6501 Progress Report Group 4

Improving Credit Card Fraud Detection using Generative Adversarial Networks

Group 4 Team Member: Hao Ning, Jun Ying

Working Schedule

Time	Milestone
09/21/2020	Exploratory Data Analysis (EDA): Jun Base Model: Hao
09/28/2020	Original data + GAN
10/05/2020	Network & Framework Development WGAN: Hao BEGAN: Jun
10/12/2020	WGAN & BEGAN Evaluation & Analysis
10/19/2020	Network & Framework Development BAGAN: Hao SNGAN: Jun
10/26/2020	Preliminary Presentation
11/02/2020	BAGAN, SNGAN Evaluation & Analysis
11/09/2020 & 11/16/2020	Summary of Results
11/23/2020	Manuscript
11/30/2020 & 12/07/2020	Mock Presentation & Presentation and Journal Submission

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09/21/2020

EDA

```
Index(['Time', 'V1', 'V2', 'V3', 'V4', 'V5', 'V6', 'V7', 'V8', 'V9', 'V10',
       'V11', 'V12', 'V13', 'V14', 'V15', 'V16', 'V17', 'V18', 'V19', 'V20',
       'V21', 'V22', 'V23', 'V24', 'V25', 'V26', 'V27', 'V28', 'Amount',
       'Class'],
```

About the dataset, there are 30 features and 1 class (normal:0, fraud:1)

	Time	V1	V2	V3	...	V27	V28	Amount	Class
0	0.0	-1.359807	-0.072781	2.536347	...	0.133558	-0.021053	149.62	0
1	0.0	1.191857	0.266151	0.166480	...	-0.008983	0.014724	2.69	0
2	1.0	-1.358354	-1.340163	1.773209	...	-0.055353	-0.059752	378.66	0
3	1.0	-0.966272	-0.185226	1.792993	...	0.062723	0.061458	123.50	0
4	2.0	-1.158233	0.877737	1.548718	...	0.219422	0.215153	69.99	0

There is no null value in the dataset.

```
 Total null values in the dataset
0
```

As we know, the dataset is extremely imbalanced(0.173%).

```
The amounts of normal transactions (class 0) & fraud transactions (class 1)
0    284315
1       492
```

We have observed that there are some transactions which are 0.

	Time	V1	...	Amount	Class
count	284807.000000	2.848070e+05	...	284807.000000	284807.000000
mean	14.537951	3.919560e-15	...	88.349619	0.001727
std	5.847061	1.958696e+00	...	250.120109	0.041527
min	0.000000	-5.640751e+01	...	0.000000	0.000000
25%	10.598194	-9.203734e-01	...	5.600000	0.000000
50%	15.010833	1.810880e-02	...	22.000000	0.000000
75%	19.329722	1.315642e+00	...	77.165000	0.000000
max	23.999444	2.454930e+00	...	25691.160000	1.000000

The total number of 0 amount: 1825 (1.479% fraud)

```
The null amounts of normal transactions (class 0) & fraud transactions (class 1)
0    1798
1      27
Name: Class, dtype: int64
```

