Machine Learning-Driven Decision Making based on Financial Time Series

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The field of financial time series analysis has witnessed remarkable advancements in recent years, driven by the integration of data science and machine learning techniques. This PhD thesis investigates the application of machine learning techniques in financial time series analysis to enhance decision-making processes and improve financial practices. The research objectives of this thesis encompass various research topics, including time series classification, forecasting, clustering, embedding, and summarization, all tailored to the financial domain. The research addresses several fundamental research questions, guiding the investigation into key aspects of financial time series analysis. These questions cover topics such as the determination of optimal time frequencies for trading, the usefulness of stock chart patterns, the unique behaviors of cryptocurrencies, the selection of locally optimal stock portfolios, the extraction of domain-related knowledge from financial time series, the feasibility of plug-and-play machine learning-based trading systems, and the trustworthiness of machine-generated signals.

The thesis encompasses multiple studies, each contributing to the overall understanding of financial time series analysis and addressing specific aspects of the research questions.

The findings from the studies provide valuable insights into financial time series analysis. The optimal time frequency for stock trading is not necessarily the most fine-grained or coarse-grained, emphasizing the importance of selecting appropriate time frequencies based on the data and trading objectives. Stock chart patterns prove to be valuable in filtering machine learning-generated signals, proving their complementary nature. Cryptocurrencies exhibit distinct behaviors (e.g., the momentum effect) that can be leveraged by Machine Learning-based systems to enhance trading strategies. Data-driven taxonomies outperform domain-specific taxonomies in terms of portfolio diversification, and the integration of an optimization step over a heuristic based portfolio generator proves to be able to enhance the selected portfolios profitability. Extracting meaningful insights from financial time series is achievable through time series embedding, enabling effective comparison of stocks

behaviors even in the form of human readable summaries. And, finally, eXplainable AI techniques can guide feature selection and increase trust in data-driven systems.

These findings collectively demonstrate the potential of machine learning techniques in uncovering hidden patterns, making accurate predictions, and generating informative signals for financial decision-making. The research highlights the value of machine learning in enhancing financial practices by leveraging its strengths in identifying complex temporal dependencies and capturing underlying dynamics within financial markets.

Importantly, the thesis emphasizes the need for collaboration between machine learning algorithms and domain experts. While machine learning techniques can offer powerful tools for analyzing financial time series, the involvement of domain experts is crucial for interpreting the generated signals, providing contextual knowledge, and making informed decisions based on the recommendations. Machine learning-based trading systems should not be considered as standalone, *plug-and-play* solutions, but rather as complementary tools that require the expertise and judgment of seasoned investors.

The research presented in this thesis contributes to a deeper understanding of the complexities of financial markets and provides insights for practitioners, researchers, and investors seeking to leverage machine learning for financial decision-making.