Low-variance Deep Graph Learning for Predictive Pipeline Assessment with Interacting Threats

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Main Objective

This project was awarded to Dr. Hao Zhang (Mines) and Dr. Yiming Deng (MSU) in order to develop low-variance interacting threat assessment approaches that address the key gap of interacting threat modeling and variance reduction, by proposing new data-driven algorithms that integrate deep learning and graph theory.

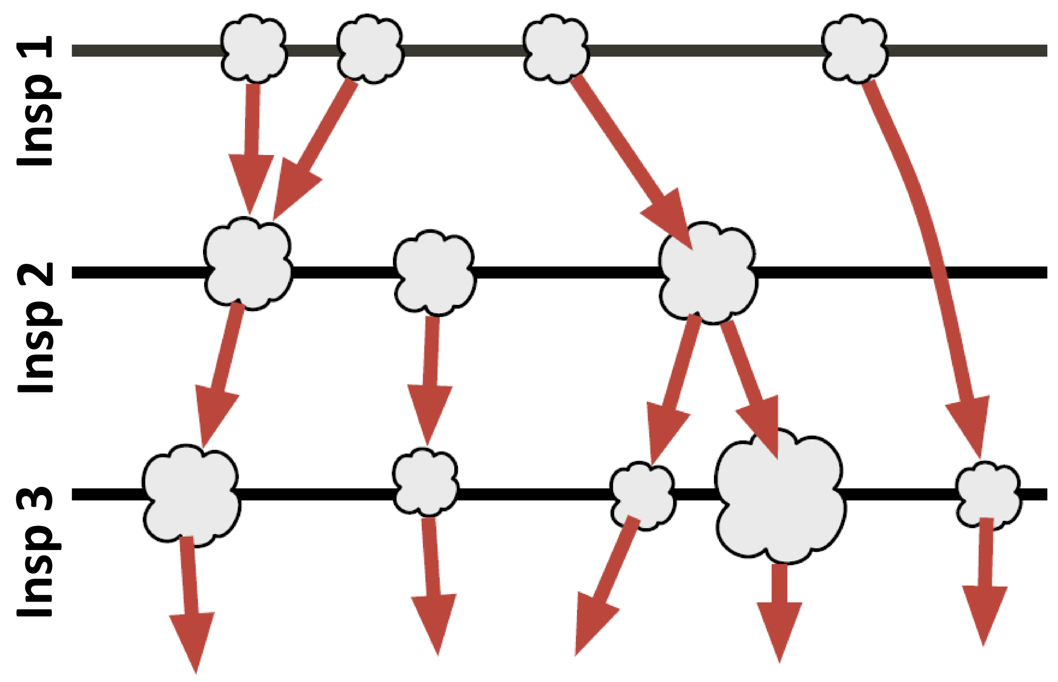

Figure 1. Morphological dynamics of interacting threats.

