RoboGarden Bootcamp Capstone Project

Credit Card Fraud Detection

July 2019

(update Oct 2019)

https://github.com/dvbckle

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Credit Card Fraud Project

Description:

- 284,807 credit card transactions made by European cardholders in September 2013

Features:

- Time: seconds since first transaction
- V1 – V28: Anonymous data – Confidentiality
- Amount: Transaction value (Unspecified currency)
- Class (T/F): fraudulent / genuine

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Available: *Data World & Kaggle****:*** https://data.world/raghu543/credit-card-fraud-data

File: creditcard.csv

Reference use of dataset: Dal Pozzolo, Olivier Caelen, Reid A. Johnson and Gianluca Bontempi. Calibrating Probability with Undersampling for Unbalanced Classification. In Symposium on Computational Intelligence and Data Mining (CIDM), IEEE, 2015

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Credit Card Fraud Project Dataset

• *normal amount total*	***25,043,410***
• *fraud amount total*	***58,591*** ***(0.25%)***
• *# transactions over 2 days*	***284,807***
• *# fraud transactions*	***492*** ***(0.17%)***
• *# non-fraud duplicates*	***1062*** ***(0.4 %)***
• *# fraud duplicates*	***19*** ***(4.0 %)***
• *# zero amount normal transactions*	***1798*** ***(0.6%)****
• *# zero amount fraud transactions*	***27*** ***(5.5%)****

* Retained zero amount transactions. Insufficient information to remove them.

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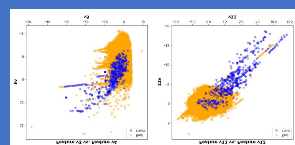
Work Process

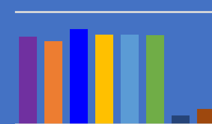
Clean Data

Remove Duplicates

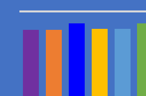
Visualize Data



Screen 8 Classifiers

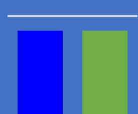


Optimize 6 Classifiers
All Features

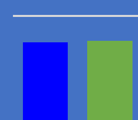


Optimize RF & MLP on
10 Features

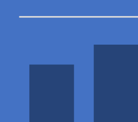
Feature Importance



Optimize RF & MLP on
Undersampled Dataset
All Features



Run Autoencoders on
10 Features
4 Features



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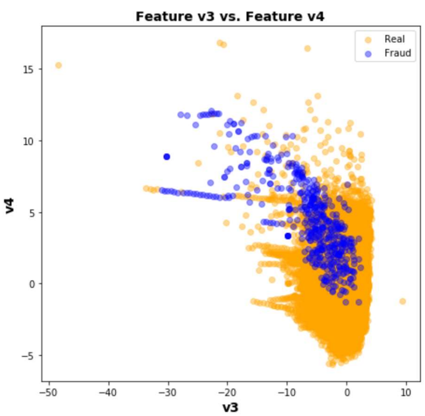
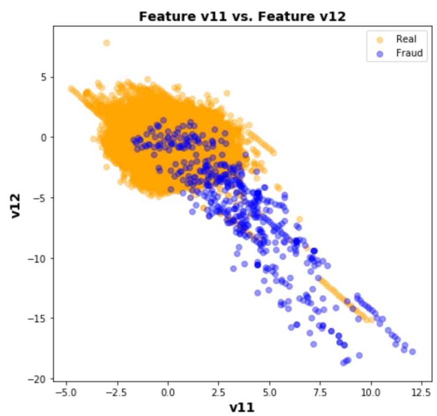
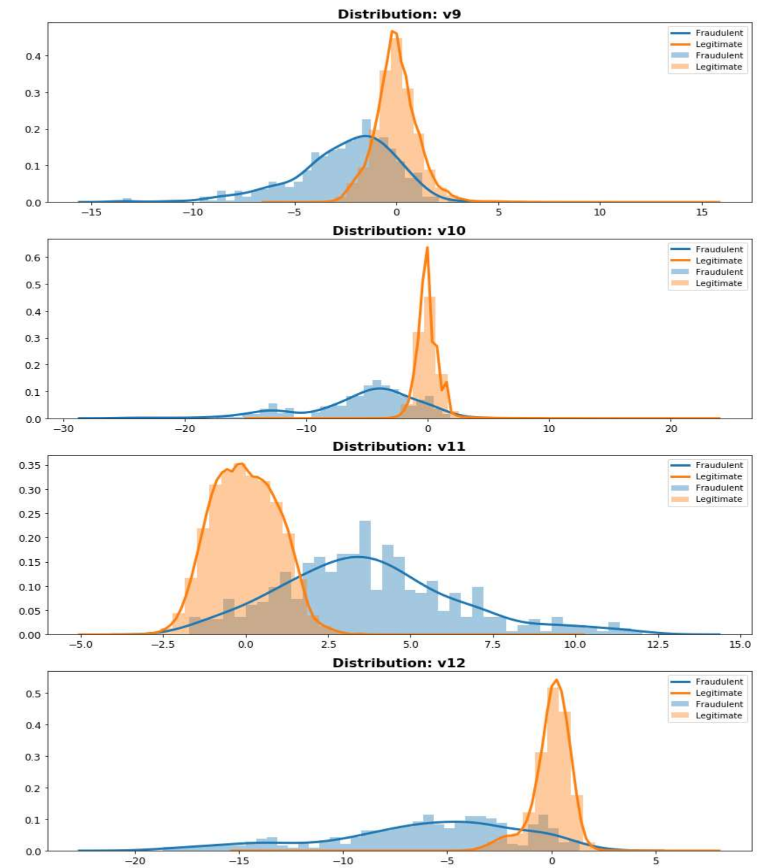
Visualization Examples







