Prediction on the rating of fine food and evaluation for the helpfulness of review based on the Amazon Fine Food Review

Capstone Project by Liyan Cen

The problem & who might care?

Customer reviews is an important part of the Amazon shopping experience. It is so far the major reference and indicator for Amazon to evaluate the quality of their products, and the performance of their sellers.

Additionally, it is a great tool for customers to compare between products. Amazon always tend to place the most helpful reviews at the first place of the list as a reference for customers, and also as a standard for reviewers to follow. The company carefully considers any changes to the ratings and review system to ensure customers and sellers continue to trust it.

Data Information

This dataset consists of reviews of fine foods from amazon. The data span a period of more than 10 years, including all ~500,000 reviews up to October 2012. Reviews include product and user information, ratings, and a plain text review.

Data Cleaning

- This dataset consists of reviews of fine foods from amazon. The data span a period of more than 10 years, including all ~500,000 reviews up to October 2012. Reviews include product and user information, ratings, and a plain text review.

- Because there is memory limitation of our CPU, we first cross out the “HelpfulnessDenominator” value that is smaller than 10. Also, we cross out all rows which has null values, and make sure there is no duplicate contents. As a result, the length of data changes from 568,454 to 21,463.

Data Cleaning - Continued

- In order to make prediction models with better performance along with less noises or outliers, we first reprocess the text to make our feature set more correlated with the target variable. By doing that, we create a function called “normalize_corpus” to remove punctuations, digits, html tags, accented characters, special characters,and stop words. At the same time, we lower all strings of each text.

Data Cleaning - Continued

- For both the classification and regression models, we use text as our feature set by converting each word from each text into numerators by “TfidfVectorizer”. Frequent words across all documents may tend to overshadow other terms in the feature set. The TF-IDF model is functioned to solve this issue by using a scaling or normalizing factor in its computation.

Data Wrangling and Cleaning - “Ratings vs. Reviews”

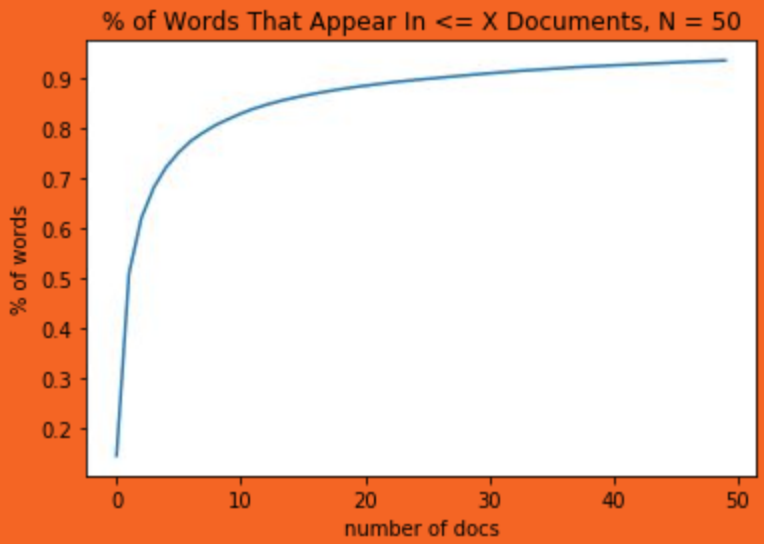
For this section, we use text feature as our feature set, and score as our target variable. Classification models are used because our model predicts and classifies reviews into a score ranging from 1 to 5.

Data Wrangling and Cleaning - “Helpfulness vs. Reviews”

For this section, we use text feature as our feature set, and “Helpful” as our target variable. We get “Helpfulness ratio” by having “HelpfulnessNumerator” divided by “HelpfulnessDenominator”. Classification models are used because our model predicts and classifies reviews into either “0” or “1”, while ratio greater than the mean will be equal to “1”, and less than the mean will be equal to “0”.

