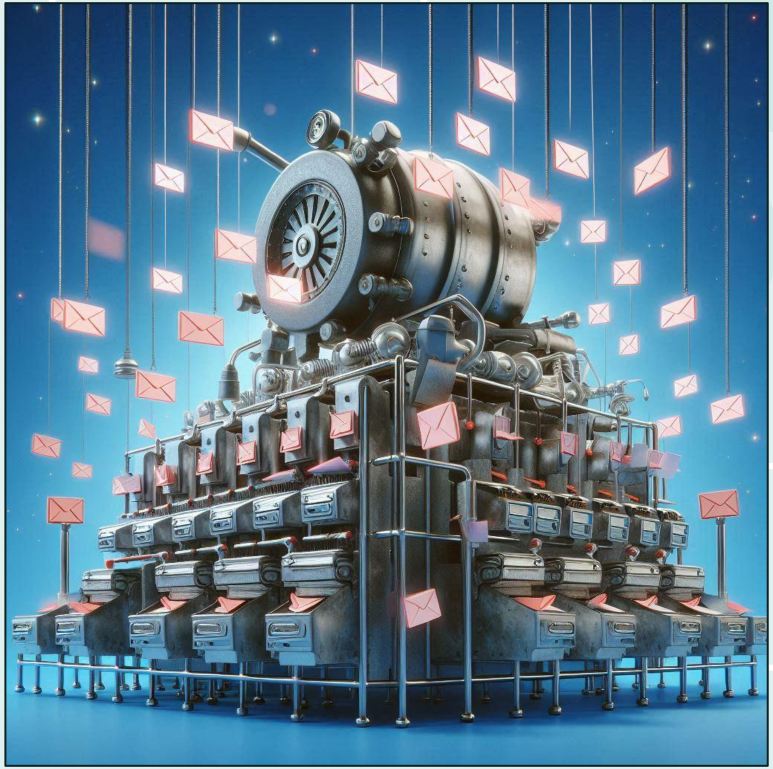
Spam Email Filter - Machine Learning Model



Agenda

01 Business Problem

02 Exploratory Data Analysis

03 Predictive Modeling

04 Conclusions

05 Recommendation

06 Next Steps

01 Business Problem

Our telecommunications company wants to break into the email market and needs to implement an effective SPAM filter.

We are charged with:

- Create a model that reliably detects SPAM in a way that will maximize customer satisfaction

02 Data Analysis

Actual emails in the form of individual HTML files were used in the analysis

- 5825 HTML files in total
- Each email was previously labeled as HAM or SPAM and sorted into folders

Source: Index of /old/publiccorpus (apache.org)

Email Importing and Preprocessing

```
From rssfeeds@jmason.org  Tue Oct  8 10:56:10 2002
Return-Path:
Delivered-To: yyyy@localhost.example.com
Received: from localhost (jalapeno [127.0.0.1])
        by jmason.org (Postfix) with ESMTP id EEE0616F03
        for ; Tue,  8 Oct 2002 10:56:09 +0100 (IST)
Received: from jalapeno [127.0.0.1]
        by localhost with IMAP (fetchmail-5.9.0)
        for jm@localhost (single-drop); Tue, 08 Oct 2002 10:56:09 +0100 (IST)
Received: from dogma.slashnull.org (localhost [127.0.0.1]) by
    dogma.slashnull.org (8.11.6/8.11.6) with ESMTP id g9881LK06173 for
    ; Tue, 8 Oct 2002 09:01:21 +0100
Message-Id: <200210080801.g9881LK06173@dogma.slashnull.org>
To: yyyy@example.com
From: newscientist
Subject: Species at risk of extinction growing
Date: Tue, 08 Oct 2002 08:01:21 -0000
Content-Type: text/plain; encoding=utf-8
X-Spam-Status: No, hits=-1014.1 required=5.0
        tests=AWL,T_NONSENSE_FROM_40_50
        version=2.50-cvs
X-Spam-Level:

URL: http://www.newsisfree.com/click/-2,8653742,1440/
Date: Not supplied

The latest "Red List" adds 124 to the 11,000 endangered species around the
globe - but also includes a stick insect revival
```

```
Subject: Species at risk of extinction growing


The latest "Red List" adds 124 to the 11,000 endangered species around the
globe - but also includes a stick insect revival
```

Subject Line vs Email Body

Subject Line:
- We expect 'dense' information about the nature of the email

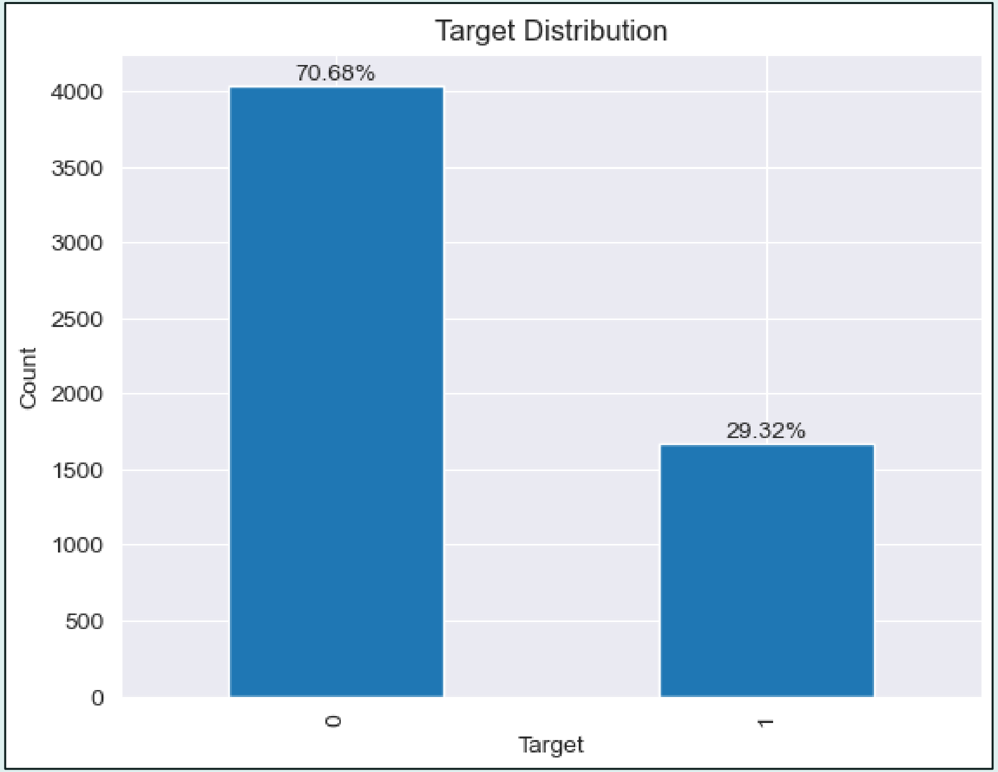
Email Body:
- More information about the nature of the email, more verbose

```
Subject: Species at risk of extinction growing


The latest "Red List" adds 124 to the 11,000 endangered species around the
globe - but also includes a stick insect revival
```

