Final Presentation

Betas
Visualization

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Project Background

- A simple visualization tool
- A pip installable library
- Designed for data scientists or analysts who:
    - Do not want to generate custom plots for analyzing model scores or model assumptions
    - Use ML models without a detailed understanding of how the models work and would like to rely on a pre-configured solution for applying commonly used methods
    - Are familiar with: Python and command line

Data Sources

➔ *betas* makes it easy to analyze scores from models trained on a variety of data sources

		Spam Data	Breast Cancer Data	Auto Data	College Data
Number of Instances		4601	569	398	777
Number of attributes	Continuous	57	30	5	19
	Discrete / Nominal	1	1	4	2
Source		ESL*	scikit-learn	ISL*	ISL*

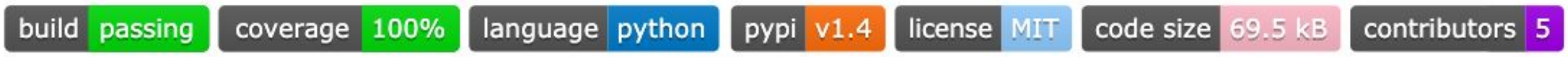
* ESL: *The Elements of Statistical Learning*; ISL: *An Introduction to Statistical Learning*

Software & License

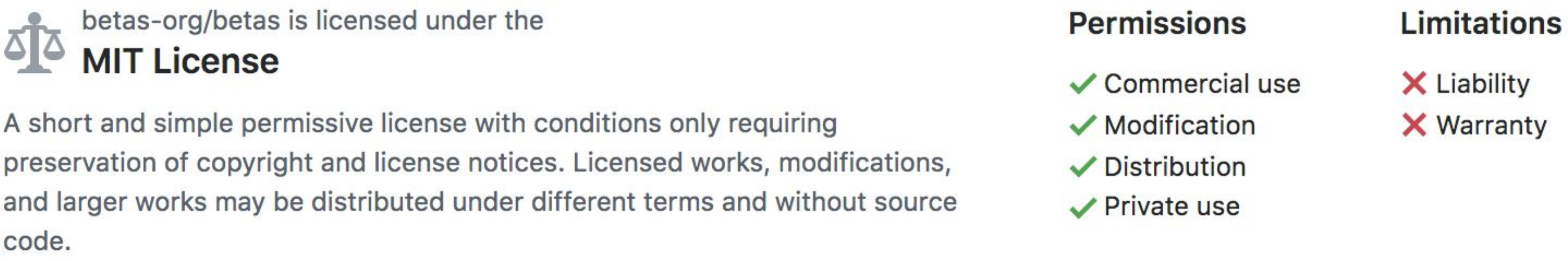
```
pip install betas
```

❑ **Python 3.6 / 3.7**

❑ Passing build with 100% test coverage



build passing | coverage 100% | language python | pypi v1.4 | license MIT | code size 69.5 kB | contributors 5



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MIT License

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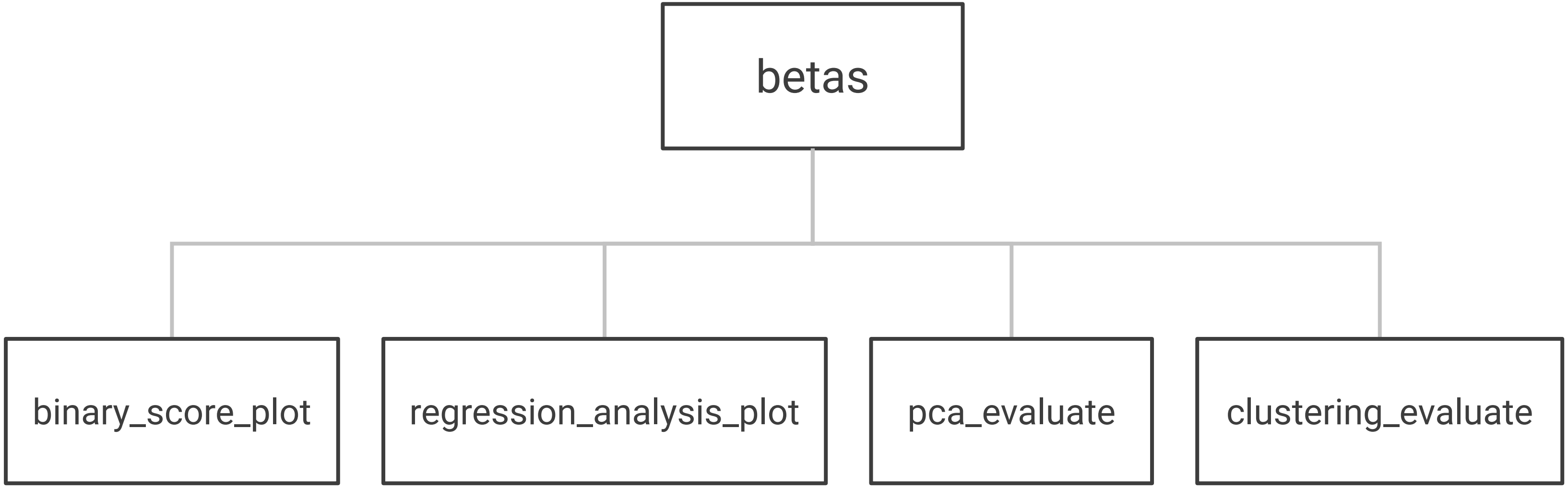
Permissions	Limitations
✓ Commercial use	✗ Liability
✓ Modification	✗ Warranty
✓ Distribution	
✓ Private use	

betas Library

Individual modules support evaluating four key data science methods



betas

binary_score_plot

regression_analysis_plot

pca_evaluate

clustering_evaluate

betas Library

		Unit Test	Documentation	Related demo files
1	binary_score_plot.py	✓	✓	• test_binary_score_plot.py • demo_binary_scoe_plot.ipynb • binary_score_diagnostics.py
2	regression_analysis_plot.py	✓	✓	• test_regression_analysis_plot.py • demo_binary_scoe_plot.ipynb • binary_score_diagnostics.py
3	pca_evaluate	✓	✓	• test_pca_evaluate.py • demo_pca_evaluate.ipynb
4	clustering_evaluate	✓	✓	• test_clustering_evaluate.py • demo_clustering_evaluate.ipynb