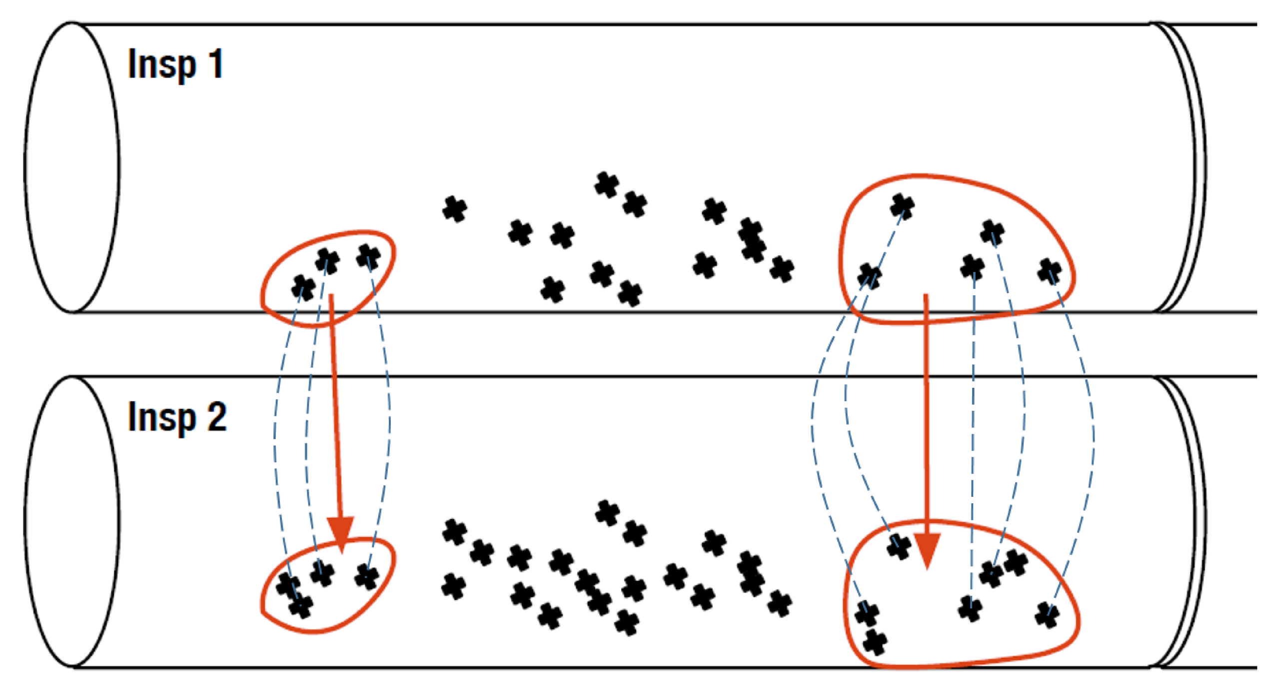

Figure 2. Spatiotemporal interacting threat identification and matching.

Project Approach/Scope

The project focuses on developing and evaluating new methods for low-variance interacting threat assessment:

- Hybrid modeling of interacting threats and risk identification
- Interacting threat segmentation and spatiotemporal matching
- Interacting threat characterization and diagnosis
- Interacting threat prognosis by deep graph learning

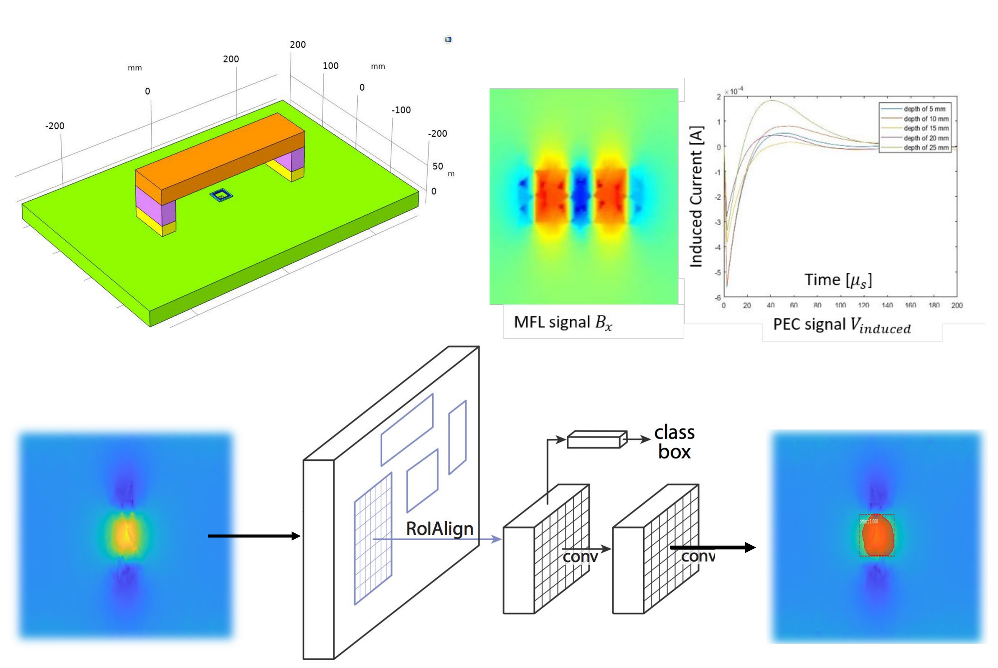

Figure 3. MFL simulation, and deep learning for threat diagnosis.

