📄 Assignment: Time Series Analysis for Bitcoin Price Prediction using RNN, LSTM, and GRU

Problem Statement

In this assignment, you will build deep learning models to **predict Bitcoin prices** using time series data.
The dataset contains historical Bitcoin price information such as **date, open, high, low, close, and volume**. Students will perform an end-to-end workflow: **Exploratory Data Analysis (EDA)**, preprocessing, building baseline and optimized models using **RNN, LSTM, and GRU**, and evaluation.
The goal is to understand how sequential models can capture temporal dependencies in financial data for forecasting tasks.

Dataset Options

1. 📎 Bitcoin Historical Price Dataset (Kaggle)
2. 📥 Fetch live historical data using the `yfinance` library:

Guidelines for Students

1. Data Understanding

- Download the dataset from Kaggle **or** use `yfinance` to fetch Bitcoin data.
- Check available columns (Date, Open, High, Low, Close, Volume, Adj Close).
- Convert the **Date** column to datetime format (if needed).
- Set the Date as index and sort data in ascending order.

2. EDA (Exploratory Data Analysis)

- Plot the **closing price trend** over time.
- Plot the **daily returns** to visualize volatility.
- Plot the **moving averages** (7-day, 30-day).
- Check correlations between features (Open, High, Low, Close, Volume).

3. Preprocessing

- Normalize values (e.g., MinMaxScaler to scale Close prices between 0 and 1).
- Create supervised sequences using a sliding window approach (e.g., past 60 days → predict next day).
- Split dataset into **training and validation sets** (e.g., 80/20).
- Reshape data into `(samples, timesteps, features)` format for RNN models.

4. Model Building

Baseline RNN

- Architecture: `SimpleRNN → Dense (1)`
- Loss: **Mean Squared Error (MSE)**
- Optimizer: **Adam**
- Evaluate on validation set.

LSTM Model

- Architecture: `LSTM → Dropout → Dense (1)`
- Add callbacks like **EarlyStopping, ReduceLROnPlateau**.
- Compare results with baseline RNN.

GRU Model

- Architecture: `GRU → Dropout → Dense (1)`
- Experiment with stacked layers (e.g., GRU(128) → GRU(64)).
- Compare performance with RNN and LSTM.

5. Evaluation

- Report **RMSE (Root Mean Squared Error)** and **MAE (Mean Absolute Error)**.
- Plot predicted vs actual Bitcoin prices.
- Plot training & validation **loss curves**.
- Compare performance of RNN vs LSTM vs GRU in a summary table.
- Show some example future predictions vs actual outcomes.
- Discuss limitations (e.g., high volatility, market unpredictability).

Expected Outcomes

- Students will learn to **analyze time series datasets** and identify trends.
- Students will gain skills in **data scaling, sequence generation, and sliding windows**.
- Students will understand how **RNN, LSTM, and GRU** capture temporal patterns in financial data.

- Students will be able to **evaluate models with regression metrics** and compare forecasting accuracy.

- Students will learn to interpret results, analyze model strengths/weaknesses, and understand challenges of predicting volatile assets like Bitcoin.