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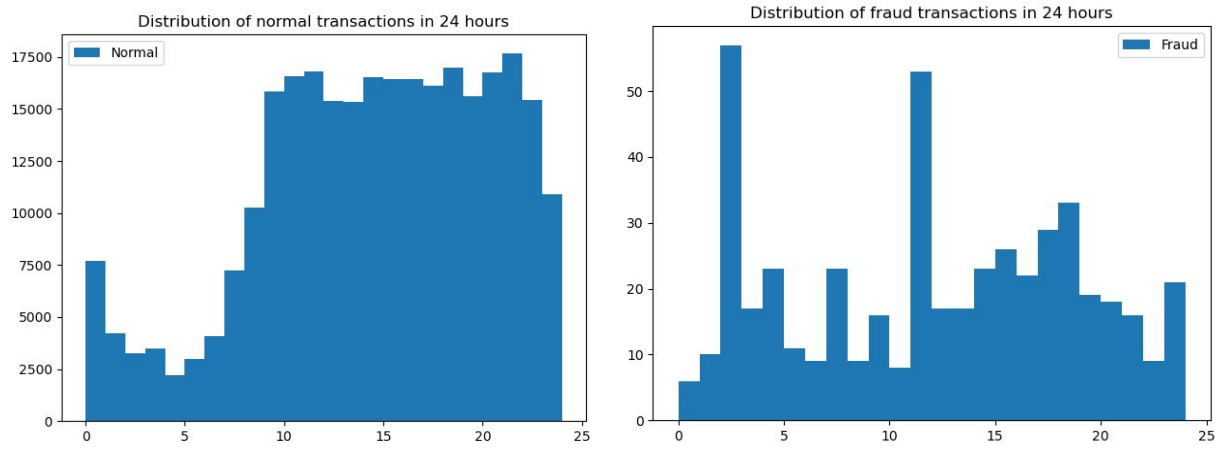
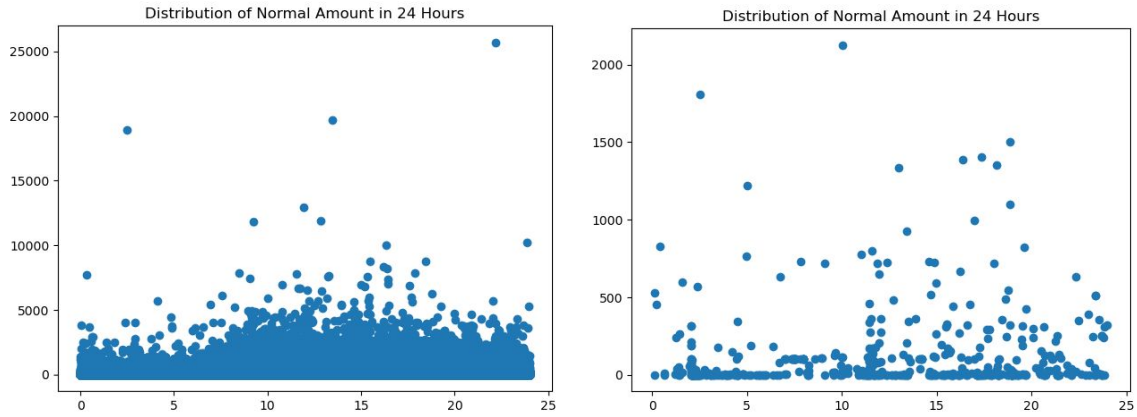
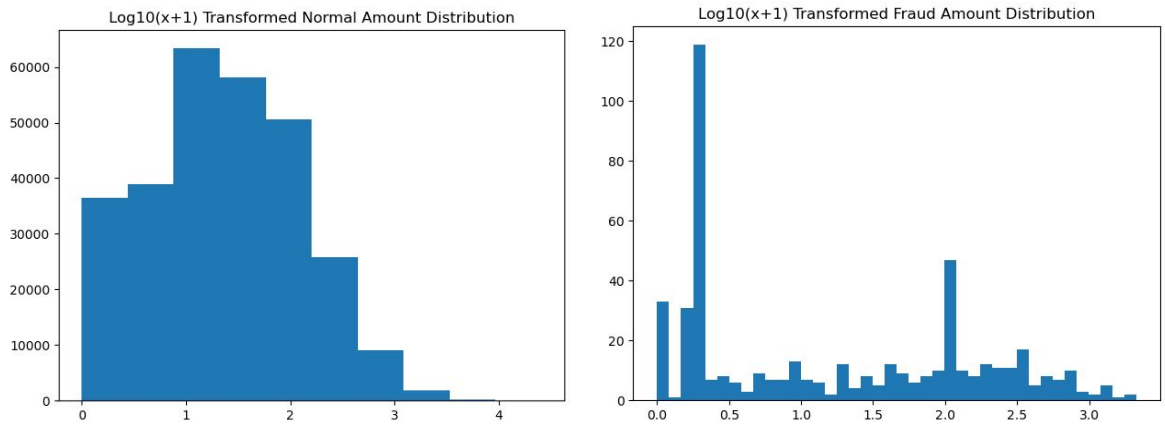


From the histogram, we can observe that normal transactions generally occur from 9 am to 0 am. However, the fraud transactions occur particularly frequently at 2 am and 12 pm.



We can find from this scatter plot that the amount of super large transactions is very small. In comparison, the largest amount of nurmal transactions is over €25,000. However, the largest amount of fraud transactions is only €2,000.



Normal amount was from ten to hundred. Fraud Amount distributed in less than €1.

