Stock News Classification, Prediction, & Analysis

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Outline

- Business Problem & Understanding
- Data
- Modeling Methodology & Metrics
- Results
    - Title and Text sentiment analyses are equally important for machine learning
    - What weights to use to deal with class imbalance
    - Best model for stock news classification
- Conclusions
- Further Work

Business Problem

- Predicting stock prices is a highly valuable asset to have. Assuming high precision in our predictions, we can:
    - Profit from short or long term stock purchases
    - Analyze company projected growth or decline
    - Determine public sentiment toward a company or industry

- The Assumption of this project is that stock news is related to stock price. This assumption is based on:
    - How stock prices move up or down
    - Public sentiment toward a stock and stock price

Business Understanding

- Understanding the value that comes from stock prediction, I went into this project with the following goals:
    - Build various machine learning models predicting stock price with precision and accuracy as the goal metrics.
        - Value: If we have a model that can confidently predict a gain or loss for a given stock then we can invest company funds with higher confidence
    - Derive Importance Results
        - Value: Is the headline of a news article have more valuable information than the text? Knowing this will allow for more advanced models in the future
    - Visualize Relationships
        - Value: By creating a visual representation of the relationship between stock news and a given stock we can detect patterns which can be used to enhance model performance

Data

- All of the data was retrieved from the FMP Cloud API (https://fmpcloud.io/)
- Preprocessing:
  - Obtain Stock News using api key, limit (Number of News articles to retrieve) stock symbol list
    - This returns the title and text of the news, date + time published
    - Custom Features:
      - Vader_sentiment_scores (For first two models)
      - Boolean is_weekday (True if on Friday, Saturday, Sunday)
      - Weekday number (0 = Monday)
      - Stock Prediction Day
  - Obtain stock price using the date range from the stock news dataframe above

NLP

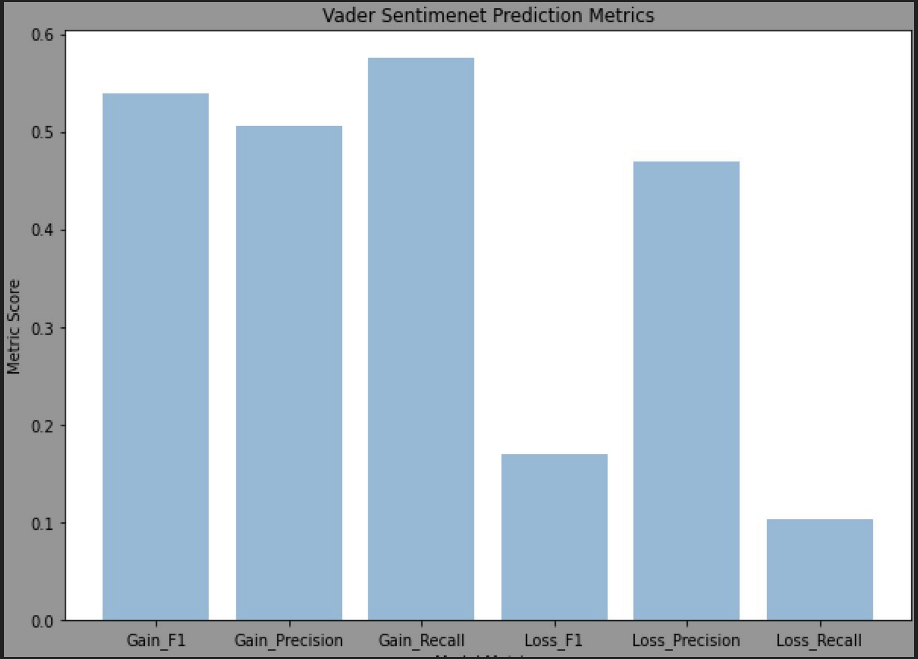
- For the recurrent networks and transformer model I took the following natural language process steps
  - Combine title and text of a news article
  - Count unique words
  - Determine max length of a given text
  - Tokenize words (removes punctuation)
  - Embed words using Glove word vector matrix
    - (https://nlp.stanford.edu/projects/glove/)

Methodology (Baseline Models)