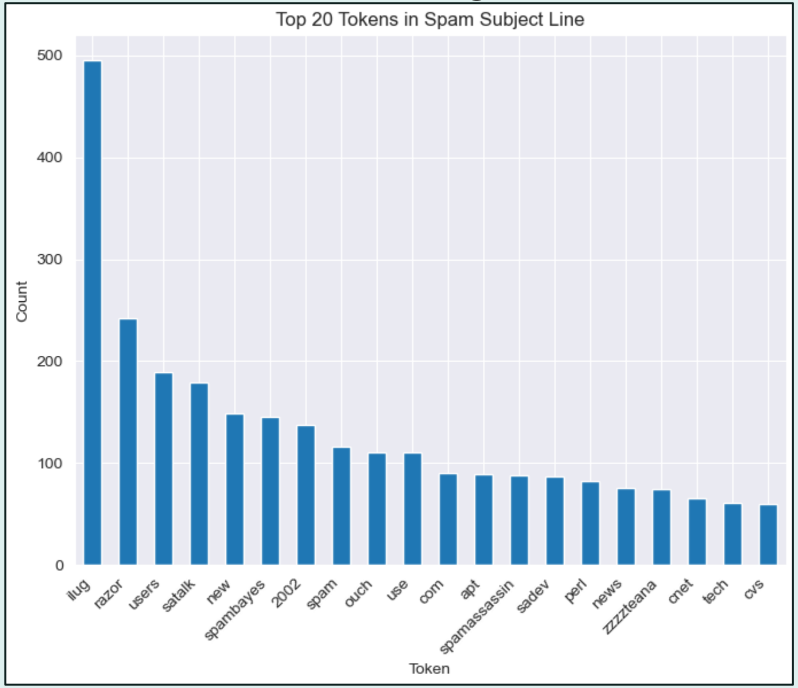
- Modeling the Subject and Body separately…

Target Distribution Imbalance



Subject Line EDA – Ham Class

Token Histogram

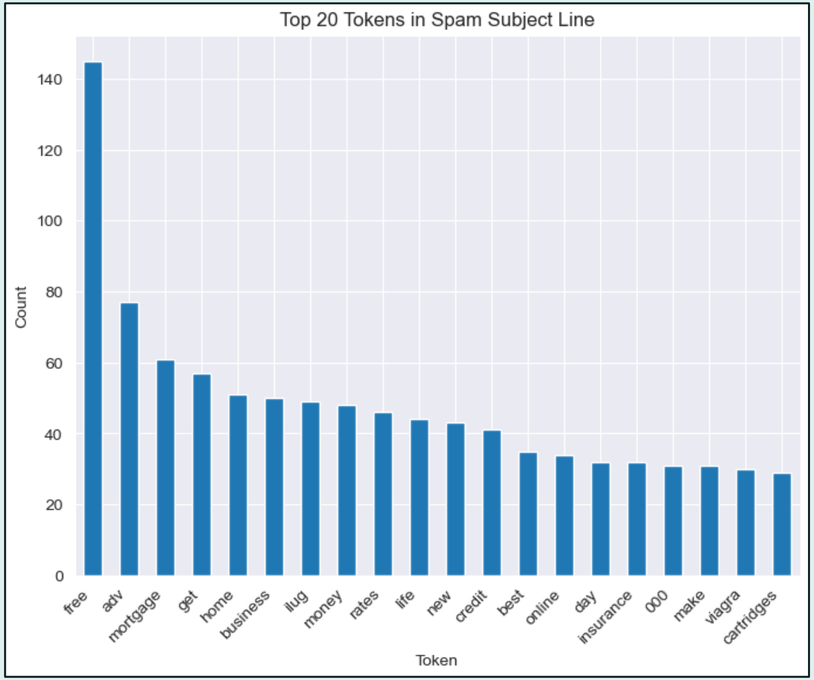


Word Cloud Top 100

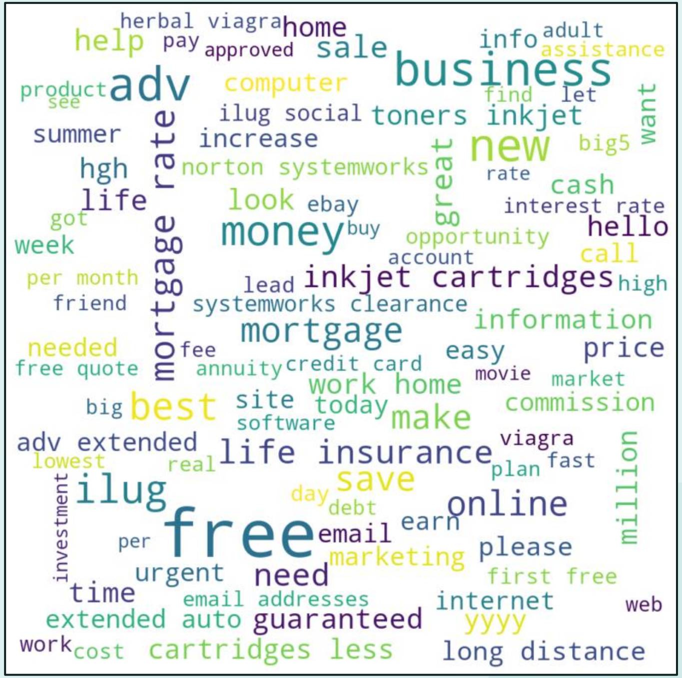
Note: Models are built on company internal ‘jargonized’ email data, will need to adjust models trained on anonymized customer emails data after deployment

