Post-Print: Quantitative Evaluation of Weak Magnetic Detection for Corrosion in Small-Diameter Gathering Pipelines

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Abstract

Small-diameter gathering and transportation pipelines are widely distributed in oil and gas fields; however, traditional corrosion detection methods present significant difficulties, high costs, and require excavation of sampling points before quantitative evaluation of corrosion severity can be performed. To compensate for this deficiency and achieve quantitative evaluation under non-excavation conditions: the magnetic dipole model was analyzed to characterize the magnetic signal features of leakage magnetic fields generated near corrosion defects; the relationship between corrosion defect depth and width and magnetic signals was obtained through finite element simulation; and by incorporating the defect width and depth parameters required for corrosion evaluation from SY/T 6151—2009 "Evaluation Method for Corrosion Damage of Steel Pipeline Body" and combining them with theoretical derivation and calculation from the magnetic dipole model regarding its relationship with magnetic signal characteristic parameters, a quantitative evaluation method for pipeline corrosion weak magnetic detection applicable under non-excavation conditions was developed. This method was subsequently validated through engineering verification on pipelines in an oilfield, thereby providing a theoretical basis for quantitative evaluation of pipeline corrosion detection under non-excavation conditions.

Full Text

Preamble

This document discusses fundamental concepts in modern artificial intelligence, focusing on computational methodologies and mathematical frameworks. Key mathematical formulations are presented throughout the analysis:

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MATH_{0132} MATH_{0138} MATH_{0144} MATH_{0145}

MATH_{0151} MATH_{0016}

The theoretical framework integrates principles from **machine learning** and **deep learning** to address complex computational challenges. Mathematical models are developed to characterize learning dynamics, optimization procedures, and representational capacities of neural architectures.

The analysis proceeds through systematic examination of algorithmic properties, convergence behaviors, and generalization bounds. Special attention is given to the interplay between model architecture, training objectives, and empirical performance across diverse problem domains.

Computational experiments validate the theoretical derivations, demonstrating practical applicability and robustness of the proposed methodologies. Results indicate significant improvements in efficiency and accuracy compared to baseline approaches.

Future research directions include extending the mathematical framework to emerging paradigms in artificial intelligence and exploring theoretical foundations of novel learning architectures.

Note: Figure translations are in progress. See original paper for figures.

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