Handling Domain Shift in Industrial Error Detection: A Comparative Study

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Introduction

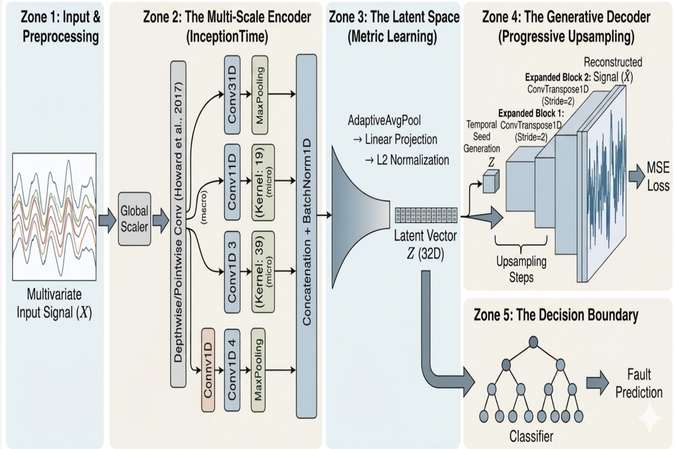
Context: Predictive maintenance for complex industrial machines using multivariate electrical and mechanical time series.

Challenge: Domain shift caused by varying operating conditions can reduce model robustness and degrade error detection accuracy.

Objective: Compare CNN, TCN, and hybrid CNN-TCN architectures for robust industrial error detection under domain shift.

CNN[1]

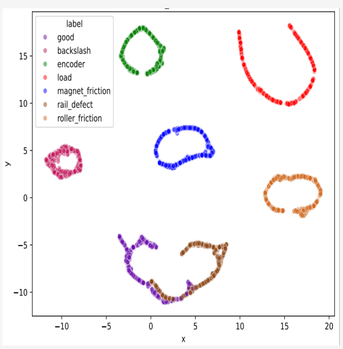
Title: Multi-Scale Inception CNN



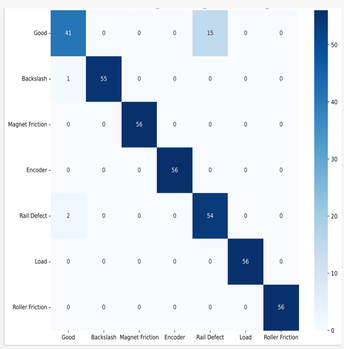
Model Architecture

Key Features: Captures micro-shocks and macro-trends simultaneously using multi-scale parallel branches without temporal smoothing.

Source Results:

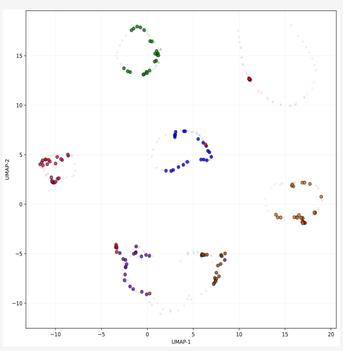


Umap



Matrix

Target Results:



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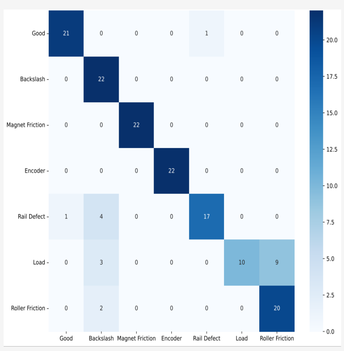
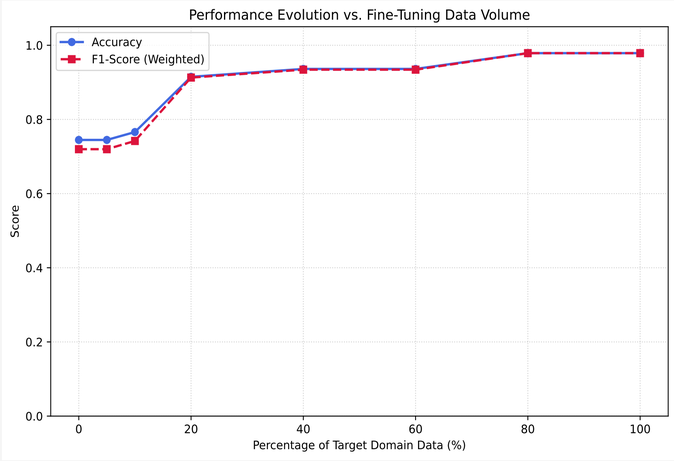


