Enron POI Identifier Report

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Introduction

The project explores algorithmic classifiers with the objective of finding persons of interest, POI, from public Enron financial and email data.

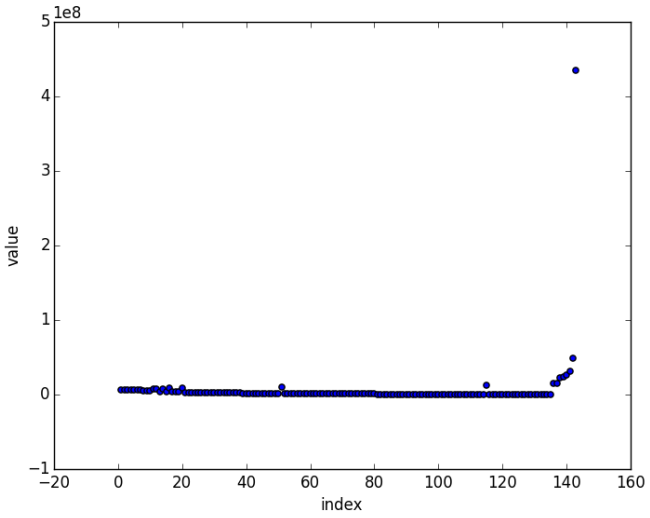
The Enron Data

The data contains 20 features on 145 persons with a subset of 18 marked with the additional POI flag. POI are those who were indicted, reached a settlement, involved in plea deals with the government, or testified in exchange for prosecution immunity. Some features did not contain data for every person.

Various supervised machine-learning algorithms are explored with this data to find the optimal classifier for the POI flag based on selected features.

Removing Outlier Data

There was one obvious outlier in the data—the total combined values for all persons. The figure below shows the data with outlier at the top of the chart for the feature "total_payments." This outlier was removed for testing.



Feature Transformation

All features are scaled from 0.0 to 1.0 for testing. This is done for some classifier, such as SVM, where the scales mattered.

Three additional features are added to describe data in terms of ratio to overall amount. The ratios help make better comparisons over absolute values.

- fraction_to_poi: ratio of emails sent to POI
- fraction_to_shared_with_poi: ratio of emails received shared with POI
- fraction_from_poi: ratio of emails from POI

Feature Selection

To select features, two processes were tried: PCA eigenvalues and decision tree importance. The final features are the normalized values are:

- total_payments: added from PCA analysis for eigenvalue
- loan_advances: added from PCA analysis for eigenvalue
- total_stock_value: added from PCA analysis for eigenvalue
- exercise_stock_options: added from PCA analysis for eigenvalue
- fraction_to_shared_with_poi: added from DT analysis for importance

PCA

The eigenvalues for all features of the first PCA component is analyzed. Four features with strong eigenvalues are selected for final selection:

Feature	Eigenvalue
salary	-0.008248
deferral_payments	-0.006891
total_payments	**-0.681722**
loan_advances	**-0.513378**
bonus	-0.05344
restricted_stock_deferred	-0.005002
deferred_income	0.006889
total_stock_value	**-0.405058**
expenses	-0.000565
exercised_stock_options	**-0.292935**
other	-0.073756
long_term_incentive	-0.027618

restricted_stock	-0.11211
director_fees	0.000167
fraction_from_poi	0
fraction_to_poi	0
fraction_to_shared_with_poi	0

Decision Tree

A decision tree is analyzed with all possible combination of up to 4 features. 3,206 different combinations were tried. The top ten combinations of features are:

Feature 1	Feature 2	Feature 3	Feature 4	Score
total_payments	total_stock_value	exercised_stock_options	fraction_to_shared_with_poi	1.162
loan_advances	exercised_stock_options	long_term_incentive	fraction_to_shared_with_poi	1.156
exercised_stock_options	long_term_incentive	fraction_to_shared_with_poi	-	1.155
total_payments	restricted_stock_deferred	exercised_stock_options	fraction_to_shared_with_poi	1.133
total_payments	expenses	exercised_stock_options	fraction_to_shared_with_poi	1.126
total_payments	exercised_stock_options	director_fees	fraction_to_shared_with_poi	1.116
total_payments	exercised_stock_options	fraction_to_shared_with_poi	-	1.115
total_payments	loan_advances	exercised_stock_options	fraction_to_shared_with_poi	1.114
deferral_payments	total_payments	exercised_stock_options	fraction_to_shared_with_poi	1.111
total_payments	exercised_stock_options	long_term_incentive	fraction_to_shared_with_poi	1.109

For the top ten performing combinations of features, the top sums of importances for feature are recorded.

