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

# QNDE2019-1234

## 3D MACHINE VISION TECHNOLOGY FOR AUTOMATIC DATA INTEGRATION OF ULTRASONIC DATA

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### ABSTRACT

Our research addresses manual inspection and automatic registration of NDE data in the context of the digital thread / digital twin via inspection location tracking. Here, manual inspection refers to all tasks where an inspector acquires NDE data manually using a handheld probe. Automatic data integration is challenging in this situation since this task requires spatial position and orientation (pose) data for each NDE measurement. We investigate 3D machine vision methods for pose estimation. In brief, an RGB-D camera observes the asset under inspection along with the probe; 3D machine vision processes the camera data to actively track the probe in relation to the asset, which further allows one to augment each NDE dataset with its inspection location. This location facilitates to automatically integrate the data into a shape model of a digital twin. We already presented a system prototype focusing on flash thermography, which successfully addressed challenges affecting the accuracy and robustness [1].

This contribution will focus on ultrasonic inspection. We use our method to track an ultrasonic transducer and a specimen (Figure 1a); we initially worked with UT calibration specimens, their flaws are known which simplifies validation. An inspector can guide the transducer over the surface of the specimen. Our method tracks the position and orientation of specimen and transducer actively; the green frame in Figure 1b) indicates that the transducer is recognized and tracked. Thus, each ultrasonic waveform is associated with its 6D pose so that one can embed it into a shape model (Figure 2). Figure 2 demonstrates the visualization of this data on the surface of the 3d model as a C-scan.

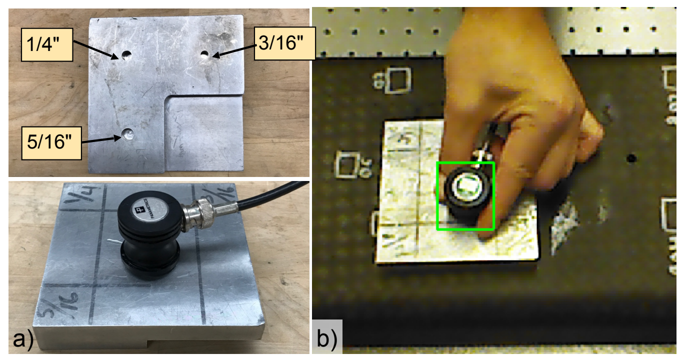

*Figure 1: a) We used a UT calibration specimen for the experiment. b) UT waveform data was collected while the transducer's pose was tracked.*

A challenge with this setup was accuracy and robustness since the ultrasonic transducer is quite small and almost disappears in RGB-D data. In comparison to our previous work, we integrated an additional detection step based on a convolutional neural network (CNN). It identifies the transducer in the camera data. Thereby, it limits the RGB-D search space, a measure that simplifies the spatial registration of the probe with point cloud data - less data yields higher detection probabilities - so that online registration with 30 frames/sec is feasible.

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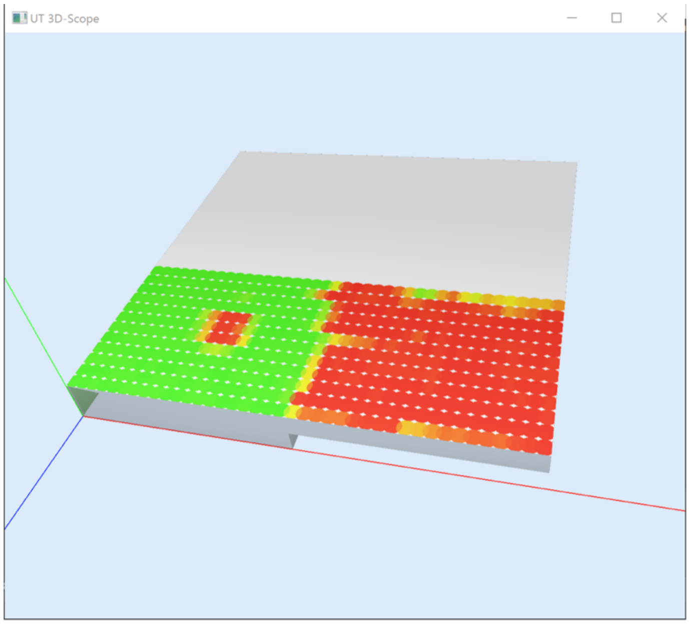


*Figure 2: Our software UT 3D-Scope allows us to visualize the waveform after a post-process; this image shows a C-scan.*

The paper/presentation will introduce the system and its components, highlight the new challenges in comparison to our previous research, and demonstrate C-scan results that our experiments yielded. In detail, we intend to structure the paper as follows: The first section will introduce the addressed research area and the challenges. Section 2 will briefly review some fundamentals and introduce related work. The following section will focus on the tracking and spatial registration approach. We will introduce the CNN in particular since it is the main driver responsible for the current accuracy. Section 4 will introduce experiments we made with three different UT calibration specimens. As results, we intend to demonstrate several C-scans obtained with our method. The paper will close with a conclusion and an outlook.

## REFERENCES

[1] Rafael Radkowski, Stephen Holland and Robert Grandin, 2017, " Evaluation of the Fidelity of Feature Descriptor-based Specimen Tracking for Automatic NDE Data Integration." QNDE 2017