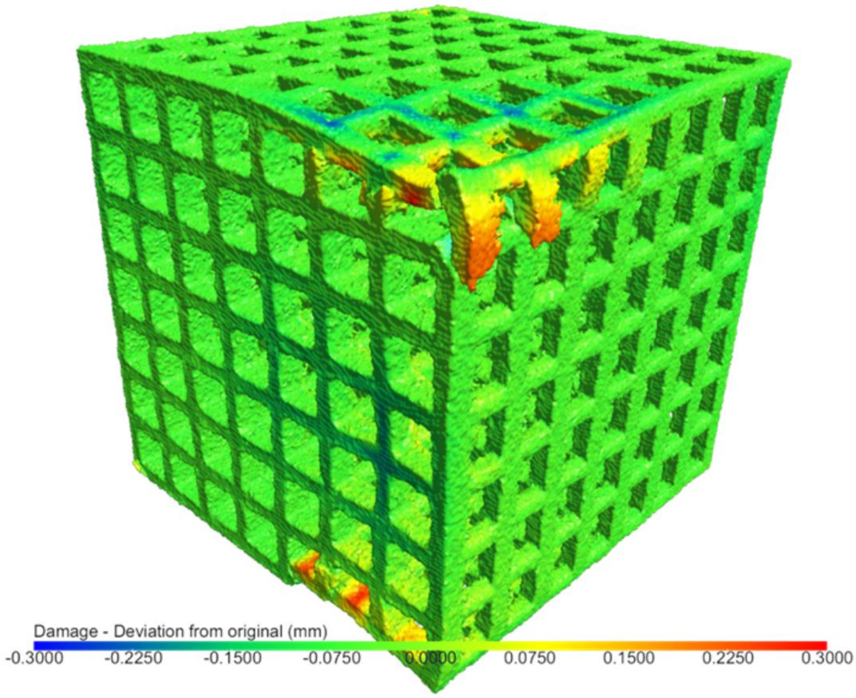
Application Note



Deviation analysis using Dragonfly 3D World

What you will learn in this application note:

- How to make deviation analysis in Dragonfly
- Highlighting deviations between design and actual parts
- Highlighting deviations from part to part, or due to some change in the same part

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Introduction

The focus of this application note is deviation analysis – also known as nominal-actual comparison, part to part deviation analysis or 3D comparison. It allows to visualize deviations between two parts that are well aligned in 3D space, using color coding to highlight the size of the deviation. In Dragonfly 3D World this is achieved using a function called “signed deviation map” and is applied to mesh representations of the “before” and “after” datasets. Two examples are used to demonstrate this: a lattice structure sample that was hit multiple times with a hammer to induce damage (part to part comparison), and a bracket that warping during manufacturing compared to its design intent (part to design comparison).

Requirements

A high-resolution micro-CT scan of the object in question is needed, plus a reference design mesh file (STL file), or two scans of the object in question – before and after some change. The lattice structure and bracket samples used here were additively manufactured in Ti6Al4V using the laser powder bed fusion process. The lattice is 20 mm across and the bracket is 60 mm in length.

Typical outputs

- Deviation analysis color coded 3D images and video
- Highlight of damage areas or highest deviation locations
- Histogram for quantifying deviation across full part
- CSV outputs possible

How does it work?

The first example is the bracket. What is needed is to import the mesh design file (STL file) to the same workspace as the CT scan in Dragonfly 3D World. The CT data is segmented using an upper-Otsu thresholding, and a surface mesh is created. In this case the surface mesh was created using sampling of 2x2x2 and smoothing 3 times. Once the mesh is created, the two meshes (design vs CT mesh) should be registered. The mesh registration tool is useful for this step – using a best-fit algorithm. The resulting “signed deviation map” calculation shows the color-coded deviation results, as in Figure 1.