Matrix

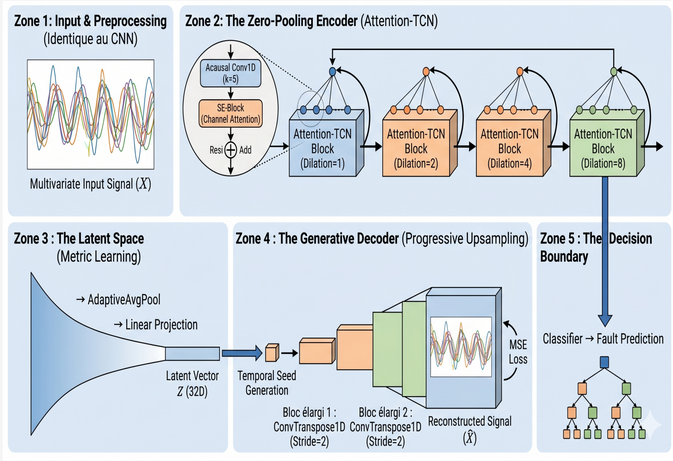
Fine-tuning:



Conclusion: Drop in accuracy from 95% to 89% and achieving 95% acc with fine-tuning on 40% of the data.

TCN[2]

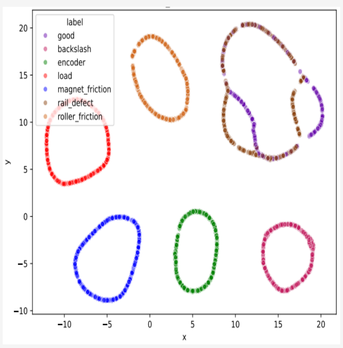
Title: Acausal Attention-TCN



Model Architecture

Key Features: Preserves high-frequency transients and bidirectional context via a zero-pooling, acausal dilated architecture.

Source Results:



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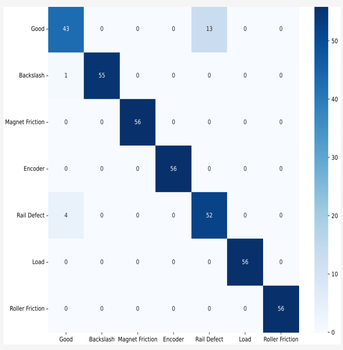

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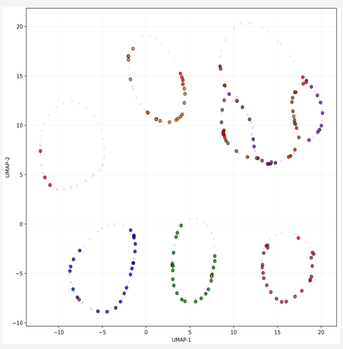
Target Results:



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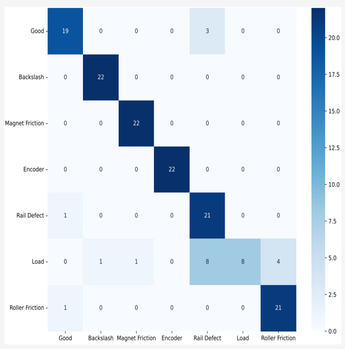
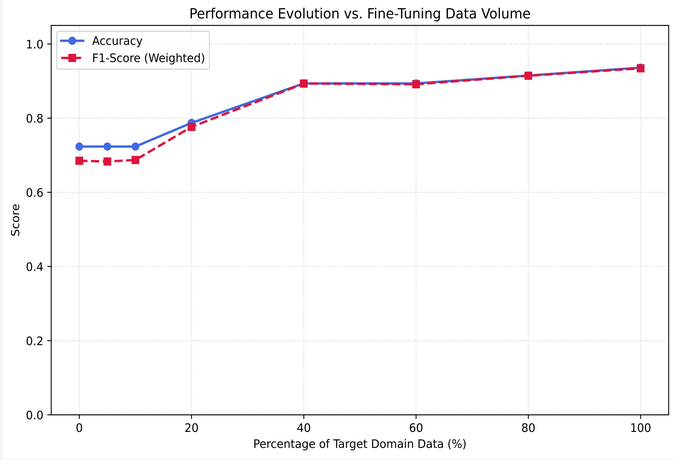


