**46th Annual Review of Progress
in Quantitative Nondestructive Evaluation
QNDE2019
July 14-19, 2019, Portland, OR, USA**

QNDE2019-1234

IMPROVING ULTRASONIC IMAGING IN COMPLEX COMPONENTS THROUGH TOPOLOGICAL IMAGING WITH CYCLE-SKIPPING ELIMINATED

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ABSTRACT

Topological imaging is an adjoint-based inversion technique that reconstructs defects in an interrogated medium. Its chief benefit over classical imaging techniques is that it accounts for multiple-scattering, thus allowing occluded defects to be imaged, as well as providing more views to improve standard images. Topological imaging works by performing forward-adjoint simulation pairs using a particular topology, and comparing these with measured data from the true medium. An objective functional defines the effect of a topology change on the error between the simulated and true media, and the topological image indicates a gradient direction for this objective functional. Topological imaging is nominally iterative, with the gradient being used to adjust the simulated topology until the simulations match the measurements. However, it is typically terminated after a single iteration. This is because the oscillatory nature of the probing waveforms leads to a solution landscape with many local minima. If the initial topology is far from the optimal one then the iterations will get stuck and never find the topology corresponding to the global minimum. This problem is known as cycle-skipping, and it is visible in topological images as artefacts. This study demonstrates a topological imaging algorithm that avoids these artefacts. It works by replacing the original error functional with an alternative that is not prone to local minima. By removing cycle-skipping artefacts, topological imaging can much more accurately position and size defects, and more fully account for multiple scattering. Iterative implementations also become feasible, potentially improving the quality of topological reconstruction much further.

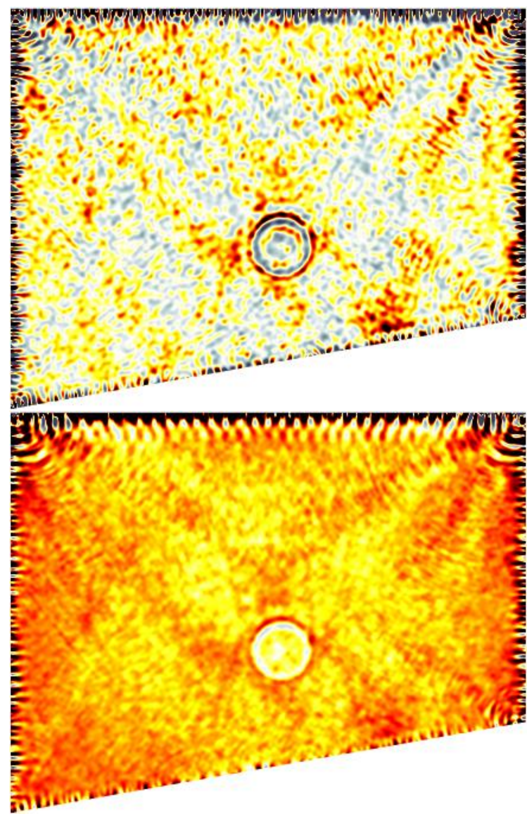

FIGURE 1: Simulated topological images of an aluminium wedge with a side-drilled hole. The interrogation was performed with a 32 element linear array emitting a 4 cycle tone-burst. Images were computed using a conventional objective functional (top) and the proposed alternative objective functional (bottom). The colour-scale goes from black through red/yellow to white for regions which increase the objective functional (unlikely to be a hole), and from white to dark grey for regions which decrease the objective functional (likely to be a hole). Cycle-skipping artefacts (spurious grey regions) can be seen to have been greatly reduced with the alternative objective functional.

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