Calandria Tubesheet Bore Inspection Decision Support

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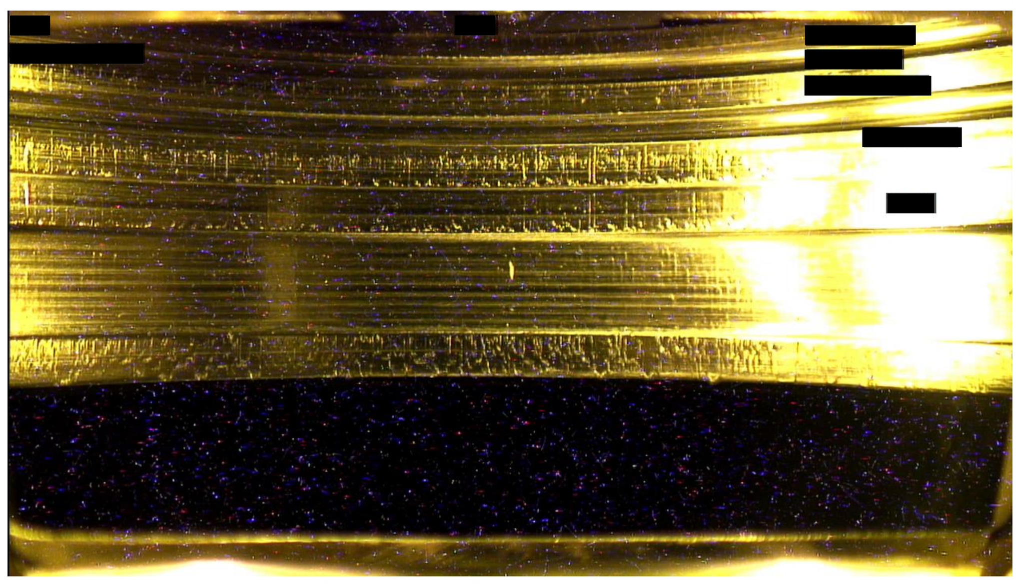
Introduction

- Bruce Power's Major Component Replacement (MCR) programme focuses on replacing major components in nuclear power plants.
- The program includes the replacement of steam generators, pressure tubes, calandria tubes, and feeder tubes.
- Inspection of Calandria Tubesheet Bores (CTSB) is a time-consuming task within the programme.
- Currently, engineers manually watch inspection videos to detect defects that could cause a leak test failure.
- The project aims to automate the inspection process and provide engineers with improved videos or images for faster and more reliable decision-making.

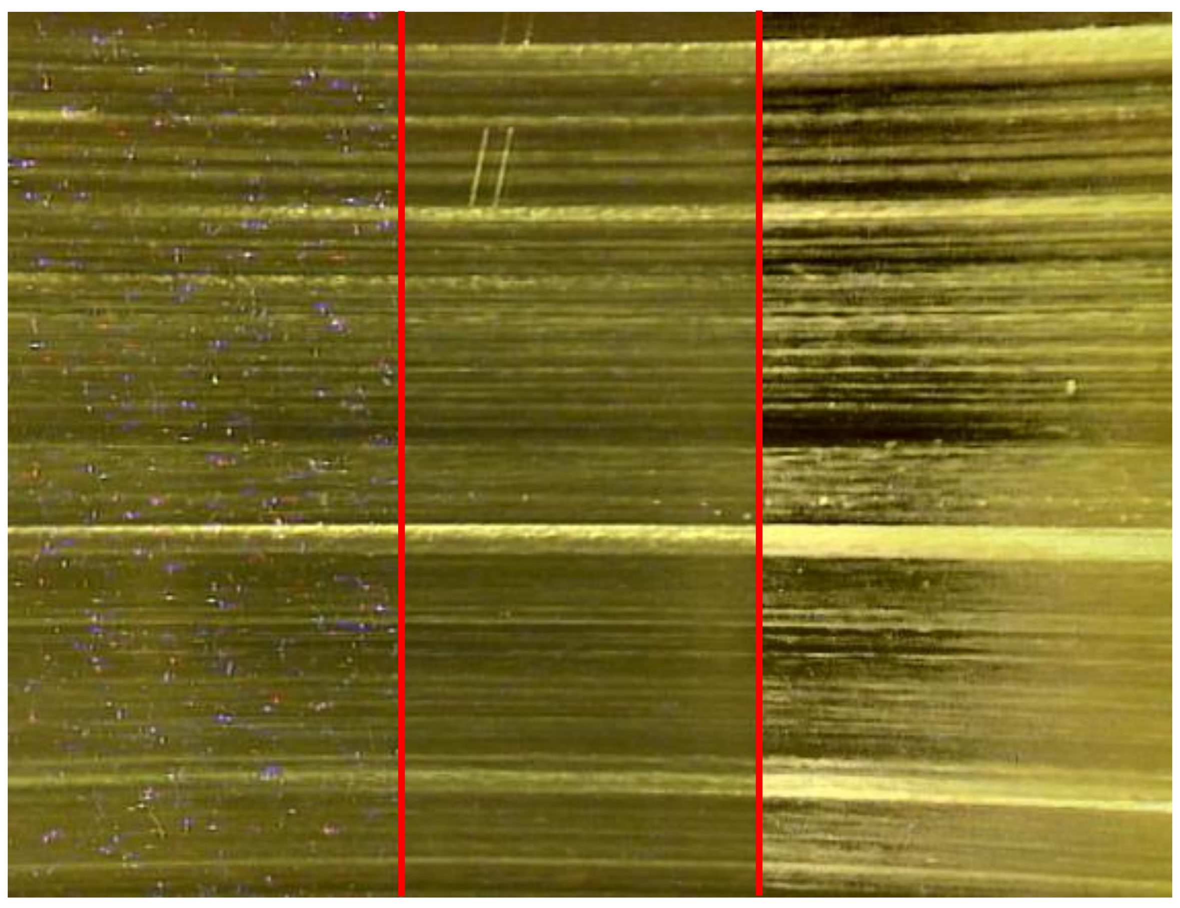
Ahlberg radiation hardened camera used for CTSB inspection.
[https://www.ahlbergcameras.com/products/cameras/ptz620/]



