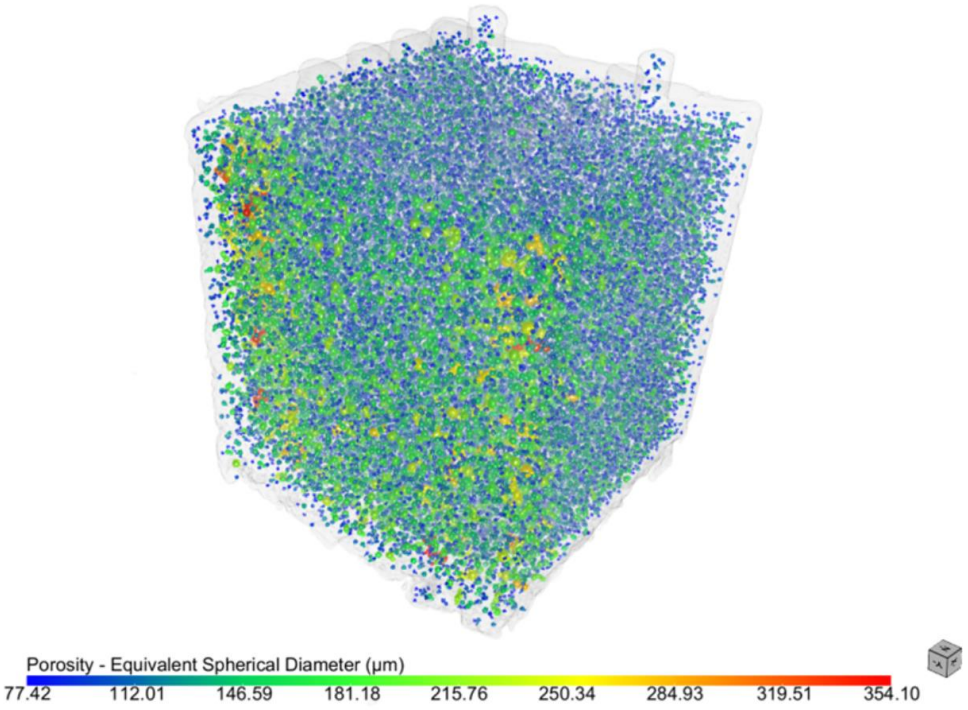
Application Note:



Dragonfly Basic Automated Porosity Analysis For Additively Manufactured Parts

What you will learn in this application note:

- Automated thresholding methods for porosity segmentation
- Some tools for quick evaluation of porosity in any parts
- See three examples of additively manufactured parts evaluated with these quick methods

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Introduction

This application note shows some simple cases where porosity analysis is possible using automated segmentation tools in Dragonfly 3D World. In particular, these three examples all use the automated porosity – advanced Otsu method. This method is applicable in cases of simple single-material CT scans – the threshold is then applied using an automated Otsu method, based on all grey values of the part and the internal pores, excluding external air space. This often makes a simple, accurate segmentation of most porosity types, including that found in additive manufacturing. The segmentation is then used to calculate pore sizes and much more.

Requirements

A workstation with Dragonfly 3D world is needed, and a CT scan of an additively manufactured part. Typically, coupons would be investigated for porosity as a function of parameter changes. The segmentation and analysis method described here is reliable for comparison across multiple datasets.

Typical outputs

- Visualizing and quantifying the porosity content in a part – pore volume fraction
- Making 3D images and videos of the porosity
- Quantifying for each pore: size, volume, sphericity, max Feret diameter, aspect ratio and much more
- Color coded images and videos of quantified values

How does it work?

In the first example, a lattice structure with internal porosity (microporosity) is segmented using the automated porosity – basic Otsu method first. This is a fast method that gives the yellow segmentation shown in Figure 1 (second image). The automated porosity – advanced Otsu method makes use of a better threshold based on the material and pores (including a thin layer of air around the part) and gives the segmentation shown in the third image in Figure 1 – also capturing the edges of the smaller pores.

