Research Literature Survey

For personal research

By Xingsheng Li

Master's Student, Department of Computer Technology

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目录

Abstract

This document serves as a comprehensive, living survey of three major fields: Large Language Models, Computer Vision, and Quantitative Finance. It tracks the evolution from classical theories to state-of-the-art (SOTA) methodologies.

Part I

2025-2026 winter break research

Chapter 1

智慧矿山数字孪生技术与平行智能研究综述

随着新一代信息技术与煤炭工业的深度融合，煤矿智能化已成为实现煤炭工业高质量发展的核心技术支撑。当前，我国煤矿建设正处于从"单机自动化"向"智能感知、智能决策"跨越的关键时期。本文基于相关文献，从智慧矿山建设的必要性与顶层设计、数字孪生关键技术的发展现状、以及向平行智能演进的未来趋势三个方面进行综述。

1.1   智能化建设的必要性与顶层设计

煤炭开采面临着地质条件复杂、作业环境恶劣、设备群耦合关系强等严峻挑战。传统的"人-机"交互监控模式已难以满足安全高效生产的需求，亟需向"传感—机器认知—机器决策"的智能化模式转变 [1]。针对这一行业痛点，王国法等 [2] 明确提出了煤矿智能化的科学内涵，指出智慧煤矿的建设目标是实现煤炭资源的机器人化替代和全流程的智能管控。在具体的实施路径上，王国法等 [3] 进一步分析指出，为了解决多源异构数据统一表达及复杂围岩环境下的设备协同控制问题，必须构建包括多系统综合管理（MOS）、井下机器人群协同智慧在内的八大智能系统平台。这些顶层设计为后续的技术研发确立了"少人化、无人化"的根本导向。

1.2   数字孪生驱动的智能化技术发展现状

在明确了顶层设计后，如何实现物理矿山与数字世界的实时交互成为研究热点，数字孪生（Digital Twin, DT）技术因此被引入矿山领域。张帆等 [4] 系统梳理了智慧矿山数字孪生技术架构，提出了基于"数字孪生 +5G"的矿山数字孪生模型（MDTM），旨在通过虚实映射解决矿山开采过程中的非结构化环境感知难题。

　　在综采工作面这一核心场景中，葛世荣等 [5] 创新性地提出了数字孪生智采工作面（DTSMW）架构，将复杂的采煤过程归纳为环境、控制和能量三条信息流，并基于此构建了涵盖物理工作面、虚拟工作面及数据信息交互的完整技术体系。为了进一步提升控制的实时性与准确性，尤秀松等 [6] 聚焦于采煤机、液压支架和刮板输送机的协同作业，建立了"三机"数字孪生驱动控制架构，利用知识模型解决数据拥堵问题，实现了复杂工况下的设备自适应控制。此外，针对被动交互机制的局限性，郭一楠等 [7] 引入了知识驱动的主动管控模式，通过挖掘"环-机-物"孪生体间的隐含知识链，增强了虚拟空间对物理空间的管控鲁棒性。

　　除综采工作面外，掘进系统的智能化也在同步推进。杨健健等 [8] 针对掘进巷道环境恶劣、群体设备难以协同的问题，提出了基于 ACP（人工社会、计算实验、平行执行）理论的"平行掘进"思想，利用自适应动态规划多智能体方法，为掘-支-锚系统的智能控制提供了新的理论框架。

　　值得注意的是，上述理论已开始在实际工程中落地验证。李浩荡等 [9] 于 2026 年发布的最新研究显示，基于数字孪生与规划放煤协同的智能开采系统已在新疆乌东煤矿成功应用。该系统通过 RBF 神经网络动态博弈算法与多源数据融合，使生产系统自动化率达到 95%，规划放煤准确率达到 93%，有力证明了数字孪生技术在复杂地质条件下的实战价值。

1.3　　从数字孪生到平行智能的未来展望

　　尽管数字孪生技术在矿山感知与控制方面取得了显著进展，但现有的应用多侧重于对物理系统的精准映射与实时监控，缺乏对未来场景的预测与引导能力。针对这一问题，陈龙等 [10] 提出了从"数字孪生"向"平行矿山"演进的学术观点。未来的智慧矿山将不再局限于对物理世界的被动反映，而是通过构建人工矿山系统进行计算实验，产生海量虚拟数据以训练智能模型，最终通过平行执行实现对物理矿山的引导与优化。

