Dragonfly's AI solution to casting porosity analysis

In this app note:

- See how the AI tools in Dragonfly 3D World can be used for the analysis of high-resolution CT scans of castings, focusing on porosity segmentation.

- Learn the importance of casting porosity analysis for industrial quality control and improving casting processes for safer and stronger parts.

- Explore the limitations of typical thresholding-based porosity segmentation methods in capturing all types of porosity.

- See how AI tools can be applied to address limitations and improve evaluation of casting quality.

- Discover the benefits of using Dragonfly's AI tools for more accurate and comprehensive porosity analysis in 3D images and volumetric measurements.

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Introduction

In this application note, we demonstrate the benefit of the AI tools in Dragonfly 3D World for the analysis of high-resolution CT scans of castings, focusing on porosity segmentation. Casting porosity analysis is important for industrial quality control, and greatly helps to understand the part quality and improve the casting processes, making safer and stronger parts by adjusting casting processes in and thereby reducing porosity. Despite the success of this technology, it can be pushed one step further by AI tools.

The typical thresholding-based porosity segmentation methods can be used for fast inspection and are quite successful with different thresholding methods, as described before:
https://dragonfly.comet.tech/getmedia/a990ac15-e98c-4b44-b98a-7c8c2e98c6af/DF_AppNote_Fast_porosity_castings_24-03.pdf?disposition=attachment

However, these methods can also often underestimate the true porosity, as they capture mainly large gas pores and not shrinkage pores or pores near the voxel size of the acquired images (all imaging devices have limits). This means that important features like narrow crack-like voids, clusters of many small pores or even larger shrinkage pores (with insufficient contrast) can be missed in 3D images and volumetric measurements. This application note shows how AI can solve these problems, doing it with a model trained on one dataset and applied to the same data as well as a different sample. This demonstrates how Dragonfly's AI tools can be useful for improved evaluation of casting quality.
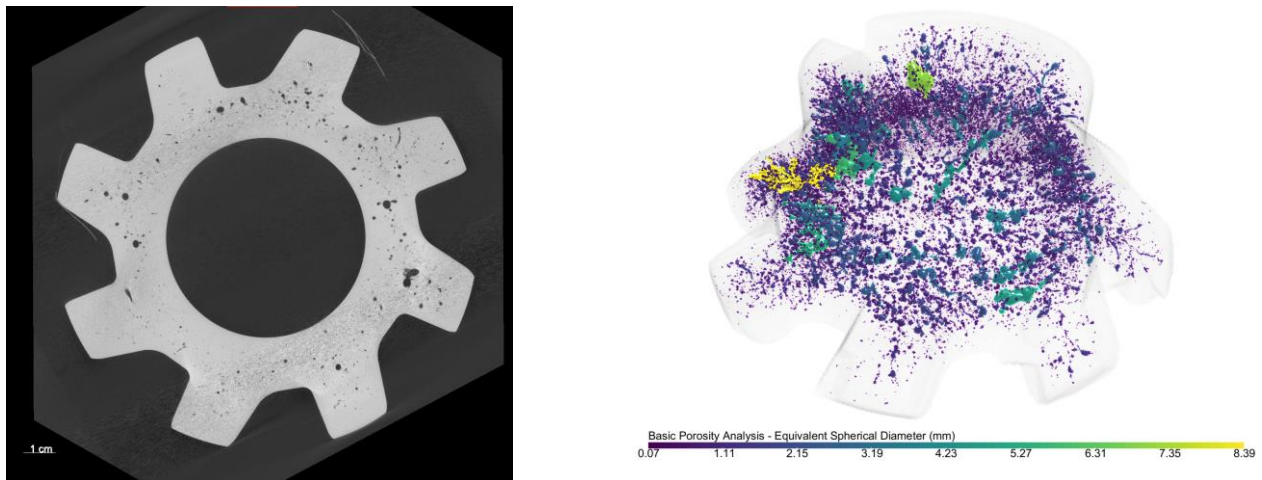
Requirements