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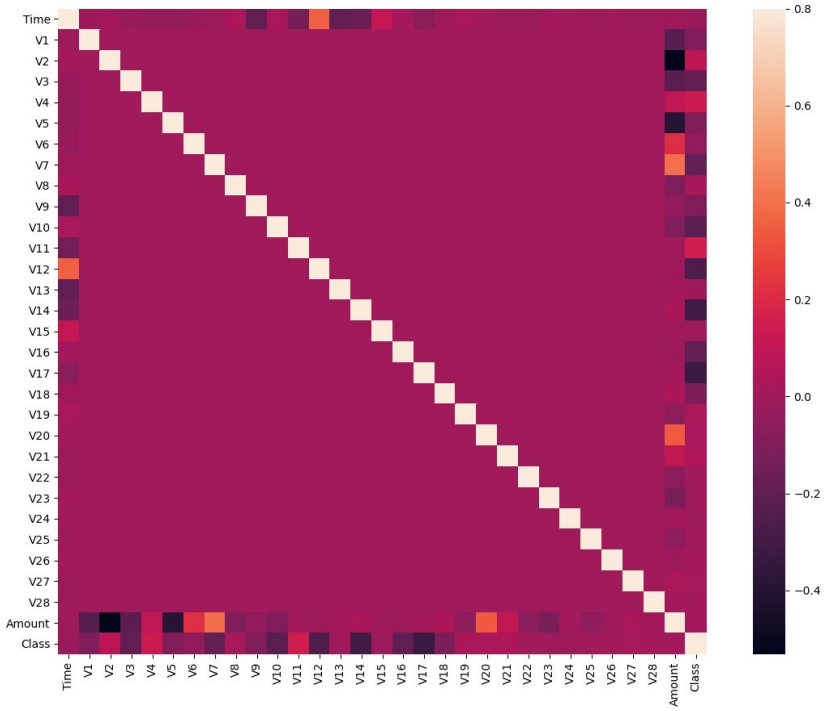