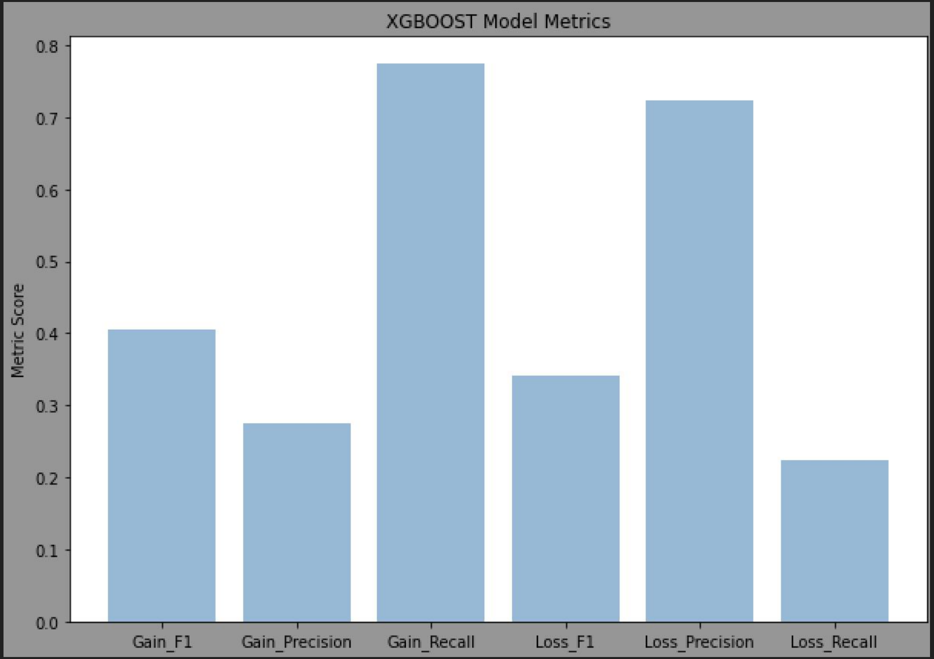
- I define gain/loss by change i.e. Stock Open Price - Stock Close Price
  - If change > 0 stock == gain
  - If change < 0 stock == loss
- Baseline Model (Vader Sentiment Scores)
  - Does not use machine learning
  - Predicts stock price using average score of title and text
- Baseline Model (XGBOOST with Vader Sentiment Scores)
  - Supervised binary classification machine learning
  - Predicts stock price using vader sentiment scores after being trained on actual gain/loss of a stock

Metrics (Baseline Models)