A high resolution CT scan of a casting, the example here is from a Comet Yxlon CT system. A computer is needed with Dragonfly 3D World installed.
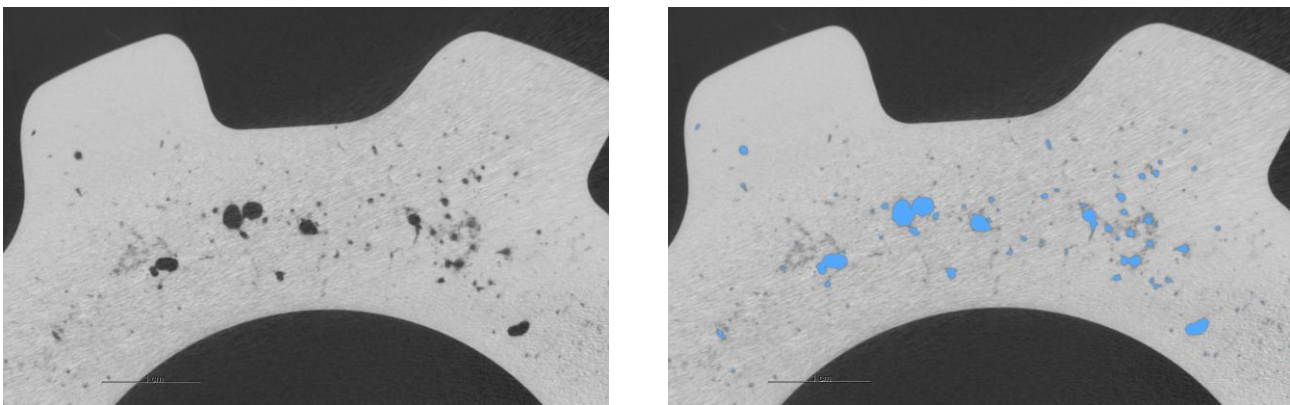
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Typical outputs:

- 3D Porosity images
- Porosity % values, largest pore size, pore size distribution analysis
- Pore shape analysis to distinguish gas pores from shrinkage pores

How does it work?

X-ray computed tomography of cast metal parts (castings) is useful for checking and quantifying the porosity that is formed inside the part during production. If there is too much porosity, the part integrity can be compromised and it can indicate incorrect casting parameters. If such parts are left unchecked, they can fail prematurely during use, causing high expenses and even loss of life, depending on where the part is used. A typical cross-section CT slice image is shown in Figure 1, with the associated 3D analysis applied using the typical Otsu thresholding method. The Otsu thresholding is further shown in detail in a cross-sectional zoom view in Figure 2. This is well known and works successfully for fast evaluations.
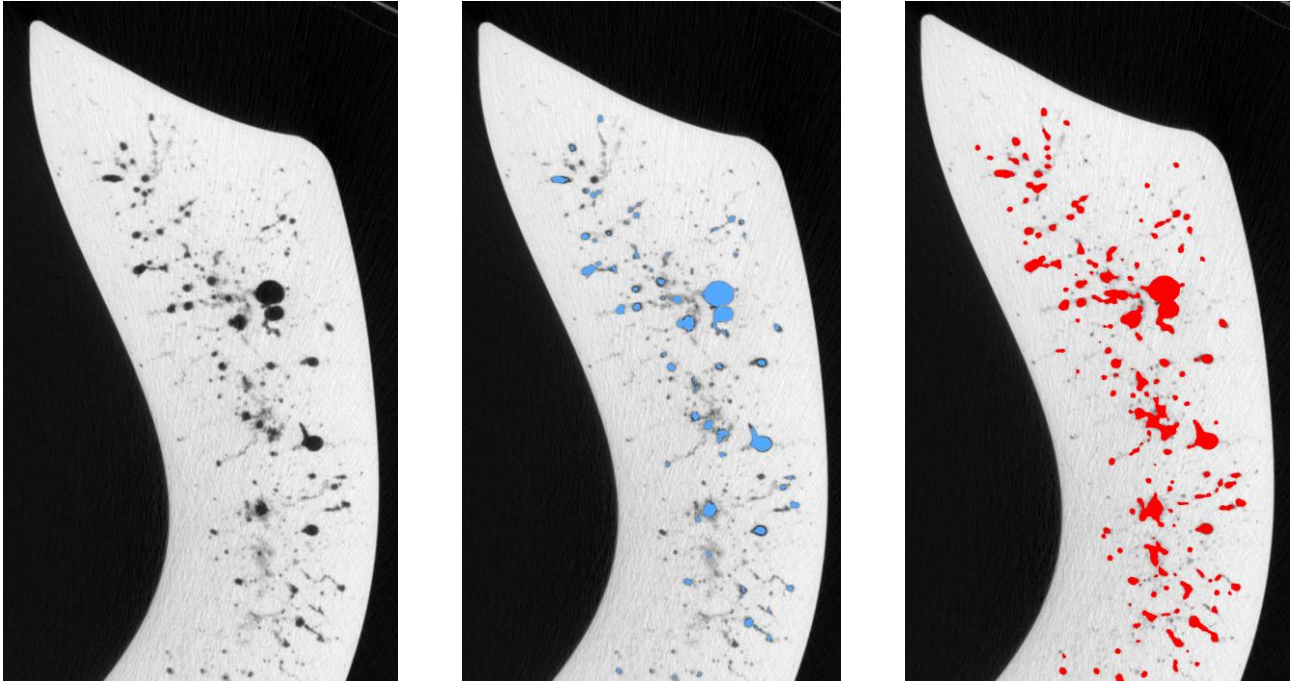

