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Automated Crack Feature Detection in Remote Visual Inspection of Nuclear Power Plant Structures

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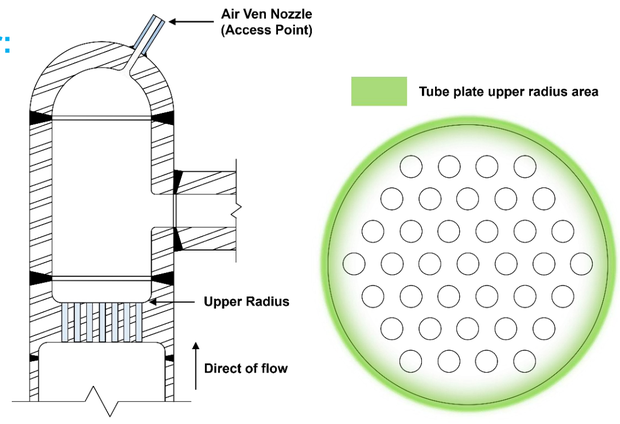
Introduction

- Assurance of the normal condition of components is necessary for safe continued operation
- Manual visual inspection may be prone to large volume of inspection data, making the manual assessment laborious and lengthy
- This project develops a decision-support tool to automatically detect crack features in the inspection footage of superheater tube plate upper radius region

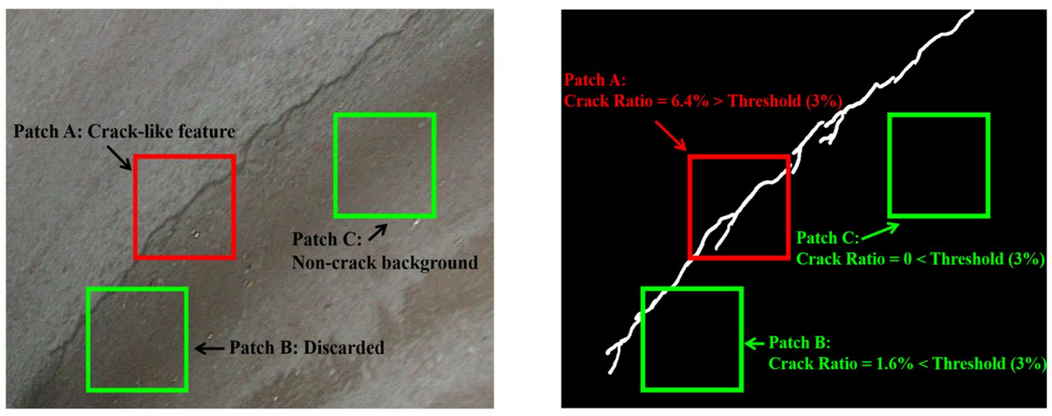
Superheater:



(a) Cross-section view (b) Bird's-eye view of tube plate

Efficient Preparation of Dataset

- Large datasets are typically needed to train an automated detection system (in our case: detecting cracks)
- Efficient labelling process is performed by applying a threshold to automatically label patches as "crack" or "non-crack", based on the binary masks of ground-truth crack frames

