Option Pricing Model

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Introduction

Options are derivative contracts that give the holder the right, but not the obligation, to buy or sell an underlying asset at a predetermined price (the strike price) before or on a specified date (the expiration date). The pricing of options involves two key components:

1. **Intrinsic Value**: This is the difference between the current market price of the underlying asset and the strike price of the option. For a call option, the intrinsic value is the amount by which the market price exceeds the strike price. For a put option, the intrinsic value is the amount by which the strike price exceeds the market price. Intrinsic value can never be negative.

2. **Time Value**: This is the additional premium that an option commands due to the time remaining until expiration. The more time until expiration, the higher the time value, as there is a greater chance the option will become profitable to exercise. Time value declines as the option approaches expiration (time decay).

The "Option Pricing Models" project aims to provide a robust framework for predicting the accuracy of various option pricing models using historical data. The project includes the implementation of three major option pricing models: Monte Carlo Simulation, Black-Scholes Model, and Binomial Option Pricing Model. This framework fetches option pricing data, computes the prices using the models, and calculates accuracy metrics such as Mean Absolute Error (MAE) and Mean Squared Error (MSE) over a specified period.

Methodology

1. Data Extraction

The `extract_data.py` module is designed to fetch option pricing data. The `get_option_pricing_data` function extracts essential data such as the current stock price (`S0`), strike price (`K`), time to expiration (`T`), risk-free interest rate (`r`), volatility (`sigma`), and option type (call or put).

2. Pricing Models

The `models.py` module implements the following option pricing models:

1. Binomial Model

    - The Binomial Model is a discrete-time model used for pricing options. It simulates possible price paths of the underlying asset over the option's life, assuming up and down movements with specific probabilities.

2. Black-Scholes Model

    - The Black-Scholes Model is a continuous-time model that assumes the underlying asset follows geometric Brownian motion. It provides a closed-form solution for European-style options by considering factors such as volatility, time to expiration, strike price, and risk-free rate.

3. Monte Carlo Simulations

    - Monte Carlo Simulations involve generating random price paths for the underlying asset based on its historical volatility and other parameters. It calculates option prices by averaging the payoff of these simulation.

Backtesting models in different markets

What is Backtesting?

- Backtesting is the process of testing a trading strategy on historical market data to see how it would have performed.
- It allows you to evaluate the potential profitability and risk of a trading strategy before risking real money.

Why is Backtesting Important?

- Backtesting helps validate a trading strategy and identify potential flaws or weaknesses.
- It provides insights into the strategy's performance under different market conditions.
- Backtesting data can be used to optimize and refine the trading strategy.

Backtesting Process

1. Define the trading strategy rules for entry, exit, and position sizing.
2. Apply the strategy rules to historical market data.
3. Record the simulated trading results, including profits, losses, win/loss ratio, etc.
4. Analyze the backtesting results to assess the strategy's performance and risk.
5. Refine the strategy based on the backtesting insights.

Limitations of Backtesting

- Backtesting assumes that past performance is indicative of future results, which may not always be the case.
- Backtesting does not account for real-world factors like slippage, commissions, and market impact.

- Backtesting results can be sensitive to the choice of historical data and the specific time period used.

Accuracy

The article from the Journal of Financial Economics discusses the sensitivity of the calculated option value to roundoffs made during the calculations and to how the normal probability is calculated. This sensitivity is crucial in understanding the accuracy and reliability of option pricing models. The article highlights the importance of precise calculations in option pricing, as even small errors can significantly impact the estimated option value.

The article specifically focuses on the Black-Scholes model, which is widely used in corporate finance and investments. The Black-Scholes model is a mathematical framework for determining the theoretical value of options based on several variables, including the current stock price, strike price, time to expiration, risk-free interest rate, and volatility. However, the article emphasizes that the accuracy of the model depends on the precision of these inputs and the calculations involved.

In particular, the article notes that the normal probability distribution used in the Black-Scholes model can be sensitive to small changes in the inputs. This sensitivity can lead to significant errors in the calculated option value, which can have real-world implications for traders and investors. The article provides detailed analysis of these sensitivities and offers insights into how to mitigate these errors.

Overall, the article underscores the importance of careful and precise calculations in option pricing, highlighting the need for robust and accurate models to ensure reliable financial decisions.

The `analysis.py` script integrates the data extraction and pricing models to evaluate their accuracy. The `predict_accuracy` function calculates the prices using each model for a specified period (e.g., the last 30 days) and computes the MAE and MSE for each model.

Results and Discussion

The results are presented in a DataFrame showing the MAE and MSE for each model. This allows for a clear comparison of the accuracy of each model over the specified period.

Conclusion

The "Option Pricing Models" project successfully implements and evaluates the accuracy of three key option pricing models. The framework provides a comprehensive approach to fetching historical data, computing option prices using different models, and evaluating their accuracy. This can be a valuable tool for traders, analysts, and researchers in the field of finance.

Future Work

Future enhancements to this project could include:

1. Expanding the Range of Models:
   - Implement additional models such as the Heston model or GARCH models.
2. Real-time Data Integration:
   - Integrate real-time data feeds for more dynamic and timely analysis.
3. User Interface:
   - Develop a user-friendly interface for easier interaction and visualization of results.

References

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