

Franky: An Intelligent Agent for Stock Portfolio Management Using Large Language Models and Deep Reinforcement Learning

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This study proposes an innovative trading agent "*Franky*" designed to revolutionize stock portfolio management by integrating Large Language Models (LLMs) with Deep Reinforcement Learning (DRL). Unlike traditional systems that rely predominantly on historical price data, our agent adeptly combines quantitative market analysis with qualitative insights derived from financial news and corporate reports. Leveraging a memory architecture inspired by human cognition, the system dynamically processes and prioritizes data streams, generating actionable trading decisions in real-time. Initial experiments, focused specifically on technology-sector stocks, demonstrate the agent's capability in predicting stock movements and managing portfolio risk, underscoring the potential of artificial intelligence in advancing autonomous financial trading. The agent demonstrated a return of 57% during backtesting, indicating its effectiveness in the tested conditions. The study concludes by proposing pathways for future research and further development, highlighting opportunities in real-time scalability and broader adaptability to diverse market environments.

Methodology

The combined architecture, inspired by FINMEM [1] and FinRL [2] frameworks, comprises three core modules, with LLM acting as a portfolio manager:

- ETL [3] Pipeline*
This module focuses on qualitative data ingestion. Market sentiment is derived by extracting financial news, reports, and publications, transforming this information into a summarised format, and loading it into a centralized knowledge repository. This ensures a rich contextual foundation for trading decisions.
- DRL Trading Agent*
Leveraging the Advantage Actor-Critic (A2C) algorithm, this agent learns and adapts to varying market conditions. It operates on historical market data and technical indicators to generate quantitative portfolio balance recommendations, optimizing for returns while managing risk.
- LLM Portfolio Manager*
At the system's core lies the LLM Portfolio Manager, which merges insights from both modules. It synthesizes real-time sentiment analysis with DRL-generated trading strategies to make informed, strategic portfolio adjustments.

The proposed architecture is presented below on figure 1.