Subject Line EDA – Spam Class

Token Histogram



Word Cloud Top 100



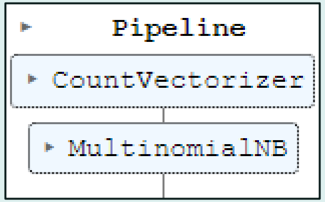
03 Predictive Modeling

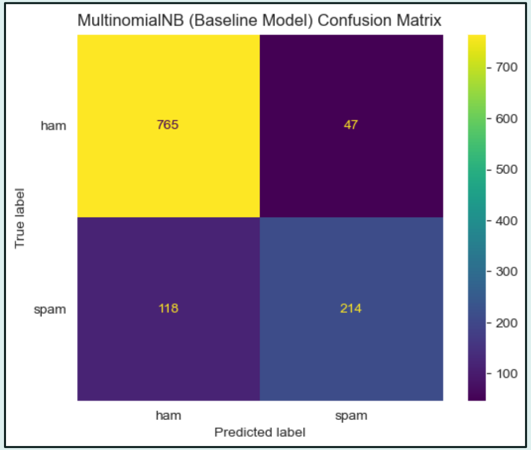
BUSINESS REQUIREMENT:

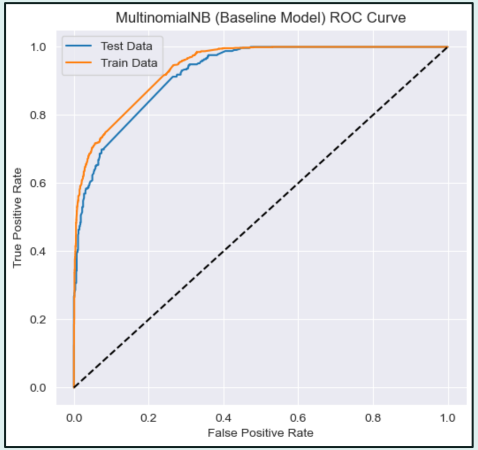
- Getting SPAM in the inbox irritates our customers, but missing an important message because we classified it as SPAM will really anger them!
- Optimizing models on **Precision (minimize False-Pos)**, then **Accuracy**
- Less than 1% of customers HAM emails are allowed to go to the SPAM classification

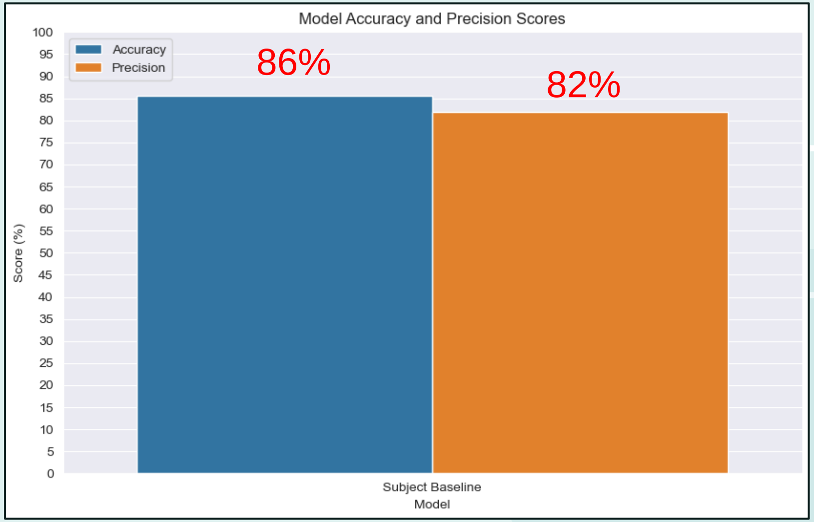
Subject Line Baseline Model

- Regex tokenizer of >2 characters
- Binary vectorizer
- Multinomial Bayes Classifier