Vader Sentiment Model



Vader Sentiment XGBOOST Model

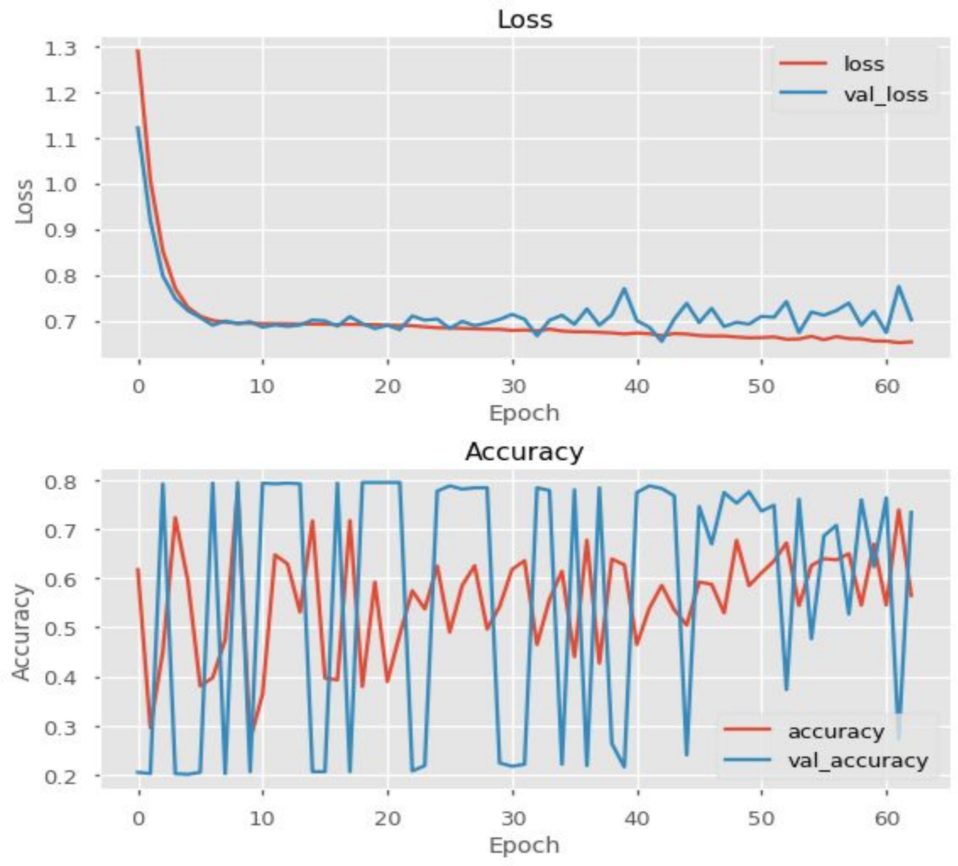


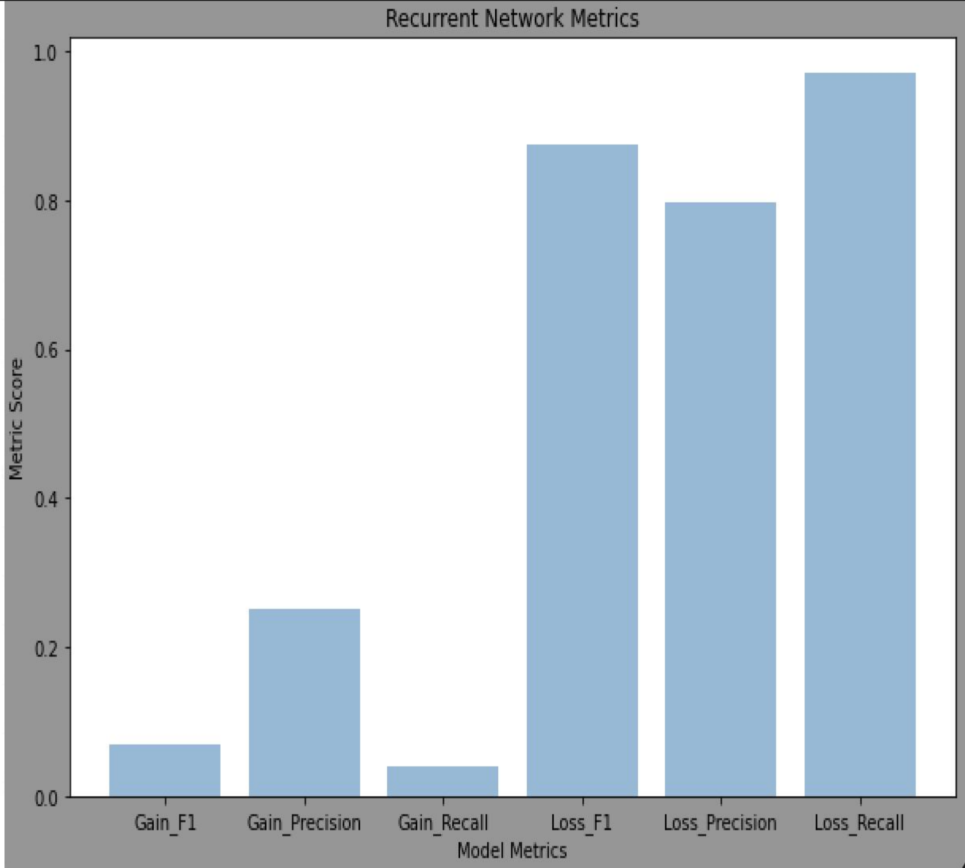
Methodology (Recurrent Neural Networks)

- GRU Model
  - Embedding layer with 50 vector size
  - GRU layer
    - 64 neurons
    - L2 regularizer
  - Dense Layer
    - 128 neurons
    - Tanh activation
  - Output Layer
    - Sigmoid activation