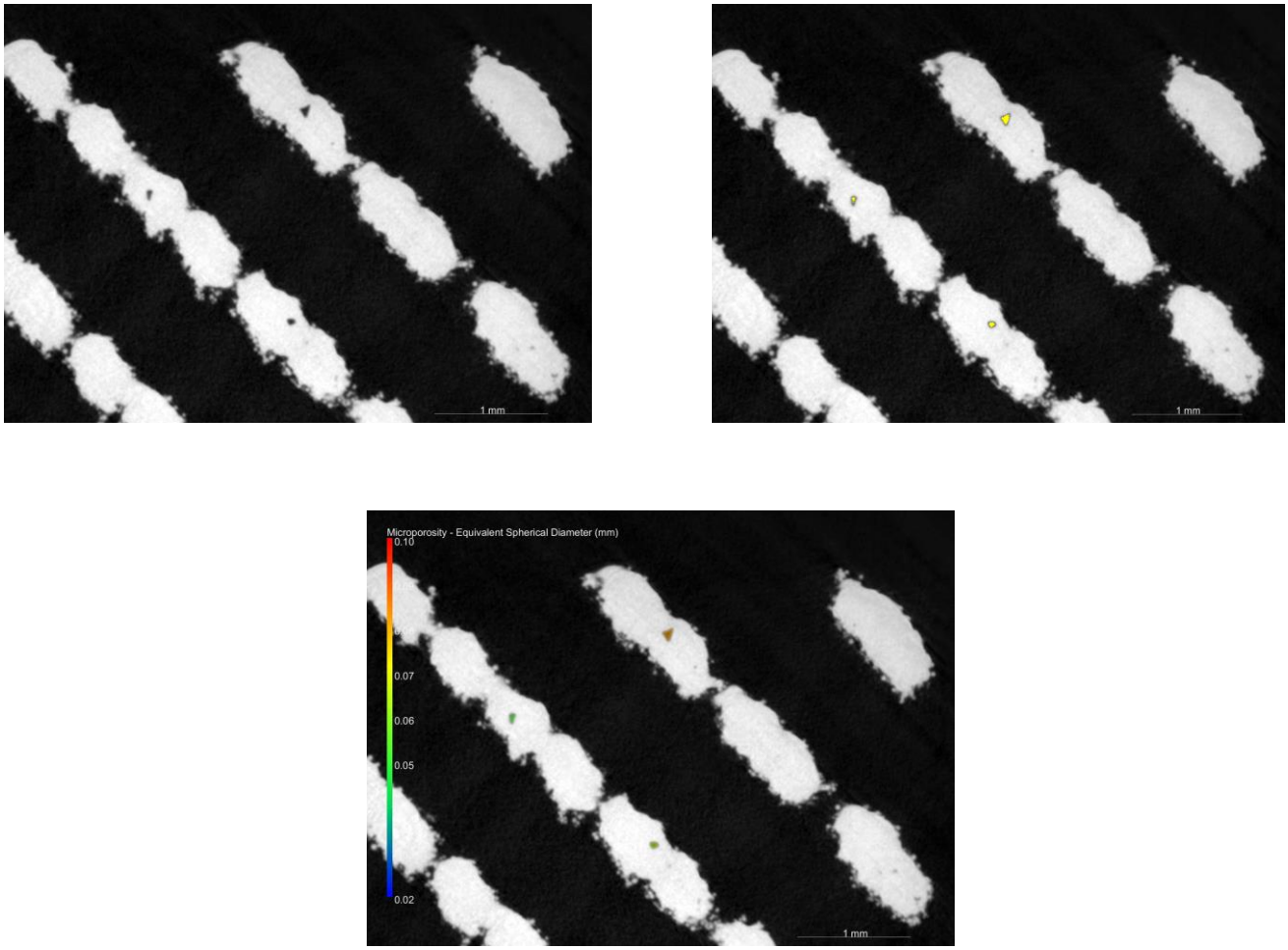