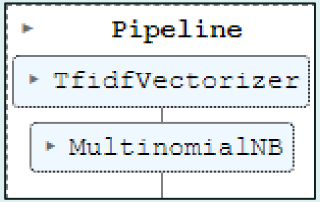


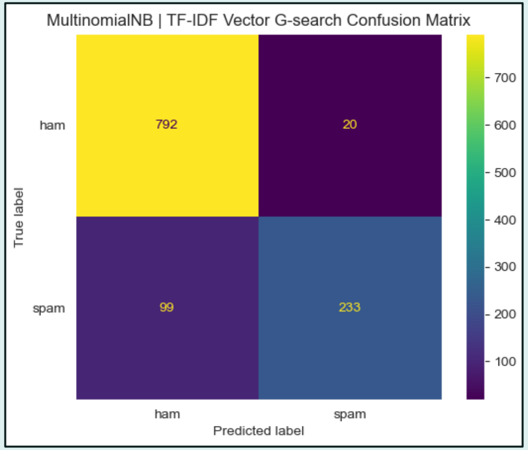


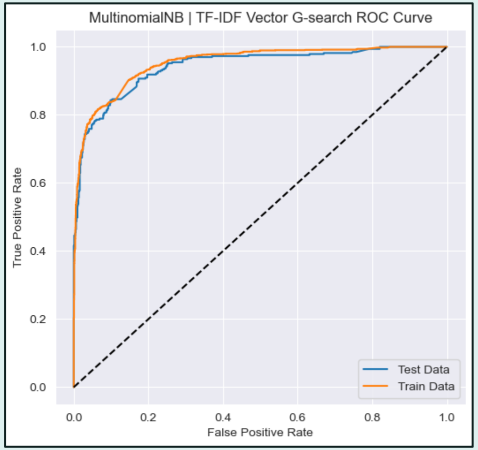


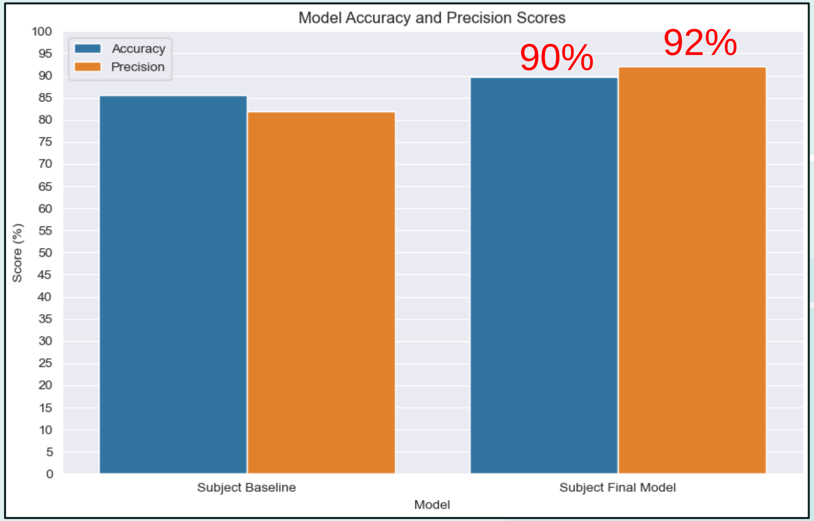
Subject Line Final Model

- Word_punct_tokenizer
- TFIDF vectorizer
- Multinomial Bayes Classifier

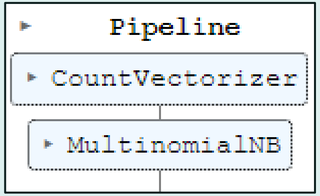