Figure 1: Typical cross sectional view of a casting – pore spaces in black (left), typical 3D view of porosity color coded by size after segmentation using Otsu thresholding (right)
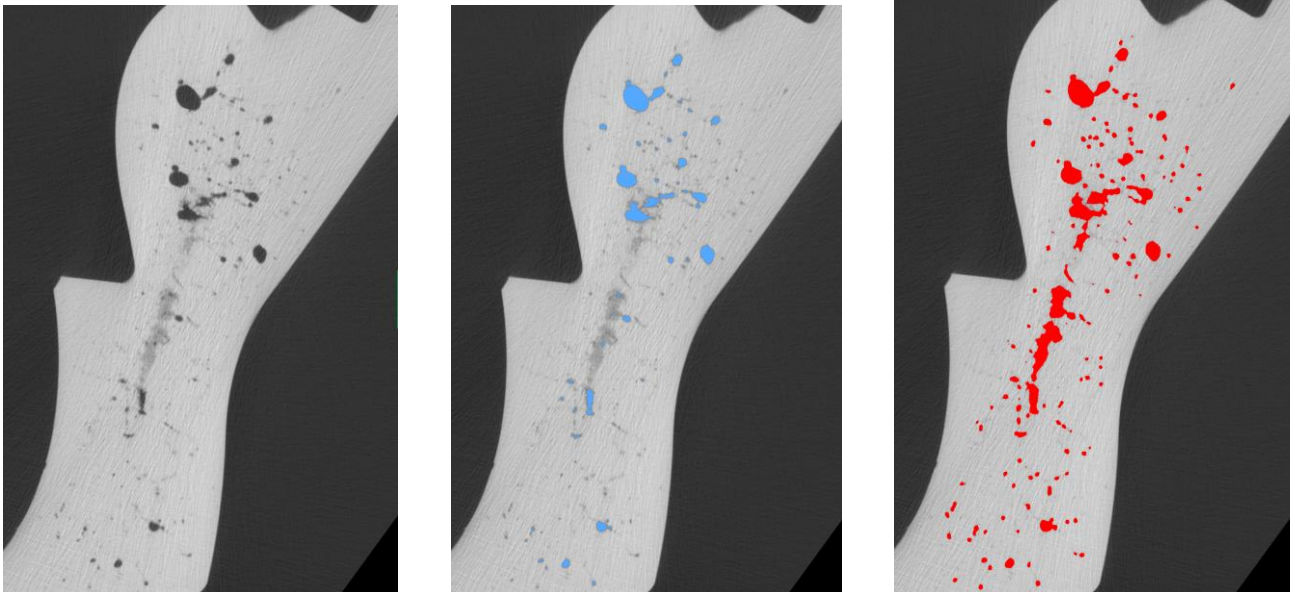

