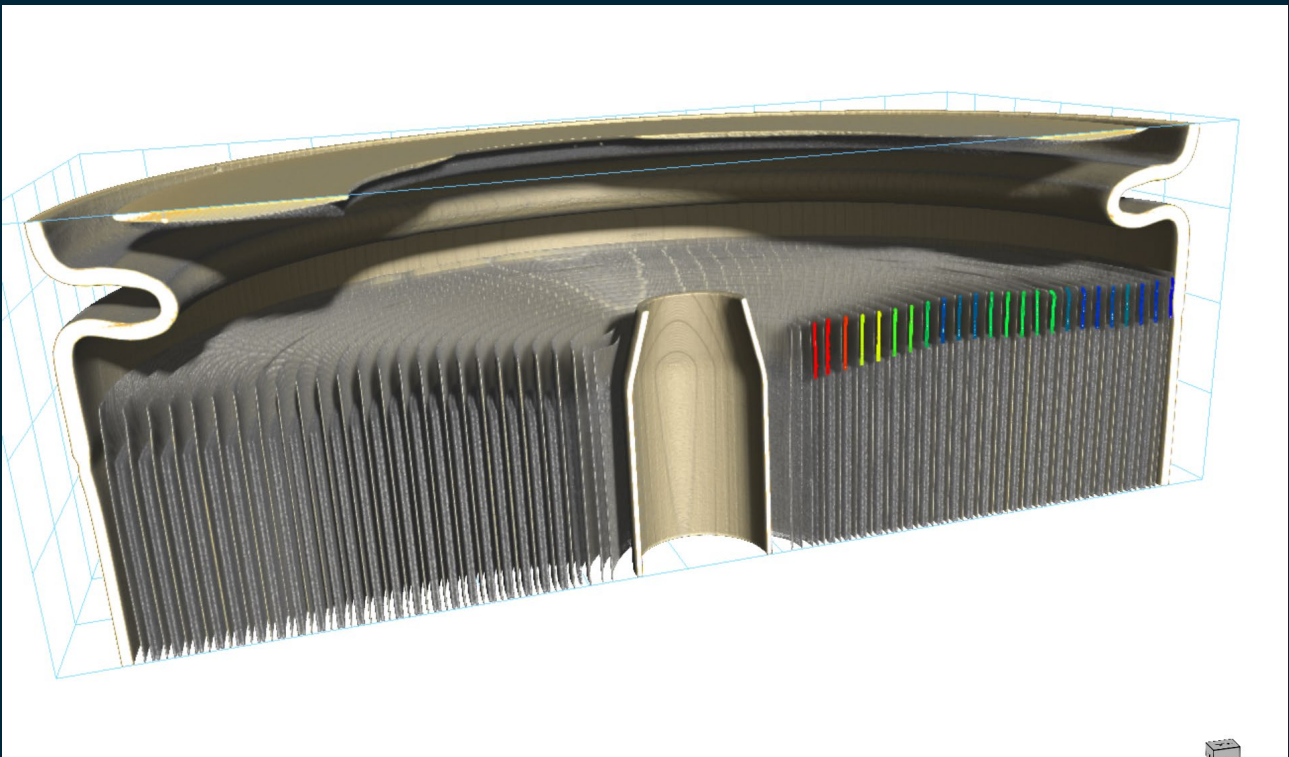
Figure 5: Deep learning of battery cathode-anode overhang regions using a Unet depth-7 neural network

Advanced:

- Manual segmentation is possible in 2D cross-sectional images at all times
- Deep learning can be used to automate the segmentation and reduce manual work
- This is especially useful when the same model is applied to multiple samples daily
- Basic measurements are possible as shown
- Further automation and reporting is possible with the Battery Insights package

The benefits:

The benefits for you as a battery manufacturing quality control engineer or battery researcher, is an improved understanding of the structural details of your battery samples. Detailed inspection and quality evaluation of the internal details of batteries are made possible using non-destructive CT imaging coupled with Dragonfly. These tools allow you to ensure safer battery products, improve the battery manufacturing process and limit possible failures that could be prevented. 3D analysis tools give you the opportunity to develop a database of information giving more insight into the safe manufacturing limits and the variability in battery production. These benefits are crucial for safer and larger-scale battery production.





For a video workflow demonstration of the above case:
<https://youtu.be/kogBTx9WddI>



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