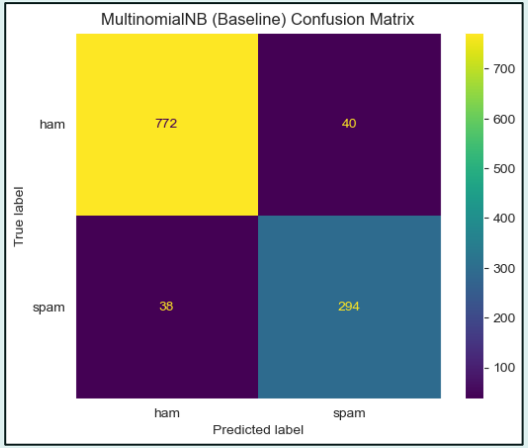


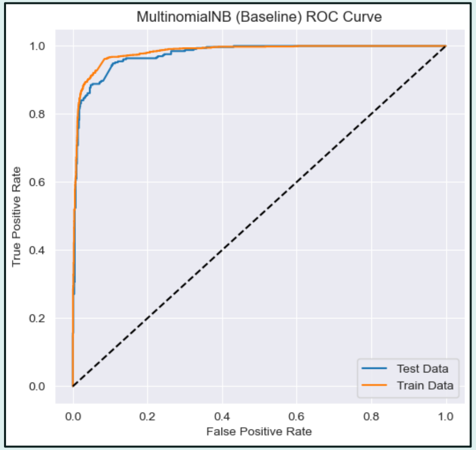


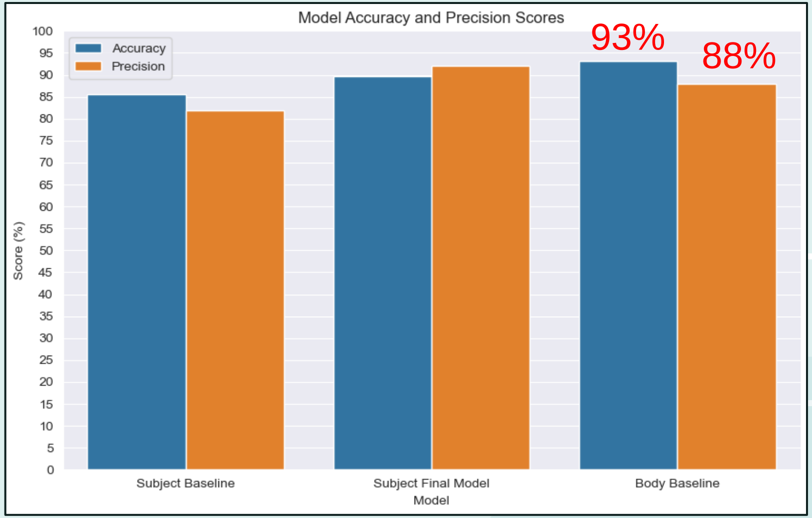
Email Body Baseline Model



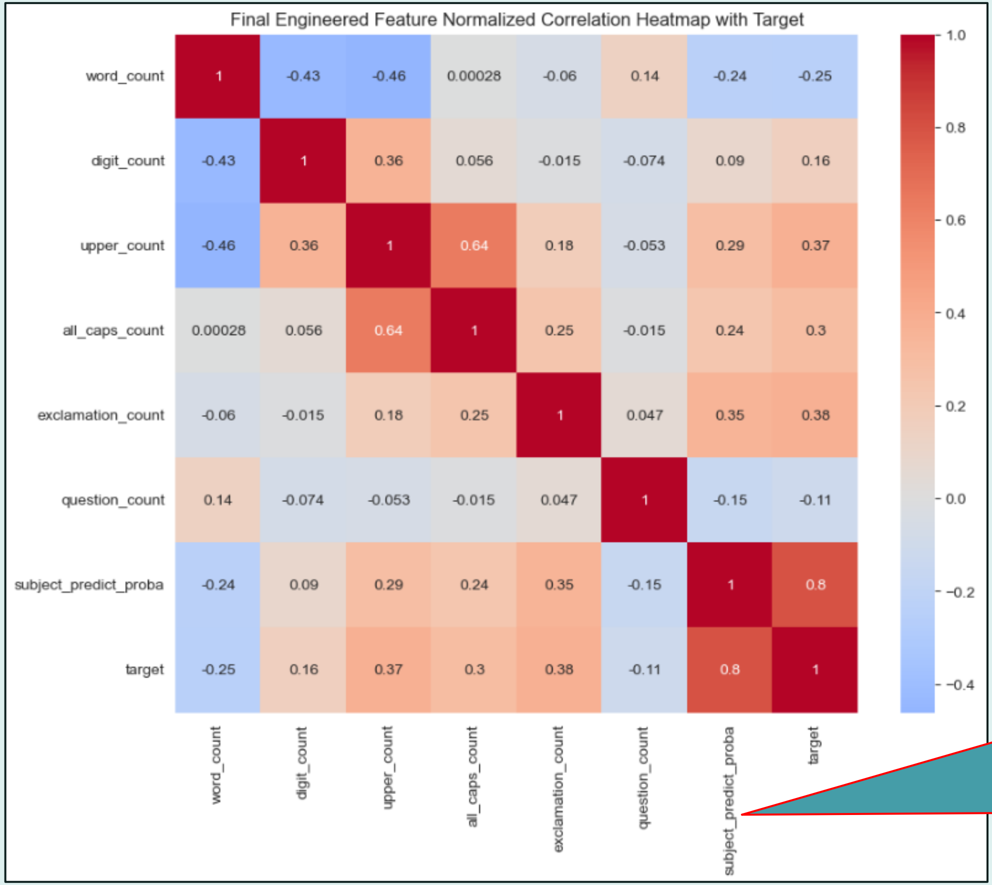
- Regex tokenizer of >2 characters
- Binary vectorizer
- Multinomial Bayes Classifier