  - Loss: binary_crossentropy
  - Optimizer : Adam

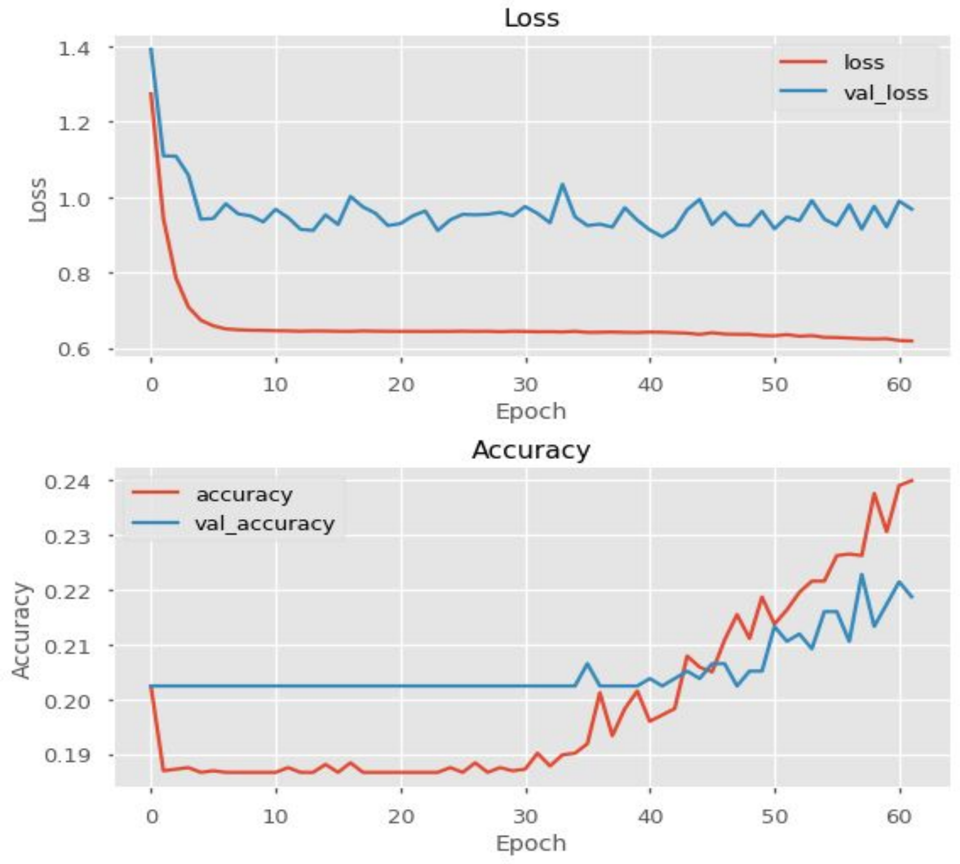
- LSTM Model
  - Embedding layer with 50 vector size
  - LSTM Layer
    - 64 neurons
    - L2 regularizer
  - Dropout Layer
    - Rate : .2
  - Dense Layer
    - 128 neurons
    - Tanh activation
  - Output Layer
    - Sigmoid Activation
  - Loss: binary_crossentropy
  - Optimizer : Adam