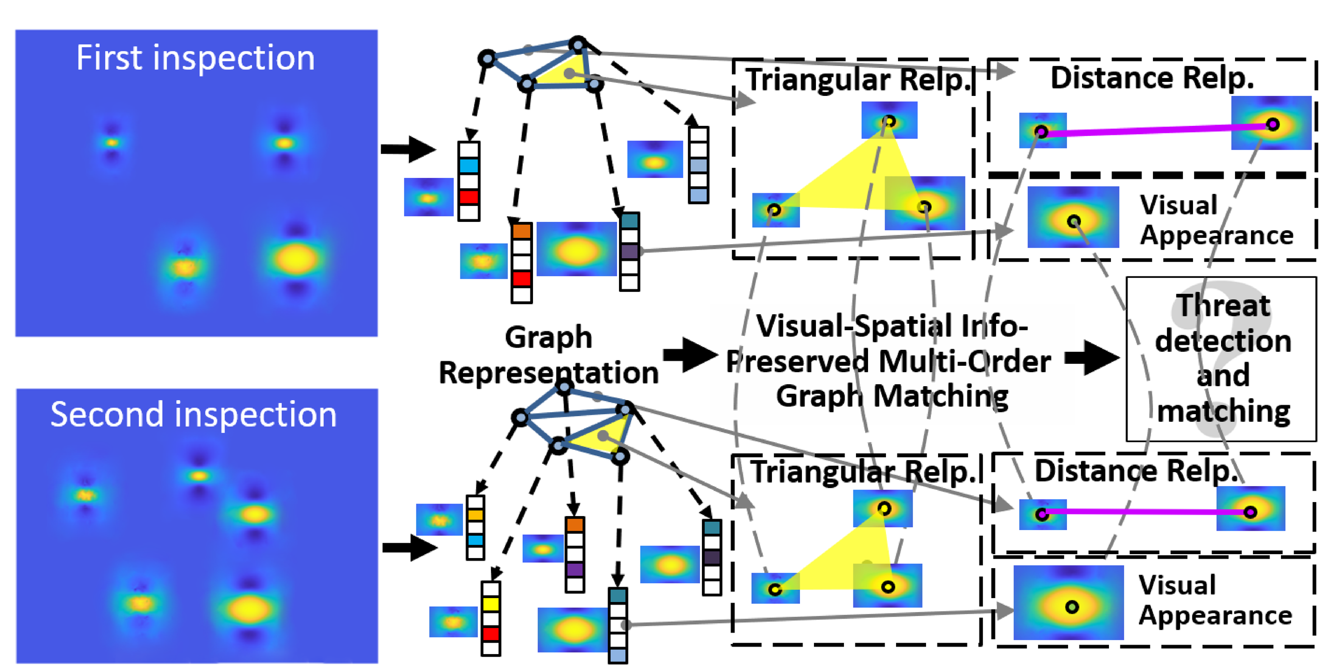

Figure 4. Spatiotemporal interacting threat detection and matching

Results to Date

1. Our deep learning approach based on the Mask Region-based Convolutional Neural Network (Mask-RCNN) accurately detects individual threats and identifies threat boundaries in sensor data.

2. We developed an approach based on graph representation learning to represent interacting threats as graphs and fuse both spatial and visual information, which accurately matches interacting threats (including growing and new threats) across multiple inspections.

3. We developed a COMSOL-based multi-NDE model consisting of magnetic flux leakage (MFL) and pulsed eddy current (PEC) inspection tools. Various design parameters are tested in order to enhance the sensitivity and robustness of detection.

4. Defects modelled as material loss are introduced to the simulation with refined finite element analysis. Multiple isolated defects with different spatial distributions and interacting threat pairs are designed for data-driven risk identification.