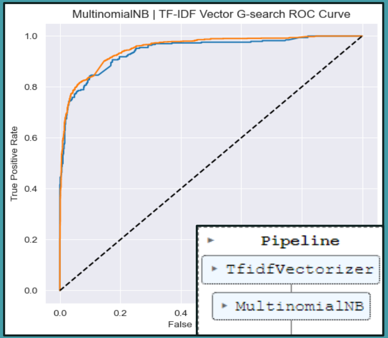




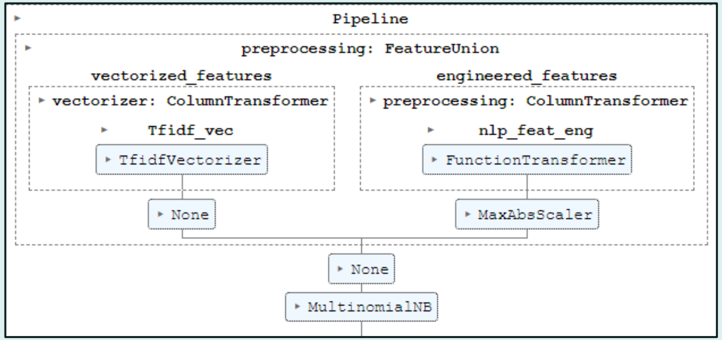
Email Body Feature Engineering



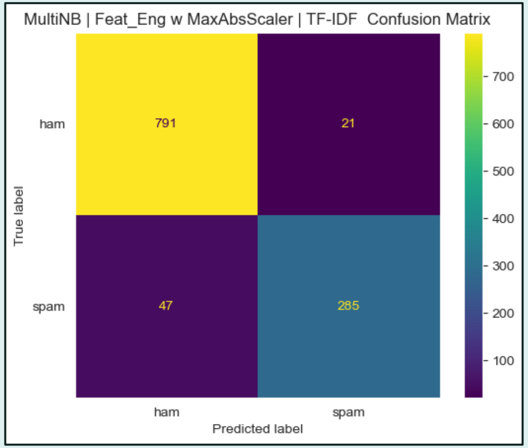
SUBJECT LINE PREDICTIONS

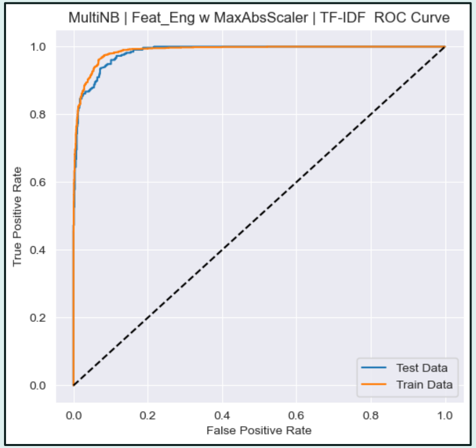


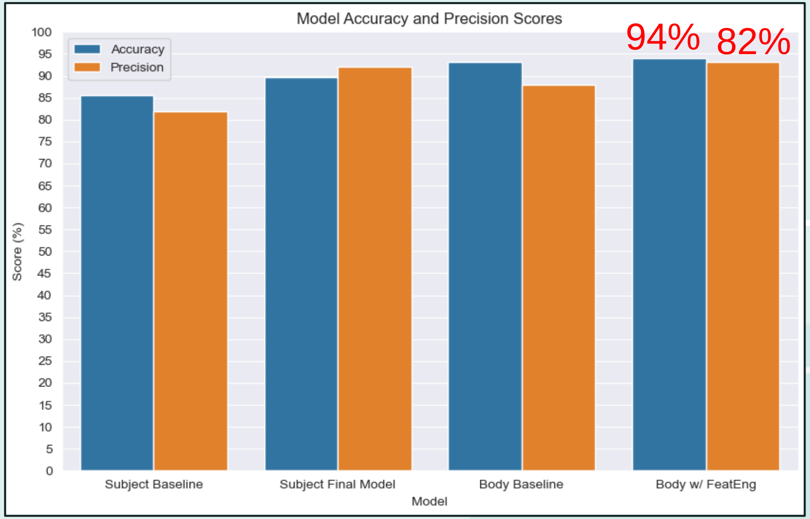
Email Body With Feature Engineering



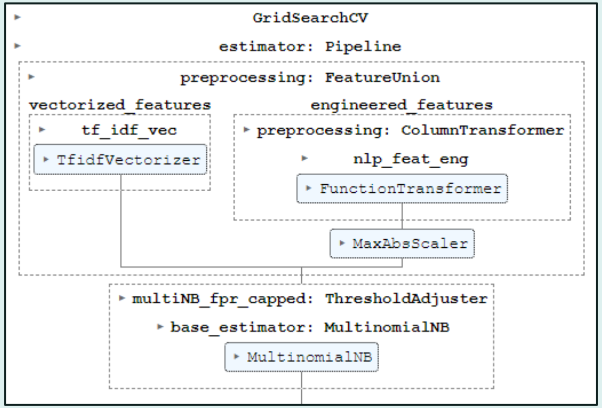
- Regex tokenizer of >2 characters
- TF-IDF vectorizer
- Multinomial Bayes Classifier



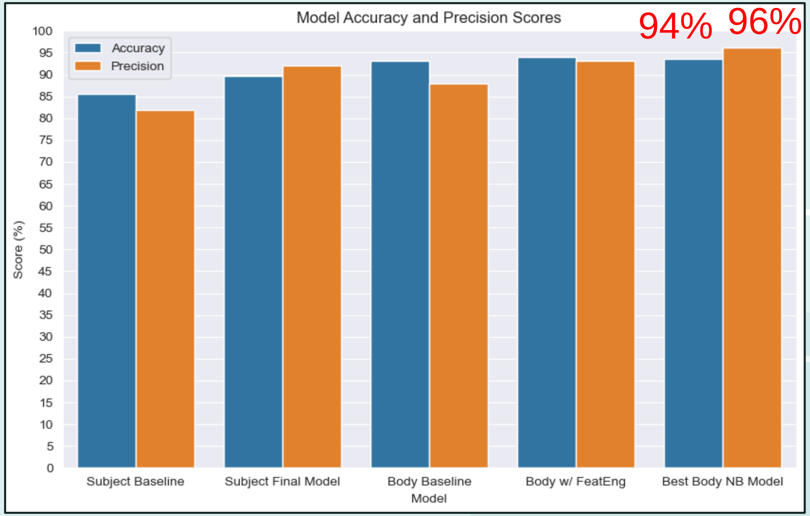


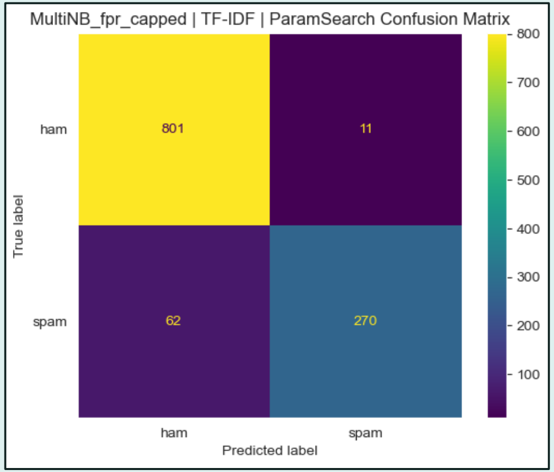


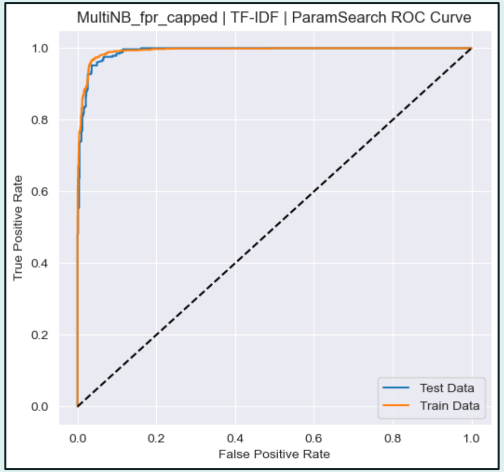
Email Body – Best Naive Bayes Model



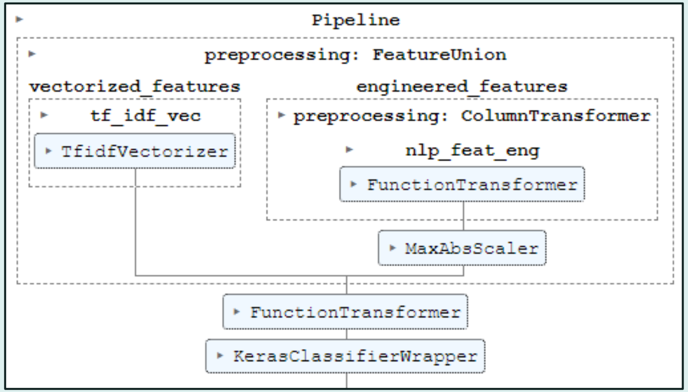
- Hyperparameter Gridsearch
- NB Model wrapped in Prob Threshold Adjuster (<1% FPR)