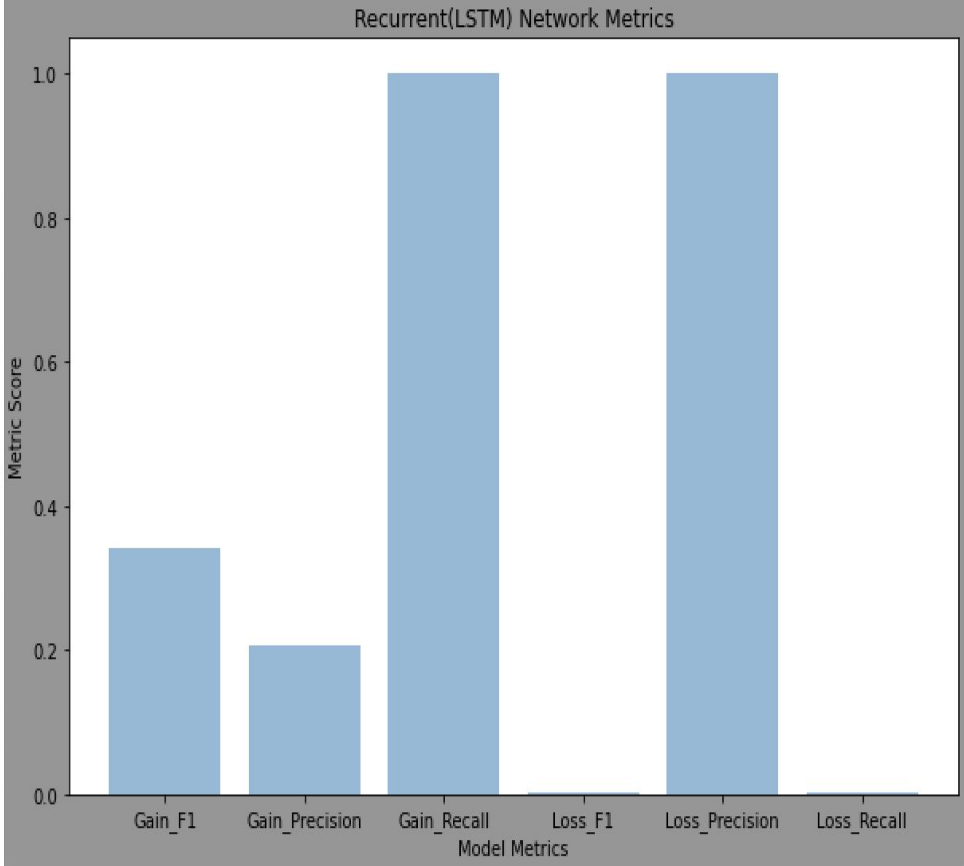
Metrics (GRU Recurrent Network)





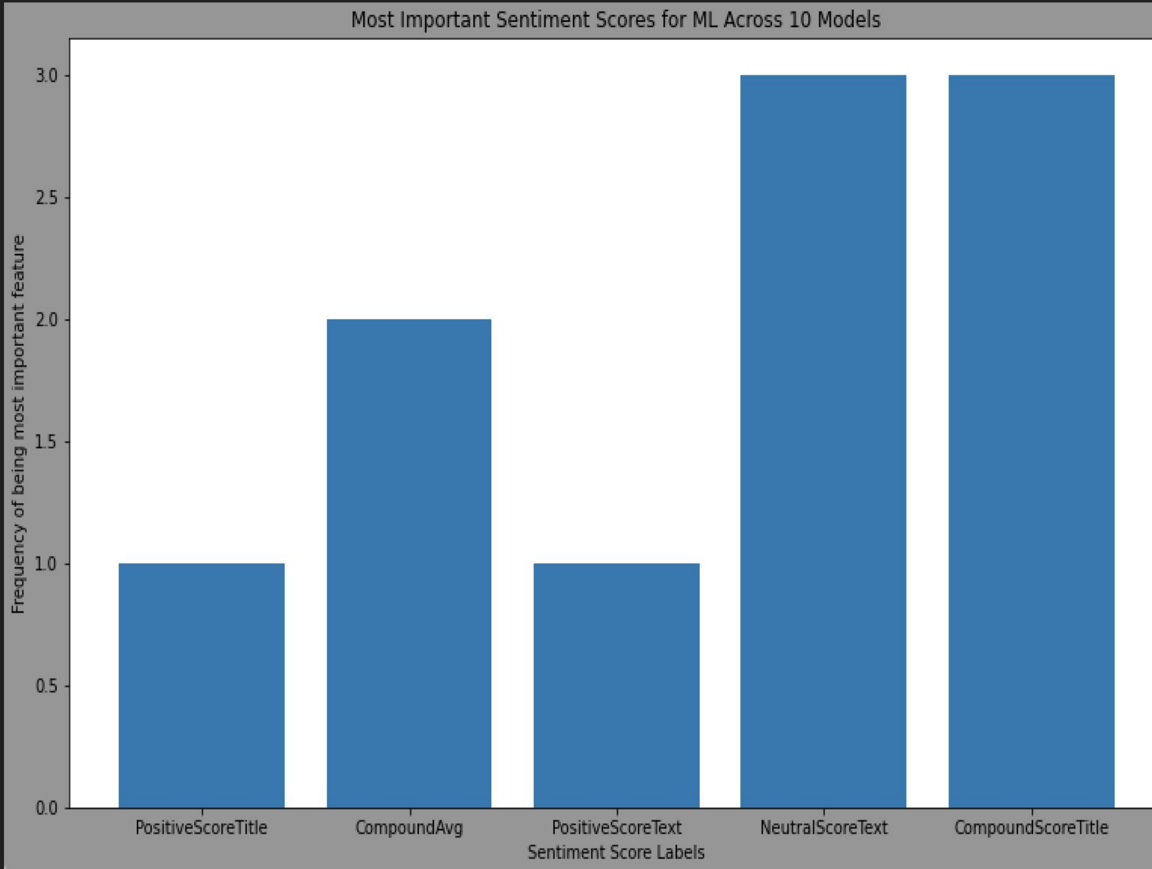
Metrics (LSTM Recurrent Network)



