AI-enabled Interactive Threats Detection using a Multi-camera Stereo Vision System

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Objective

This project was awarded to Arizona State University in order to detect and characterize interactive threats on gas pipelines. The objective is to develop a multi-camera stereo vision system to achieve fast, cost-effective AI-enabled anomaly detection. Depth data is first extracted using the proposed stereovision camera system. We then aim to explore how RGB image data along with the extracted depth information obtained through stereo-vision algorithms can be combined to aid in prognostic assessments.

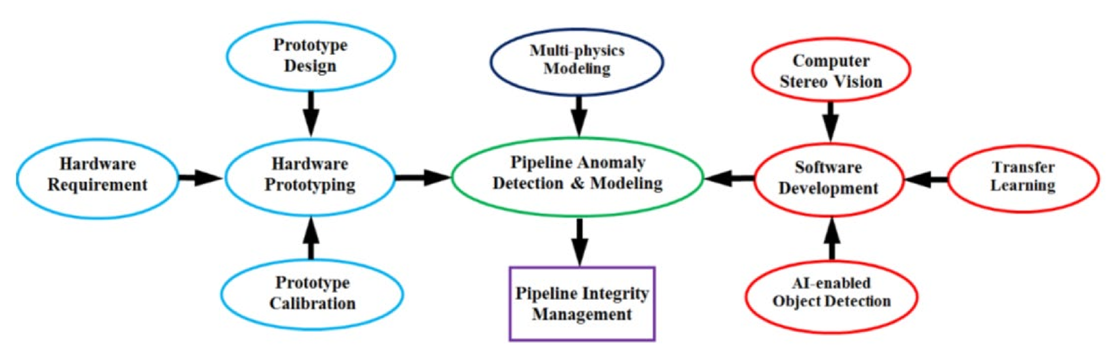

Figure 1: Proposed approach for pipeline integrity management.

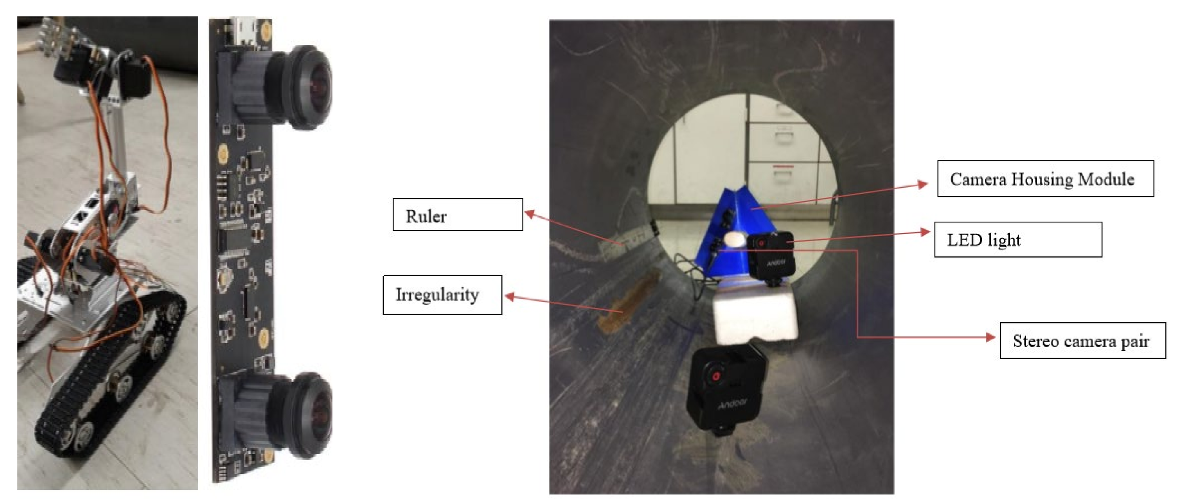

Figure 2. (Left): Robot prototype for collecting data along with a binocular stereo-vision camera system. (Right): Experimental setup for test images to construct disparity maps.

Project Scope and Approach

- Development of a multi-camera stereovision system: Extract depth maps to add an extra layer of information apart from the RGB data.
  - Algorithm development: develop fast stereo vision algorithm to achieve real time depth map generation for 3D reconstruction of pipeline inner surface.
  - Hardware prototyping: develop three main modules include camera housing module, robotic carrier module, and computing module.
- Development of machine learning algorithms: Data acquired from both the multi-camera system and the monocular camera is used to train novel learning algorithms.