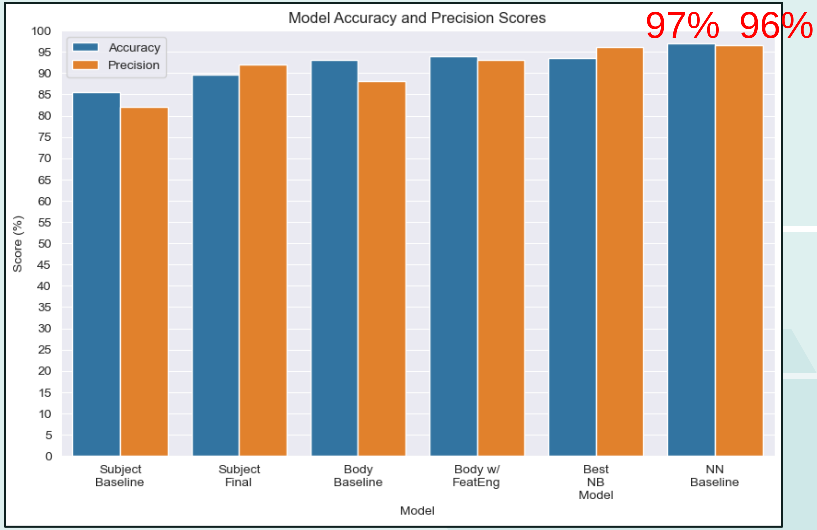


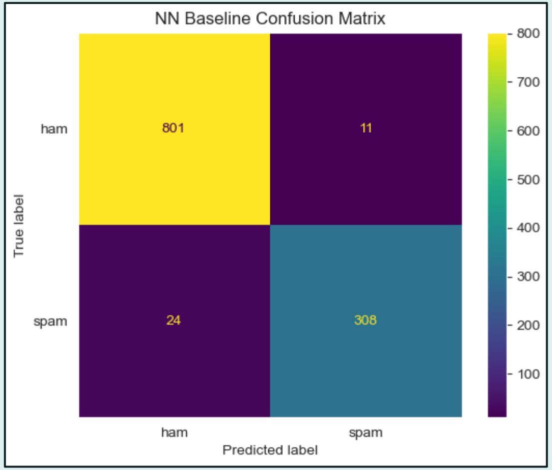


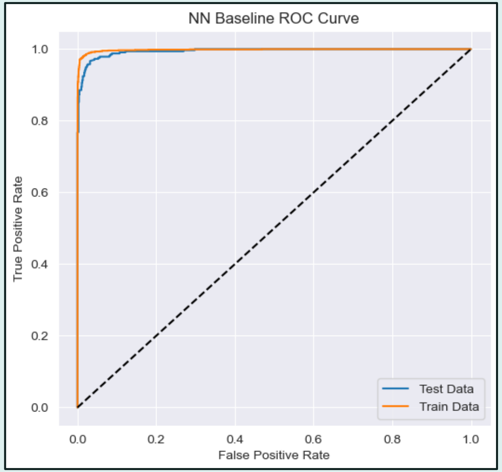
Email Body – Neural Network Baseline



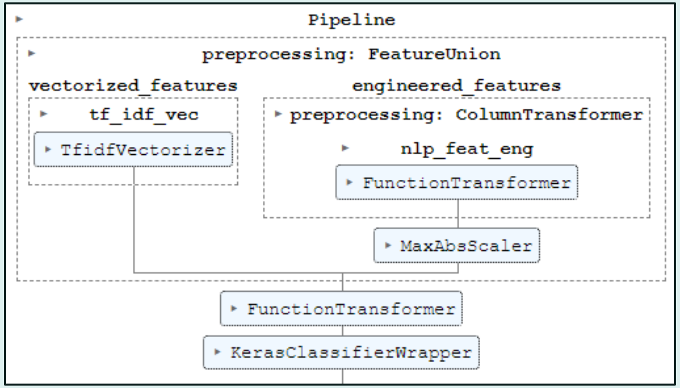
- One hidden layer
- Threshold Adjusted (<1% FPR)