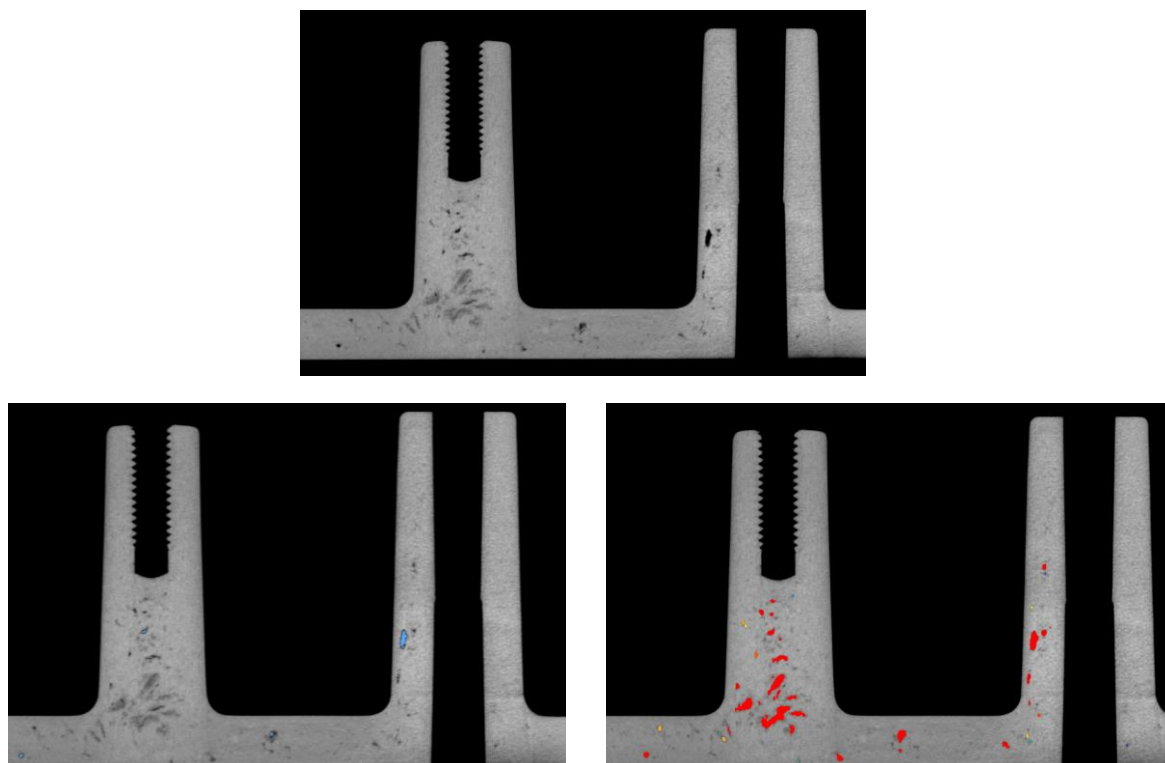*Figure 2: Examples of cross-section and thresholding (Otsu) segmentation of pores*

However, in some special cases, the images do not allow all features of interest to be segmented and more can be achieved. Below are some cases comparing the Basic Otsu and AI segmentation for such cases in the same dataset.
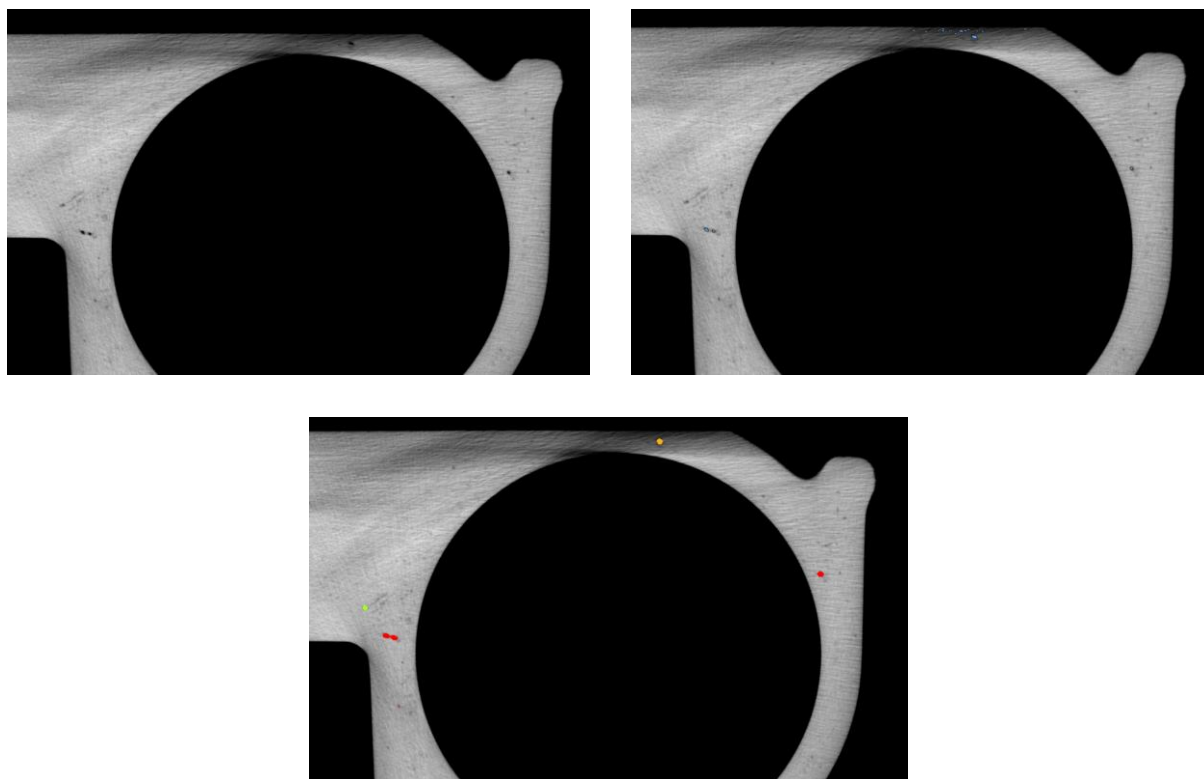

