Project Report: Parametric Implied Volatility using NIFTY Options

Project Overview:

- The goal of this project is to compute and analyze the implied volatility (IV) surface of NIFTY options.
- This study involves fetching live option chain data, computing implied volatility using numerical methods, and visualizing its variation across strikes and expiries in the form of a volatility surface.

Tools Used

1. Python 2. Pandas 3. NumPy 4. SciPy (brentq root-finding method) 5. Matplotlib & Plotly 6. NSE Option Chain Data: Black-Scholes Model:

Data Collection and Preprocessing

- Source: The NIFTY option chain was fetched directly from the NSE website.
- Relevant fields like 'Strike, Spot_price (current NIFTY index level), Close_price (option price), and Expiry (option expiry date)' extracted:
- The data was cleaned and structured into a DataFrame.

Computing Implied Volatility

- For each option entry, implied volatility was computed using the Black-Scholes model. Since Black-Scholes does not offer an analytical formula to solve for volatility, it was numerically inverted using the brentq method from scipy.optimize.
- The assumptions for the Black-Scholes model included:
  - European-style options
  - Constant risk-free rate (r = 0.65)
  - No dividends
- A new column IV was appended to the DataFrame to store the computed implied volatilities.

Visualization and Analysis

- Term Structure
    - Time Series of IV for Fixed Strike
    - Selected strikes within ±1% of the closest strike to the spot price to ensure relevance and liquidity.
    - For a fixed strike, the variation of implied volatility over time to maturity was plotted.
    - This helps analyze how near-the-money option IVs evolve as expiry approaches.
- Smile Patterns
    - The DataFrame was grouped by expiry, and for each group, a plot of log-moneyness (ln(K/S)) versus IV was created.
    - These plots display the volatility smile or skew, a well-known feature in real-world markets deviating from the flat IV curve assumed by Black-Scholes.
- Volatility Surface Construction
    - Using cubic interpolation, a smooth surface of implied volatility as a function of strike and time to maturity was created.
    - This 3D volatility surface helps visualize market sentiment comprehensively across different strikes and maturities.

Outcomes and Insights

- The project successfully constructed a parametric volatility surface from real market data.
- Observed volatility smiles and term structure patterns consistent with empirical market behavior.

Future Work and Extensions

- Introduce stochastic volatility models (like Heston) to better capture observed IV dynamics.
- Add real-time updating capability with automated fetching and plotting.
- Integrate put options for a more holistic view.
- Explore regression or machine learning techniques to parametrize the volatility surface more robustly.