Use Cases

Four use cases:

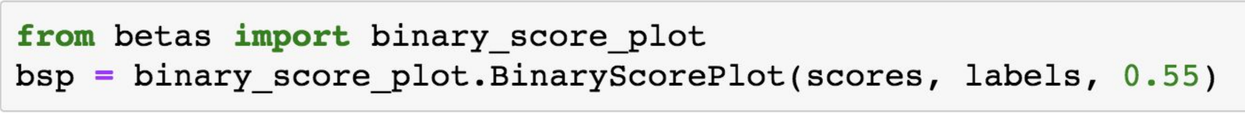
1. Fit binary classification model
2. Fit linear regression model
3. Evaluate PCA performance
4. Evaluate clustering performance

With betas, users can

- ★ Install and import betas
- ★ Input an interesting dataset
- ★ Run simple code
- ★ Create plots and explore dataset

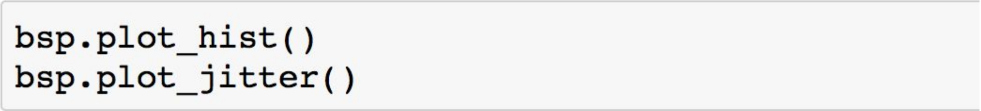
Binary Classification: Binary Score Plot

- Histogram of model scores
- Scatterplot of model scores vs. actual labels
- ROC curve
- Precision-recall curve
- Optimal threshold

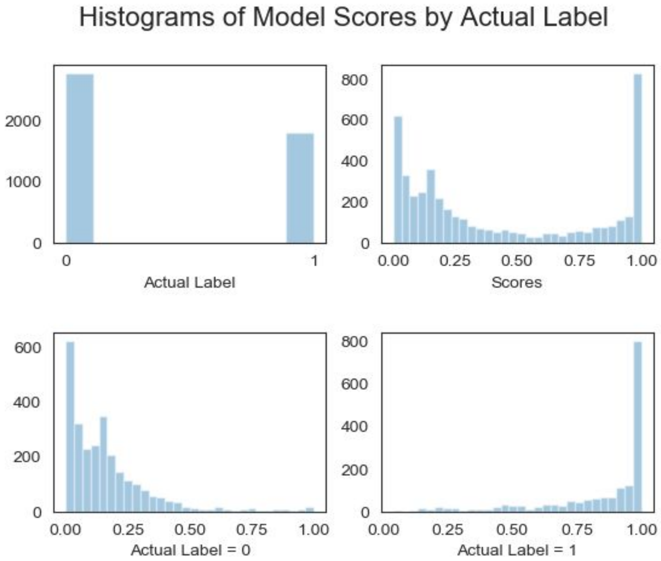


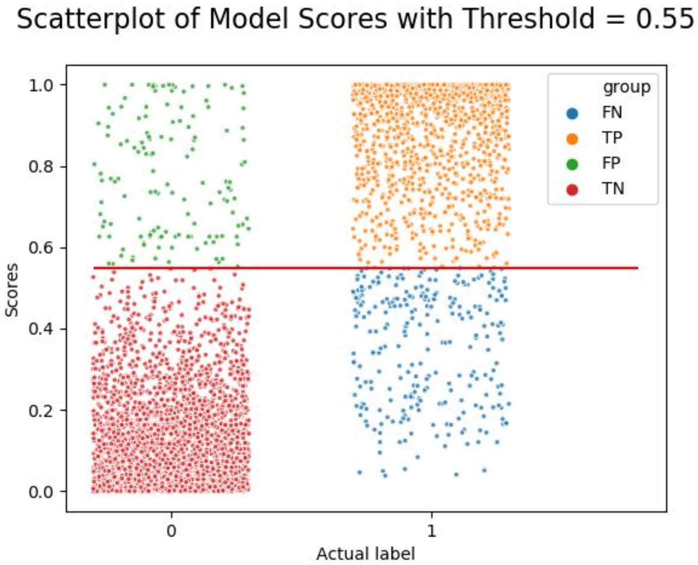
```
from betas import binary_score_plot
bsp = binary_score_plot.BinaryScorePlot(scores, labels, 0.55)
```

Binary Classification: Binary Score Plot

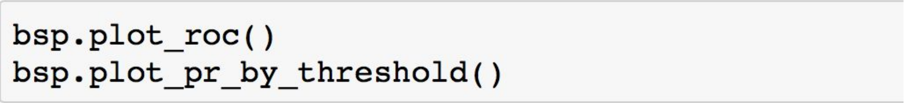


```
bsp.plot_hist()
bsp.plot_jitter()
```