- **2D Scatter plots show some overlap & separation.**

Showing 4 of 28 Features: Fraud vs. Normal Histograms

- **Several have distinctive range differences.**
- **Some distributions are aligned, (not shown).**

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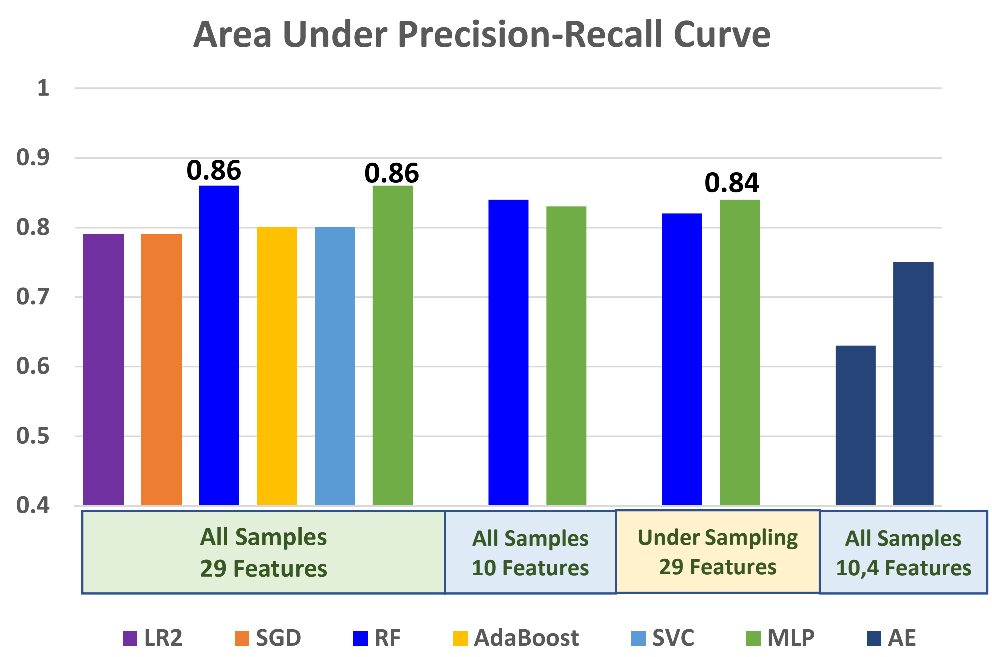
Modelling Results

Model	Application	Features	Scores AU-ROC	AU-PRC*	F-1	TP	FP	FN
LR	All Samples	29	0.98	0.79	0.69	65	5	53
SGD	All Samples	29	0.98	0.79	0.79	83	7	35
RF ★	All Samples	29	0.96	0.86	0.86	92	4	26
SVC	All Samples	29	0.95	0.80	0.78	77	3	41
AdaBoost	All Samples	29	0.97	0.80	0.80	84	8	34
MLP ★	All Samples	29	0.99	0.86	0.86	92	5	26
RF	All Samples	10	0.95	0.84	0.85	90	4	28
MLP	All Samples	10	0.98	0.82	0.83	88	6	30
RF **	Undersampling	29	0.99	0.82	0.85	91	6	27
MLP **	Undersampling	29	0.98	0.84	0.82	90	11	28
AE	All Samples	10	0.97	0.57	0.58	66	45	52
AE	All Samples	4	0.96	0.75	0.78	83	11	35



★ *Model results shown on following slides, Highest AU-PRC and Highest amount of fraud found*

* *AU-PRC: Area under the Precision-Recall Curve is the recommended measure of accuracy stated by the dataset provider due to the imbalance in the dataset.*
***Under Sampling applies calibration to the sample probabilities.*

