Artificial Intelligence for Real-Time Identification of Rail Cars

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Abstract:

The real-time identification of railway carriage numbers is a pivotal innovation in enhancing railway logistics and operations, enabling automated tracking, monitoring, and maintenance. This study proposes an artificial intelligence (AI) system powered by a convolutional neural network (CNN) optimized using the steepest descent method, a widely recognized optimization technique. The framework is designed to address the challenges inherent in dynamic environments, including variations in lighting, motion blur, dirt accumulation, and other environmental interferences.

The proposed methodology integrates advanced image recognition capabilities with adaptive optimization strategies, ensuring robust and reliable performance. The CNN model is fine-tuned to minimize classification errors through iterative parameter adjustments, while preprocessing techniques such as noise reduction and normalization are employed to improve input quality. Adaptive learning rates and step-size adjustments further enhance the training process, reducing oscillations and improving convergence even under experimental errors.

Field testing of the system demonstrated remarkable performance, achieving a 97% accuracy rate in ideal conditions and maintaining 89% accuracy under challenging scenarios such as low lighting and rapid movement. The system's real-time deployment pipeline, which includes high-resolution image capture, preprocessing, and rapid inference, ensures a mean latency of just 0.25 seconds per image.

This AI-powered approach delivers significant operational improvements by overcoming the limitations of traditional manual and semi-automated identification methods. The results highlight the potential of AI in transforming railway logistics, offering a scalable and efficient solution for modern transportation networks. Future research will focus on integrating edge computing and advanced deep learning models to further enhance robustness and speed.

Keywords:

Artificial Intelligence, CNN, Steepest Descent Method, Railcar Recognition.