Data Exploration

Based on the graph, we can see that around 70% of the text features appeared in about 4 or 5 documents, so we set our min_df to be “5”, which means we cut off the words that occur in 5 documents or less.



Modeling

We use supervised learning algorithms to build predictive models, and find out the best model based on their performance, specifically regarding to each Accuracy and Precision on testing sets. As we mentioned earlier, we will have the cleaned and vectorized “reviews” as our feature set, and the “ score” and “Helpful” as our predictors. We perform Logistics regression, Naives Bayes, LinearSVC, Random Forests,Gradient Boosting and SGDClassifier as our models, and compare accuracy for each to figure out the best model, and parameter.

Ratings vs. Reviews - Naive Bayes

By referring to the data above, we can tell that the model does not perform very well, this might be caused by the oversimplified assumption.

Accuracy on training set: 0.6767744085304899
Accuracy on testing set: 0.6559390547263682

```
Model Performance metrics:
------------------------------
Accuracy: 0.6559
Precision: 0.7426
Recall: 0.6559
F1 Score: 0.5752

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          1       0.76      0.63      0.69      1873
          2       0.92      0.05      0.09       474
          3       1.00      0.00      0.00       480
          4       1.00      0.03      0.07       534
          5       0.62      0.97      0.76      3071

avg / total       0.74      0.66      0.58      6432


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   1   2  3   4     5
Actual: 1       1189   0  0   0   684
        2        138  22  0   0   314
        3        115   0  1   0   364
        4         39   0  0  18   477
        5         80   2  0   0  2989
```

Ratings vs. Reviews - Logistic Regression

Accuracy on training set: 0.87350883038987
Accuracy on testing set: 0.7184390547263682

By referring to the data above, we can tell that the model performs pretty well, especially for score 1 and score 5. Comparatively, score 2,3, and 4 do not perform as well as the other ones; this might be caused by the fact we do not have as many reviews with score 2 to 4 as we have for score 1 and 5 from our dataset.

Model Performance metrics:

Accuracy: 0.7184
Precision: 0.7222
Recall: 0.7184
F1 Score: 0.7199

Model Classification report:
----

	precision	recall	f1-score	support
1	0.75	0.79	0.77	1815
2	0.44	0.43	0.43	502
3	0.43	0.43	0.43	494
4	0.40	0.42	0.41	524
5	0.86	0.82	0.84	3097
avg / total	0.72	0.72	0.72	6432

Prediction Confusion Matrix:

	Predicted: 1	2	3	4	5
Actual: 1	1432	117	88	64	114
2	144	215	55	31	57
3	102	55	214	52	71
4	39	31	51	220	183
5	203	73	93	188	2540

Ratings vs. Reviews - LinearSVC

Accuracy on training set: 0.9538820393202266
Accuracy on testing set: 0.7580845771144279

Given the fact that this project is to predict on text classification, the feature sets and the target variables may not be linearly related. Also, due to the large amount of unique words in the dataset, 44,755 features in specific, we choose to perform SVC models, one of models in SVM, with a non-linear kernel, RBF.

By referring to the data above, we can tell that the LinearSVC model performs pretty well, and actually a little bit better than logistic regression.

Model Performance metrics:

Accuracy: 0.7581
Precision: 0.7424
Recall: 0.7581
F1 Score: 0.7424

Model Classification report:
----

	precision	recall	f1-score	support
1	0.74	0.83	0.79	1815
2	0.64	0.38	0.48	502
3	0.61	0.40	0.48	494
4	0.56	0.36	0.44	524
5	0.81	0.90	0.85	3097
avg / total	0.74	0.76	0.74	6432

Prediction Confusion Matrix:

	Predicted: 1	2	3	4	5
Actual: 1	1508	48	39	24	196
2	172	193	32	19	86
3	117	24	196	32	125
4	50	17	17	189	251
5	179	18	37	73	2790

Ratings vs. Reviews - SGDClassifier

While Logistics Regression and Support Vector Machines have a disadvantage of discriminating linear classifiers under convex loss functions, we try out SGDClassifier model to compensate this issue.

