1 Historical_volatility.py: Realised Volatility and Sharpe Ratios

Purpose

Fetches historical prices (via Yahoo Finance) and computes:

- **Historical volatility**: rolling standard deviation of log returns, annualised.
- **Sharpe ratio**: rolling measure of risk-adjusted return.

Learning focus

- Shows how volatility clusters over time.
- Sharpe ratio adds performance context to volatility — high Sharpe with low vol is optimal.
- Two plots: one for a single ticker, one comparing all tickers.

Trading intuition

Historical volatility is backward-looking, capturing actual realised variability. Used to compare against **implied volatility** for relative value trading.

2 IV_Newton.py: Implied Volatility via Newton–Raphson

Purpose

Solves for **implied volatility** given an option market price using Newton–Raphson.

Learning focus

- Starts from Black–Scholes price.
- Iteratively adjusts volatility until model price matches market price within tolerance.
- Uses autograd to compute derivative (Vega).

Trading intuition

Implied volatility reflects market expectations of future variability, not past moves. Traders watch IV for skew, term structure, and relative richness/cheapness.

3 Term_structure.py: Futures Curve Simulation

Purpose

Generates synthetic futures price data in two regimes:

- **Contango**: futures > spot, premium increases with maturity.
- **Backwardation**: futures < spot, discount increases with maturity.

Learning focus

- Visualises regime change and associated volatility differences.
- Demonstrates spread between spot and futures over time.

Trading intuition

Contango hurts long futures via negative roll yield; backwardation benefits them. Curve shape drives roll strategies and inventory decisions in commodities.

4 Forecasting_GARCH.py: Volatility Forecasting

Purpose

Fits **GARCH(1,1)** models to S&P 500 returns over crisis and calm periods, compares realised and conditional volatility.

Learning focus

- Shows persistence of volatility via $\alpha + \beta$.
- Evaluates forecast accuracy (RMSE, MAE, correlation).
- Compares crisis vs calm model performance.
- Tests for asymmetric effects using GJR–GARCH.

Trading intuition

GARCH models help forecast volatility surfaces, assess risk, and price volatility-dependent instruments. During crises, persistence may rise and correlation between realised and modelled vol may change.