Example frame from CTSB inspection video

Noise Removal and Contrast Enhancement

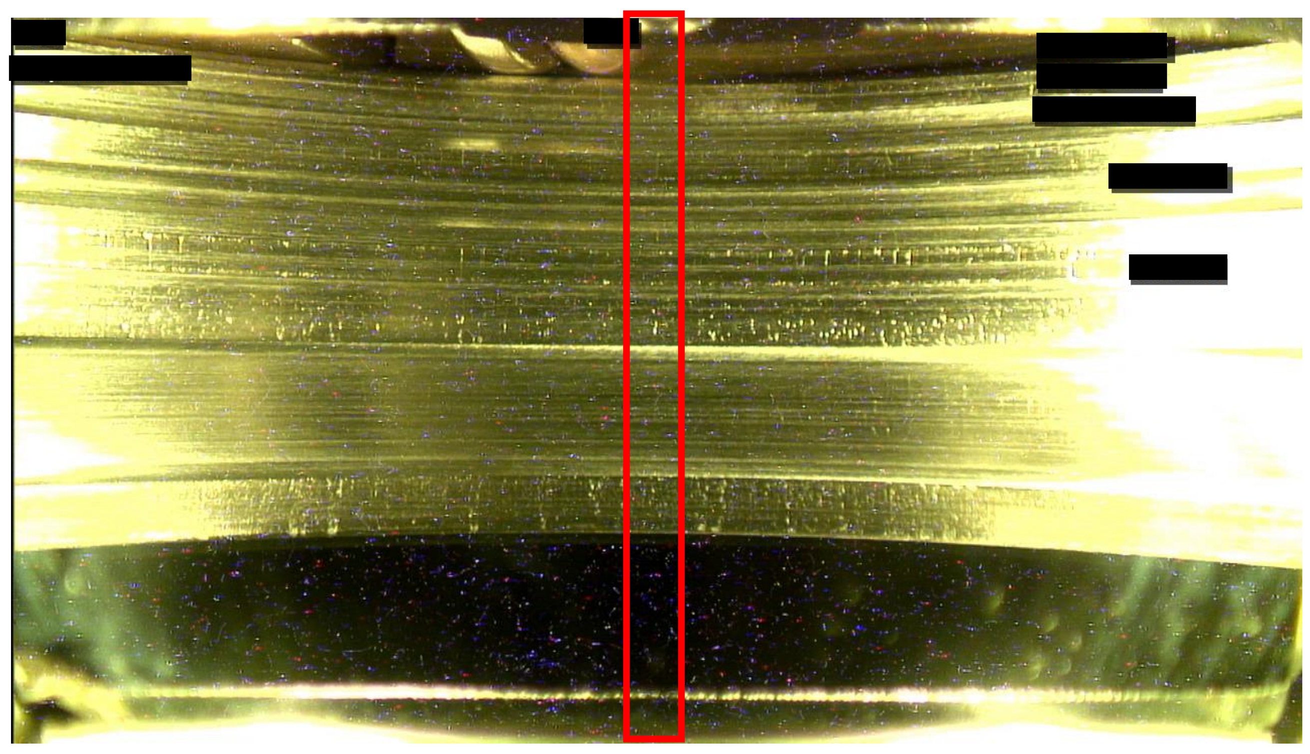
- High radiation causes noisy inspection videos with coloured speckle noise.
- Noise slows down defect detection in the CTSB inspection videos.
- Custom filter based on camera movement removes noise, aiding defect identification.
- Post noise removal, contrast enhancement with Contrast Limited Adaptive Histogram Equalization (CLAHE) improves defect perceptibility.