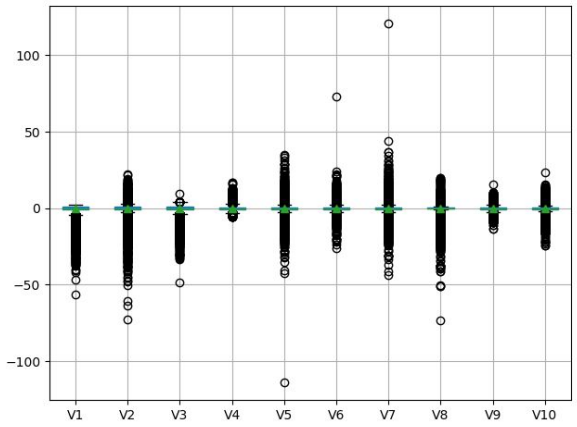

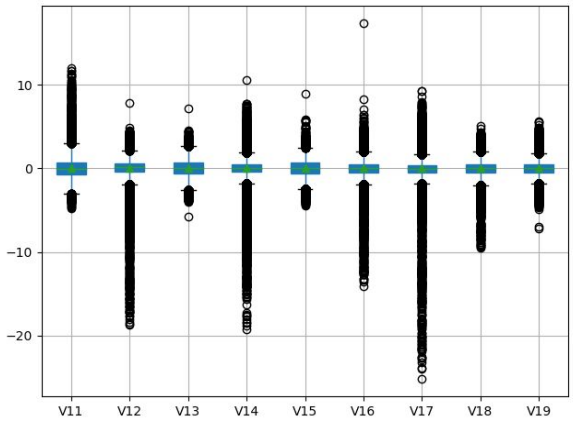

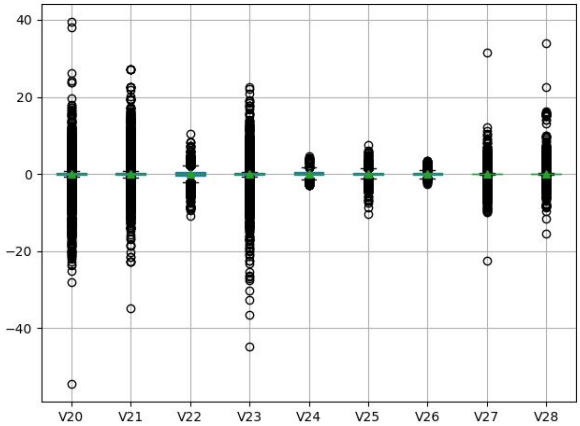

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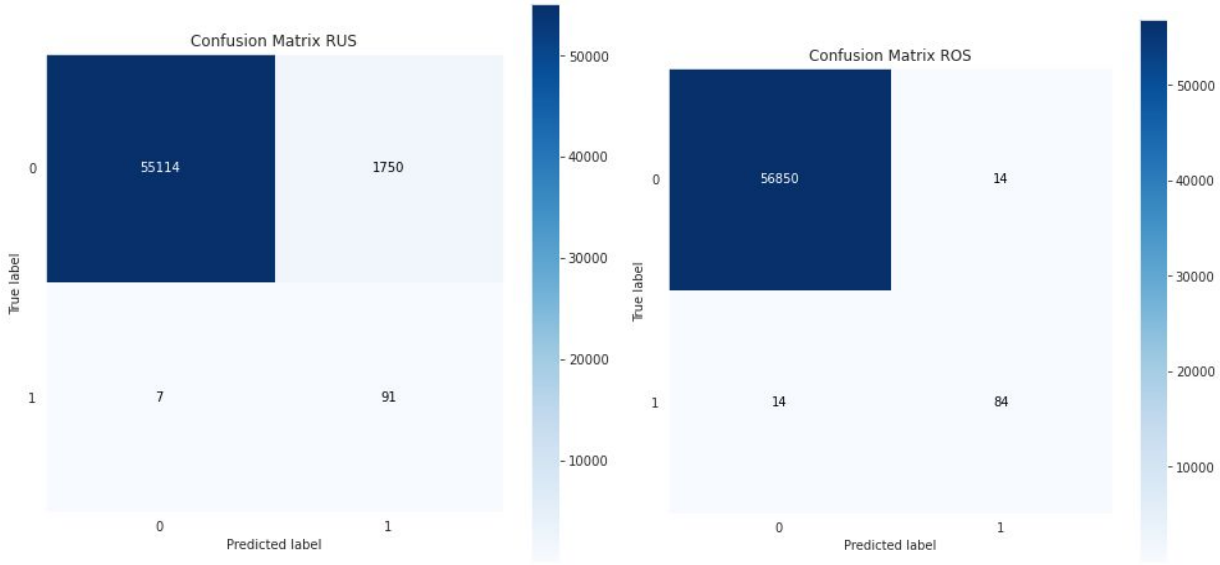
Base Model:

1. Train Test Split & Stratified: 80% 227845 (**394 fraud**), 20% 56962 (**98 fraud**)
2. Random Under Sampling (RUS) and Random Over Sampling (ROS)
3. GridsearchCV for XGBoostClassifier
4. Predict with best_params
5. Test result comparison

RUS 1 394 0 394	ROS 1 227451 0 227451
Accuracy: 0.9691548751799445 Precision: 0.049429657794676805 Recall: 0.9285714285714286 F1 score: 0.09386281588447654 ROC AUC score: 0.9488981228394566	Accuracy: 0.9995084442259752 Precision: 0.8571428571428571 Recall: 0.8571428571428571 F1 score: 0.8571428571428571 ROC AUC score: 0.9284483278398585



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09/28/2020

Implemented with Keras

Generator

Discriminator

Train

Original data + GAN

Original x_train has total of 227451 transactions, 227451 normal & 394 Fraud

1000

	Time	V1	V2	V3	V4	V5	V6	V7
count	1000.000000	1000.000000	1000.000000	1000.000000	1000.000000	1000.000000	1000.000000	1000.000
mean	1.705863	-0.389961	0.402280	-0.679441	0.026302	-0.807352	-0.231370	-0.42902
std	0.469486	0.196144	0.227128	0.295721	0.242404	0.291625	0.233276	0.244944
min	0.602538	-1.098236	-0.274687	-2.079900	-0.865937	-1.734678	-1.088720	-1.45883
25%	1.365533	-0.506325	0.248550	-0.854513	-0.133793	-0.995170	-0.377086	-0.59152
50%	1.651262	-0.377364	0.400120	-0.658193	0.027595	-0.780409	-0.215505	-0.41083
75%	1.977582	-0.258227	0.534954	-0.478576	0.182285	-0.586832	-0.076296	-0.26430
max	3.685767	0.283151	1.292993	0.067721	0.973806	-0.147021	0.420937	0.264664

