CS898BD- Deep Learning, Fall 2025
Project Proposal

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Project Title: Stock Market Prediction using LSTM, GRU and Transformer model on Tesla Stock Data from 2015 until 2024 years.

General Requirements:
Each project is required to have the following components:

1. Machine Learning Architecture
2. Dataset
3. Evaluation Metrics

Project Summary:

Nowadays, people are interested in the prediction of the stock market because of the complexity and volatility of it. Our aim is to make a comparison between deep learning models such as LSTM (Long Short-Term Memory), GRU (Gated Recurrent Unit) and Transformer model to forecast tesla stock market from 2015 to 2024. Those deep learning models will overcome the challenges faced by traditional methods to get accurate prediction. In the literature some authors have already used those deep learning models such as [1].

Proposed Method:
In this project, we will apply time series analysis to predict future market prices and identify trends. Throughout time series analysis we will be using EDA (exploratory data analysis), plotting charts for visualization, data preprocessing which includes data cleaning and predicting Tesla's stock price using deep learning models for 30 days.

In this project we will leverage three deep learning models for forecasting the stock market price:

- LSTM (Long Short-Term Memory): LSTM is a type of recurrent neural network, well-suited for handling sequential data with its gates and memory cells. This model will be used because predicting the stock market relies heavily on past data. LSTM will be trained in Tesla's historical stock prices to predict future prices.

- GRU (Gated Recurrent Unit): GRU has fewer parameters compared to LSTM and it can also capture long-term dependencies. In our project we will compare the different stock price results obtained from GRU and LSTM models.

- Transformer model: Since LSTM and GRU struggle with remembering long sequences. In our project we aim to use an improved version of LSTM and GRU called transformer which is a type of deep learning neural network. It can process all data points at once, even in long sequences, using a mechanism known as self-attention. In our project, the Transformer will be compared to the results obtained from LSTM and GRU.

Datasets:
In our project we will use tesla (TSLA) stock data from kaggle, that was originally sourced from yahoo finance. The dataset gives records from 2015 to 2024, which includes 2843 rows it represents the trading days and 7 columns each represent:

- Date: trading day
- Open, high, low, close: stock prices at the start, peak, lowest point, and end of each day
- Adjusted close: closing price adjusted for splits (the shares of the company are divided into many shares) and dividends (money is given to shareholders)
- Volume: number of shares traded

Experiments and Evaluation Metrics:
To perform the experiment, we will use three deep learning models: LSTM, GRU, and Transformer. The dataset will be divided into training, validation, and test sets to evaluate how well the models perform on unseen data. We will begin by exploring the dataset to check data quality, including whether it contains missing values, outliers, or errors. Next, we will apply data preprocessing to address these issues, such as handling missing values and normalizing stock prices. After preparing the dataset, we will train the models to predict the target variable: the future closing price of Tesla for 30 days of the month, based on past price sequences. To prevent overfitting, we will incorporate regularization techniques such as dropout, early stopping with patience, and learning rate scheduling. For evaluation, we plan to use several metrics:

- **MSE (Mean Squared Error):** squares the errors so that larger prediction errors are penalized more heavily.
- **RMSE (Root Mean Squared Error):** represents the average difference between the model's predicted prices and the real market prices.
- **R^2 (Coefficient of Determination):** indicates how much of the variation in stock prices is explained by the model; higher values mean better performance.
- **MAE (Mean Absolute Error):** measures the average absolute difference between predicted and actual prices.

In addition to these metrics, we will also evaluate the models across different prediction horizons, such as the next 7, 15, and 30 days. This will allow us to assess how far into the future each model can make accurate predictions and determine which of the three models performs best over longer horizons. Furthermore, we will visualize how prediction errors increase as the forecast horizon extends.

Each of the three models LSTM, GRU, and Transformer has its own strengths. LSTM is valuable because of its ability to capture long-term patterns through gates and memory cells. GRU, while simpler than LSTM, is still effective in handling sequential data, which is essential for stock price prediction. Finally, transformers are powerful because they process all data points simultaneously using attention mechanisms. Our goal in this project is to identify the model that can forecast stock prices most accurately and effectively.

Deliverable:
By the end of the project, we will submit the source code in a GitHub repository. We will also prepare a presentation to explain our research question, the methods and architecture used, and the

models we implemented. We will present the results we achieved and discuss their significance. Finally, we will submit the complete report gathering all the details of the project.

Project Milestone:

Weeks	Tasks
Week 8-9	Exploratory data analysis (EDA) on the Tesla dataset, clean and preprocess the data (handle missing values, normalization), and set up the train/validation/test splits.
Week 10 -11	Implement and train the LSTM, GRU models, tune hyperparameters, generate plots (loss curves, predicted vs actual prices) and evaluate their performance using validation data. Start preparing the report.
Week 12 – 14	Implement and train the Transformer model, compare results with LSTM and GRU, generate plots (loss curves, predicted vs actual prices) and evaluate their performance using validation data.
Week 15-16	Prepare the final report, presentation, revise the code, gather all the results.

References:

[1] Xiao, J., Deng, T., & Bi, S. (2024, August). Comparative analysis of LSTM, GRU, and transformer models for stock price prediction. In *proceedings of the international conference on digital economy, blockchain and artificial intelligence* (pp. 103-108).