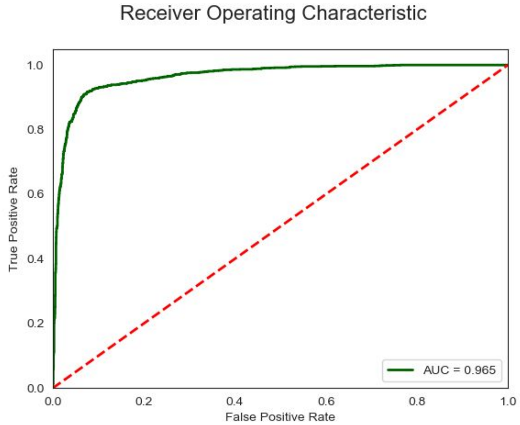

Histograms of Model Scores by Actual Label

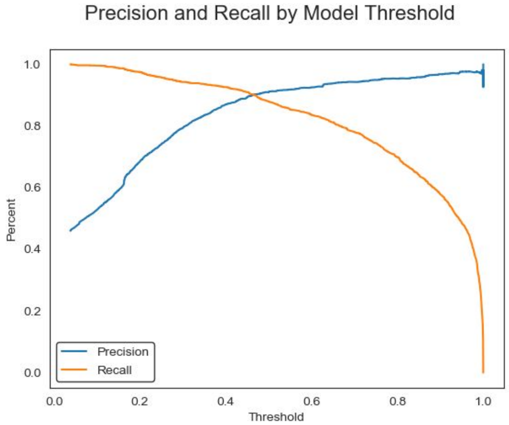

Scatterplot of Model Scores with Threshold = 0.55

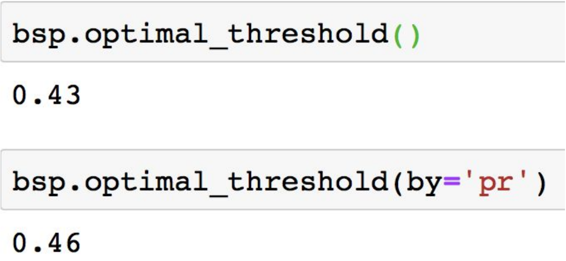
Binary Classification: Binary Score Plot



```
bsp.plot_roc()
bsp.plot_pr_by_threshold()
```







```
bsp.optimal_threshold()
```

```
0.43
```

```
bsp.optimal_threshold(by='pr')
```

```
0.46
```

Binary Classification: Dashboard

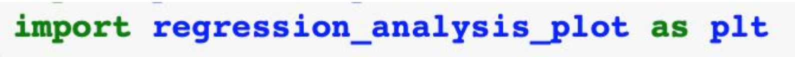
- Interactive dashboard built with bokeh
- Helps users better understand the distribution of modeled scores
- Demo

Linear Regression: Analysis Plot

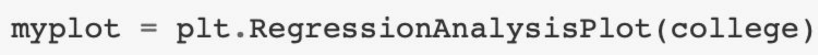
User Input

- A dataframe
- A list of predictor variable(s)
  - *optional**
- A response variable
  - *optional**

** Predictor(s) and response can be reselect*



```
import regression_analysis_plot as plt
```



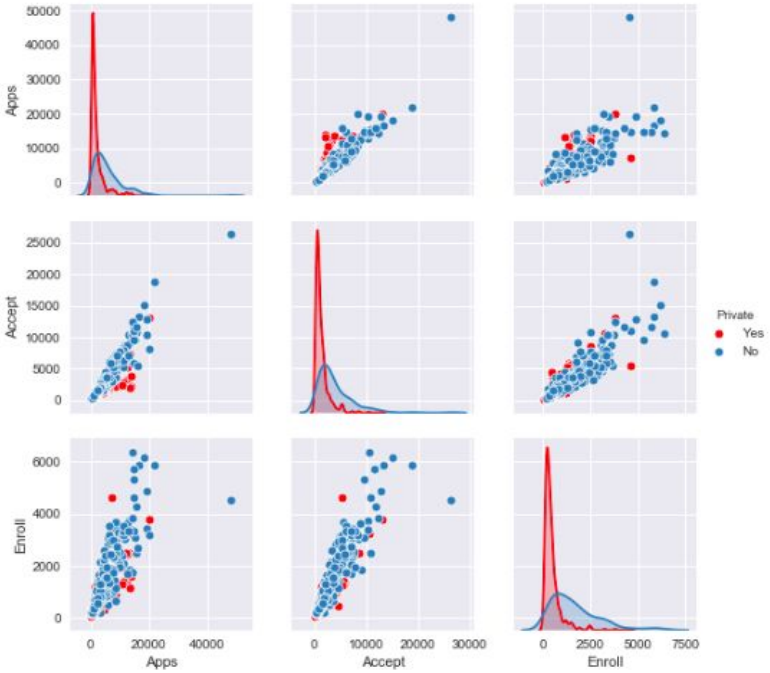
```
myplot = plt.RegressionAnalysisPlot(college)
```

Main Methods

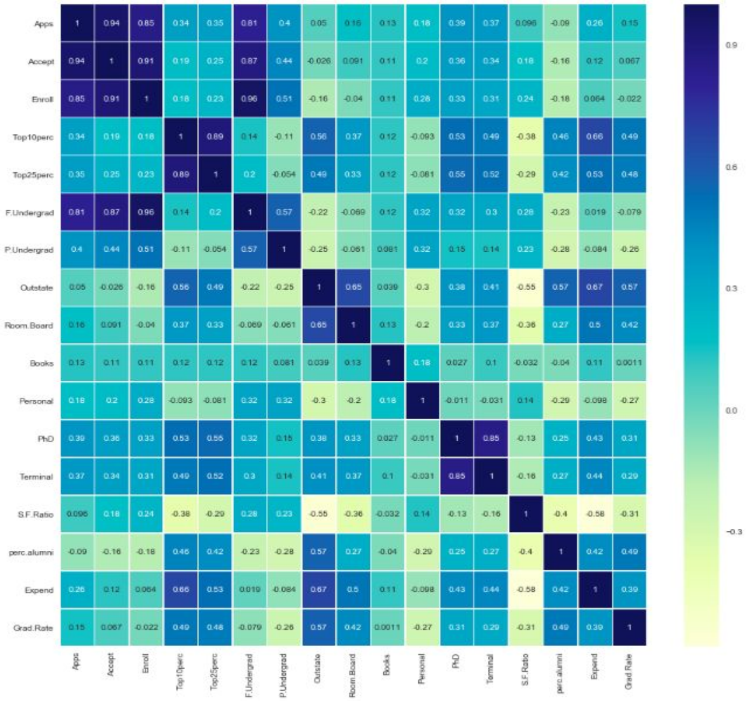
- Scatter matrix plot
- Correlation heatmap
- Box plot
- Distribution plot
- Scatter plot with regression line
- Basic linear regression model
- Model diagnostics

Linear Regression: Analysis Plot Demo

```
myplot.matrix_plot()
```

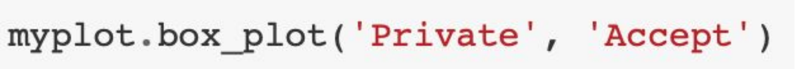


```
myplot.corr_heatmap(figsize=(15,15))
```