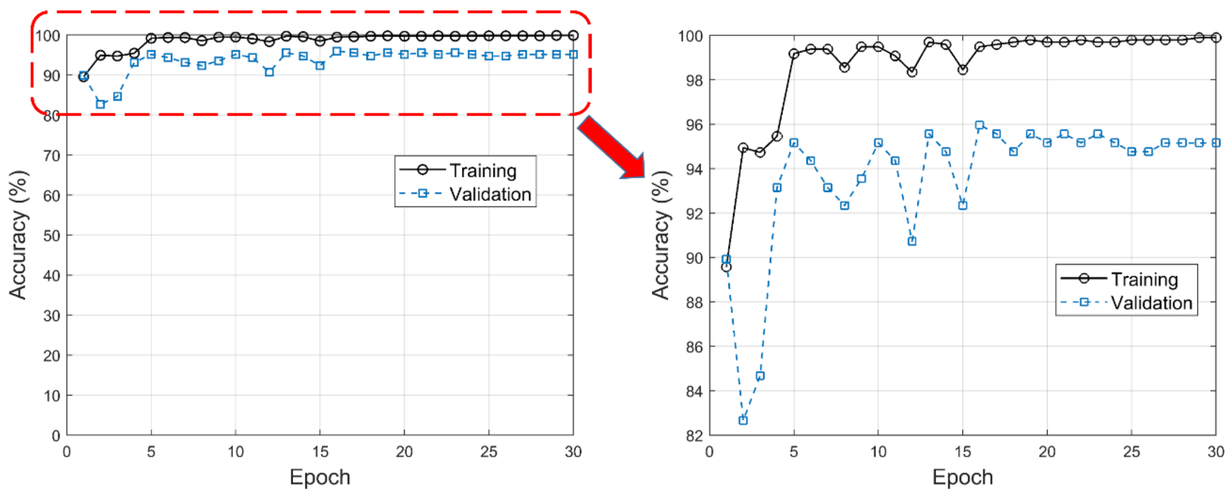


Ground-truth frame Binary crack mask

- With this technique, 1600 patches are automatically labelled in 83 seconds

Detection Model Training

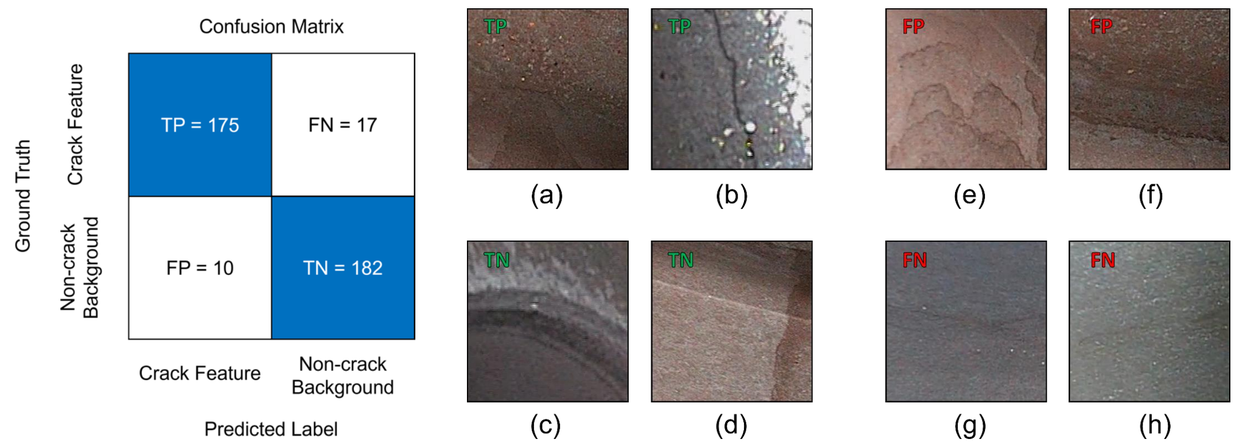
- The automatically labelled datasets are used to fine-tune a pre-trained deep learning network (GoogLeNet) via transfer learning