Matrix

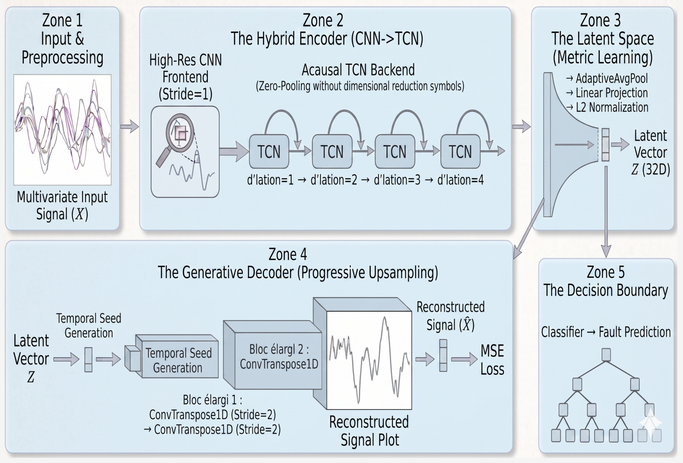
Fine-tuning:



Conclusion: Drop in accuracy from 95% to 87% and achieving 90% acc with fine-tuning on 40% of the data.

CNN-TCN[3]

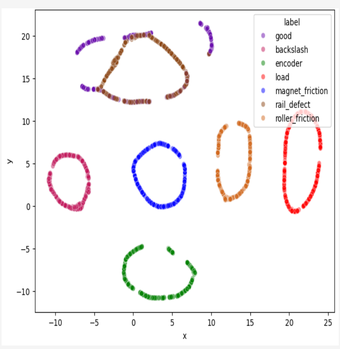
Title: Hybrid CNN-TCN



Model Architecture

Key Features: Fuses power of CNN local feature extraction with deep TCN sequential reasoning across complex multivariate series.

Source Results:



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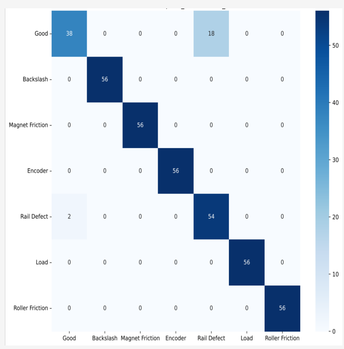
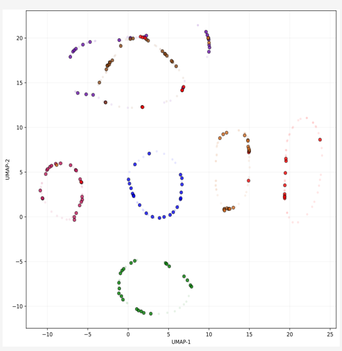


Matrix

Target Results:



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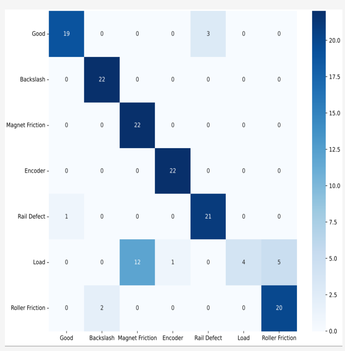

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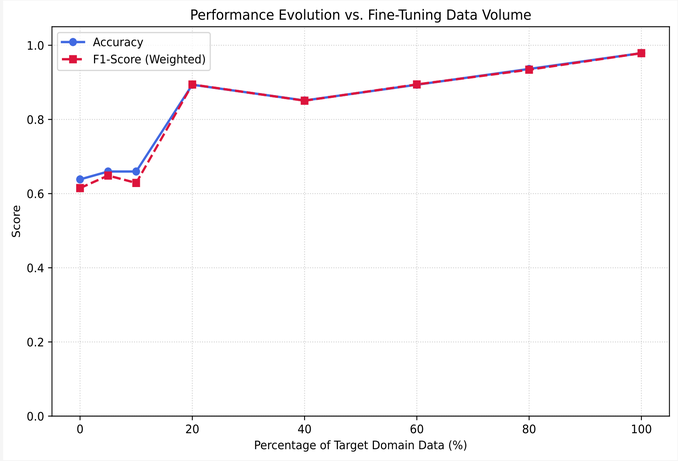
Fine-tuning:



Conclusion: Drop in accuracy from 95% to 85% and achieving 87% acc with fine-tuning on 40% of the data.

General Conclusion

While performance across the three models remains nearly equivalent on the source dataset, the comparative study demonstrates that CNN architectures provide the most stable performance across different complex machines operating domains, whether utilizing noise-robust training or fine-tuning strategies.

[1] Ismail Fawaz, H., et al. (2020). Data Min. Knowl. Discov., 34(6)

[2] Bai, S., et al. (2018). arXiv:1803.01271.

[3] Ordóñez, F. J., & Roggen, D. (2016). Sensors, 16(1), 115.