Figure 3: *Examples of improved segmentation using AI tools (right) compared to thresholding (left), in this case for narrow void regions and some shrinkage porosity regions in particular.*
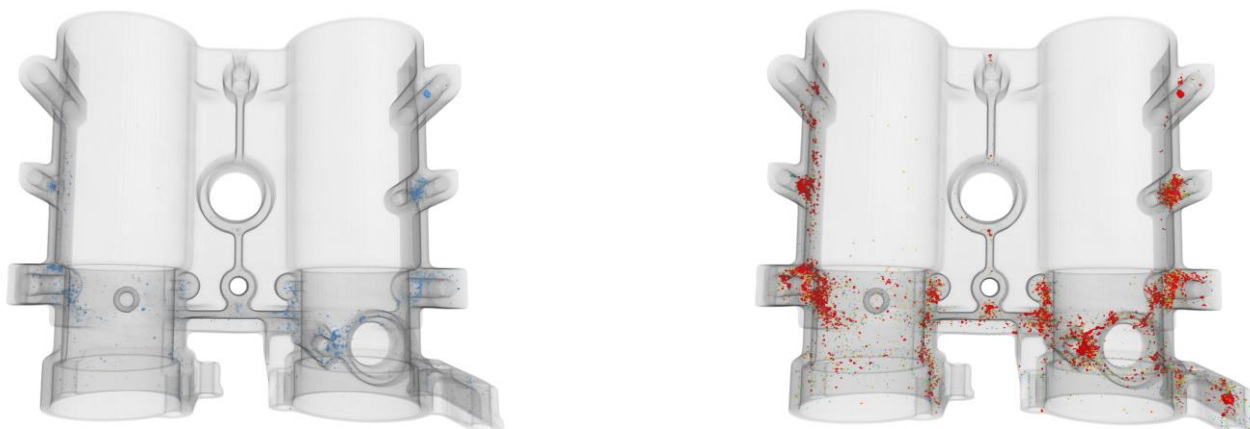

Figure 4: *Examples of improved segmentation using AI tools (right) compared to thresholding (left), in this case especially visible for shrinkage porosity (middle).*

Figure 5: An example of improved segmentation using AI tools (right) compared to thresholding (left), in this case for a different sample using the model trained on the previous data only.

Figure 6: An example of improved segmentation using AI tools (right) compared to thresholding (left), in this case for a section of the second sample with artifacts (dark area near top) where thresholding makes mistakes and AI can still segment it properly.

Figure 7: *Visualization of porosity in second sample, segmented using basic Otsu thresholding (left) and AI segmentation (right) based on training data of first sample only.*

Advanced

- 2D Cross-sectional images always give insight in shortest possible time
- Segmentation allows 3D visualization and quantification of porosity
- AI outperforms thresholding methods, in particular segmenting shrinkage pores and narrow and small features better than thresholding methods
- A single AI model was trained on selected sections of sample 1 and applied to the full sample 1, as well as to sample 2
- The model can be used as a starting point of further training to allow individualized models for specific sample and scan types
- This was achieved with segmentation wizard in Dragonfly
- AI tools must be used with caution and with supervision: in cases where the model makes mistakes, the model can be further trained and each sample type requires some retraining taking time.

The benefits:

The benefits for you as casting engineer is a more detailed quantification of defects in your castings, allowing a better insight into casting quality. Detailed inspection and quality evaluation of the internal details of castings are made possible using non-destructive CT imaging coupled with Dragonfly, and AI tools take it one step further in its capabilities. Besides allowing to quantify more of the porosities as shown here, the AI models can be applied in an automated workflow using macro's ensuring no time is wasted by the human operator.

These tools allow you to ensure safer manufacturing of end-use products, improve the casting 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 production.

Further information

Get Dragonfly 3D World today on a 30 day trial at: https://dragonfly.comet.tech/en/free-trial-dragonfly-3d-world and get in touch with our sales team sales.dragonfly@comet,tech to set you up with a full license with support plan included

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