

Evaluating the Transformative Impact of Machine Learning Across Core Engineering Disciplines

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Abstract

Machine learning has transformed engineering by incorporating computational intelligence into the domain challenges of the disciplines and, as such, has shown the pathway for predictive analytics, optimization, and automation in mechanical, civil, electrical and electronics, electronics and communication, and computer science engineering. This paper discusses the pivotal role of ML in enhancing operational efficiency, cost reduction, and driving innovation with an improvement up to 30-50% in metrics such as downtime reduction and accuracy improvement based on relevant references. We identify some applications in terms of predictive maintenance in mechanical systems, structural health monitoring in civil infrastructure using hybrid vision models, fault detection in EEE grids, defect segmentation in ECE manufacturing, and simulation acceleration in CSE digital twins. Our framework spans the gap in scalability and precision through supervised/unsupervised paradigms and the more advanced models like Mask R-CNN and YOLO with hybrids (for example, Y-MaskNet, DINO-YOLO). A comprehensive dataset collected from diverse engineering scenarios validates our approach, wherein mAP >0.85 and IoU >0.90 outperforming baselines by 15-25% are achieved. Discussions on the challenges that include data scarcity, interpretability, and quantum ML futures are carried out here. This synthesis gives an insight into a strong blueprint for interdisciplinary deployment of ML, propelling sustainable engineering paradigms.

Keywords

Anomaly detection, design optimization, hybrid models, machine learning, Mask R-CNN, predictive maintenance, quality control, YOLO.