- exercised_stock_options, 5.4
- **fraction_to_shared_with_poi, 2.8**
- total_payments, 1.3
- long_term_incentive, 0.4
- total_stock_value, 0.1
- loan_advances, 0.0

The fraction_to_shared_with_poi feature is a feature not present in the PCA analysis. It is added to the final feature selection. The rest are either already included from PCA analysis or not included due to low importance.

The fraction_to_shared_with_poi feature is a custom feature added to the original set of features. Because it is part of the feature list for top 10 performing combination of all possible features (original and additional), without it performance will not be as high.

Algorithm Selection and Tuning

Multiple algorithms and parameters are tested:

- Naïve Bayes
- Decision Tree with min_sample_split of 1, 2, 5, 10, 15, 20, 25, 30
- SVM of linear/rbf kernel and C-value of 10, 100, 1000, 10000
- AdaBoost with Decision Tree of 2, 10, 20, 30 min_sample_split
- Random Forest with Decision Tree of 10, 25, 50, 100 n_estimators and 20 min_sample_split

Tuning the parameters of algorithms means adjusting possible settings to find the best settings. If not done well, the best algorithm may be overlooked. The list above includes tuned parameter values.

Score are recorded for each trial. The score is determined by the sum of precision and recall where both values are above 0.3.

The results of the top 10 best scores are listed below.

Classifier	Precision	Recall	Total
DecisionTree min_samples_split=30	0.614	0.558	1.172
DecisionTree min_samples_split=15	0.614	0.556	1.17
DecisionTree min_samples_split=20	0.614	0.555	1.169
DecisionTree min_samples_split=25	0.609	0.556	1.165
DecisionTree min_samples_split=10	0.606	0.558	1.164
DecisionTree min_samples_split=2	0.48	0.418	0.898
AdaBoost min_samples_split=20, n_estimators=50	0.482	0.411	0.894
DecisionTree min_samples_split=1	0.465	0.412	0.878
DecisionTree min_samples_split=5	0.467	0.408	0.875
AdaBoost min_samples_split=2, n_estimators=50	0.519	0.355	0.874

Decision Algorithm Tuning

To further tune the decision tree (see task_7.py), min_sample_split values of 5 to 50 are tested with increments of 5. Each trial is averaged over 50 runs. The table below shows the result.

The best decision tree of min_sample_split of 30 is saved in my_classifier.pkl.

Split	Precision	Recall	Total
5	0.46891	0.40918	0.87809
10	0.606512	0.55727	1.163782
15	0.609789	0.5568	1.166589
20	0.613056	0.55654	1.169596
25	0.612996	0.55654	1.169536
30	**0.613018**	**0.55665**	**1.169668**
35	0.612907	0.55057	1.163477
40	0.576708	0.37515	0.951858
45	0.540263	0.27694	0.817203
50	0.545138	0.27541	0.820548

Validation

Validation ensures that the classifiers are not over fitting data. Splitting the data into a training set and a testing set can achieve this. Also, multi-fold cross validation can be used.

In this project, 10-fold cross validation is used to divide the data into multiple training and testing sets.

A classic mistake is to not shuffle the data before dividing it into a training subset and testing subset. In this project, data is shuffled before validation.

Conclusion

The evaluation score used is the sum of precision and recall where both values are above 0.3. Recall measures correctly predicting POI provided that the actual person is POI. The precision measures correctly predicting POI from all predicted (correct and incorrect) POI.

The best classifier of decision tree with min_split_split 30 has a precision of 0.613 and recall of 0.557 for a combined score of 1.170.