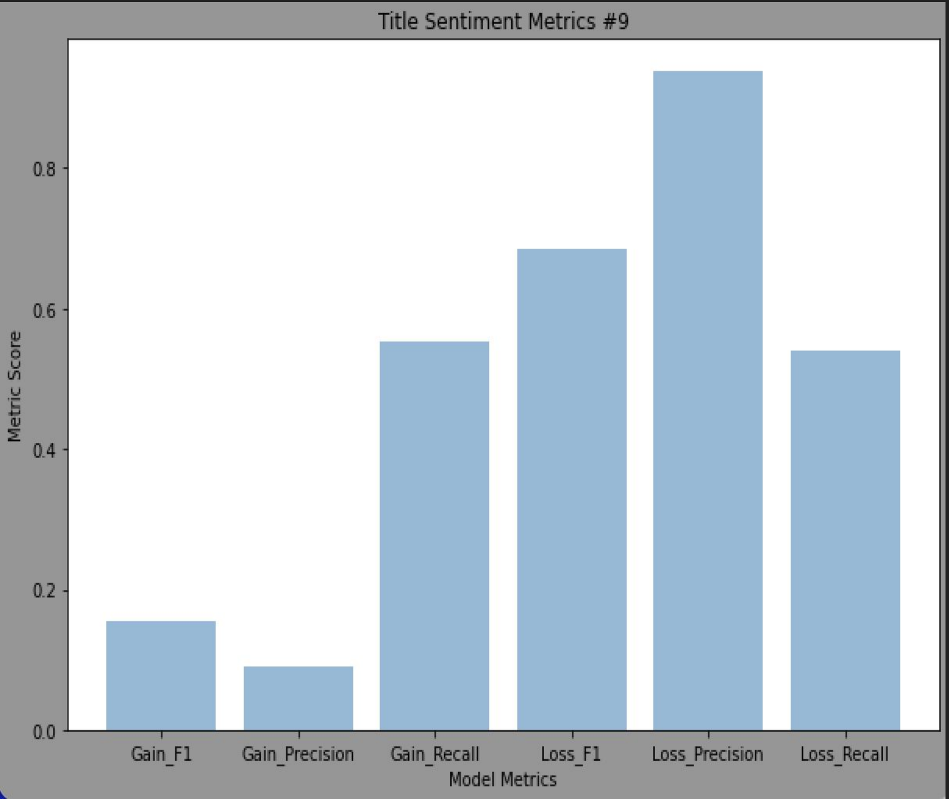


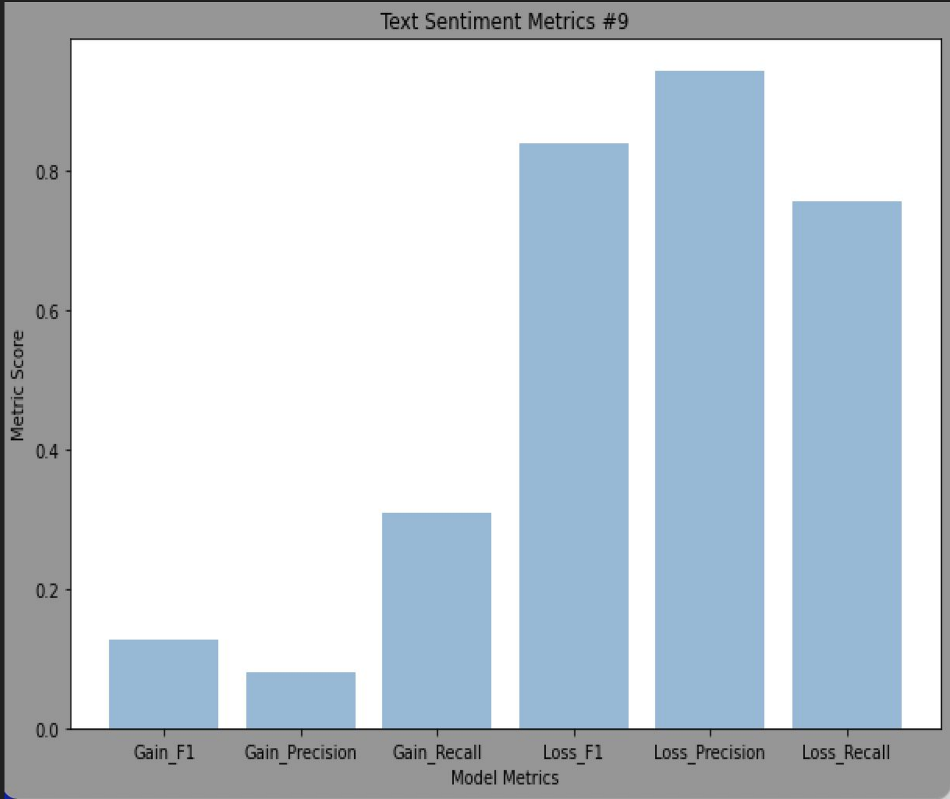
Results #1

- Text & Title are equally important when classifying stock news data



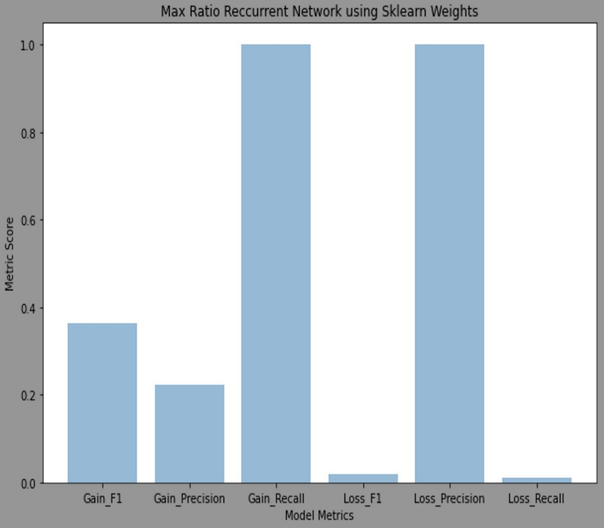
Results #1 Additional Evidence



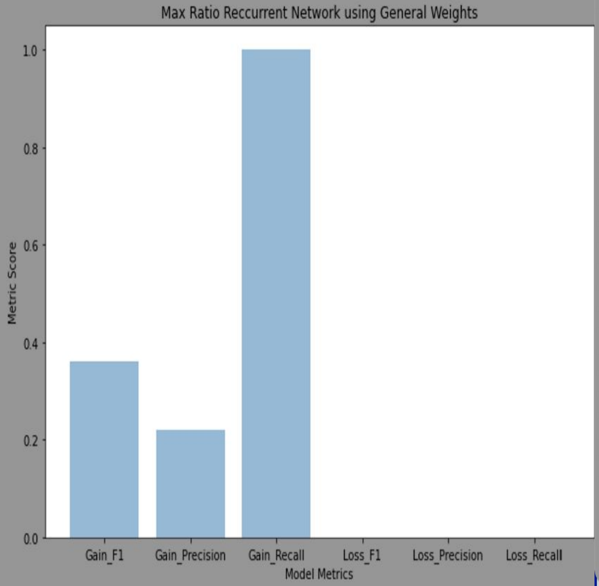


Results #2

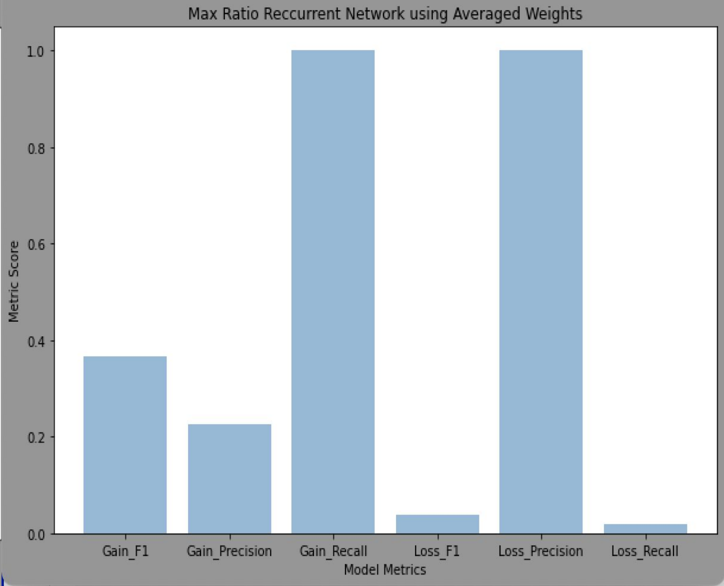
The best weighting system for larger ratios, loss/gain, is the averaged weights