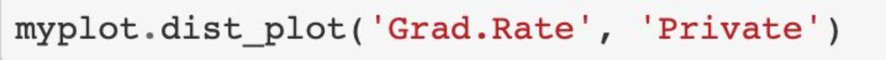


	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undergrad	Outstate	Room.Board	Books	Personal	PhD	Terminal	S.F.Ratio	perc.alumni	Expend	Grad.Rate
Apps	1	0.94	0.85	0.34	0.35	0.81	0.4	0.05	0.16	0.13	0.18	0.39	0.37	0.096	-0.09	0.26	0.15
Accept	0.94	1	0.91	0.19	0.25	0.87	0.44	-0.026	0.091	0.11	0.2	0.36	0.34	0.18	-0.16	0.12	0.067
Enroll	0.85	0.91	1	0.18	0.23	0.96	0.51	-0.16	-0.04	0.11	0.28	0.33	0.31	0.24	-0.18	0.064	-0.022
Top10perc	0.34	0.19	0.18	1	0.89	0.14	-0.11	0.56	0.37	0.12	-0.093	0.53	0.49	-0.38	0.46	0.66	0.49
Top25perc	0.35	0.25	0.23	0.89	1	0.2	-0.054	0.49	0.33	0.12	-0.081	0.55	0.52	-0.29	0.42	0.53	0.48
F.Undergrad	0.81	0.87	0.96	0.14	0.2	1	0.57	-0.22	-0.069	0.12	0.32	0.32	0.3	0.28	-0.23	0.019	-0.079
P.Undergrad	0.4	0.44	0.51	-0.11	-0.054	0.57	1	-0.25	-0.061	0.081	0.32	0.15	0.14	0.23	-0.28	-0.084	-0.26
Outstate	0.05	-0.026	-0.16	0.56	0.49	-0.22	-0.25	1	0.65	0.039	-0.3	0.38	0.41	-0.55	0.57	0.67	0.57
Room.Board	0.16	0.091	-0.04	0.37	0.33	-0.069	-0.061	0.65	1	0.13	-0.2	0.33	0.37	-0.36	0.27	0.5	0.42
Books	0.13	0.11	0.11	0.12	0.12	0.12	0.081	0.039	0.13	1	0.18	0.027	0.1	-0.032	-0.04	0.11	0.0011
Personal	0.18	0.2	0.28	-0.093	-0.081	0.32	0.32	-0.3	-0.2	0.18	1	-0.011	-0.031	0.14	-0.29	-0.098	-0.27
PhD	0.39	0.36	0.33	0.53	0.55	0.32	0.15	0.38	0.33	0.027	-0.011	1	0.85	-0.13	0.25	0.43	0.31
Terminal	0.37	0.34	0.31	0.49	0.52	0.3	0.14	0.41	0.37	0.1	-0.031	0.85	1	-0.16	0.27	0.44	0.29
S.F.Ratio	0.096	0.18	0.24	-0.38	-0.29	0.28	0.23	-0.55	-0.36	-0.032	0.14	-0.13	-0.16	1	-0.4	-0.58	-0.31
perc.alumni	-0.09	-0.16	-0.18	0.46	0.42	-0.23	-0.28	0.57	0.27	-0.04	-0.29	0.25	0.27	-0.4	1	0.42	0.49
Expend	0.26	0.12	0.064	0.66	0.53	0.019	-0.084	0.67	0.5	0.11	-0.098	0.43	0.44	-0.58	0.42	1	0.39
Grad.Rate	0.15	0.067	-0.022	0.49	0.48	-0.079	-0.26	0.57	0.42	0.0011	-0.27	0.31	0.29	-0.31	0.49	0.39	1

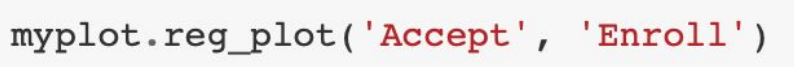
Linear Regression: Analysis Plot Demo



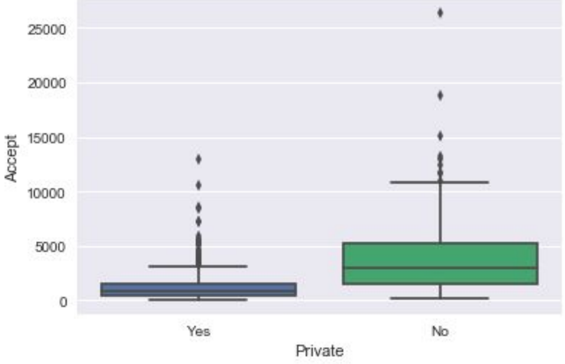
```
myplot.box_plot('Private', 'Accept')
```

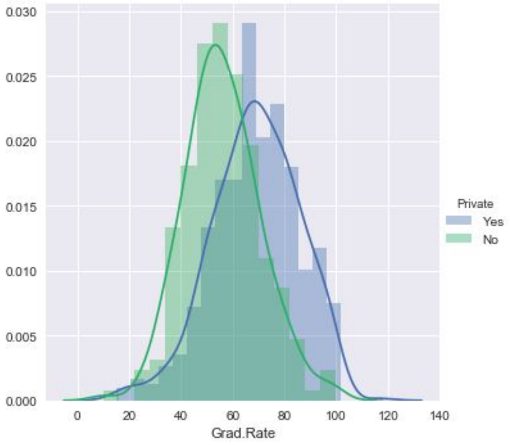


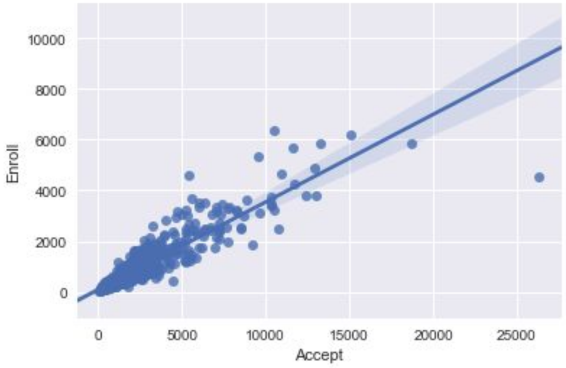
```
myplot.dist_plot('Grad.Rate', 'Private')
```