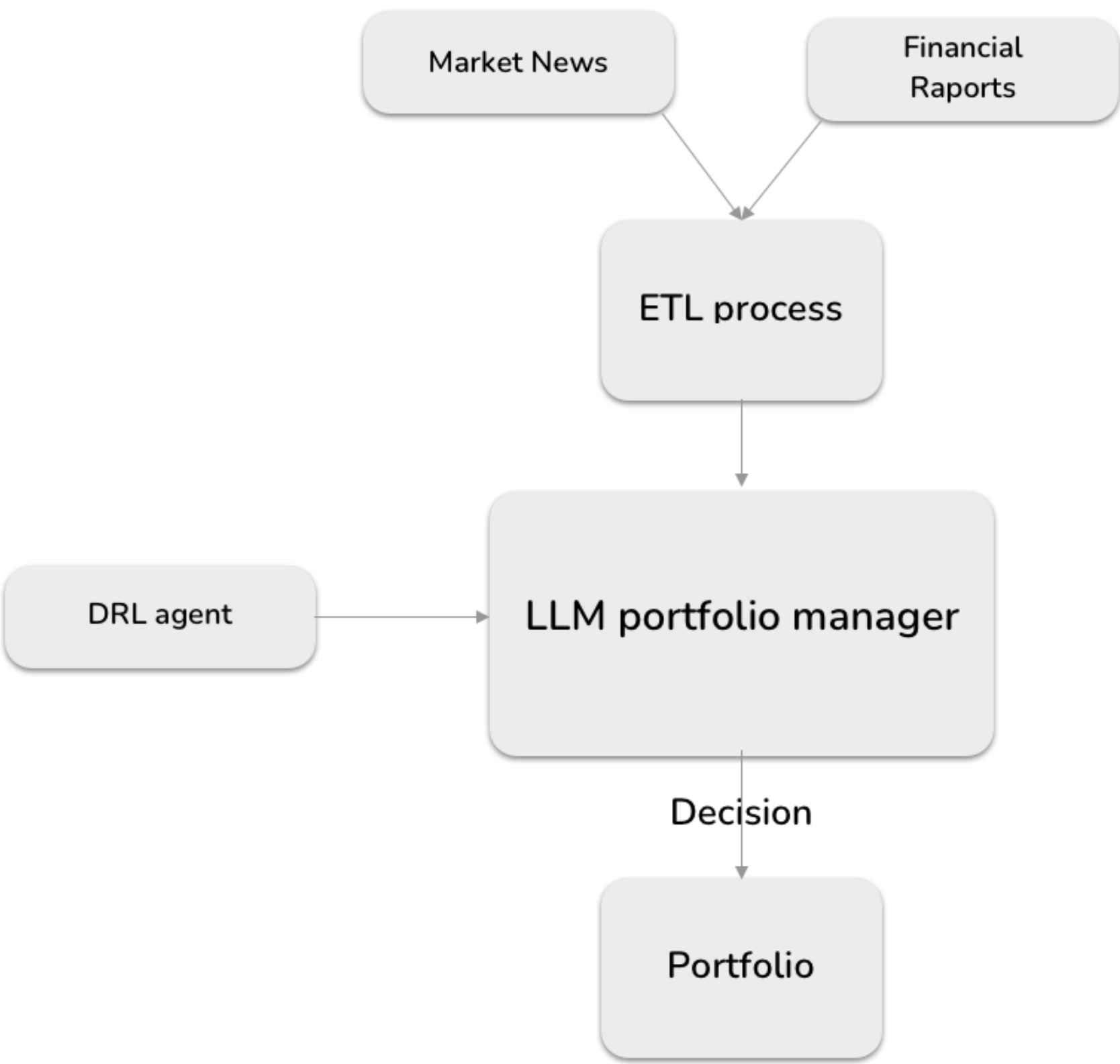


Figure 1: The overall architecture of Franky.

Results

Backtesting conducted over the dynamic market conditions of 2024 demonstrated the framework's effectiveness. Comparative analysis identified Advantage Actor-Critic (A2C) as the optimal Deep Reinforcement Learning algorithm, outperforming four other candidates by approximately 23% in year-to-year cumulative portfolio value. Among the tested Large Language Models (Gemini-2.0-flash, GPT-4o-mini, and the locally runnable DeepSeek-R1-14B), Gemini-flash achieved the highest standalone performance (although marginally), as presented on figure 2.