227451

	Time	V1	V2	V3	V4	V5	V6
count	227057.000000	227057.000000	227057.000000	227057.000000	227057.000000	227057.000000	227057.00
mean	1.708374	-0.393808	0.398990	-0.670787	0.026841	-0.810465	-0.232531
std	0.462913	0.189808	0.225360	0.281548	0.237714	0.292137	0.232690
min	0.240171	-1.468923	-0.628445	-2.425254	-1.185536	-2.930725	-1.455245
25%	1.377550	-0.516910	0.244866	-0.845061	-0.131113	-0.991146	-0.382999
50%	1.670537	-0.387175	0.391337	-0.645978	0.025858	-0.785670	-0.227924
75%	1.998045	-0.263956	0.545245	-0.470083	0.184095	-0.602572	-0.076197
max	4.212597	0.412227	1.578318	0.269768	1.187458	0.064927	0.826037

The fraud in x_train

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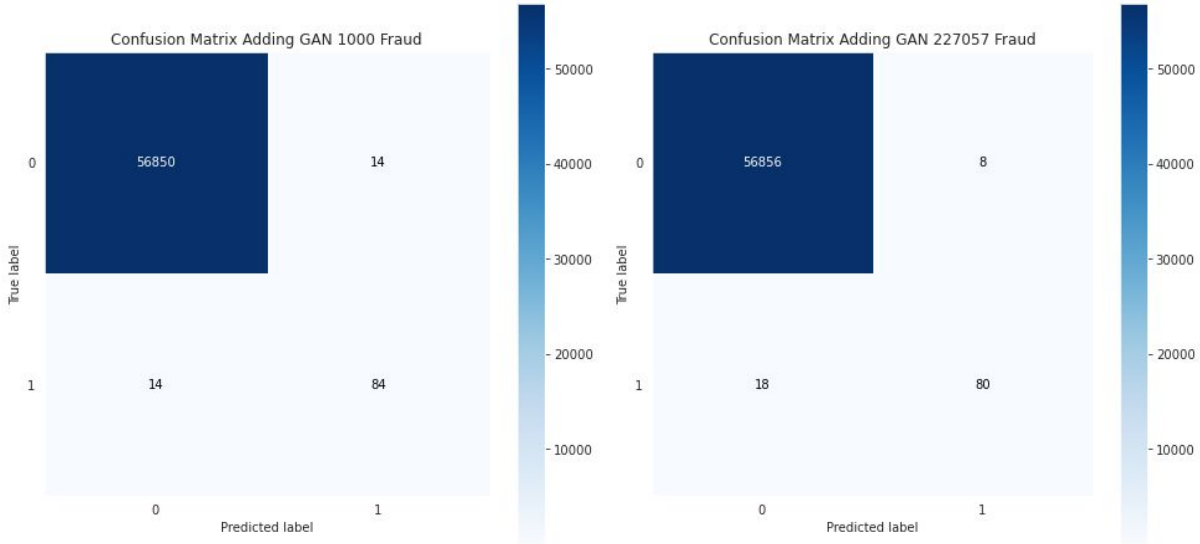
	Time	V1	V2	V3	V4	V5	V6	V7
count	394.000000	394.000000	394.000000	394.000000	394.000000	394.000000	394.000000	394.000000
mean	23.008938	-4.707808	3.588729	-7.068378	4.592975	-3.101629	-1.387192	-5.539909
std	13.347935	6.841390	4.309436	7.166449	2.883467	5.406586	1.864770	7.316745
min	1.239444	-30.552380	-8.402154	-31.103685	-1.313275	-22.105532	-5.773192	-43.557242
25%	11.500278	-5.996596	1.229209	-8.436924	2.419178	-4.741036	-2.504633	-7.765017
50%	21.393056	-2.272114	2.662472	-5.133485	4.258196	-1.522962	-1.421577	-2.926216
75%	35.912917	-0.410418	4.737900	-2.302626	6.390866	0.240184	-0.361122	-0.900824
max	47.318889	2.132386	22.057729	2.250210	12.114672	11.095089	6.474115	5.802537

The little std observed in the GAN generated data indicates **mode collapse** in vanilla gan

ADD GAN 1000 then ros.fit Normal: 227451 Fraud: 227451	GAN 227057 Normal: 227451 Fraud: 227451
Accuracy: 0.9995084442259752 Precision: 0.8571428571428571 Recall: 0.8571428571428571 F1 score: 0.8571428571428571 ROC AUC score: 0.9284483278398585	Accuracy: 0.9995435553526912 Precision: 0.9090909090909091 Recall: 0.8163265306122449 F1 score: 0.8602150537634408 ROC AUC score: 0.9080929220309395



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10/05/2020

WGAN development: Hao

Why WGAN:

Implementation in Keras:

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10/12/2020

WGAN performance evaluation: Hao