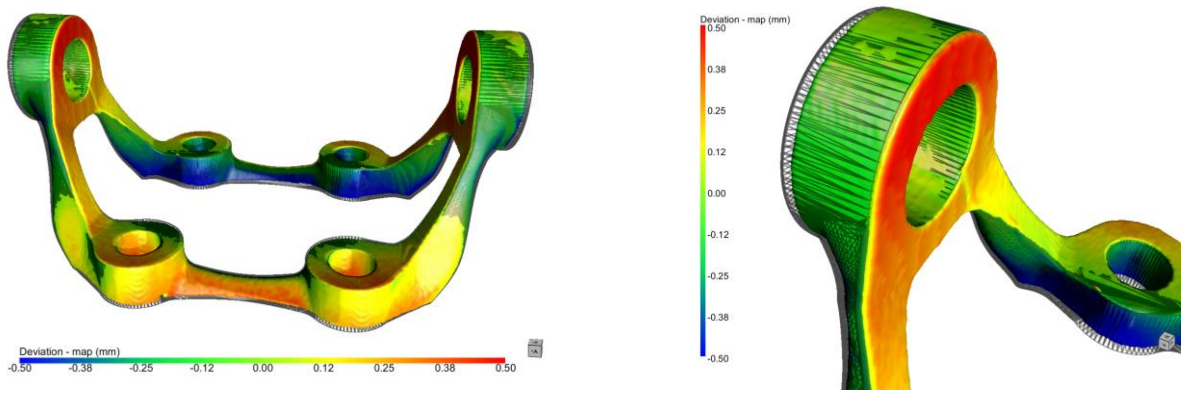


Figure 1: Example of mesh deviation analysis comparing the actual part to the design mesh. Color coding is based on positive and negative deviations, where positive = part is outside of design and negative = part is under design.

Individual locations can be inspected using the “probe” tool and measurements included as annotations, as shown in Figure 2 for one area of large positive deviation, that is attributed to warping in this case.

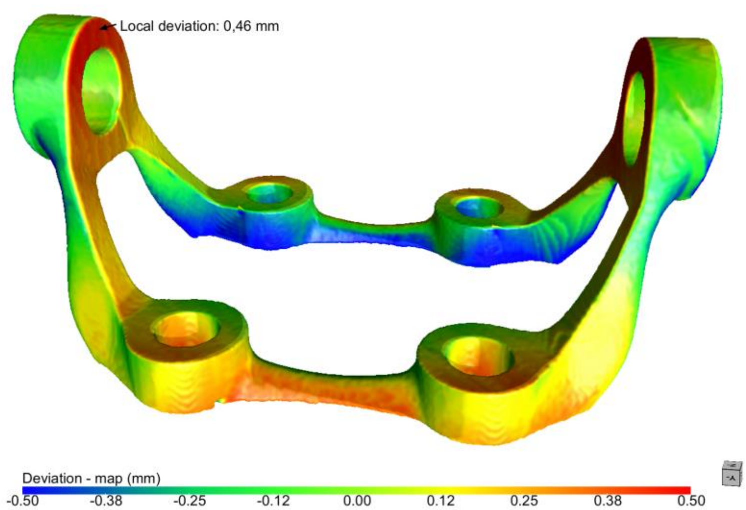


Figure 2: Mesh deviation analysis with large local deviation measured using “probe” tool and shown using annotation.

In the second example, a lattice structure sample was hit by a hammer multiple times (on different sides) to cause damage intentionally. In this case the sample was CT scanned before and after the damage, making direct comparison possible using the same tools. Figure 3 shows one area of damage – where deviation is large – and it is easily visualized using the deviation tool. In this case the “before” scan is shown in transparent rendering.