Based on the Accuracy and Precision on the testing set, this model performs just as well as LinearSVC.

Accuracy on training set: 0.8421859380206598
Accuracy on testing set: 0.755907960199005

```
Model Performance metrics:
------------------------------
Accuracy: 0.7559
Precision: 0.7512
Recall: 0.7559
F1 Score: 0.7207

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          1       0.74      0.84      0.79      1791
          2       0.74      0.29      0.42       456
          3       0.82      0.26      0.39       468
          4       0.64      0.20      0.30       536
          5       0.77      0.94      0.85      3181

avg / total       0.75      0.76      0.72      6432


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   1    2    3    4     5
Actual: 1       1508   14    7    4   258
        2        194  132   10   12   108
        3        124   13  120   23   188
        4         63   11    5  106   351
        5        152    9    4   20  2996
```

Ratings vs. Reviews - Decision Tree

Based on the “Accuracy on testing set” above, we can tell that the Decision Tree model does not perform as well as the other ones. This might be due to the nature of decision tree model, which it tends to make the most optimal decision at each step, instead of taking into account the global optimum. The other reason may also be that decision tree trains data based on the results of the last training data.

Accuracy on training set: 1.0
Accuracy on testing set: 0.6731965174129353

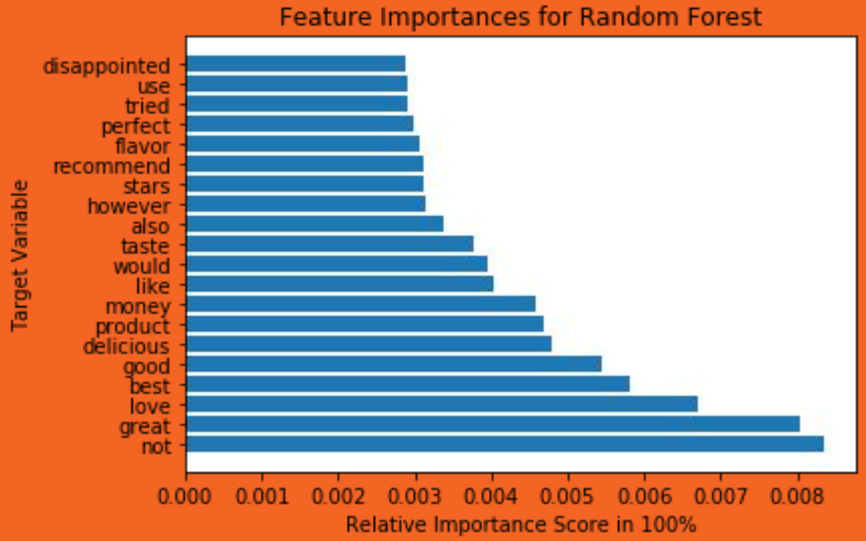
```
Model Performance metrics:
------------------------------
Accuracy: 0.6732
Precision: 0.6614
Recall: 0.6732
F1 Score: 0.6658

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          1       0.68      0.70      0.69      1815
          2       0.47      0.39      0.43       502
          3       0.47      0.38      0.42       494
          4       0.44      0.36      0.40       524
          5       0.75      0.80      0.78      3097

avg / total       0.66      0.67      0.67      6432


Prediction Confusion Matrix:
------------------------------
          Predicted:
                 1    2    3    4     5
Actual: 1     1265   88   62   45   355
        2      120  195   35   19   133
        3      103   36  186   31   138
        4       80   15   30  191   208
        5      289   79   84  152  2493
```

Ratings vs. Reviews - Random Forests

Based on the top 20 feature importances listed above, we get a sense of which word variables have the most effect in our models. As we can tell, the model performs pretty well because all the words listed above are the common words we see and use in reviews.

