

Automated Flaw Detection from Eddy Current Data Using Convolutional Neural Networks

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Eddy current testing (ECT) is a widely used non-destructive evaluation method for detecting surface and sub-surface flaws in conductive materials. Recent advancements in artificial intelligence and machine learning, particularly convolutional neural networks (CNNs) have shown great potential in automated flaw detection tasks. We present a novel CNN for the detection of anomalous eddy current inspection signals. To the best of our knowledge, the proposed method is the first such complex solution able to successfully analyze a real-world eddy current dataset and the first artificial intelligence automated analysis successfully qualified at EPRI. Our contributions are not limited only to the architecture of the CNN, but the overall construction of the experiment and the format of the input data. For CNN, we propose a 1D U-Net architecture for defect detection in multi-channel eddy current signals, leveraging a series of downsampling and upsampling layers with skip connections to capture both local and global features. The model was trained using the Focal Loss function to address class imbalance, with optimization performed via the Adam algorithm and a learning rate scheduler for gradual decay. To train the neural network, we utilized tube signals, indication positions, and indication widths as input features. Each neural network employs a specific filter through which the tube signal is processed. During runtime, preprocessing involves passing the input signal through a designated filter and segmenting it into chunks to prepare it for further analysis. We also employed ensemble learning, a methodology that integrates multiple neural networks to enhance predictive accuracy. Each network within the ensemble is trained on distinct datasets, optimizing its performance for specific types of inputs or indications. The outputs of these convolutional neural networks (CNNs) are subsequently aggregated to generate a unified and precise prediction. Neural network approach to automated analysis has half the amount of overcalls per tube compared to automated analysis approach with signal curve comparison INETEC has previously qualified at EPRI.

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