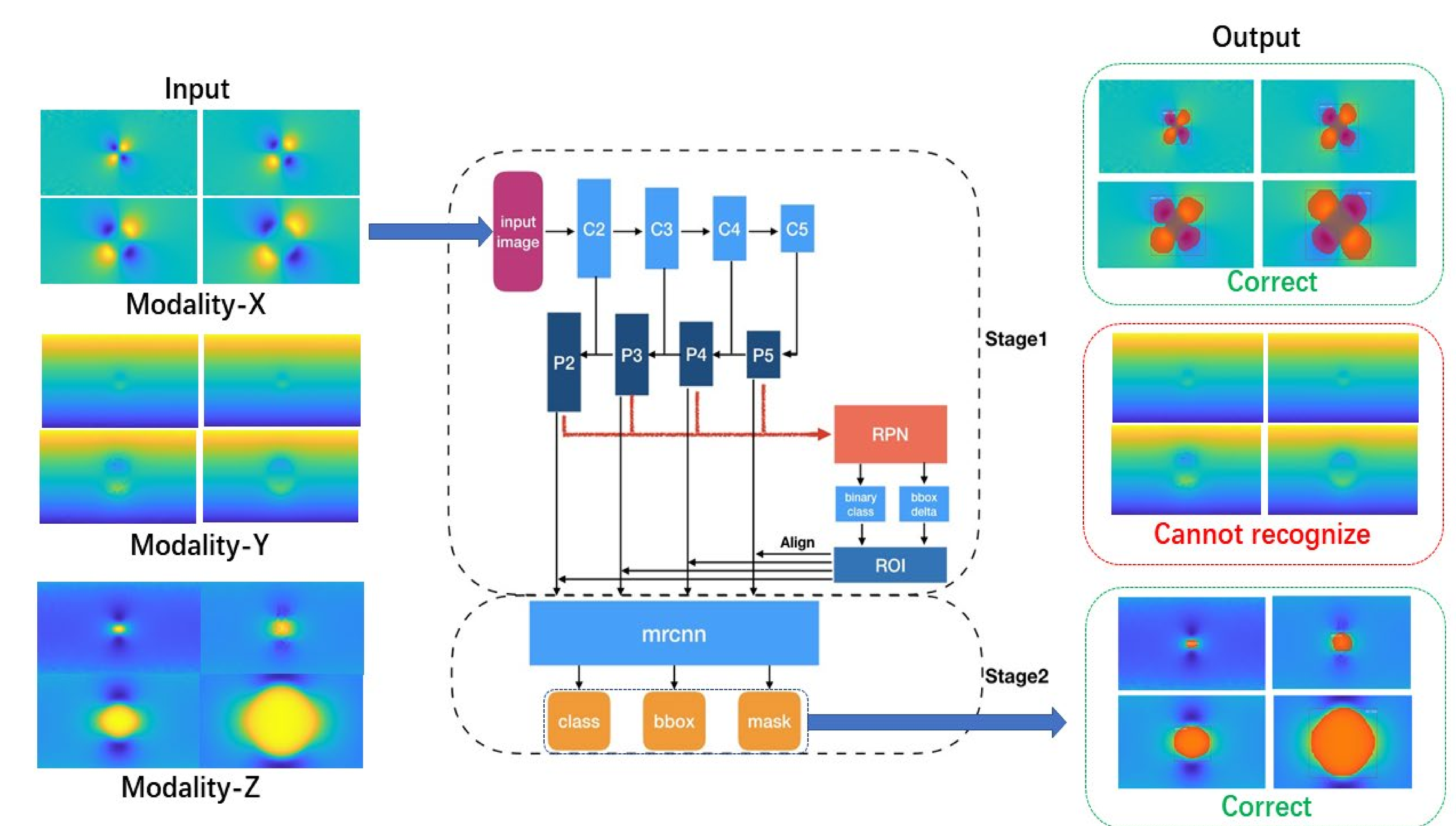

Figure 5. Results of Mask-RCNN on threat detection and boundary identification

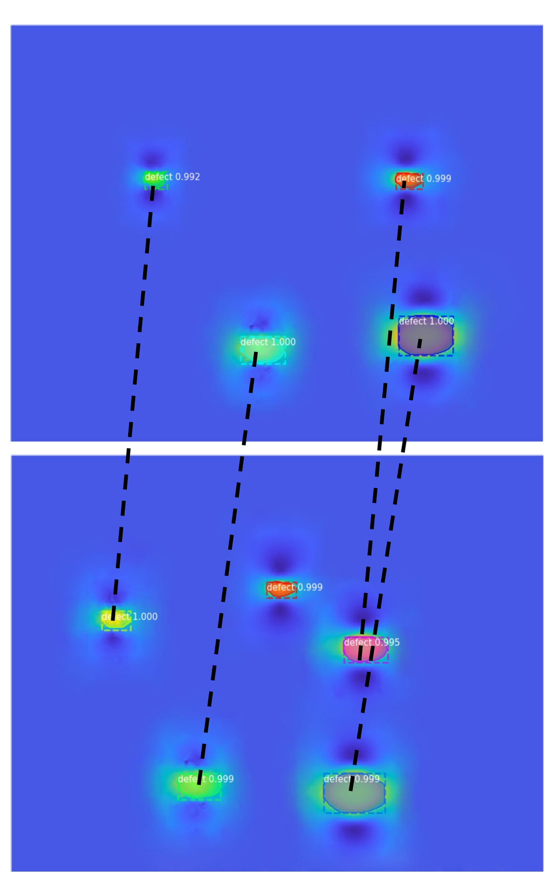

Figure 6. Results on interacting threat matching

Acknowledgments

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Public Project Page

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