Max Ratio Reccurrent Network using Sklearn Weights



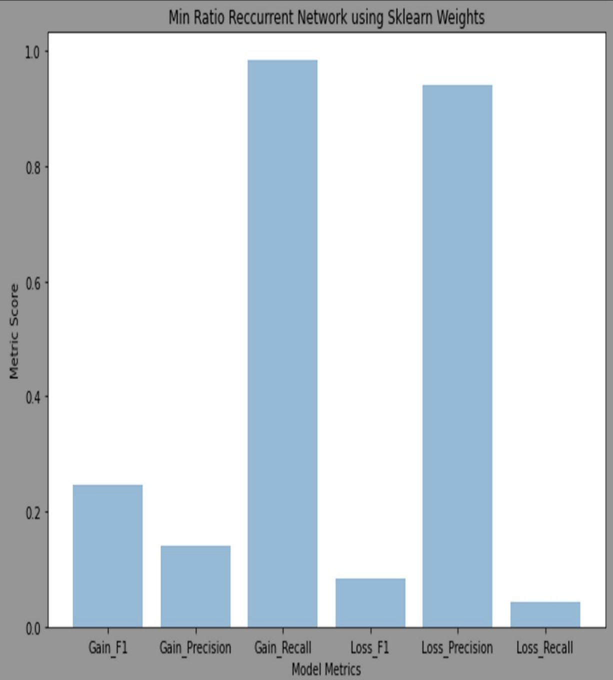
Max Ratio Reccurrent Network using General Weights



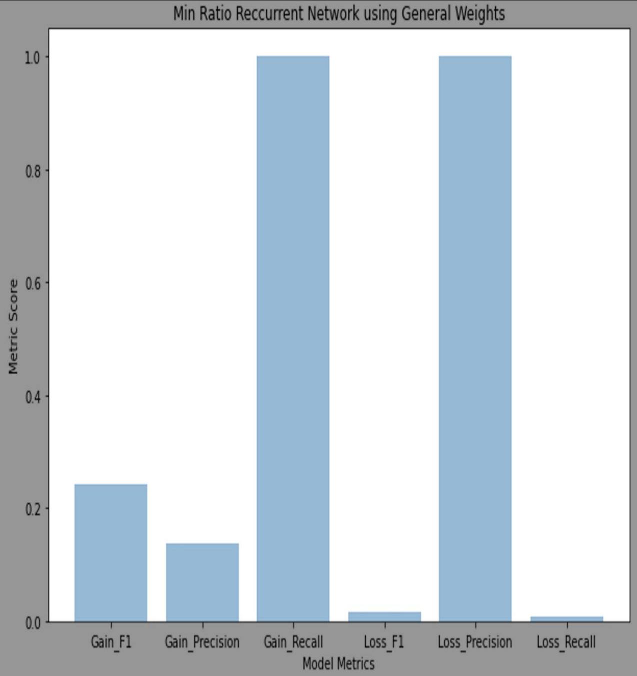
Max Ratio Reccurrent Network using Averaged Weights

Results #2

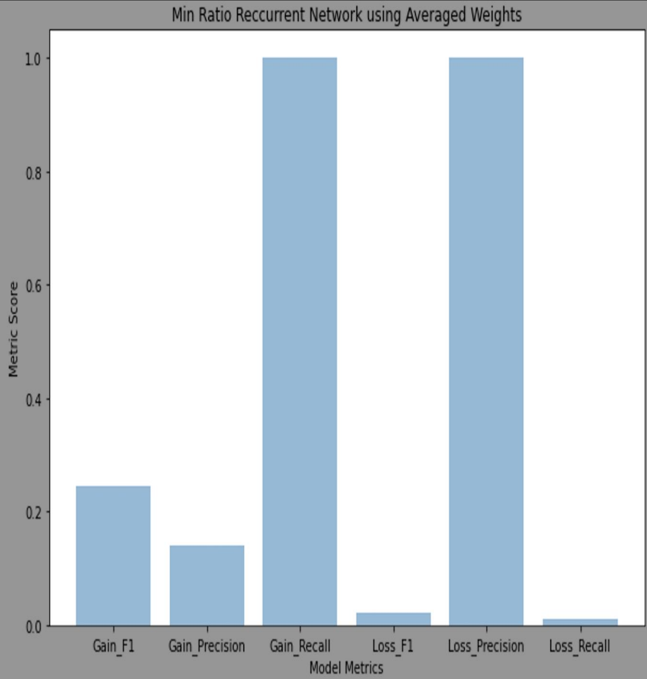
The best weighting system for larger ratios, loss/gain, is the sklearn weights



Min Ratio Reccurrent Network using Sklearn Weights



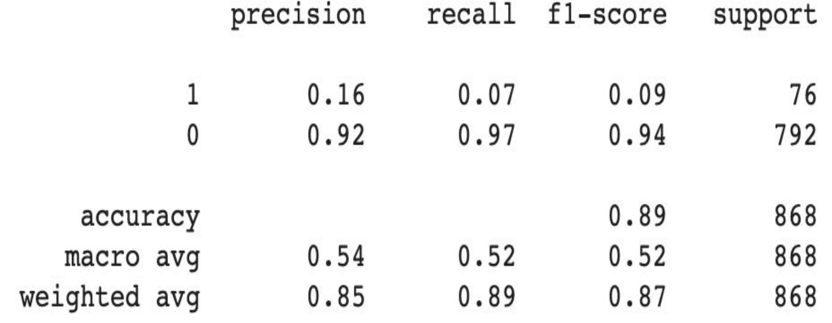
Min Ratio Reccurrent Network using General Weights