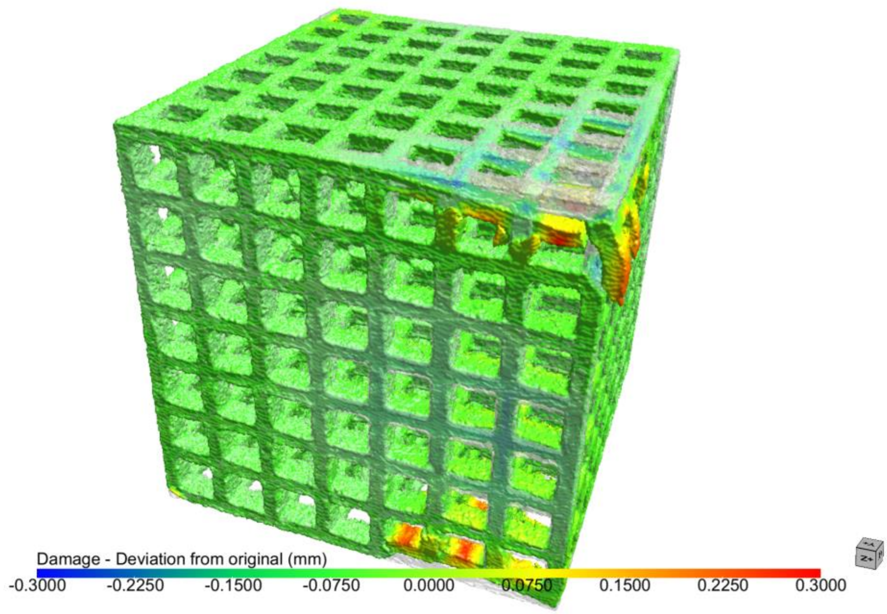
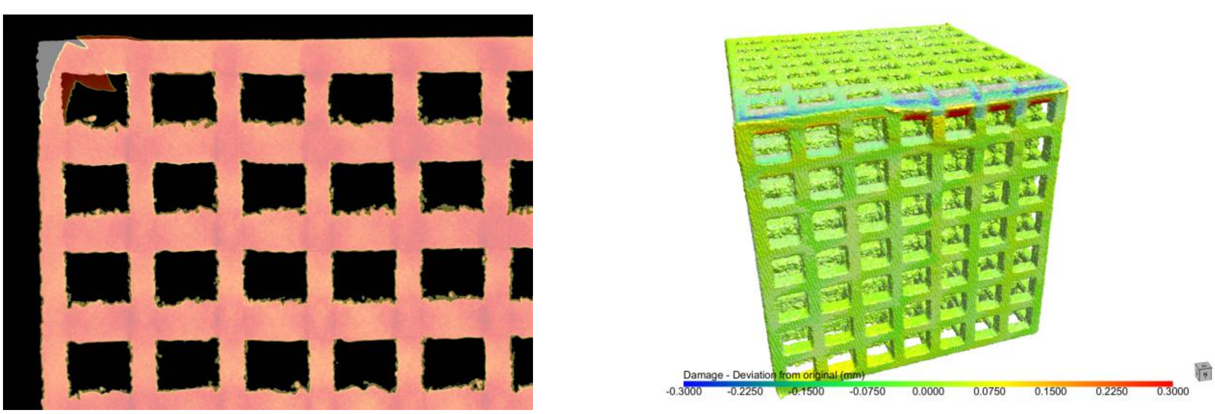


Figure 3: Mesh deviation analysis applied to a lattice, showing the area of largest deviation corresponding to clear damage on the corner.

In the case of two CT scan datasets, the registration can be done manually using opacity reduction to see both images overlapped. This allows fine adjustment and highlights deviations in 2D cross sectional images as shown in Figure 4 (left). Figure 4 (right) shows the same area in a 3D view and statistical deviation results are shown below.



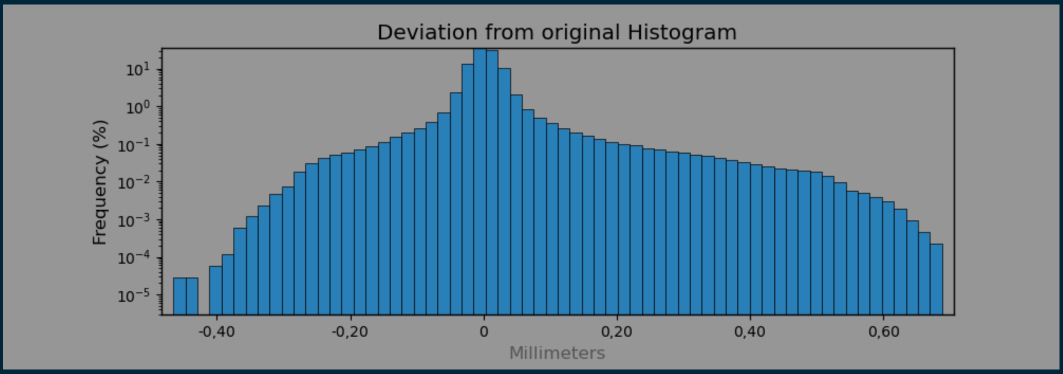


Figure 4: Cross-section and 3D view of the same area of damage in the Ti6Al4V lattice, with statistical deviation analysis over the full volume.

Summary

- Local deviation analysis is possible in 3D using design mesh as reference, or two scans of the same object
- Surface-based mesh registration is used (manual also possible)
- 3D color coded deviation maps highlight areas of warping or damage
- Good for visual understanding of damage or deviations
- Statistical and CSV outputs possible

The benefits

The ability to visualize differences between two scans of the same object, or between a real part and its design file was demonstrated in this application note. The benefit is the clear identification of major deviations such as damage areas (e.g. where the hammer hit the lattice) and warping (on the bracket). This is usually combined with other information also available in CT such as porosity analysis, to get a holistic understanding of the quality of the part.

For a video workflow demonstration of the above case:
https://www.youtube.com/watch?v=aJ88jYhWLEA

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