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Theme

Multi-Horizon Temporal Decay in Deep Learning: Novel Theoretical Frameworks for Sentiment-Enhanced Financial Forecasting

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Abstract

Financial markets represent complex adaptive systems where sentiment-driven information from textual sources significantly influences asset price movements across multiple temporal horizons. While sentiment analysis has demonstrated substantial predictive power in financial forecasting applications, contemporary approaches systematically overlook the well-documented exponential decay patterns of sentiment effects, as originally established by Tetlock (2007). This comprehensive state-of-the-art review addresses this critical theoretical and methodological gap through systematic analysis of horizon-adaptive temporal decay frameworks for sentiment-enhanced financial forecasting.

Our primary contribution lies in synthesizing empirical evidence from 85+ peer-reviewed studies spanning 2007-2024 to establish theoretical foundations for integrating behavioral finance principles with cutting-edge deep learning architectures. We demonstrate how ignoring temporal decay patterns leads to suboptimal forecasting performance and propose mathematically rigorous solutions that bridge this gap between theory and practice. The theoretical framework introduces horizon-specific decay parameters following the relationship $\lambda_h = \lambda_0 \cdot h^{-\alpha}$, enabling differentiated decay rates for short-term (5-day), medium-term (30-day), and long-term (90-day) forecasting horizons. Integration with quality-weighted sentiment aggregation from multiple sources provides comprehensive market sentiment assessment while maintaining the interpretability required for institutional deployment and regulatory compliance. Comparative analysis of existing approaches reveals that exponential decay weighting improves forecasting accuracy by 15% over uniform aggregation methods, while domain-adapted FinBERT provides 8-12% performance gains over general sentiment models. Horizon-adaptive parameters consistently outperform fixed decay assumptions across all temporal scales, and enhanced Temporal Fusion Transformer (TFT) architectures maintain interpretability while achieving superior multi-horizon performance.

This review provides essential theoretical foundations and methodological guidance for developing next-generation sentiment-enhanced financial forecasting systems that satisfy both performance requirements and regulatory compliance standards, including emerging explainable AI mandates under frameworks such as the EU AI Act.

Keywords— temporal decay, sentiment analysis, FinBERT, Temporal Fusion Transformer, multi-horizon forecasting, financial prediction, explainable AI, behavioral finance, yfinance dataset, nasdaq external data