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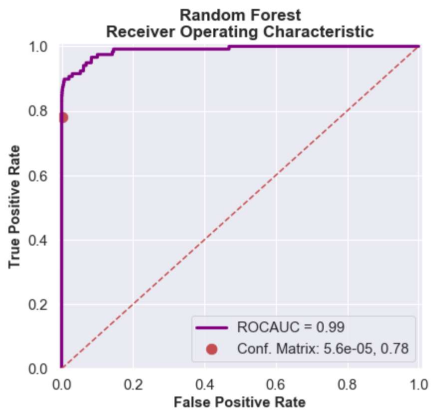
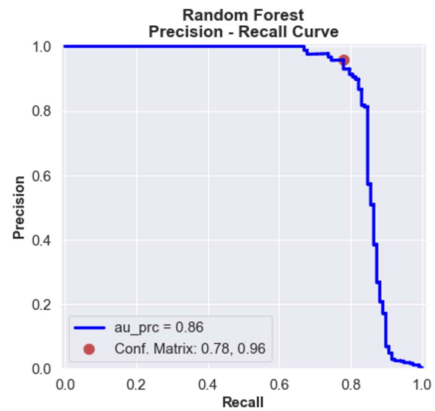
Random Forest Results



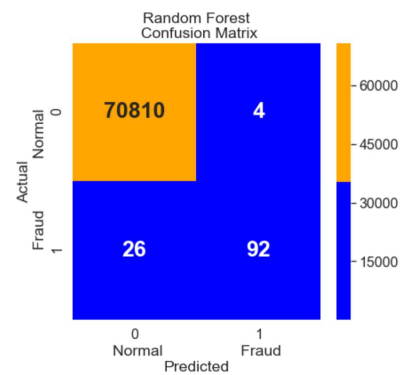


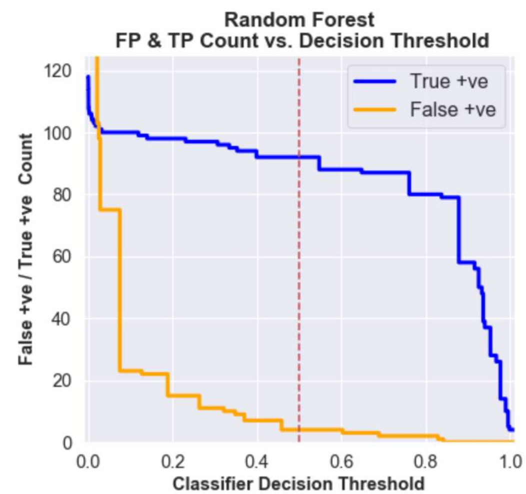
ROC and Precision-Recall Curves:

- Area under Precision-Recall of 0.86.
- Area under ROC of 0.96.
- Confusion Matrix corresponds to markers on ROC & PRC and decision threshold line on the FP & TP Count plot.

Random Forest trained on the full dataset *:

- Found 78% of frauds at 0.5 decision threshold.
- Has a low false positive rate.
- 67% of frauds have a classification probability over 0.8.





Trained on 29 Features: Amount + Features v1 to v28 (time was dropped)

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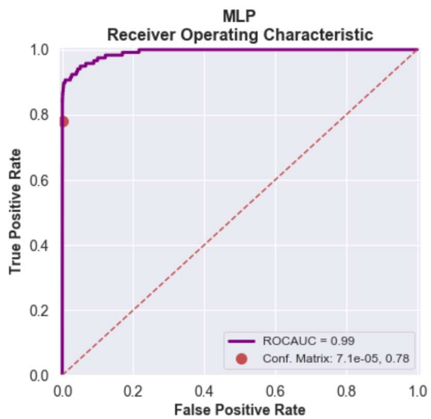
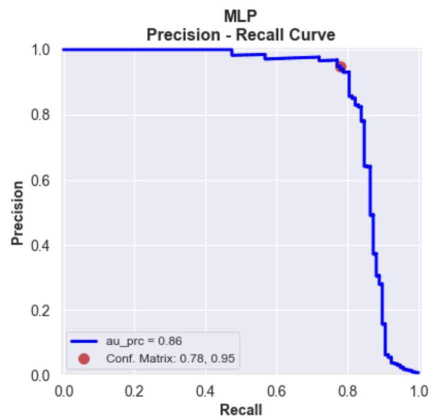
MLP Results