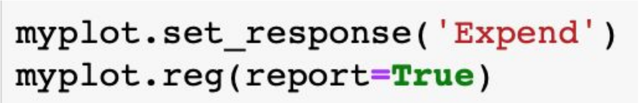
```
myplot.reg_plot('Accept', 'Enroll')
```



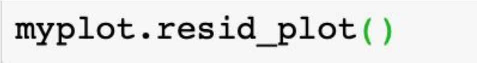




Linear Regression: Analysis Plot Demo



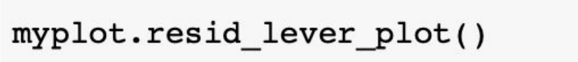
```
myplot.set_response('Expend')
myplot.reg(report=True)
```



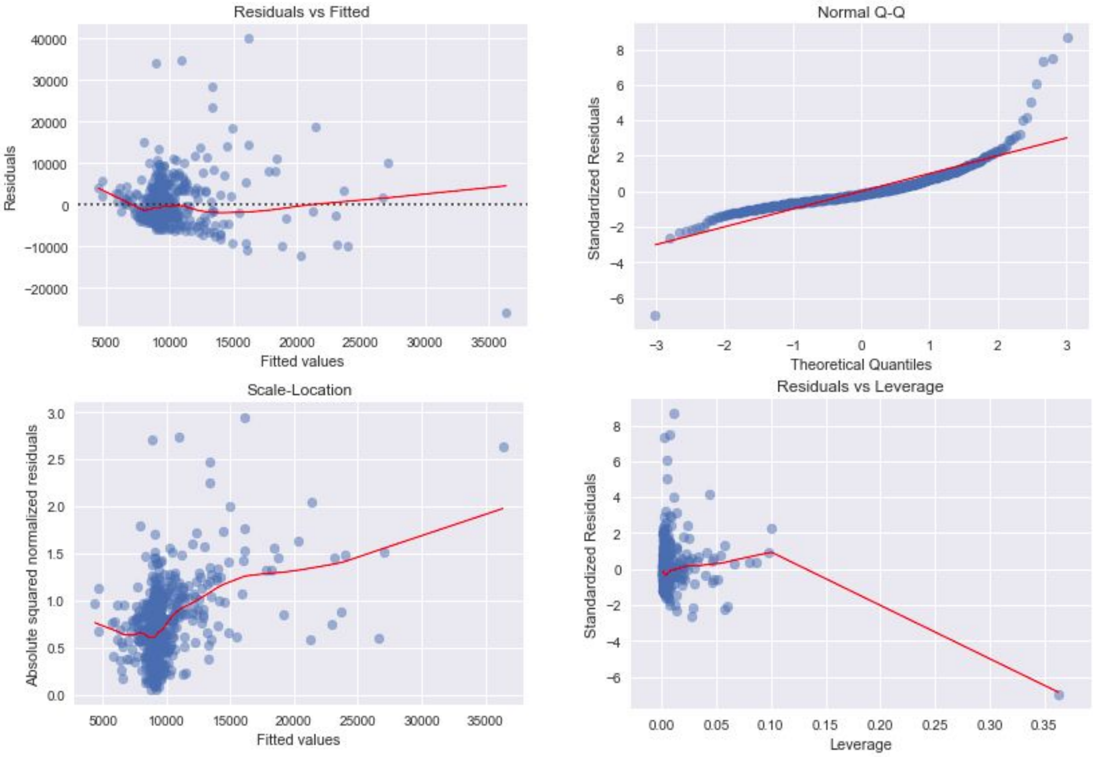
```
myplot.resid_plot()
```

```
myplot.qq_plot()
```

```
myplot.scale_loc_plot()
```



```
myplot.resid_lever_plot()
```



Linear Regression: Dashboard

An interactive dashboard built with Dash

Designed for users to assess linear regression model assumptions

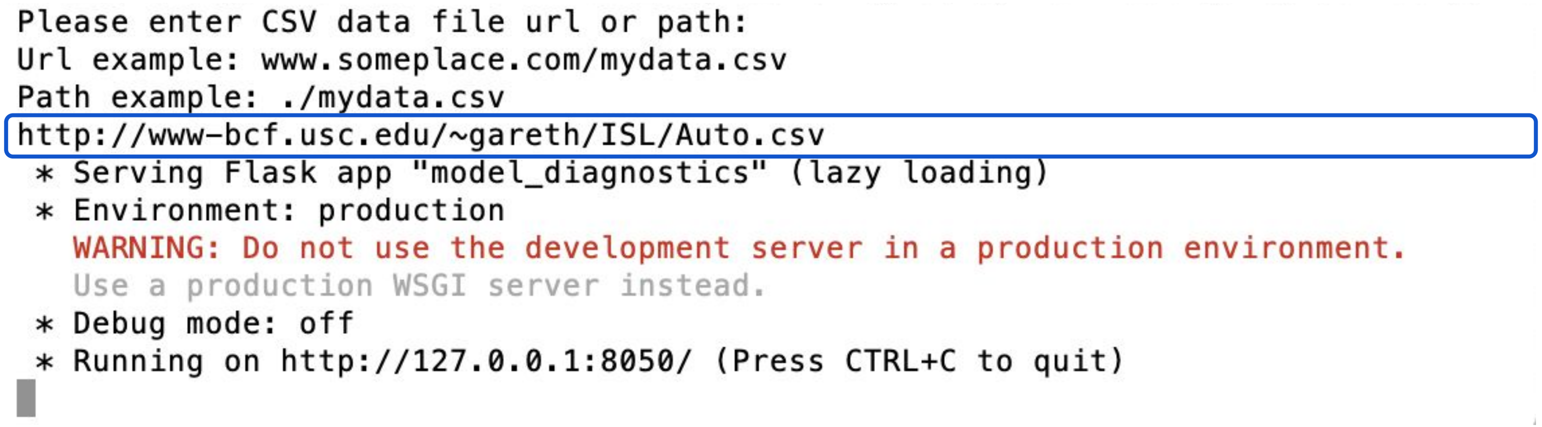
Users need to:

➔ Prepare a CSV data source (online source or local file)
➔ Run Model Diagnostics Tool
➔ Select metrics
➔ Explore plots!