　　与此同时，丁恩杰等 [11] 指出，未来的核心竞争力将在于知识服务体系的构建。通过将矿山运行机理、经验知识与大数据分析深度融合，构建可信的数字孪生模型，并结合边缘计算与云边协同机制，将进一步提升智能装备的即时响应能力。综上所述，未来的研究将更加注重机理模型与数据驱动的深度融合，向着"虚实融合、以虚控实、平行智能"的终极目标迈进。·

References for 2025-2026 winter break research

[1] 丁恩杰 et al., "基于物联网的矿山机械设备状态智能感知与诊断," 煤炭学报, vol. 45, no. 6, Apr. 10, 2023, ISSN: 0253-9993. DOI: 10.13225/j.cnki.jccs.ZN20.0340. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtxb.com.cn/cn/article/doi/10.13225/j.cnki.jccs.ZN20.0340.

[2] 王国法, 刘峰, 庞义辉, 任怀伟, and 马英, "煤矿智能化———煤炭工业高质量发展的核心技术支撑," 煤炭学报, no. 2, Feb. 28, 2019, ISSN: 0253-9993. DOI: 10.13225/j.cnki.jccs.2018.2041. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtxb.com.cn/cn/article/doi/10.13225/j.cnki.jccs.2018.2041.

[3] 王国法, 赵国瑞, and 任怀伟, "智慧煤矿与智能化开采关键核心技术分析," 煤炭学报, no. 1, Jan. 31, 2019, ISSN: 0253-9993. DOI: 10.13225/j.cnki.jccs.2018.5034. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtxb.com.cn/cn/article/doi/10.13225/j.cnki.jccs.2018.5034.

[4] 张帆, 葛世荣, and 李闯, "智慧矿山数字孪生技术研究综述," 煤炭科学技术, vol. 48, no. 7, Jul. 25, 2020, ISSN: 0253-2336. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtkxjs.com.cn/cn/article/id/3a06c655-8805-44cc-a5a9-53f238a7fd37.

[5] 葛世荣, 张帆, 王世博, and 王忠宾, "数字孪生智采工作面技术架构研究," 煤炭学报, vol. 45, no. 6, Apr. 10, 2023, ISSN: 0253-9993. DOI: 10.13225/j.cnki.jccs.ZN20.0327. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtxb.com.cn/cn/article/doi/10.13225/j.cnki.jccs.ZN20.0327.

[6] 尤秀松, 葛世荣, 郭一楠, and 苗丙, "智采工作面三机数字孪生驱动控制架构," 煤炭学报, vol. 49, no. 7, pp. 3265–3275, Jul. 25, 2024, ISSN: 0253-9993. DOI: 10.13225/j.cnki.jccs.2023.0684. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtxb.com.cn/cn/article/doi/10.13225/j.cnki.jccs.2023.0684.

[7] 郭一楠, 杨帆, 葛世荣, 黄遥, and 尤秀松, "知识驱动的智采数字孪生主动管控模式," 煤炭学报, vol. 48, no. S1, pp. 334–344, Aug. 24, 2023, ISSN: 0253-9993. DOI: 10.13225/j.cnki.jccs.2022.0223. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtxb.com.cn/cn/article/doi/10.13225/j.cnki.jccs.2022.0223.

[8] 杨健健 et al., "平行掘进: 基于 ACP 理论的掘-支-锚智能控制理论与关键技术," 煤炭学报, vol. 46, no. 7, pp. 2100–2111, Jul. 31, 2021, ISSN: 0253-9993. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtxb.com.cn/cn/article/id/6a44cbf3-09d6-4b27-8f28-58764e149b6e.

[9] 李浩荡, 董启凡, and 李孝胜, "基于数字孪生与规划放煤协同的煤矿智能开采技术," 煤炭科学技术, vol. 54, no. 1, pp. 411–423, Jan. 25, 2026, ISSN: 0253-2336. DOI: 10.12438/cst.2025-0570. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtkxjs.com.cn/cn/article/doi/10.12438/cst.2025-0570.