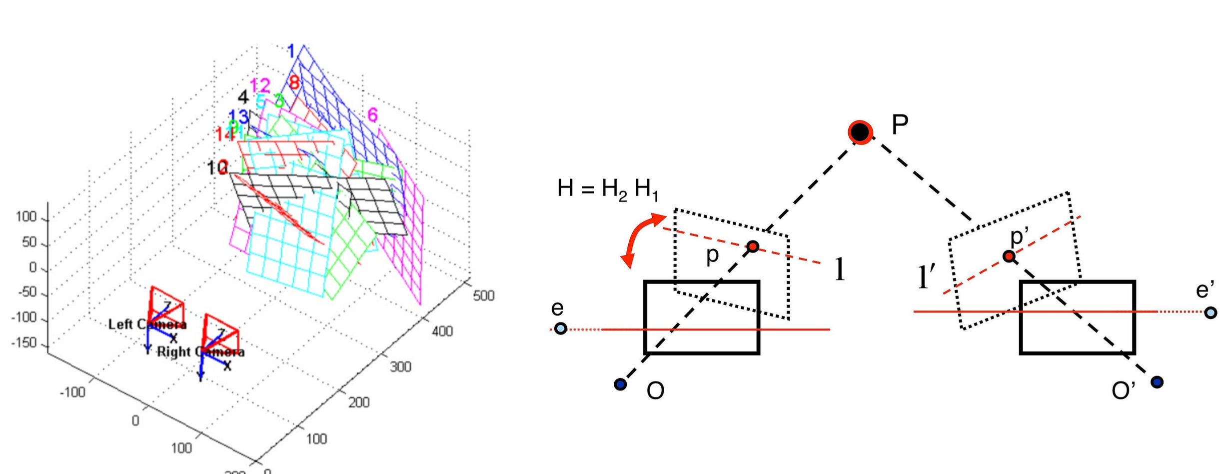

Figure 3: Obtaining disparity maps using the Block Matching algorithm

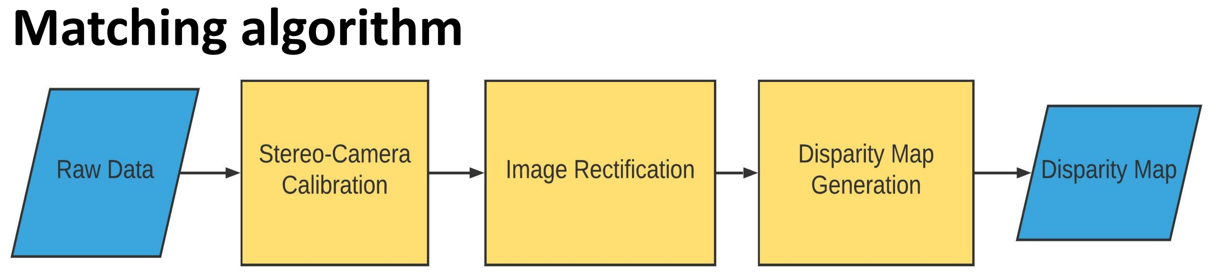

Figure 4: Obtaining disparity maps using the Block Matching algorithm

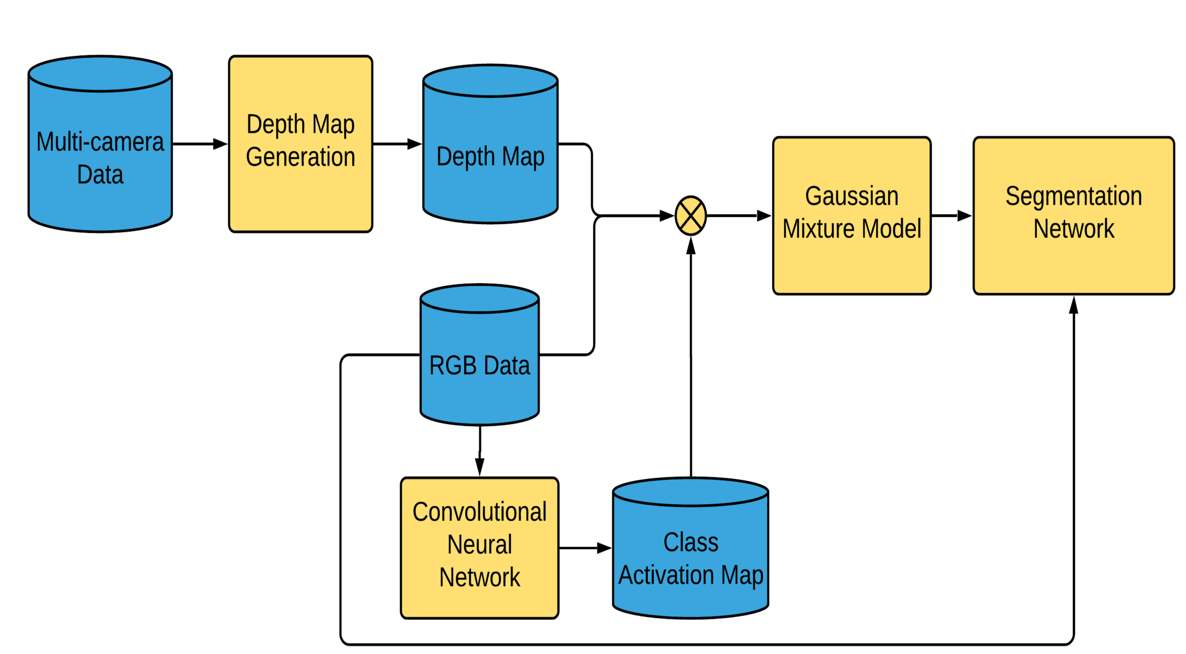

Figure 5: Process diagram for the weakly-supervised machine learning algorithm

Results

- Figure 6 shows some preliminary results for depth map of the pipeline inner surface with artificial defects. Depth map provides us with rich information about the scenes that the system would encounter in practice.
- Hierarchical Region Merging using Information Theoretic Measures: After performing model selection on the GMM using the Bayesian Information Criterion (BIC), we used an information theoretic criterion to merge regions based on how close the densities were.
- Class Activation Maps (CAMs) provide weak spatial cues for locations of objects of interest.

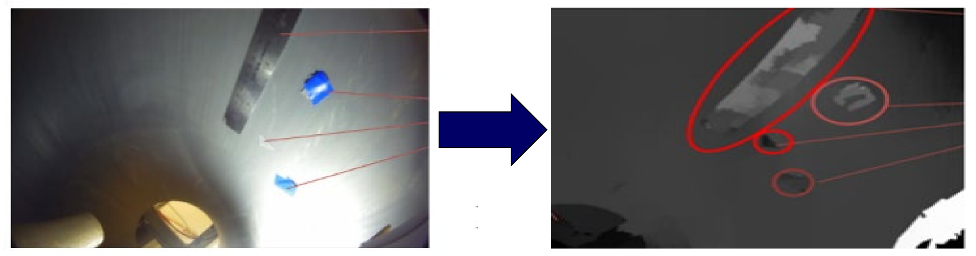

Figure 6: Stereo depth map from a raw image with simulated pipe defects.