Linear Regression: Dashboard Demo

User Input

- A CSV dataset file address

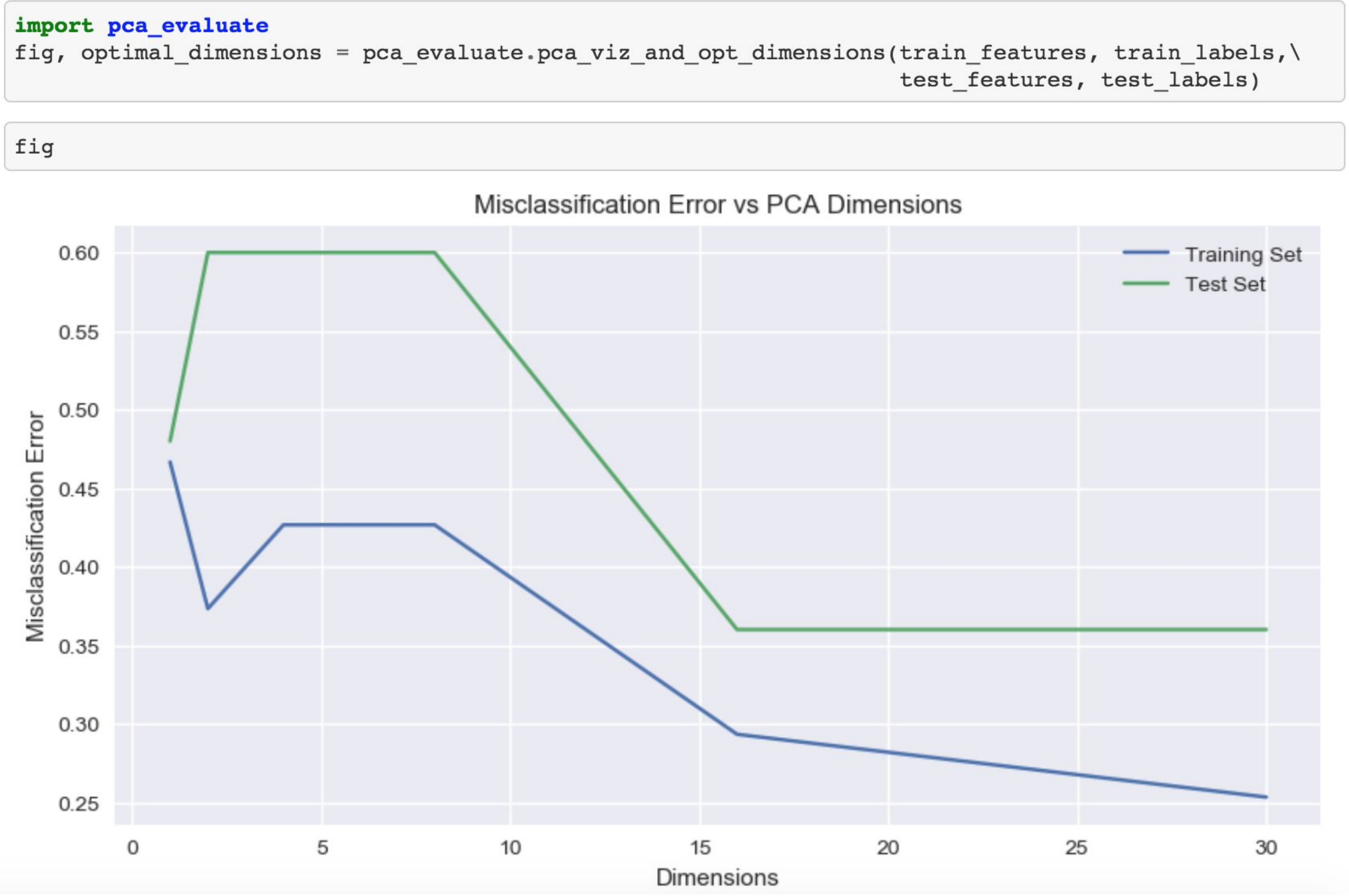


```
Please enter CSV data file url or path:
Url example: www.someplace.com/mydata.csv
Path example: ./mydata.csv
http://www-bcf.usc.edu/~gareth/ISL/Auto.csv
 * Serving Flask app "model_diagnostics" (lazy loading)
 * Environment: production
   WARNING: Do not use the development server in a production environment.
   Use a production WSGI server instead.
 * Debug mode: off
 * Running on http://127.0.0.1:8050/ (Press CTRL+C to quit)
```

PCA Evaluation

- Principal Component Analysis
  - Dimensionality reduction
  - Aiding in data visualization
  - Preprocessing step for subsequent supervised learning
- Given any dataset, one call to the betas pca library will determine the most optimal number of dimensions to use
- Generates a plot to visualize how the misclassification errors change for the test and training sets for the given data source
- Note: for this to work, one would need the response variable as well
- Unsupervised learning optimized using supervised learning metrics