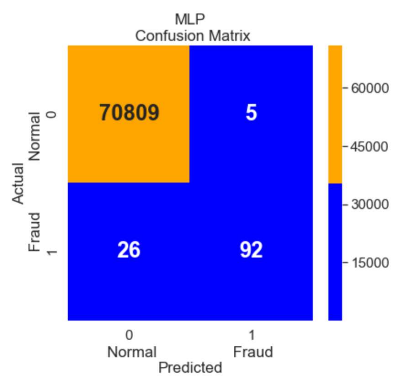


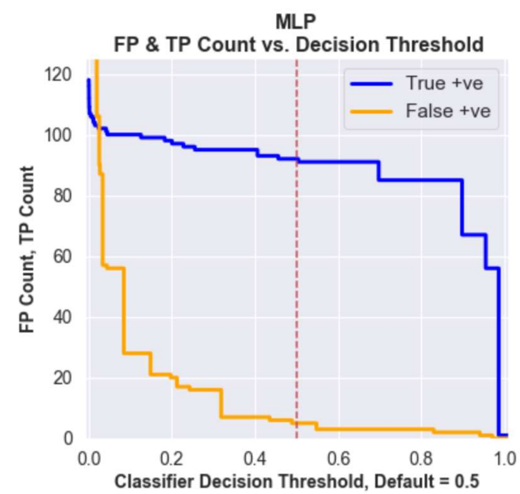
ROC and Precision-Recall Curves:

- Area under Precision-Recall of 0.86.
- Area under ROC of 0.99.
- Confusion Matrix corresponds to markers on ROC & PRC and decision threshold line on the FP & TP Count plot.

MLP trained on the full dataset *:

- Found 78% of frauds at 0.5 decision threshold.
- Has a low false positive rate.
- ~71% of frauds have a classification probability over 0.8.





**Trained on 29 Features: Amount + Features v1 to v28 (time was dropped)*

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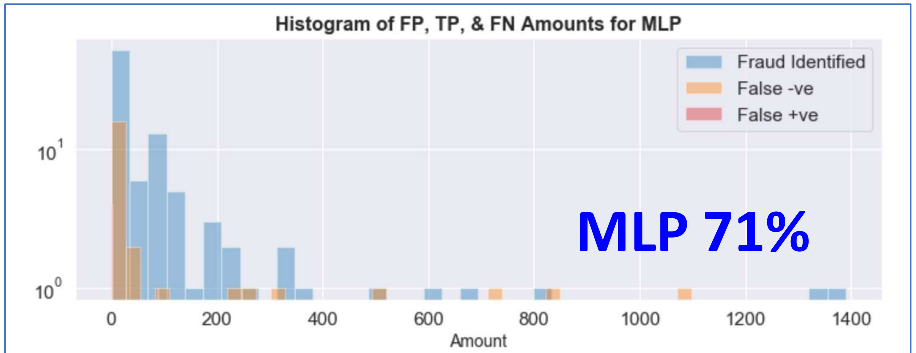
Fraud Value Identified in Test Set (25% of Dataset)

96 Frauds & 71% of value*

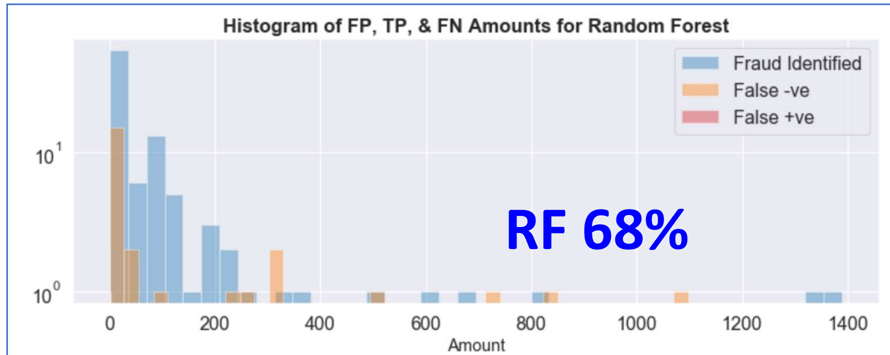
5 FP’s – 6.5% of the total Fraud value




```
Fraud total identified is 10111.10,
Fraud total missed is 4215.79,
Normal total misclassified is 94.04
```

92 Frauds & 68% of value*

4 FP’s – .03% of the total Fraud value




```
Fraud total identified is 9780.94,
Fraud total missed is 4545.95,
Normal total misclassified is 4.28
```

- Random Forest identified a slightly lower fraud amount, but misclassified a lower amount than the MLP Classifier. *All total percentages will vary with new data and the breakdown of amounts related to other features (e.g. zero or low value transactions vs larger amounts.)

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Conclusions / Future Work

Conclusions:

- Despite the extreme unbalanced nature of the dataset, Random Forest classified 78% of the fraudulent transactions with few false positives (4% of frauds identified).
- The undersampling technique did not improve the area under the Precision-Recall Curve score but identified a slightly higher value of frauds for the same number of transactions identified. The MLP model identified a higher value amount of frauds for all features, reduced features and undersampling but also misclassified a higher value amount of legitimate transactions.
- Performance degraded when features were dropped except for the Autoencoder model which improved with fewer more distinct features.

Future Work:

- Include more model parameters in a broader optimization search.
- Use time feature by setting it to time of day vs. time from first transaction.
- Investigate a hybrid classifier by combining multiple classifiers.