Also, by referring to the accuracy, we can tell the this model performs pretty well, and is actually the third best model of all besides LinearSVC and SGDClassifier. Additionally, score 2,3, and 4 perform well in this model.

Accuracy on training set: 0.9910696434521826
Accuracy on testing set: 0.7391169154228856

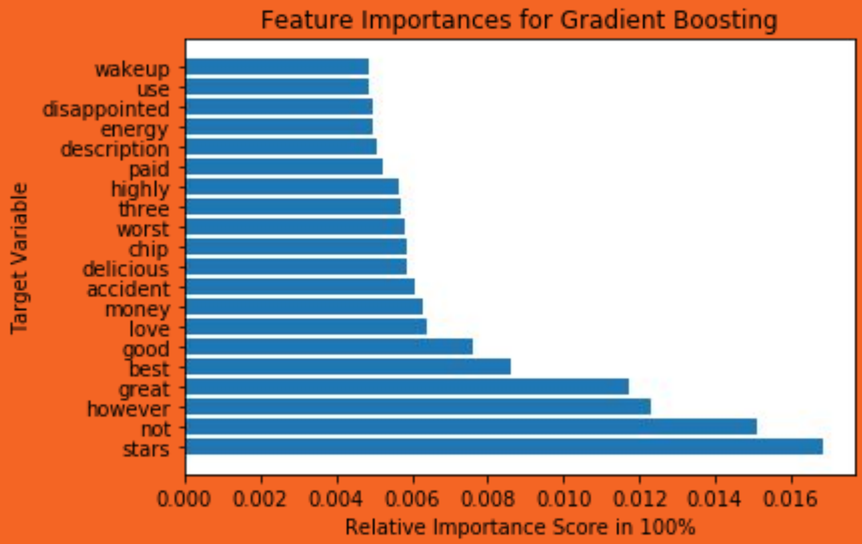


Ratings vs. Reviews - Gradient Boosting

Even though Random Forests performs well on this dataset, it does have its limitations like the features were chosen randomly with replacement. Hence, we try out another popular decision tree model, Gradient Boosting, to fix this issue by training on data instances that had been modeled poorly in the overall system before.

According to the output, Gradient Boosting does not perform as well as Random Forests. This might be due to the fact that Gradient Boosting' training is based on last training result whereas Random Forests is trained independently from the rest.

Accuracy on training set: 0.738487170943019
Accuracy on testing set: 0.6906094527363185



Ratings vs. Reviews - Hyperparameter tuning for the best parameter

Accuracy on training set: 1.0
Accuracy on testing set: 0.7657027363184079

Based on all the models listed above, it turns out that the Random Forest, SGDClassifier, and LinearSVC give us the best results. In order to re-confirm which model is the best for our dataset, we use grid search to figure out the best hyperparameter by performing each model one more time.

By referring to the output for each model, it turns out that the Random Forest gives us the best parameter.

```
Model Performance metrics:
------------------------------
Accuracy: 0.7657
Precision: 0.811
Recall: 0.7657
F1 Score: 0.7385

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          1       0.81      0.78      0.79      1873
          2       1.00      0.35      0.52       474
          3       1.00      0.31      0.48       480
          4       1.00      0.30      0.46       534
          5       0.72      0.97      0.83      3071

avg / total       0.81      0.77      0.74      6432


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   1    2    3    4     5
Actual: 1       1456    0    0    0   417
        2        120  165    0    0   189
        3        102    0  151    0   227
        4         37    0    0  161   336
        5         79    0    0    0  2992
```

Helpful vs. Reviews

Naive Bayes

Accuracy on training set: 0.7872736954206603
Accuracy on testing set: 0.7605218201584097

```
Model Performance metrics:
------------------------------
Accuracy: 0.7605
Precision: 0.78
Recall: 0.7605
F1 Score: 0.7184

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          0       0.85      0.30      0.44      2032
          1       0.75      0.98      0.85      4407

avg / total       0.78      0.76      0.72      6439


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   0     1
Actual: 0        600  1432
        1        110  4297
```

