Recession Probability Forecasting with CNN-LSTM and Treasury Spread Correlation Matrices

Core Idea

The objective of this project is to forecast recession probabilities by leveraging a hybrid deep learning model that captures both spatial and temporal dependencies in financial market structures. The spatial component is modeled through convolutional neural networks (CNNs) that learn patterns across rolling 30-day correlation matrices of Treasury bill spreads, while the temporal evolution of these correlation patterns is modeled using Long Short-Term Memory (LSTM) networks. By integrating CNN and LSTM architectures, the system aims to detect early warning signals of economic recessions with improved accuracy compared to traditional static models.

How to Approach

Step-1: Collect and Preprocess Spread Data

- Gather historical Treasury bill spread data across 210 different maturity combinations.
- Merge the spreads using an outer join to maximize the historical window, allowing missing data to persist naturally without forward filling.
- **Output**: Spread matrix with rows as dates and columns as spreads.

Step-2: Generate Rolling 30-Day Correlation Matrices

- For each day after the first 30 days, compute a rolling correlation matrix among available spreads.
- Enforce a minimum 80% spread availability rule (at least 168 spreads present) to ensure matrix stability.

- **Output**: Sequence of 30-day rolling correlation matrices of size (210 $\times$210).

Step-3: Build CNN-LSTM Architecture

- Apply a 2D Convolutional Neural Network (CNN) on each correlation matrix to extract spatial features.
- Stack spatial features across a sequence of matrices (e.g., past 5 days).
- Feed the stacked feature sequences into an LSTM network to learn temporal dependencies.
- **Output**: Deep learning model mapping sequences of correlation matrices to recession probability scores between [0,1].

Step-4: Train and Validate the Model

- Split the data into training and validation periods based on date (to respect time causality).
- Train the CNN-LSTM model using binary cross-entropy loss and monitor AUC-ROC as the primary evaluation metric.
- Use early stopping and regularization to prevent overfitting.
- **Output**: Trained model capable of predicting near-future recession probabilities.

Step-5: Analyze and Visualize

- Plot time-series of predicted recession probabilities versus actual recession periods.
- Visualize examples of correlation matrix evolution leading into recessionary regimes.
- Examine learned features to interpret what spread relationships the model considers important.

Resources and References

Research Papers

- **Inside the Black Box: Neural Network-Based Real-Time Prediction of US Recessions**
  Seulki Chung
  Read the paper
- **Economic Recession Prediction Using Deep Neural Network**
  Zihao Wang, Kun Li, Steve Q. Xia, Hongfu Liu
  Read the paper

- **Recession Prediction Using Multiple Machine Learning Methods and Historical Economic Data**
  Research paper exploring LSTM and CNN approaches
  Read the paper

GitHub Projects

- **Recession-Prediction-LSTM**
  LSTM-based recession prediction using economic variables.
  GitHub Repository
- **CNN-LSTM Stock Prediction Algorithm**
  Deep learning model predicting stock prices via CNN-LSTM combination.
  GitHub Repository
- **Attention-CLX Stock Prediction**
  Attention-based CNN-LSTM and XGBoost hybrid stock prediction model.
  GitHub Repository