Leveraging AI-Powered Large Language Models to Improve Operational Safety and Efficiency in the Metal and Steel Industry

Authors

Yale Zhang, Hatch, Mississauga, Ont., Canada
yale.zhang@hatch.com

Zahid Mohammed, Hatch, Mississauga, Ont., Canada

Zaid Marfatia, Hatch, Mississauga, Ont., Canada

Anish Shah, Hatch, Mississauga, Ont., Canada

The metal and steel industry faces persistent challenges in enhancing operational safety, efficiency and complex decision-making processes. This article explores the transformative potential of generative artificial intelligence (AI), with a focus on multimodal large language models (LLMs), to address these challenges. Unlike traditional predictive and prescriptive AI, generative AI enables new possibilities by integrating and synthesizing unstructured data (text, images, video) with domain-specific knowledge. Two case studies highlight practical applications: (1) A Vision AI system leveraging integrated LLMs to monitor electric arc furnace operations, identifying key operational events and potential safety hazards; (2) A generative AI approach for project scheduling optimization, achieving near-optimal performance for small- to medium-sized projects. The study emphasizes generative AI's ability to enhance decision automation, reduce reliance on manual oversight, and drive innovation in safety and efficiency. Challenges regarding accuracy, scalability and consistency are discussed, alongside recommendations for future advancements in agent-based refinement techniques.

Introduction

The metal and steel industry is a cornerstone of the global economy, characterized by complex metallurgical processes and high-stakes operational challenges. Achieving both safety and operational efficiency in this sector requires continuous innovation. In this regard, AI has emerged as a pivotal technology, addressing a range of issues such as reducing process variability, predicting maintenance needs and monitoring workplace safety in real time. Over the past year, the field of artificial intelligence (AI) has seen remarkable advancements, particularly in large language models (LLMs). Two key developments stand out. First, enhanced multimodal capabilities allow modern LLMs to process and analyze unstructured data across various formats, including text, images, audio and video. This makes them highly versatile for real-world applications. Second, improved reasoning abilities enable these models to perform complex problem-solving and real-time decision-making with greater accuracy. While AI innovation continues rapidly, parallel global conversations have emerged around AI safety, trust and regulation, fueled in part by the recent leadership crisis at OpenAI.[1] This incident spotlighted pressing ethical and governance concerns for policymakers, businesses and the public. Simultaneously, the DeepSeek-R1 model has reshaped the commercial landscape by demonstrating that high-quality LLMs can be developed at a fraction of the cost of traditional state-of-the-art systems.[2] This breakthrough significantly lowers barriers to AI adoption in various industries, including the metal and steel sector.

A recent McKinsey survey underscores the rapidly growing interest in AI, showing a global adoption rate increase from 55% to 72% over the past year, with much of this growth driven by increasing use of generative AI.[3] In the metal and steel industry, a similar trend is observed and marked by two significant shifts:

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