[10] 陈龙 et al., "平行矿山: 从数字孪生到矿山智能," 自动化学报, vol. 47, no. 7, pp. 1633–1645, Jul. 27, 2021, ISSN: 0254-4156. DOI: 10.16383/j.aas.2021.y000001. Accessed: Feb. 1, 2026. [Online]. Available: https://www.aas.net.cn/cn/article/doi/10.16383/j.aas.2021.y000001.

[11] 丁恩杰 et al., "矿山信息化发展及以数字孪生为核心的智慧矿山关键技术," 煤炭学报, vol. 47, no. 1, pp. 564–578, Apr. 10, 2023, ISSN: 0253-9993. Accessed: Feb. 1, 2026. [Online]. Available: https://www.mtxb.com.cn/cn/article/id/84a0eab7-ffac-4fa3-bcef-509cb4a743fa.

Part II

Uncategorized

Chapter 1

Visual Recognition Evolution

1.1 Convolutional Neural Networks

For a long time, ResNet [1] served as the backbone for most vision tasks due to its ability to solve the vanishing gradient problem in deep networks.

1.2 Vision Transformers (ViT)

Inspired by NLP success, the Vision Transformer [2] splits images into patches, treating them as sequences, challenging the dominance of CNNs.

Chapter 2

Foundations of LLMs

2.1   The Transformer Architecture

The field of Natural Language Processing was revolutionized by the introduction of the Transformer architecture [3]. This mechanism allows for parallelization tailored for modern hardware.

2.2   Scaling Laws and GPT

Recent developments have shown that scaling up model size and data volume leads to emergent abilities, as demonstrated in the GPT-4 technical report [4].

Chapter 3

Algorithmic Trading Strategies

3.1 Market Efficiency

The Efficient Market Hypothesis (EMH) [5] suggests that asset prices reflect all available information.

3.2 Machine Learning in Finance

Modern quantitative finance is moving towards ML-based approaches. As noted by Lopez de Prado [6], applying standard ML cross-validation in finance leads to overfitting due to time-series correlation.

Chapter 4

Open Source Projects

In this chapter, we track the SOTA open-source implementations for LLMs.

Llama 3

URL: https://github.com/meta-llama/llama3
Stack: Python, PyTorch
Description: The official Meta Llama 3 repository. It contains the model weights and inference code. State-of-the-art open weights model.

LangChain

URL: https://github.com/langchain-ai/langchain
Stack: Python, TypeScript
Description: Building applications with LLMs through composability. Key for RAG (Retrieval Augmented Generation) workflows.

vLLM

URL: https://github.com/vllm-project/vllm
Stack: Python, CUDA
Description: A high-throughput and memory-efficient inference and serving engine for LLMs, featuring PagedAttention.

Chapter 5

Quant Libraries & Tools

5.1   Backtesting Frameworks

Backtrader

URL: https://github.com/mementum/backtrader

Stack: Python

Description: A feature-rich Python framework for backtesting and trading. Supports multiple data feeds and brokers.

Qlib

URL: https://github.com/microsoft/qlib

Stack: Python

Description: An AI-oriented quantitative investment platform by Microsoft. It aims to realize the potential of AI technologies in quantitative investment.

5.2   Data Sources

AkShare

URL: https://github.com/akfamily/akshare

Stack: Python

Description: A purely open-source financial data interface library for Python, built for human beings! Covers stocks, futures, options, and bonds.

References for uncategorized

[1] K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition," *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2016.

[2] A. Dosovitskiy et al., "An image is worth 16x16 words: Transformers for image recognition at scale," *ICLR*, 2021.

[3] A. Vaswani et al., "Attention is all you need," *Advances in neural information processing systems*, vol. 30, 2017.

[4] OpenAI, "Gpt-4 technical report," *arXiv preprint arXiv:2303.08774*, 2023.

[5] E. F. Fama, "Efficient capital markets: A review of theory and empirical work," *The Journal of Finance*, 1970.

[6] M. L. de Prado, *Advances in Financial Machine Learning*. Wiley, 2018.