Logistic Regression

Accuracy on training set: 0.86395101171459
Accuracy on testing set: 0.8024537971734741

```
Model Performance metrics:
------------------------------
Accuracy: 0.8025
Precision: 0.8148
Recall: 0.8025
F1 Score: 0.8062

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          0       0.66      0.77      0.71      2032
          1       0.89      0.82      0.85      4407

avg / total       0.81      0.80      0.81      6439


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   0     1
Actual: 0       1571   461
        1        811  3596
```

Helpful vs. Reviews

LinearSVC

Accuracy on training set: 0.9959398296059638
Accuracy on testing set: 0.8141015685665476

```
Model Performance metrics:
------------------------------
Accuracy: 0.8141
Precision: 0.8152
Recall: 0.8141
F1 Score: 0.8146

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          0       0.70      0.72      0.71      2032
          1       0.87      0.86      0.86      4407

avg / total       0.82      0.81      0.81      6439


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   0     1
Actual: 0       1455   577
        1        620  3787
```

SGDClassifier

Accuracy on training set: 0.889310436634717 8
Accuracy on testing set: 0.8276129833825128

```
Model Performance metrics:
------------------------------
Accuracy: 0.8276
Precision: 0.8239
Recall: 0.8276
F1 Score: 0.8218

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          0       0.78      0.63      0.70      2032
          1       0.84      0.92      0.88      4407

avg / total       0.82      0.83      0.82      6439


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   0     1
Actual: 0       1273   759
        1        351  4056
```

Helpful vs. Reviews

Decision Tree

Tree One, Accuracy on training set: 0.9987353567
Tree One, Accuracy on testing set: 0.7808665941

Tree Two, Accuracy on training set: 0.68450479
Tree Two, on testing set: 0.6903245845628203

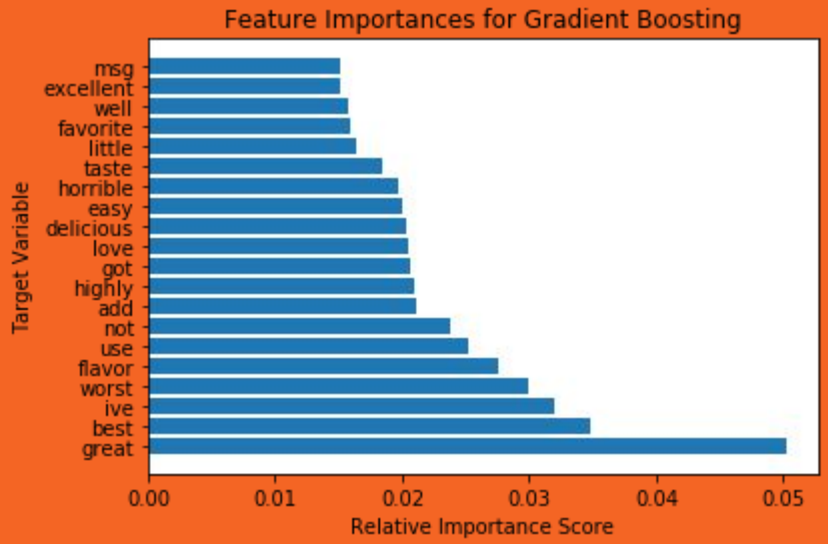
```
Model Performance metrics:
------------------------------
Accuracy: 0.7809
Precision: 0.7812
Recall: 0.7809
F1 Score: 0.781

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          0       0.65      0.66      0.65      2032
          1       0.84      0.84      0.84      4407

avg / total       0.78      0.78      0.78      6439


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   0     1
Actual: 0       1332   700
        1        711  3696
```

```
Model Performance metrics:
------------------------------
Accuracy: 0.6903
Precision: 0.713
Recall: 0.6903
F1 Score: 0.5743

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          0       0.76      0.03      0.05      2032
          1       0.69      1.00      0.81      4407

avg / total       0.71      0.69      0.57      6439


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   0     1
Actual: 0         55  1977
        1         17  4390
```