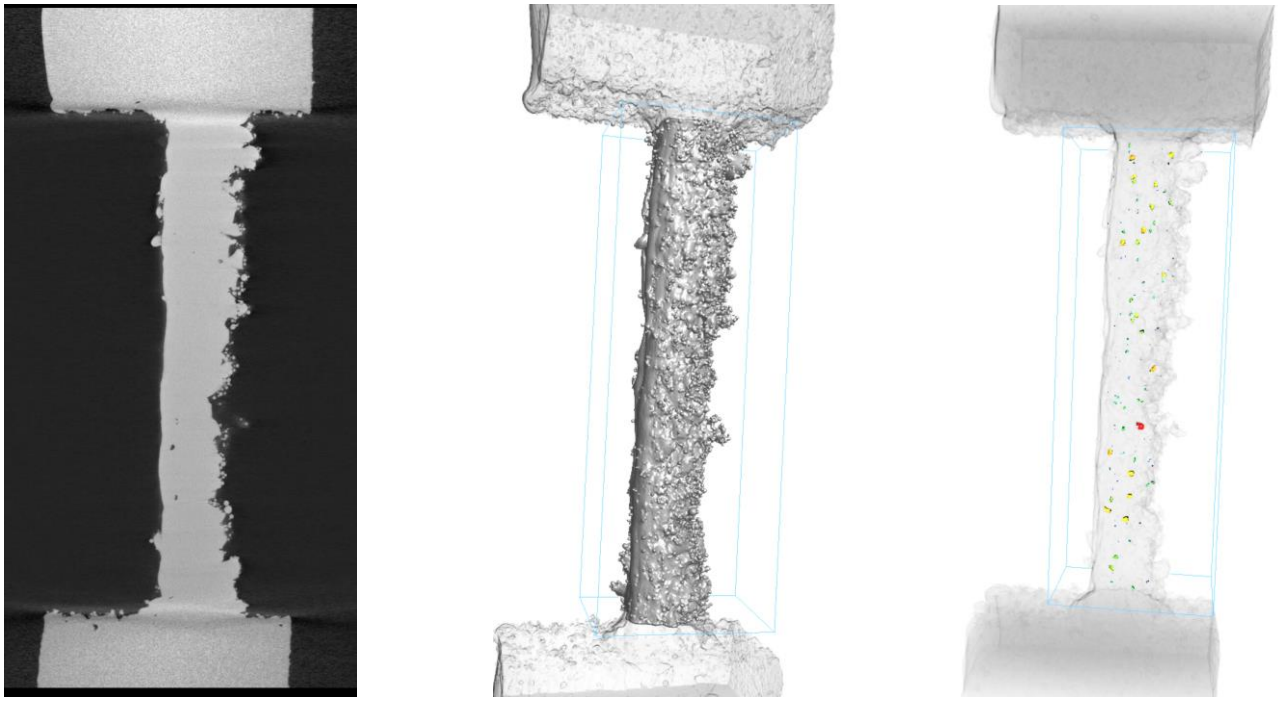


