

## Enron Submission Free-Response Questions

1. Summarize for us the goal of this project and how machine learning is useful in trying to accomplish it.

For this project, we utilize machine learning skills to choose the best algorithm to identify Enron employees who may have been involved or have vital information regarding Enron fraud based on the public Enron financial and email datasets.

The approach to arrive at a best model include:

- handling real-world dataset: Since such dataset tends to be imperfect, we may have to clean and remove the data plus make some assumptions about the data inadequacies;
- validating machine learning results using test data;
- evaluating machine learning result using quantitative metrics such as accuracy, precision, and recall scores;
- dealing with features: This includes creating, selecting, and transforming variables;
- comparing the performance of various machine learning algorithms
- fine tuning machine learning algorithms for maximum performance; and
- communicating machine learning algorithm results clearly.

We ended up removing three observations:

- TOTAL: The last line of the data table that sums up all variables.
  - THE TRAVEL AGENCY IN THE PARK: Not a person.
  - LOCKHART EUGENE E: Have 'NaN' values for all features.
2. What features did you end up using in your POI identifier, and what selection process did you use to pick them? Did you have to do any scaling? Why or why not? As part of the assignment, you should attempt to engineer your own feature that does not come ready-made in the dataset -- explain what feature you tried to make, and the rationale behind it.

I ended up using three features: exercised stock options, bonus, and salary based on K-Best algorithm and its scores. They were selected based on the SelectKBest scores, which were higher than the rest. Their selection also made sense, i.e. persons who were involved in the scandal directly may have very high values of these financial numbers. Total stock value actually had a high SelectKBest scores too but we decided to not use it because exercised stock options had a slightly high SelectKBest score and exercised stock options is a component of total stock value. My SelectKBest scores:

- exercised\_stock\_options: 24.8,
- total\_stock\_value, 24.2,
- bonus, 20.8,
- salary: 18.3,

- deferred\_income: 11.5,
- long\_term\_incentive: 9.9, and
- restricted\_stock, 9.2.

Yes, I utilized a *MinMaxScaler()* scaling in my Support Vector Machine (SVM) algorithm. After playing around with the parameters in SVM, I didn't find any solid results. So, I toyed around with scaling. My rationale was that stocks, bonus, and salary are be on a different scale and their outliers may have different magnitudes. For instance, being cumulative based on number of years with the company, stocks may be very small or very big compared to annual salary and bonus.

3. What algorithm did you end up using? What other one(s) did you try? How did model performance differ between algorithms?

I ended up with a Decision Tree Classifier algorithm with the following parameters:

- min\_samples\_leaf=1,
- min\_samples\_split=2,
- criterion='gini',
- splitter='random', and
- max\_leaf\_nodes=30.

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=10,
                        max_features=None, max_leaf_nodes=10, min_impurity_split=1e-07,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False, random_state=None,
                        splitter='best')
```

Accuracy: 0.81738	Precision: 0.38789	Recall: 0.32350
F1: 0.35278	F2: 0.33461	

Total predictions: 13000	True positives: 647	False positives: 1021
False negatives: 1353	True negatives: 9979	

The other ones that I tried were Naive Bayes (NB) and Support Vector Machine (SVM) algorithms. NB actually performed quite well for an algorithm that seemed to me very rigid – because researchers can't alter the parameters. In fact, NB performed slightly better for many of the performance metrics such as Accuracy (0.84 vs. 0.82 for Decision Tree Classifier).

4. What does it mean to tune the parameters of an algorithm, and what can happen if you don't do this well? How did you tune the parameters of your particular algorithm? What parameters did you tune?

Tuning the parameters means changing the model specifications to enhance a model's performance which includes, accuracy, precision, recall, and predictive strength. If we didn't do well with the parameter tuning, we may have to wait for a very long time for the fitting to be completed (e.g. a *linear* kernel in SVM) and overfitting that the estimated algorithm does well for the train data but poor with the test data.

For parameter tuning, we did extra research on the algorithm and asked questions on whether it makes sense for us to touch certain parameters. We did not go into depth on each algorithm's parameters in the class, though, the instructors encouraged us to be smart researchers by doing our own research on each algorithm parameters. Since this is our first experience with Machine Learning, we applied maximum likelihood approach to parameter tuning. After researching on the plausible and range for these parameters, we further altered the parameter value selection if the best parameters chosen had the lowest or highest value of the ones we considered. For instance, if we had if  $C = 10$  was the parameter for the best SVM model based on these  $C$  values ' $svm\_C$ ':  $[0.001, 0.1, 1, 10]$ , I would go with higher  $C$  values until the best model's  $C$  is not the highest one in the  $C$  array.

5. What is validation, and what's a classic mistake you can make if you do it wrong? How did you validate your analysis?

Validation is the process of analyzing algorithm performance with the test data. The most common mistake is overfitting where the algorithm works great with the train data but poor with the remaining data. We have noticed that the precision and recall metrics based on confusion metrics changed as we altered the *test\_size* percentage.

In the project, we run the `tester.py` algorithm to validate our findings. The *test\_classifier* function indicates that the performance metrics were calculated based on 1,000 runs with randomized train-test subsamples – all using the same Enron dataset.

6. Give at least 2 evaluation metrics and your average performance for each of them. Explain an interpretation of your metrics that says something human-understandable about your algorithm's performance. [relevant rubric item: "usage of evaluation metrics"]

	Accuracy	Precision	Recall	F1
<b>Gaussian Naive Bayes</b>	0.84277	0.48281	0.3090	0.37683
<b>SVM</b>	0.85485	0.63420	0.1335	0.22057
<b>Decision Tree Classifier</b>	0.81738	0.38789	0.3235	0.35278

Table: Algorithms Tested and Their Best Tuned Model

Definitions:

Accuracy: number of observations correctly predicted as POI or non-POI / number of all observations in the dataset

Precision = number of observations correctly predicted as POI / number of predicted POI observations

Recall = number of observations correctly predicted as POI / number of actual POI observation

Our best model is the Decision Tree Classifier and its best model's performance metrics are notes in the table above. Based on this algorithm, its specifications, and data, 81.7 % of the observations in the Enron dataset were correctly predicted as POIs and non-POIs. Among those predicted as POIs by my best algorithm, 38.8 % were actual POIs. Among those who were actually POI, the model successfully predicted 32.4 % of them by my best algorithm.