Automation of non-destructive testing on complex surfaces using low-cost robotic arms

IOWA STATE UNIVERSITY

[1,2]Rebeka Sultana, [2,3]Yuan Ji, [1,2]Jiming Song

[1]Electrical and Computer Engineering, [2]Center for Nondestructive Evaluation -CNDE

[3]Aipplied Engineering Technology, Virginia State University

Motivations:

Manual Inspection for flaws or surface fractures can be laborious to use, and human error can affect the inspections. A robotic inspection system can completely automate the placement and surface contact when combined with conformal eddy current probes, hence enhancing inspection reliability.

Objectives:

To develop of a low-cost fully automated eddy current (EC) testing systems based on robotic arm with enhanced position repeatability and path accuracy focusing on the following features:

- Low cost
- Sensor in-the-loop position control
- Suitable for complex surfaces
- *VTK based data visualization*

Data visualization expectation:

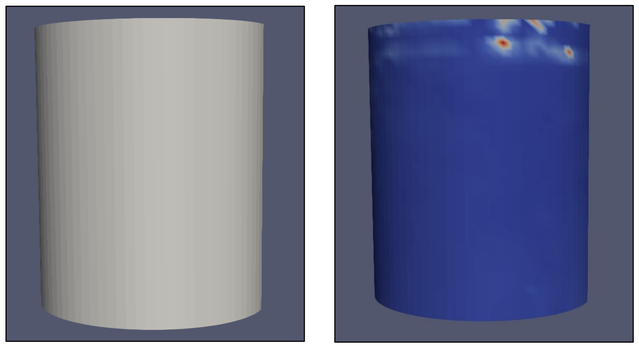


Fig. 1 Left: CAD model; Right: data points are overlaid on the surface of the CAD model.

Data points shown in Fig. 1 are from computer generated simulation result, however it demonstrates that once we can use robotic arm to collect surface scan data (e.g., eddy current coil impedance) on curved specimens, we can readily overlay the measurement data on the surface of the CAD model for visualization.

Initial testing with demo robot:

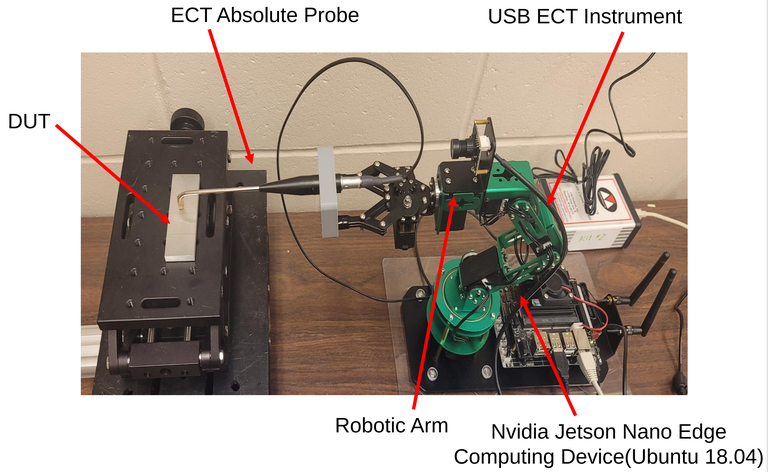
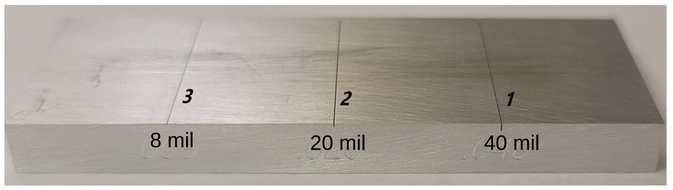
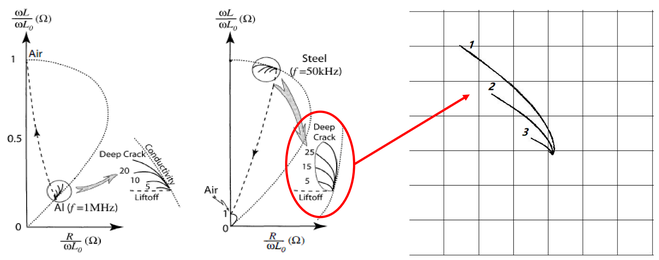


Fig. 2 Demo test setup to check robotic control of EC probe over a sample space

Initial testing result plot:





Shull, Peter J. *Nondestructive evaluation: theory, techniques, and applications*. CRC press, 2002.

This work (Assembly with robotic arm)

Fig. 3 Left: Reference plot for defect signal strength; Right: Measured result visualization with demo test setup

Six Axis Robotic Arm

This low-cost robotic arm has a radial reach of 440 mm with six joint section providing six degree of freedom. It can carry up to 1kg of payload, enabling automated experiment for various NDE modalities including eddy current, ultrasound and microwave.

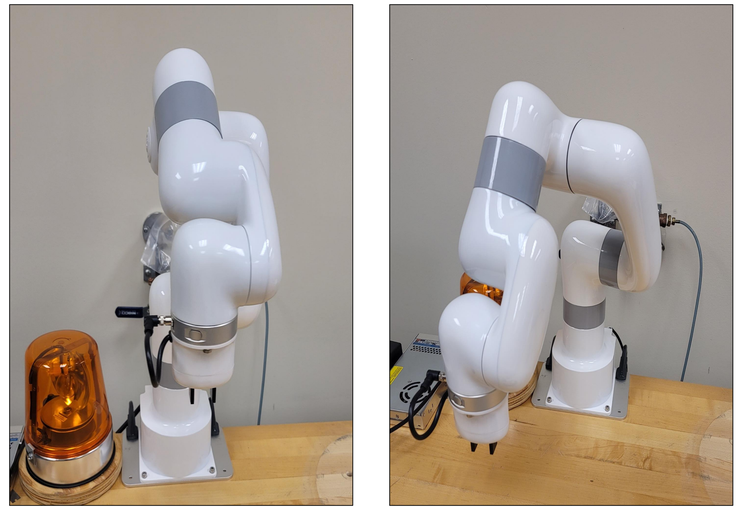


Fig. 4 Front and side view of the robotic arm (model: Ufactory Lite 6)

Next Steps:

- Multi-sensor payload to be mounted on the robotic system for feedback control
- Programming the robotic system using Python for path accuracy and position repeatability evaluation
- Incorporate sensor signal into the feedback loop of the robotic arm control for enhanced position repeatability and path accuracy
- Explore the possibility of using cameras to enhance path accuracy

Acknowledgements • This project is supported by Center of Nondestructive Evaluation (CNDE) Industrial Advisory Board (IAB) and by R. Bruce Thompson Fellowship