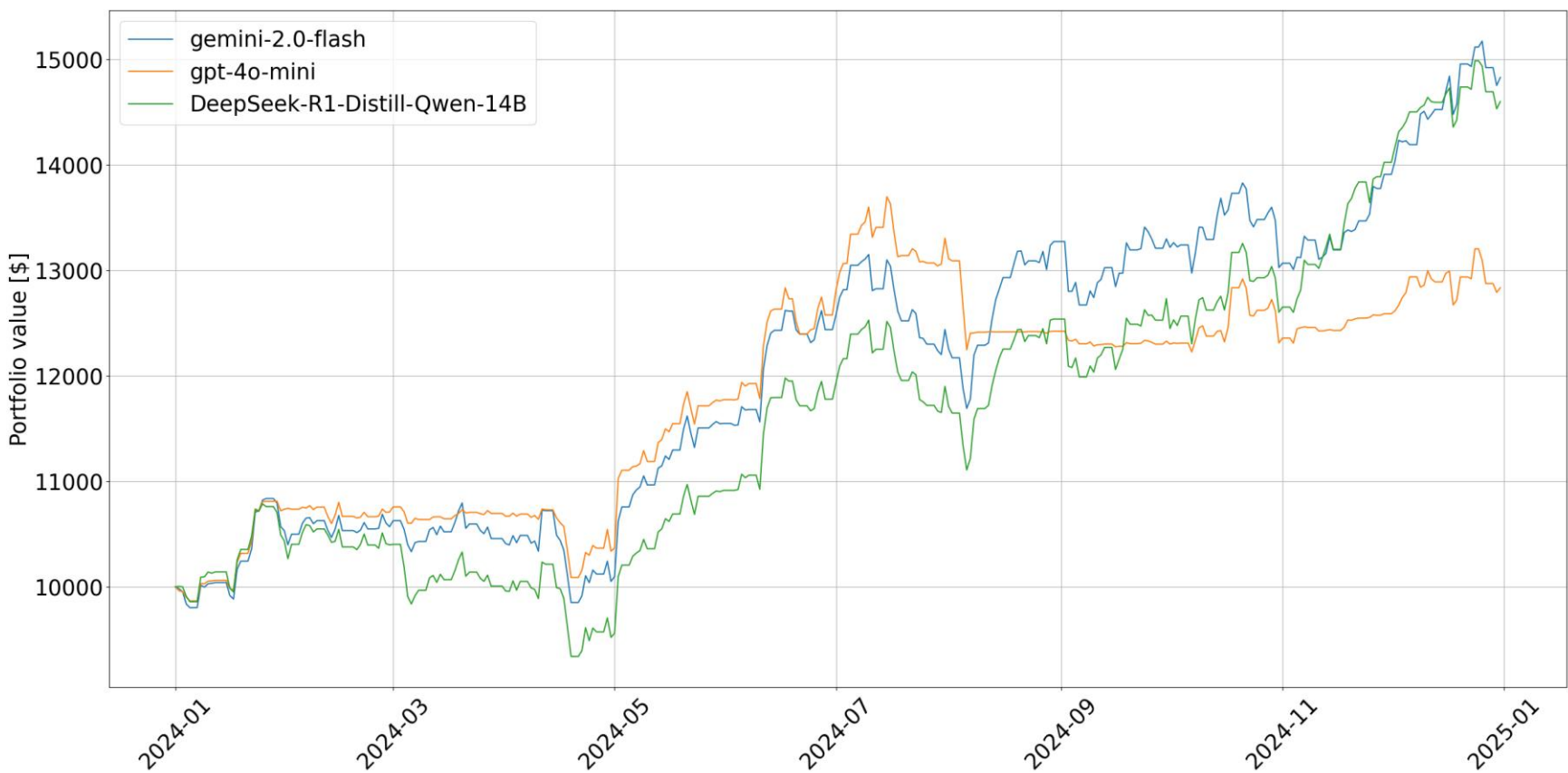


Figure 2: Impact of LLM model on the agents performance, where each colour represents specific model: blue for gemini-2.0-flash-001, orange for gpt-4o-mini-2024-07-18 and green for DeepSeek-R1-Distill-Qwen-14B.

Crucially, integrating the DRL agent's outputs as context for the LLM significantly enhanced decision-making, boosting overall returns by approximately 6% (6.7% improvement with GPT integration, 5.7% with Gemini), as shown on figure 3. The most profitable configuration yielded a total return of nearly 57% (\$5,683.36 on a \$10,000 initial investment) during the test period, validating the synergistic potential of combining sentiment analysis, DRL, and LLM reasoning for automated trading.