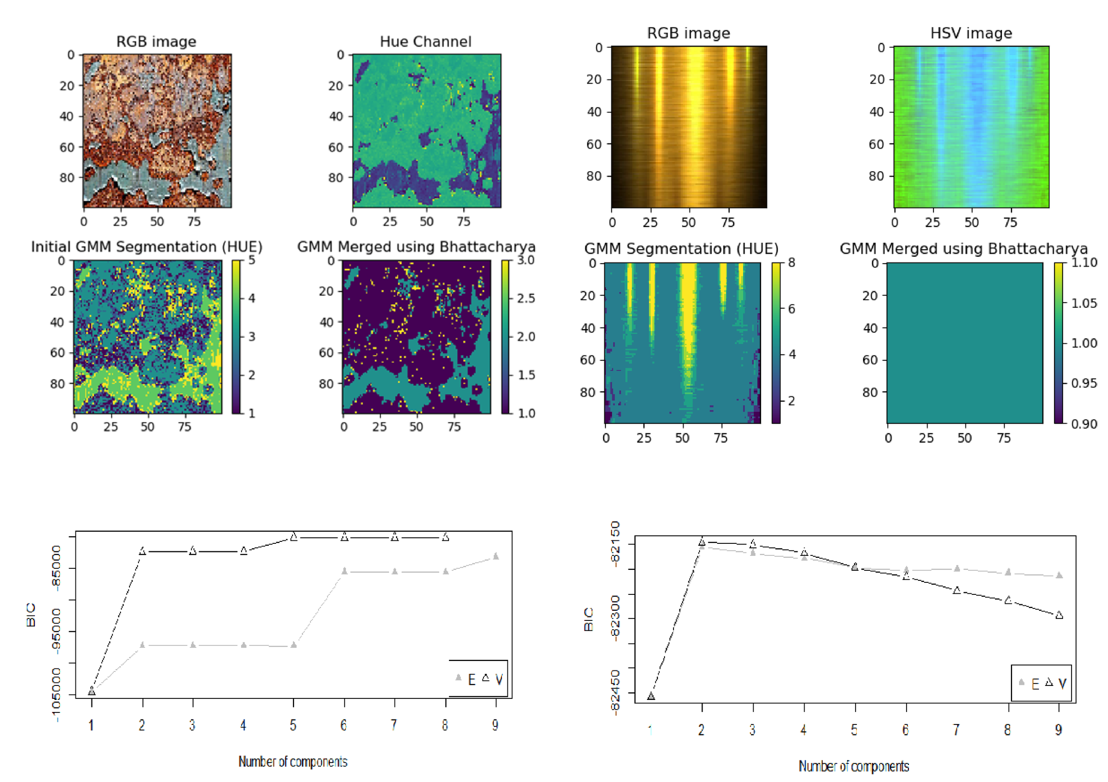

Figure 7: Demonstrations of hierarchical region merging using the Bhattacharya criterion. Initial model selection done using BIC.

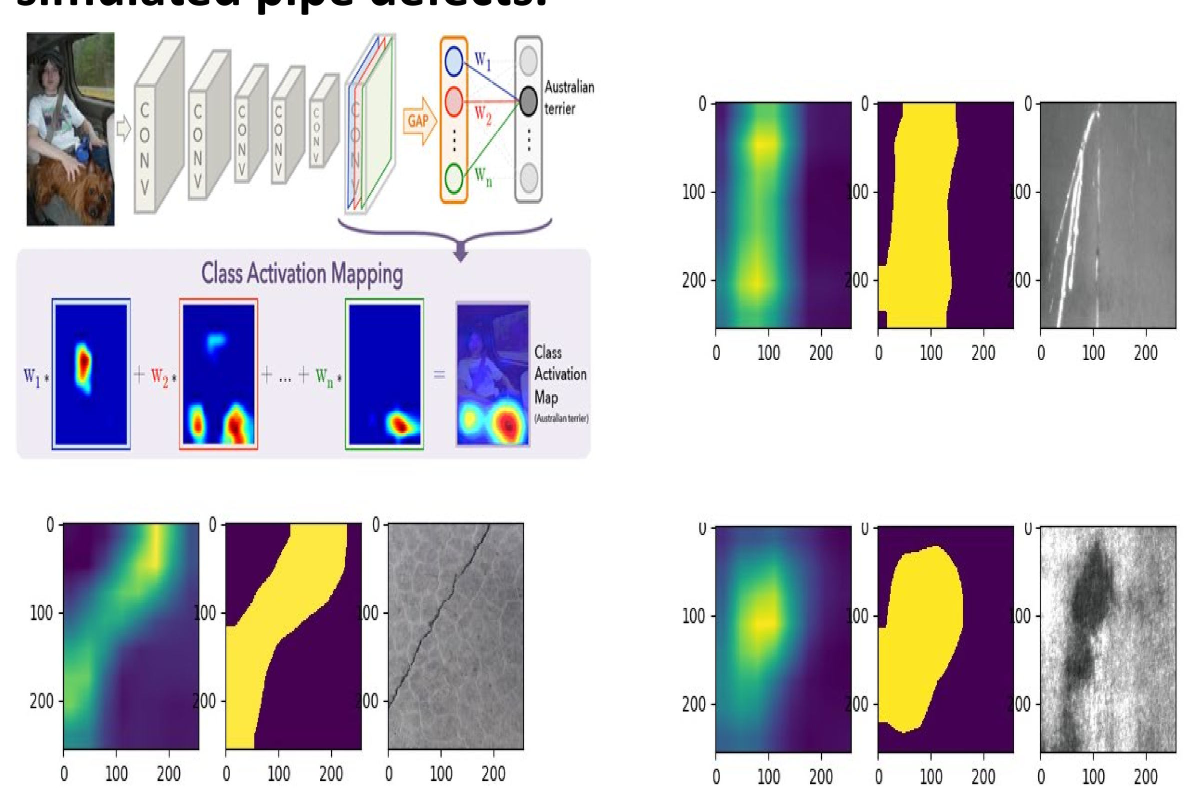

Figure 8: Demonstrations of CAMs for defect detection.

Acknowledgments

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References

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