Helpful vs. Reviews

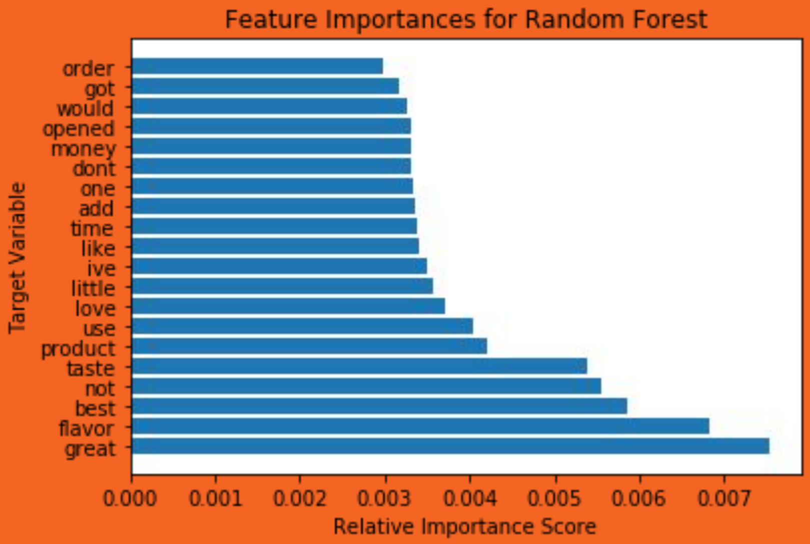
Gradient Boosting

Accuracy on training set: 0.7279685835995741
Accuracy on testing set: 0.7261997204534866



Random Forests

Accuracy on training set: 0.9932774227902024
Accuracy on testing set: 0.8120826215250815



Helpful vs. Reviews - Hyperparameter tuning for the best parameter

Accuracy on training set: 0.9987353567625133
Accuracy on testing set: 0.8350675570740799

Based on all the models listed above, it turns out that the Random Forest, SGDClassifier, Logistic Regression and LinearSVC give us the best results. In order to re-confirm which model is the best for our dataset, we use grid search to figure out the best hyperparameter by performing each model one more time.

By referring to the output for each model, it turns out that the Random Forest gives us the best parameter.

```
Model Performance metrics:
------------------------------
Accuracy: 0.8351
Precision: 0.8375
Recall: 0.8351
F1 Score: 0.8248

Model Classification report:
------------------------------
             precision    recall  f1-score   support

          0       0.85      0.58      0.69      2032
          1       0.83      0.95      0.89      4407

avg / total       0.84      0.84      0.82      6439


Prediction Confusion Matrix:
------------------------------
          Predicted:
                   0     1
Actual: 0       1171   861
        1        201  4206
```

Limitations

We lack the knowledge of the major market for each category of fine food. In other words, the reviewers are not narrowed down in ages, jobs, or other backgrounds. Hence, the degree of helpfulness could be somewhat biased.

While positive reviews are helping Amazon and sellers generating more profits, fake reviews could be a concern that hurt their reputations. For example, a Washington Post examination found that for some popular product categories, such as Bluetooth headphones and speakers, the vast majority of reviews appear to violate Amazon's prohibition on paid reviews. Such reviews have certain characteristics, such as repetitive wording that people probably cut and paste in. Regarding to this issue, we lack the knowledge of whether the review is from a verified user.

Conclusions

For both sections, the RandomForestRegressor gives us the best R^2 value among all the models we have performed. Also, it give us the best hyperparameter and model.