**Project Description**

Forecasting Bitcoin Closing Prices with Classical and Modern Time-Series Methods

**Research Question**

How accurately can we predict Bitcoin’s daily closing price one month ahead using various models , and how do they compare to the actual forecast?

**Motivation**

Bitcoin’s pronounced volatility and rapid regime shifts make it an ideal test case for evaluating forecasting techniques. By combining both classical statistical approaches (ARIMA, Holt–Winters, Theta) and a modern, user-friendly framework (Prophet), this project aims to:

**Data Sources**

* Binance (via ccxt): Daily OHLCV (“Open/High/Low/Close/Volume”) for BTC/USDT.
* Scope: April 20, 2024–April 20, 2025 for model training; April 21–May 20, 2025 for out-of-sample testing.
* Preprocessing: Timestamps converted to pandas DateTime index; missing days forward-filled; no additional feature engineering.

**Methodology Overview**

1. **Exploratory Data Analysis (EDA)**
   * Plot the one‐year price series and volume.
   * Compute summary statistics (mean, volatility) and check for missing/irregular timestamps.
   * Test for stationarity using the Augmented Dickey–Fuller (ADF) test.
2. **Baseline Forecasting**
   * Implement naïve “last‐value” forecast: the previous day’s closing price as the forecast for each of the next 30 days.
   * Compute RMSE and MAPE on the test period.
3. **ARIMA Modeling**
   * Difference the series once (d = 1) to achieve stationarity.
   * Examine ACF/PACF plots to propose initial p/q orders; fit an ARIMA(5,1,0).
   * Perform a manual grid search over p,q ∈ {0…5} to minimize AIC; refit the optimal model.
   * Forecast 30 days ahead.
4. **Prophet Modeling**
   * Reformat data into Prophet’s required “ds” (date) and “y” (value) columns.
   * Fit with default changepoint settings and daily seasonality enabled.
   * Generate a 30-day forecast.
5. **Holt–Winters Exponential Smoothing**
   * Specify additive trend and seasonality components.
   * Fit on the full training series; forecast the next 30 days.
6. **Theta Method**
   * Decompose the series into two Theta lines (θ = 0 and θ = 2) and recombine.
   * Produce a 30-day forecast.
7. **Ensemble Forecast**
   * Average the daily predictions from ARIMA, Prophet, Holt–Winters, and Theta.
   * Evaluate ensemble accuracy against each individual model.
8. **Model Evaluation & Visualization**
   * Calculate RMSE, MAE, and MAPE for all forecasts (baseline, four models, ensemble).
   * Plot actual vs. forecasted closing prices for each method.
   * Chart error metrics over the 30-day horizon to observe error growth.