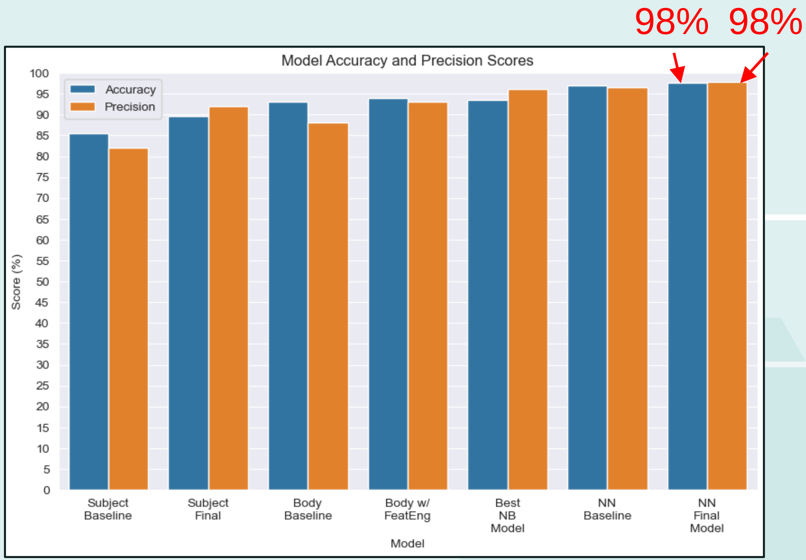


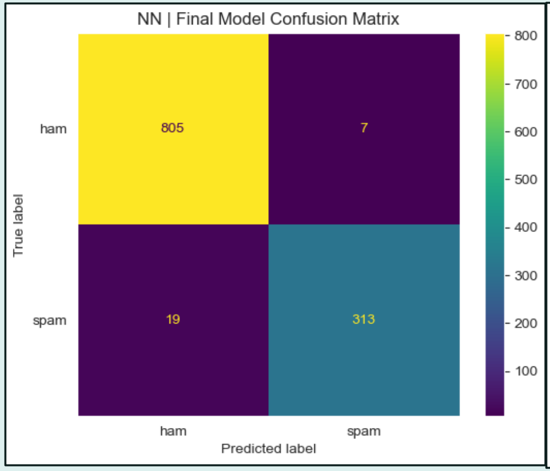


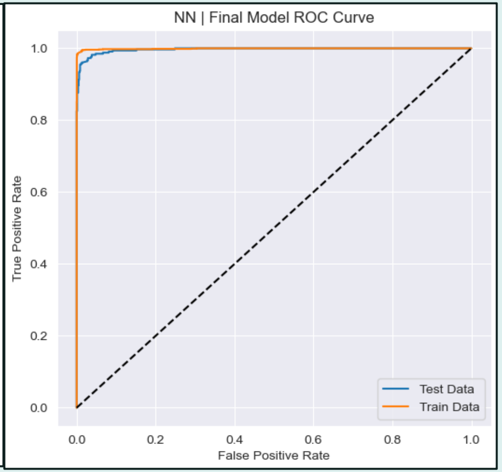
Email Body – Neural Network Final



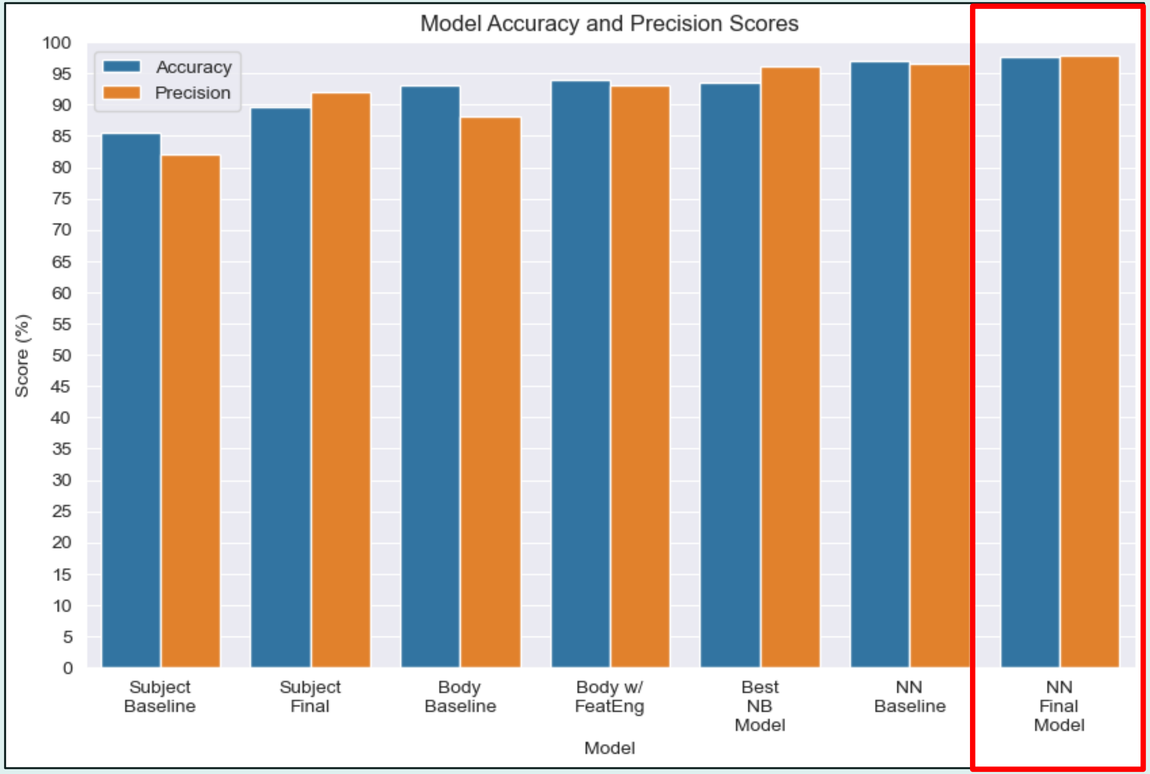
- 5 hidden layers
- 2 dropout layers
- Gridsearch using Hyperband()
- Threshold Adjusted (<1% FPR)







04 Conclusion



Final Model Test Metrics:

- Precision: **97.7%**
- Accuracy: **97.8%**

Final Business Metrics:

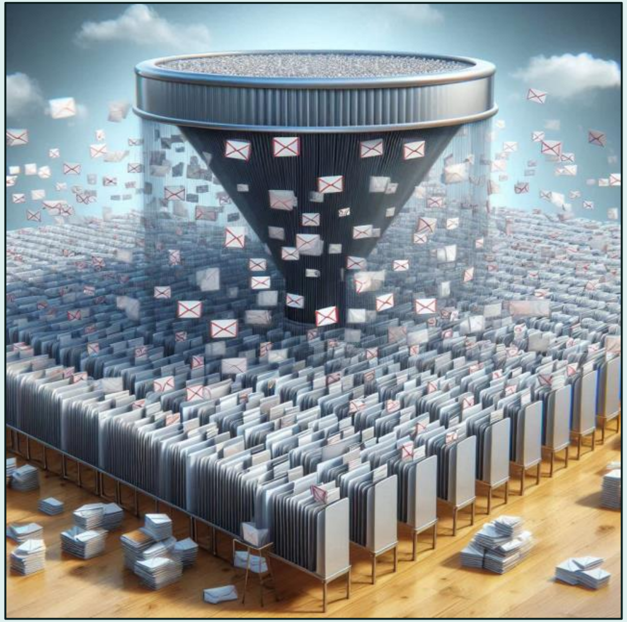
- False Pos Rate (HAM going to SPAM): **0.9%**
- False Neg Rate (SPAM going to HAM): **6%**

05 Recommendation

1. Implement the best Neural Network model during initial Email service rollout

2. Continue to retrain and retune the models on new anonymized customer data

3. Investigate other potential model improvements (see next steps)



06 Next Steps

1. Continue to improve the model
    1. Rerun and tune the models with the ‘Cheat words’ removed
    2. Investigate tokenizing based on wordcloud algorithm
    3. Check other model architectures (RandomForest, XGBoost)
    4. Tune NN for subject-line only, perhaps effective and more efficient
    5. Investigate verbiage and nature of SPAM, are there features we can capture
    6. Investigate the False cases; are there features we can capture
    7. Investigate keeping URLs instead of scrubbing them preprocess

2. Acquire larger data sets of up-to-date emails

Thanks!

Questions? Please contact me at:

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