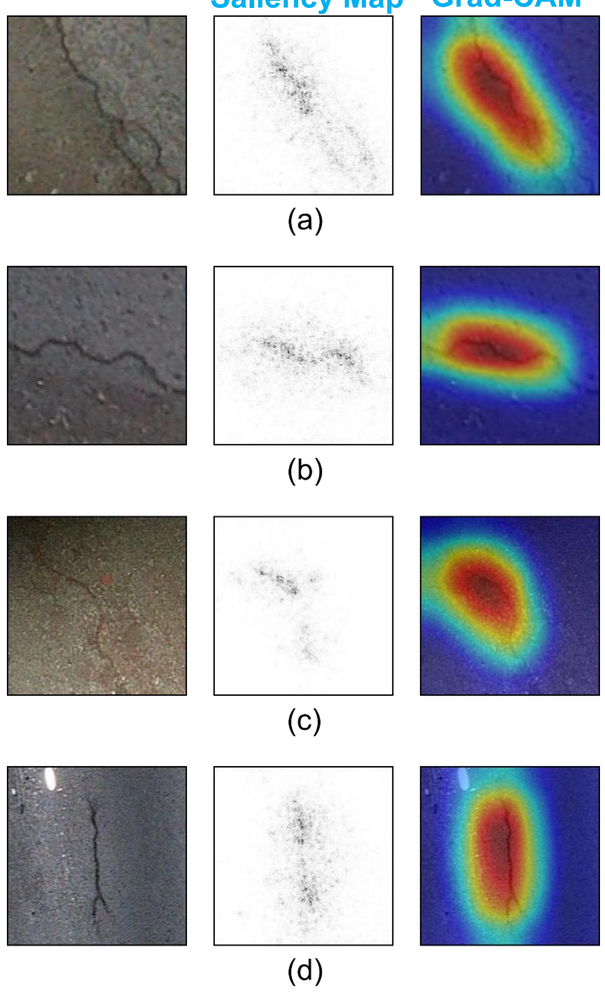
Training and validation accuracy "Zoom-in" plot

Results and Discussion

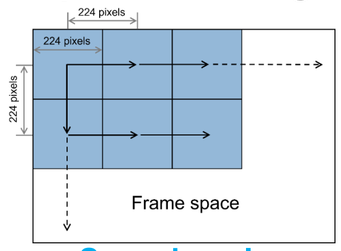
- Model performance on the testing dataset and examples of model classification results:



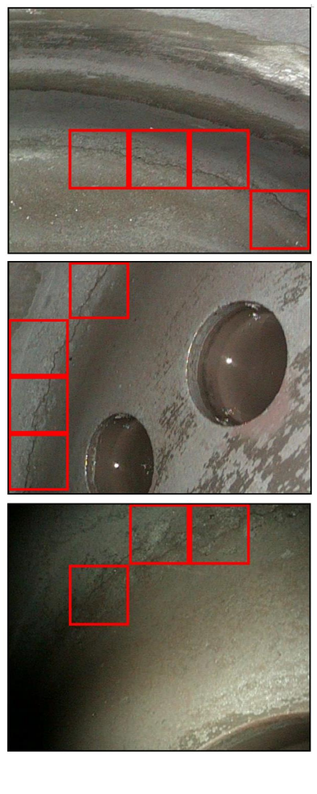
- The trustworthiness of this black-box operation is investigated using the Saliency Map and Gradient-Weighted Class Activation Mapping (Grad-CAM) techniques:



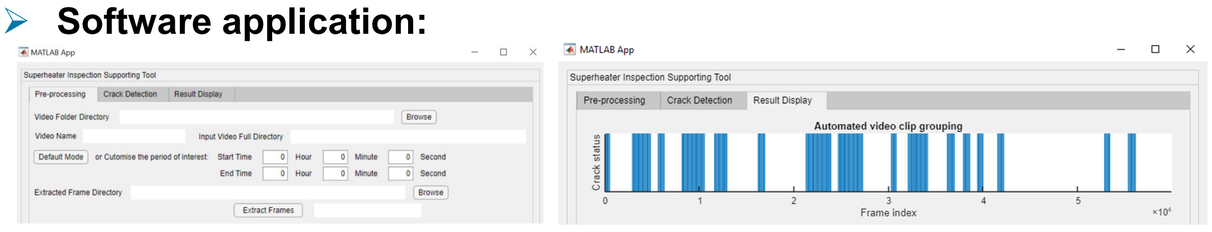
- Examples of detected crack regions in the inspection footage:



Scanning plan



- Software application:



Conclusions

- The automated crack detection system for superheater inspection has been developed and validated
- Future work is aimed at improving the efficiency and accuracy of the system and widening its adaptability

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