PCA Evaluation Demo I

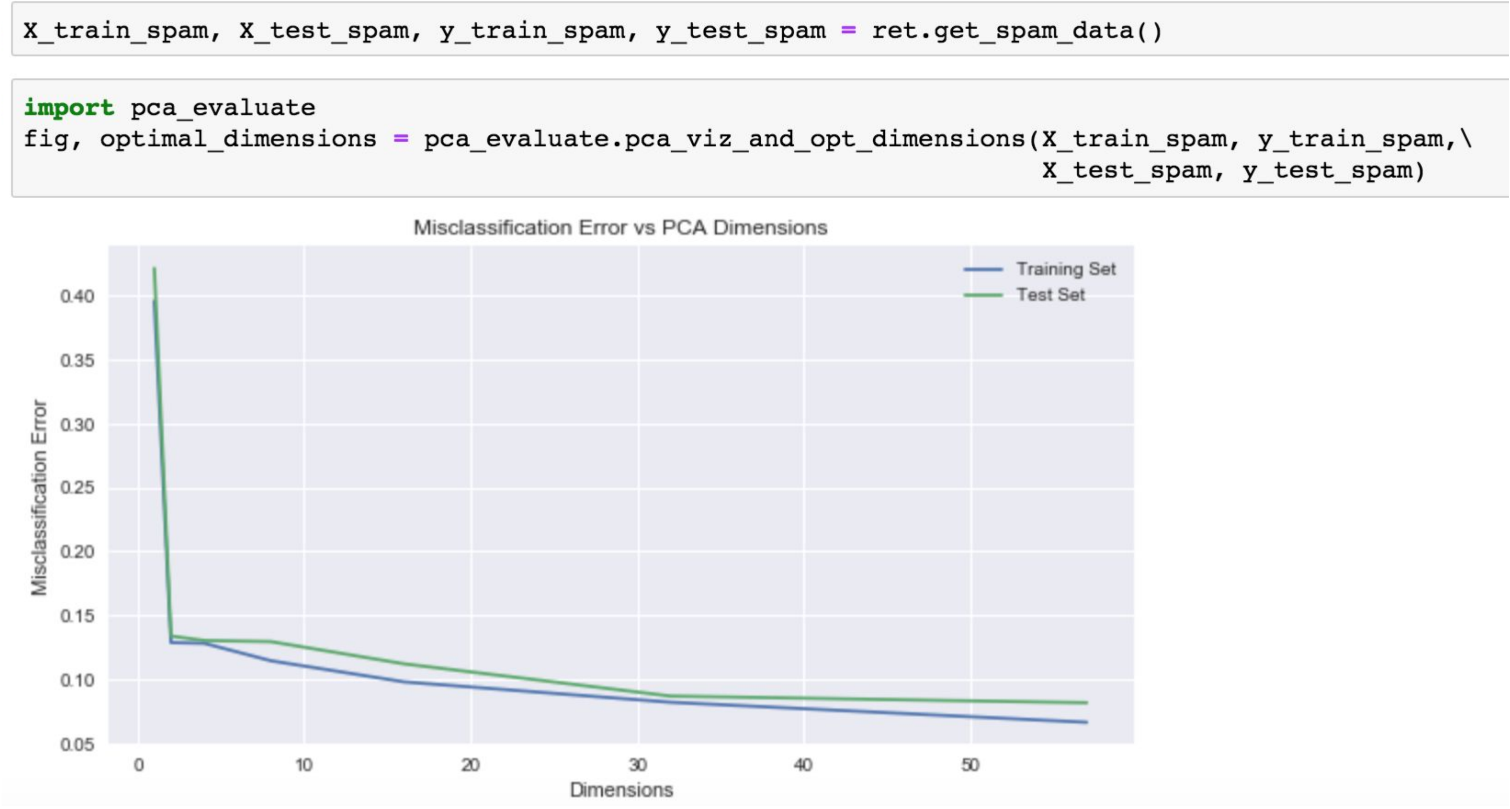


```
import pca_evaluate
fig, optimal_dimensions = pca_evaluate.pca_viz_and_opt_dimensions(train_features, train_labels,\
                                                                  test_features, test_labels)
```

```
fig
```

PCA Evaluation Demo II

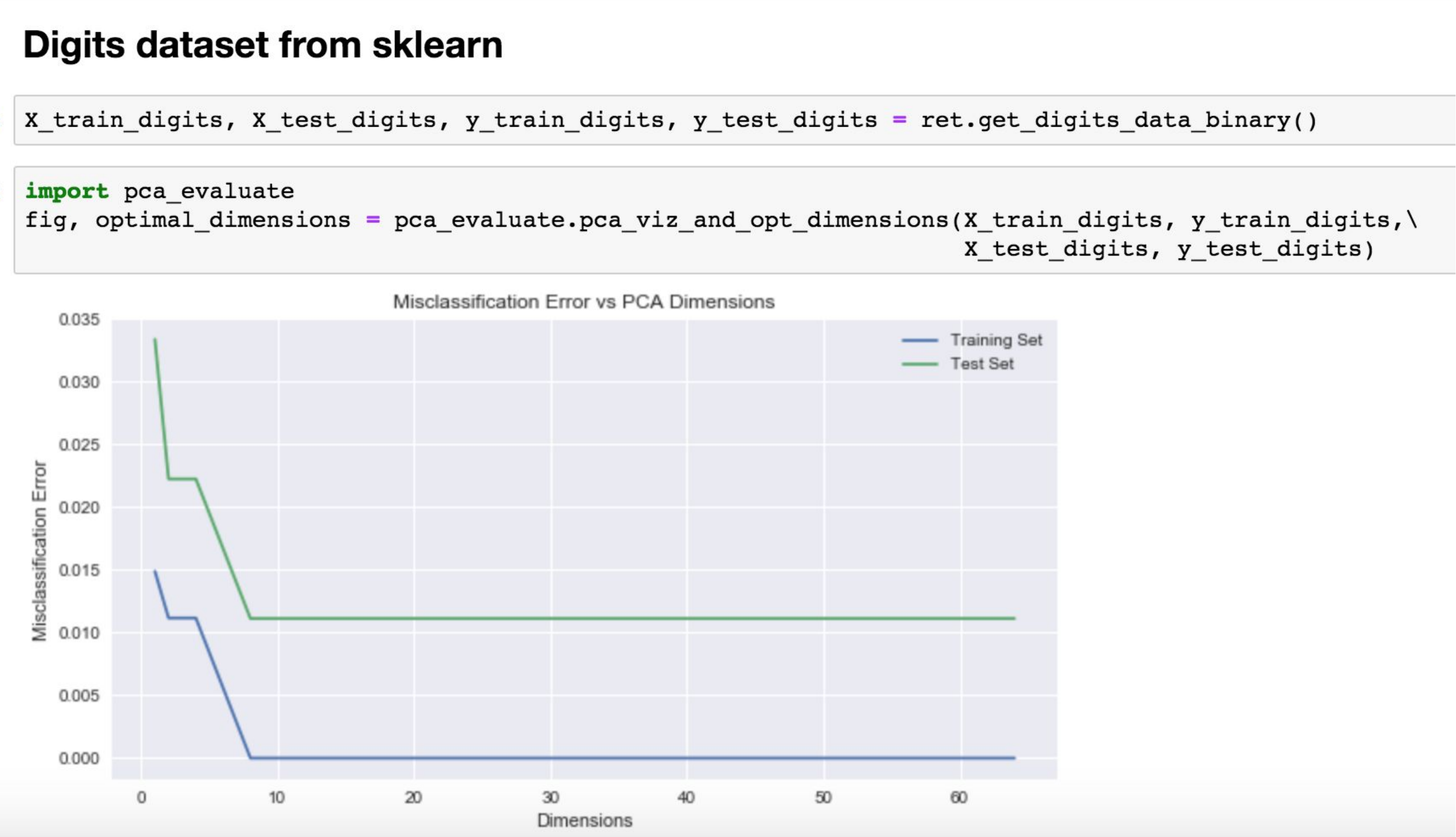
Spam dataset from ESL



```
X_train_spam, X_test_spam, y_train_spam, y_test_spam = ret.get_spam_data()
```

```
import pca_evaluate
fig, optimal_dimensions = pca_evaluate.pca_viz_and_opt_dimensions(X_train_spam, y_train_spam,\
                                                                   X_test_spam, y_test_spam)
```

