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Pendekatan Peramalan Multivariat pada Indeks Saham Berbasis Long Short-Term Memory (LSTM), Multivariate Variational Mode Decomposition (MVMD), dan Particle Swarm Optimization (PSO)
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INTISARI

Pendekatan Peramalan Multivariat pada Indeks Saham Berbasis Long Short-Term Memory (LSTM), Multivariate Variational Mode Decomposition (MVMD), dan Particle Swarm Optimization (PSO)

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Indeks bursa saham memiliki karakteristik kompleks, nonlinear, dan nonstasioner sehingga pengembangan metode peramalan yang akurat menjadi tantangan utama. LSTM telah digunakan dalam berbagai kasus peramalan dengan akurasi prediksi yang cukup baik, meskipun seringkali tidak stabil akibat kerentanan terhadap *overfitting* serta sensitivitas terhadap *hyperparameter* yang digunakan. Beberapa penelitian telah mengintegrasikan metode analisis dan dekomposisi sinyal pada model peramalan, namun ketahanannya terhadap *noise* masih kurang sehingga akurasi prediksi menjadi kurang optimal.

Penelitian ini mengusulkan model peramalan multivariat kombinasi LSTM-MVMD-PSO untuk studi kasus peramalan Indeks Harga Saham Gabungan (IHSG), S&P 500, dan Nikkei 225 (N225) dengan masukan berupa histori deret waktu harga *Open-High-Low-Close-Volume* (OHLCV) dalam rentang Januari 2015 hingga Desember 2024. Integrasi metode MVMD berperan untuk mengekstrak deret waktu yang kompleks menjadi subkomponen yang dapat diprediksi dengan optimal oleh LSTM. Sementara itu, *hyperparameter tuning* berbasis PSO diterapkan pada model LSTM-MVMD untuk mengoptimalkan akurasi prediksi akhir model.

Hasil evaluasi menunjukkan bahwa model usulan konsisten mengungguli model-model basis secara signifikan terutama pada metrik *Directional Accuracy* (DA) pada ketiga dataset S&P 500, N225, dan IHSG, dengan median DA berturut-turut 57,80%, 58,84%, dan 72,56%. Model usulan juga memperoleh median terbaik secara signifikan pada metrik lain di antaranya R^2, MSE, RMSE, MAE, dan MAPE untuk dataset S&P 500 dan IHSG, tetapi kalah unggul dibandingkan LSTM-PSO pada dataset N225. Uji statistik membuktikan signifikansi peningkatan kinerja pada 55 dari 72 kasus pengujian berpasangan antara model usulan dan model-model basis.

Kata kunci : Peramalan indeks saham, LSTM, MVMD, PSO, *deep learning*, multivariat, *hyperparameter tuning*, dekomposisi sinyal.

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ABSTRACT

A Multivariate Stock Index Forecasting Approach Based on Long Short-Term Memory (LSTM), Multivariate Variational Mode Decomposition (MVMD) and Particle Swarm Optimization (PSO)

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Stock market indices have complex, nonlinear, and non-stationary characteristics, making it challenging to develop accurate forecasting methods. Long Short-Term Memory (LSTM) has been widely used for various forecasting cases due to its good prediction performance. However, LSTM often suffers from instability due to vulnerability to overfitting and sensitivity to the chosen hyperparameters. Some studies have integrated signal analysis and decomposition methods into forecasting models, but their robustness to noise remains insufficient, resulting in suboptimal prediction performance.

This study proposes a multivariate forecasting model combining LSTM, Multivariate Variational Mode Decomposition (MVMD), and Particle Swarm Optimization (PSO) for the case study of forecasting the IHSG, S&P 500, and N225 stock indices. The input data consists of historical Open-High-Low-Close-Volume (OHLCV) prices from January 2015 to December 2024. The MVMD method serves to decompose complex time series into subcomponents that the LSTM can predict more optimally. PSO-based hyperparameter tuning is applied to find the optimal LSTM and MVMD hyperparameters to improve the final model's prediction performance.

The evaluation results show that the proposed model consistently outperforms the baseline models significantly, especially in terms of the *Directional Accuracy* (DA) metric on the three datasets: S&P 500, N225, and IHSG, with median DA of 57.80%, 58.84%, and 72.56%, respectively. The proposed model also achieved significantly best median on other metrics, including R^2, MSE, RMSE, MAE, and MAPE for the S&P 500 and IHSG datasets, but was slightly outperformed by LSTM-PSO on the N225 dataset. Statistical tests proved the significance of performance improvement in 55 of 72 paired test cases between the proposed model and the baseline models.

Keywords : Stock index forecasting, LSTM, MVMD, PSO, deep learning, multivariate, hyperparameter tuning, signal decomposition.