Section of video frame (Left – Original, Middle – Denoised, and Right – Contrast Enhanced)

Image Stitching

- Analysis of the inspection videos for the entire core is a time-consuming process (480 channels each with east and west face equals 960 videos).
- A stitched image of the CTSB's interior reduces analysis time by providing a single image for each CTSB, enabling quicker defect identification.
- The single stitched image is created by extracting strips of pixels from each frame and combining them, based on estimated camera movement.

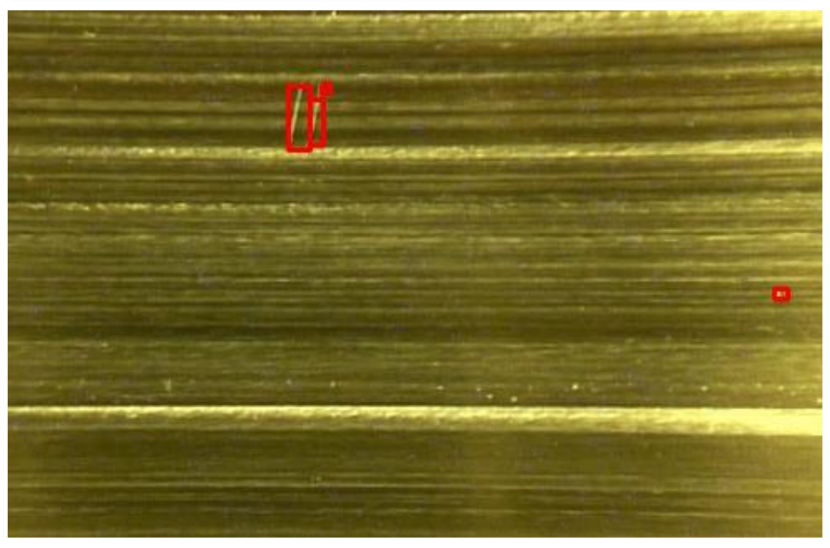


Location of strip in each frame used for image stitching

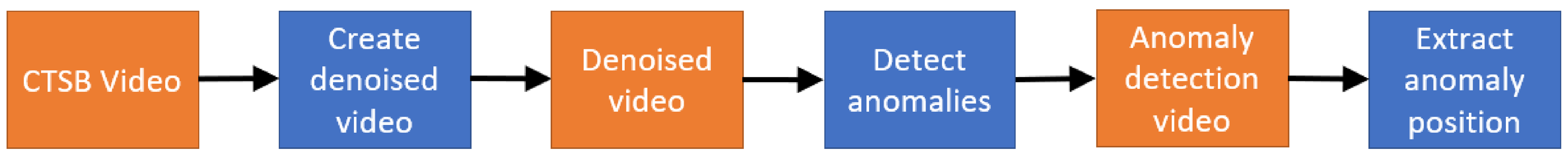
Process for creating stitched image

Anomaly Detection

- Manual inspection of videos is currently used for anomaly detection.
- A stitched image enables anomaly detection in a single image.
- Automation of anomaly detection streamlines the process while involving engineers for final decision-making.
- Background subtraction and frame differencing were employed to automatically detect defects in the CTSB.



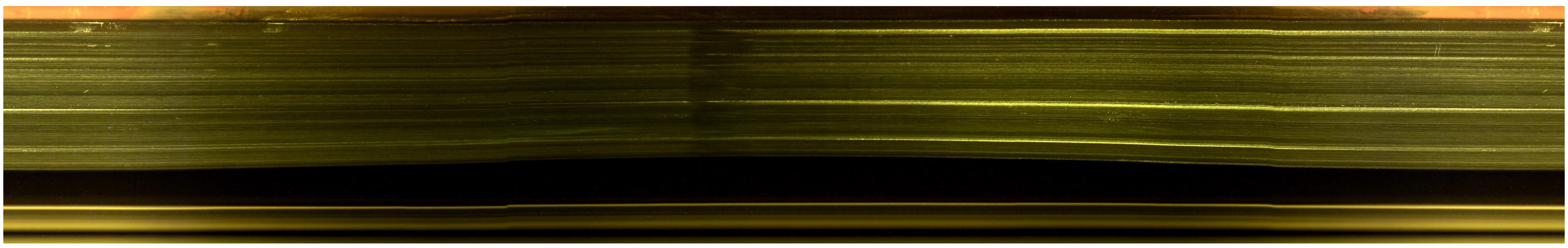
Bounding box highlighting detected defects



Process for extracting anomaly position from denoised video

Conclusions

- Stitched image creation for efficient decision-making in inspections.
- Noise reduction enables easier fault identification in radiation-affected videos.
- Contrast enhancement improves defect visibility for manual identification.
- Anomaly detection provides initial defect scanning for engineer verification.
- Machining mark detection aids defect classification based on severity.



Video converted into a single stitched image, using strip from centre of the frame

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