Figure 1: Porosity segmentation using automated porosity – basic Otsu and advanced Otsu methods. Close-up cross-sectional views of a lattice sample show small internal pores segmented using both methods.

In the next example, the sample is a small tensile bar with larger clamp ends. The larger ends cause some image artifacts, hence a good solution is to crop the region to be analysed to exclude these ends. Another solution to work with data containing artifacts is to use deep learning that is discussed in the next application note. The images in Figure 2 show the region selection, combined with the advanced Otsu automated porosity segmentation



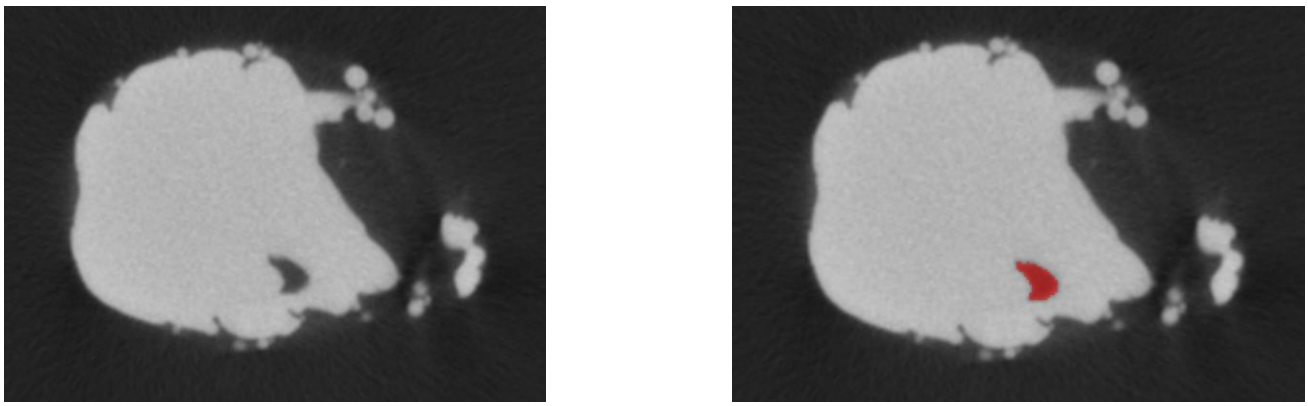


Figure 2: Porosity segmentation and analysis using the automated Otsu – advanced method. The region selected excludes the areas with image artifacts and cross-sectional images confirm the segmentation accuracy of the largest pore space.

A third example is a cube coupon (10 mm side length) with excessive porosity content. Figure 3 shows the cross- sectional images before and after segmentation using the same automated Otsu – advanced method. Figure 4 continues with the analysis showing the color-coded size analysis, with the image to the right showing only the pores larger than 200 µm. This type of range-selection is very useful to find patterns, as in this case where all large pores are found on one side of the cube.