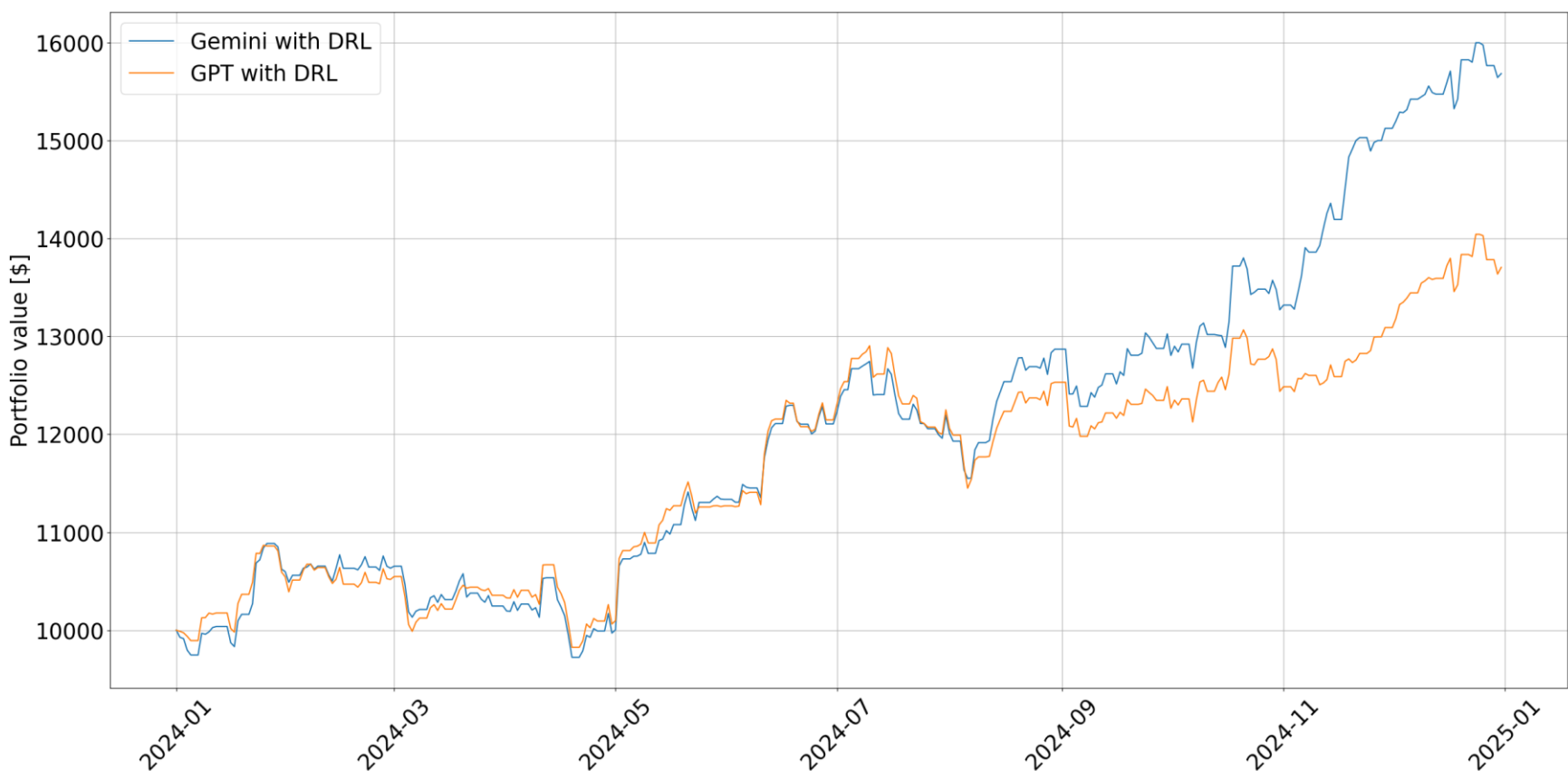


Figure 3: Comparison of the agents performance with the deep reinforcement learning sub-module, where each colour corresponds to a specific LLM used: blue for gemini-2.0-flash-001 and orange for gpt-4o-mini-2024-07-18.

Conclusion

Our research successfully demonstrates an innovative approach integrating Deep Reinforcement Learning with Large Language Models for autonomous stock portfolio management. This hybrid architecture effectively combines quantitative and qualitative analyses, yielding promising results. Future enhancements will focus on leveraging domain-specific LLMs, like BloombergGPT [4], to potentially capture more nuanced financial insights than the general-purpose models used in this proof-of-concept.

References

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