Contribution ID: **218** Type: **Oral Presentation**

Performance of AI Oriented Contrastive Learning vs Convolutional Neural Networks (CNNs) in Quality Assessment of Zinc Coating Steel Coils

Wednesday 8 October 2025 17:10 (20 minutes)

Quality control in zinc-coated steel coils is critical in industries such as automotive and construction, where defects in zinc coating can significantly impact product durability and safety. Traditional manual inspection methods are prone to errors and inconsistencies, especially in high volume production environments.
This paper compares the performance of two artificial intelligence techniques those are convolutional neural networks (CNNs) and contrastive learning, for automated quality assessment of zinc coated steel coils. We evaluate their performance in classifying the quality of zinc coatings, with a focus on defect detection.We implemented both CNNs and contrastive learning models, by using a dataset comprising 4,482 coil profiles with zinc thickness measurements and analyzed their performance. CNNs employed deep architectures with normalization and pooling layers to minimize overfitting, while contrastive learning utilized Siamese networks to learn feature representations from both labeled and unlabeled data.
Experimental results show that CNNs achieved high classification accuracy with an F1-score of 0.93 on the test set and 0.75 on gold-standard data. Contrastive learning, on the other hand, demonstrated variability in performance, with an F1-score of 0.61 for original data and 0.66 after data preprocessing transformations. Statistical analysis indicates that CNNs are robust in scenarios with ample labeled data, whereas contrastive learning excels in feature representation and generalization when labeled data is limited.
These findings have significant implications for real time industrial inspection, suggesting that contrastive learning can be a valuable tool for quality control, especially in situations with limited labeled data. The study also highlights the importance of data preprocessing in enhancing the performance of contrastive

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Session Classification: AI & Machine Learning Applications

Track Classification: Digital tranformation