Min Ratio Reccurrent Network using Averaged Weights

Results#3 Best Model

Recurrent Network

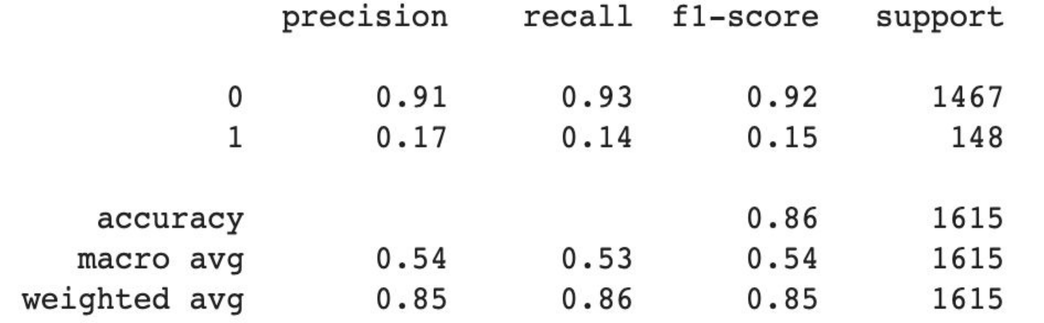


```
              precision    recall  f1-score   support

           1       0.16      0.07      0.09        76
           0       0.92      0.97      0.94       792

    accuracy                           0.89       868
   macro avg       0.54      0.52      0.52       868
weighted avg       0.85      0.89      0.87       868
```

XGBOOST (ML)

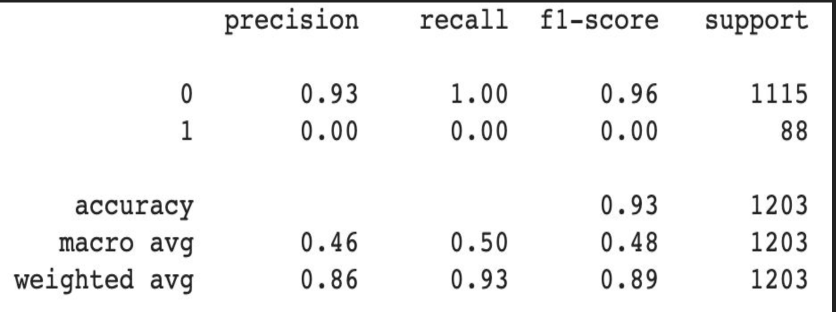


```
              precision    recall  f1-score   support

           0       0.91      0.93      0.92      1467
           1       0.17      0.14      0.15       148

    accuracy                           0.86      1615
   macro avg       0.54      0.53      0.54      1615
weighted avg       0.85      0.86      0.85      1615
```

DistilBERT

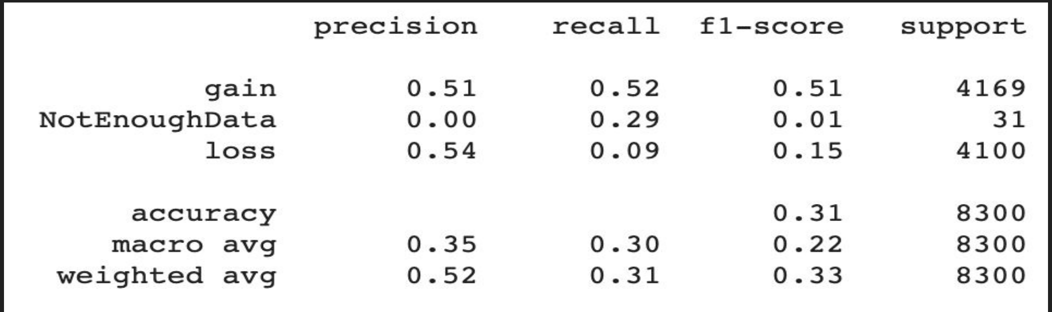


```
              precision    recall  f1-score   support

           0       0.93      1.00      0.96      1115
           1       0.00      0.00      0.00        88

    accuracy                           0.93      1203
   macro avg       0.46      0.50      0.48      1203
weighted avg       0.86      0.93      0.89      1203
```

XGBOOST (Sentiment)



```
               precision    recall  f1-score   support

         gain       0.51      0.52      0.51      4169
NotEnoughData       0.00      0.29      0.01        31
         loss       0.54      0.09      0.15      4100

     accuracy                           0.31      8300
    macro avg       0.35      0.30      0.22      8300
 weighted avg       0.52      0.31      0.33      8300
```

Conclusions

- Develop & patent custom Natural Language Processing for stock news titles AND their corresponding text.
  - This will lead to higher return on investments,
  - business insights,
  - and allow your company to understand the sentiment investors.
- To best handle the class imbalance where ratio = loss/gain:
  - Smaller Ratios (>8) : Use Sklearn generated weights
  - Larger Ratios (<8) : Use the average weight between sklearn and the general formula class/class
- Further develop the Transformer Model. This is the best in class for NLP and the unoptimized, barely trained (1 epoch), weightless, DistilBERT model outperformed the recurrent networks accuracy.

Further Work

Provided with more time, I would....

- Further develop transformer model
  - Parameter Optimization
  - Add weights
- Develop business product capable of analyzing stock sentiment to enhance company & customer return on investment
- Develop custom filtering methods capable of determining:
  - Optimal weights for class imbalance
  - Trending stocks (positive or negative)
- Develop process that collect equal gain & loss metrics so that models have higher performance

Questions?

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