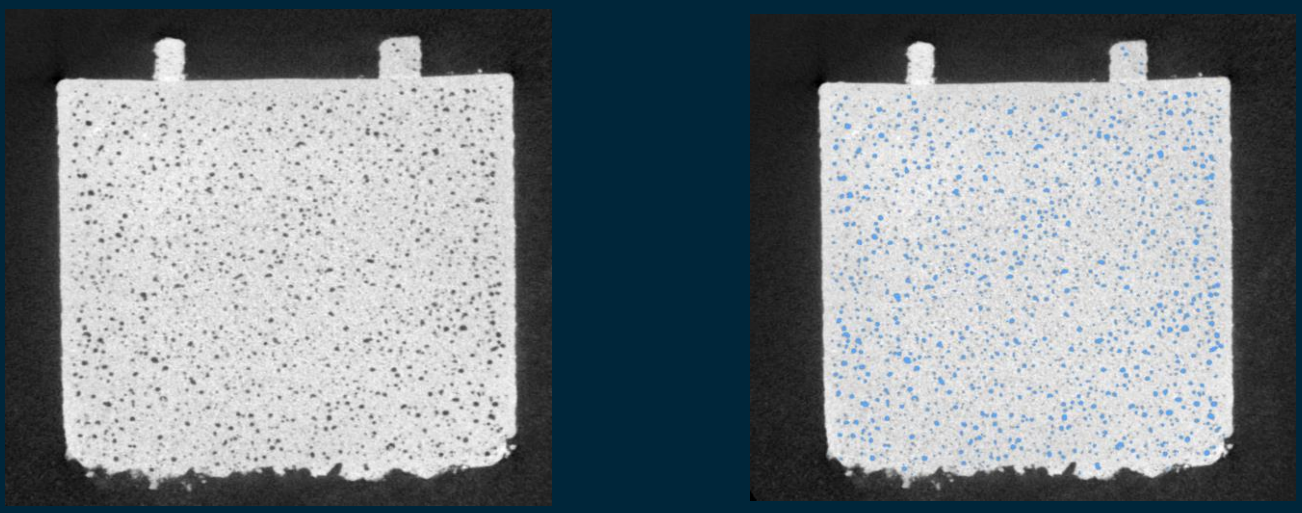


Figure 3: Automated Porosity – Advanced Otsu method applied to a 10 mm cube sample of additively manufactured AlSi10Mg. The excessive porosity is higher than usual due to incorrect process parameters. The segmentation shown is automatically achieved (no manual threshold selection).

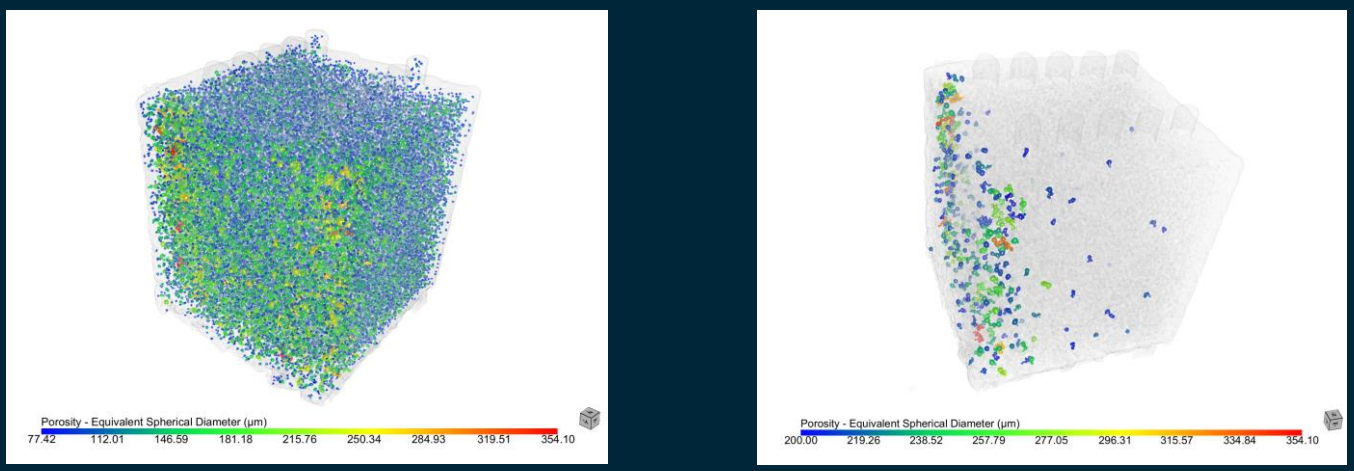


Figure 4: Porosity analysis based on the prior segmentation of the cube data. On the left: pores are color coded by equivalent spherical diameter. On the right: size range selection applied to porosity analysis, with all pores larger than 200 µm being located to the left side of the cube.

Summary:

- Porosity segmentation is easily applied using the automated Otsu thresholding methods
- Advanced Otsu is better suited to typical additive manufacturing porosity
- Three different examples are shown in this application note
- Example 1 shows the difference between basic and advanced Otsu (both are automated)
- Example 2 shows the benefit of cropping the region to be analyzed
- Example 3 shows the benefit of visualizing porosity size ranges on demand

The benefits:

Porosity analysis is highly valuable in understanding the quality and stability of the manufacturing process, in order to correct for errors and to manufacture higher quality parts. It can also be used as a quality control tool on final parts. This application note shows the value of a fast automated segmentation for quick evaluations. More complex datasets e.g. with more noise or brightness variations, can be solved by AI segmentation, but even in that case a quick automated thresholding segmentation can be useful as a first evaluation.

For a video workflow demonstration of the above case:
https://www.youtube.com/watch?v=pUCjrsl5HG0

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