PCA Evaluation Demo III



Digits dataset from sklearn

```
X_train_digits, X_test_digits, y_train_digits, y_test_digits = ret.get_digits_data_binary()
```

```
import pca_evaluate
fig, optimal_dimensions = pca_evaluate.pca_viz_and_opt_dimensions(X_train_digits, y_train_digits,\
                                                                 X_test_digits, y_test_digits)
```

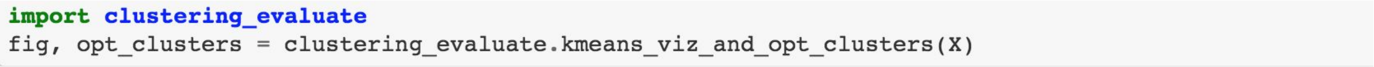
Clustering Evaluation

- Given a dataset of predictors without any response variables, the clustering library determines the most optimal number of clusters to divide the data into

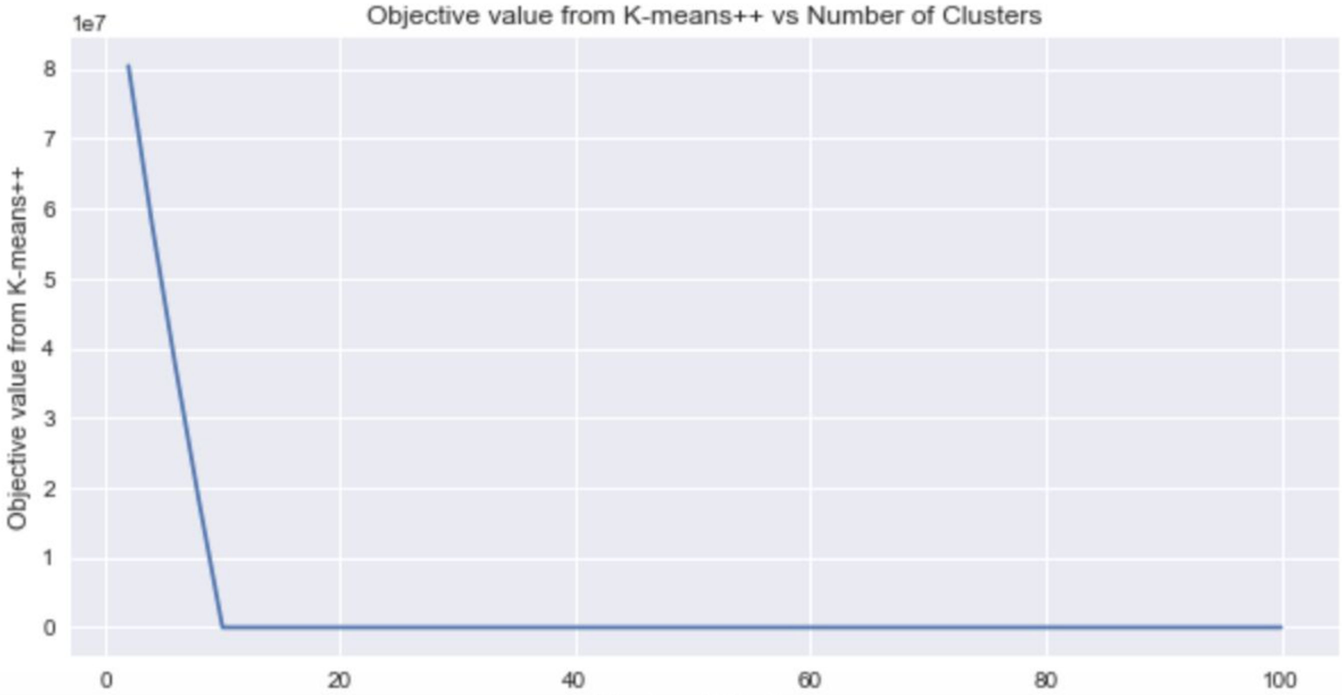
- Unsupervised learning task that uses the inertia/cost for any number of clusters for the given dataset

- Uses k-means++ for a more optimal initialization of the clustering algorithm

Clustering Evaluation Demo



```
import clustering_evaluate
fig, opt_clusters = clustering_evaluate.kmeans_viz_and_opt_clusters(X)
```



Lessons Learned

Lessons Learned

- Version control
  - Add branches
  - Pull requests
- Write unit tests
- Bokeh, Dash
- pip installable package
- Determine the project’s scope as a primary step

Future Work

- Improve the flexibility and extensibility of *betas* library
    - Add more customized arguments to the binary score plots and regression analysis plots, with automatically adjustment in figure scale
    - Addition to Kernel PCA to the PCA module
    - Make the clustering package more customizable, with inclusion of hierarchical clustering, spectral clustering, etc.
- Employ relevant representative datasets, as we want our work to be data agnostic
- Make our package conda installable