

MSCS-633: Hands-On Assignment4: Report: Credit Card Fraud Detection using PyOD
AutoEncoder

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MSCS-633 Advance Artificial Intelligence

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1. Introduction

This project demonstrates the use of an unsupervised deep learning model—AutoEncoder from the PyOD library—to detect fraudulent transactions in a highly imbalanced credit card dataset. The goal is to train the model to identify anomalies (potential frauds) based on reconstruction error.

2. Dataset Description

The dataset used for this project was sourced from Kaggle. It contains 284,807 anonymized transactions, with only 492 labeled as fraud. The features are mostly PCA-transformed, except for 'Time' and 'Amount'. The label column is 'Class', where 1 indicates fraud and 0 indicates legitimate transactions.

3. Project Setup

Environment: Python 3.13 on macOS (ARM64)

Virtual Environment: Created using ``python3 -m venv venv``

Required Python Libraries:

- pandas
- numpy
- scikit-learn
- pyod
- torch
- tqdm

- seaborn

- matplotlib

4. Implementation

The project is implemented in a script named 'fraud_detection.py', following these steps:

- Load the dataset using Pandas

- Normalize 'Time' and 'Amount' columns using StandardScaler

- Split the data into train and test sets

- Train a PyOD AutoEncoder on training data

- Predict anomalies on the test set

- Evaluate performance using classification metrics and ROC-AUC score

5. Screenshots

[Screenshot: Dataset Preview Output]

Possible Data Loss																											
Some features might be lost if you save this workbook in the classic-delimited (.csv) format. To preserve these features, save this workbook in an Excel file format.																											
Save As...																											
A1																											
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
1	Time	0	1.3580271	0.0727312	2.53634674	1.3781552	-0.338208	0.85238778	0.2396985	0.0869789	0.36378907	0.09078417	-0.6515905	-0.617609	-0.913388	-0.3111884	1.4821787	-0.470005	0.20797124	0.02570058	0.40399306	0.2514221	-0.0130308	0.37738781	-0.1104739	0.98662897	0.12833636
2		0	1.1918571	0.2661071	0.1684811	0.44815408	0.00601785	-0.0823608	-0.078803	0.0851165	-0.254251	-1.069744	0.8127766	1.0623531	0.4890974	-0.1437723	0.63558809	0.46391704	-0.1148047	-0.1833613	-0.145783	-0.0680631	-0.2257752	-0.6386872	0.0128802	-0.398465	0.1671704
3		1	1.3382451	-1.3401631	1.7720304	0.3797789	-0.053181	1.80048938	0.7914609	0.24767579	-1.514643	0.20764287	0.6240416	0.0668369	0.7172973	-0.1950489	0.34584649	-2.8900832	1.0989688	-0.1213593	-0.261871	0.52497873	0.2479815	0.7717678	0.09041228	-0.88281	-0.3274618
4		1	0.8662711	-0.185226	1.7829334	0.8629213	-0.010399	1.2470217	0.32770894	0.37416671	-1.387041	-0.5548519	-0.2284873	0.07797887	-0.2976237	-0.631431	-1.0584472	-0.8840408	1.86575	1.220262	-0.296378	-0.1330305	0.0053788	-0.1902205	-1.1757313	0.6473703	-0.1
5		2	1.558231	0.8777675	1.5871785	0.40033303	-0.4071354	0.06962146	0.5024075	-0.2765327	0.61773931	0.7530743	-0.8228429	0.5381555	1.3485159	-1.1196988	0.17512113	-0.451446	-0.273032	0.0281948	0.8034886	0.4085426	-0.094347	0.7982749	-0.1547581	0.14126808	-0.2006006
6		2	-0.4258659	0.9052304	1.14110934	0.1682521	0.4209888	-0.0297276	0.47620095	0.2603143	-0.568874	-0.3714072	1.3412619	0.35898384	-0.5880807	-0.1171327	0.51761581	0.4017259	-0.0681328	0.06863315	-0.0318139	0.0484967	-0.2082325	-0.0589404	-0.026977	-0.3714268	0.2327938
7		4	1.22687673	0.14100551	0.64537077	1.20282274	0.2518099	0.27270612	-0.001189	0.0812284	0.6484989	-0.092343	-1.4128973	-0.1538258	-0.701827	0.07701396	0.60214359	-0.4434968	0.00202611	0.6118873	-0.945175	-0.2196235	-0.0771383	0.2707897	-0.1541038	-0.780544	0.7503894
8		7	0.8296281	0.2861572	-0.1413922	0.2712581	0.26959966	0.372181806	0.37014513	0.8510844	-0.3020478	-0.4104304	0.7051196	-0.1104623	-0.286236	0.7453536	-0.3287831	-0.2100773	-0.489768	0.1187486	0.57032817	0.05275867	-0.074251	-0.2689194	-0.0042327	1.0115918	0.37302498
9		8	0.3326218	1.1595338	1.0449655	0.2221873	0.4939391	-0.2467611	0.6518281	0.0891889	-0.7867373	-0.3585456	1.0714447	0.9363957	1.0084381	-0.4032228	1.5102191	0.7584278	-0.5489789	0.4767728	0.4117729	0.2071745	-0.2489139	-0.6337628	-0.1207841	-0.350489	-0.08973
10		7	0.6404884	1.4793655	1.0743838	-0.482109	0.48883409	0.42811846	1.12963136	-0.807864	0.61537473 <td>1.24837618</td> <td>-0.6184678</td> <td>0.2914735</td> <td>1.75786421</td> <td>-0.1238952</td> <td>0.6881325</td> <td>-0.076127</td> <td>-1.222173</td> <td>0.10450473</td> <td>-0.1567419</td> <td>1.04346534</td> <td>0.1054457</td> <td>0.0759533</td> <td>-0.48079</td> <td>0.4123686</td> <td>-0.1</td>	1.24837618	-0.6184678	0.2914735	1.75786421	-0.1238952	0.6881325	-0.076127	-1.222173	0.10450473	-0.1567419	1.04346534	0.1054457	0.0759533	-0.48079	0.4123686	-0.1
11		10	0.3849782	0.6516104	-0.742907	0.6064189	0.2045438	0.351702717	0.4704587	0.5382473 <td>-0.558848</td> <td>0.3097539</td> <td>-0.2591158</td> <td>-0.3281432</td> <td>-0.000467</td> <td>0.36283237</td> <td>0.5289038</td> <td>-0.128468</td> <td>-0.089789</td> <td>0.3599639</td> <td>0.7078633</td> <td>0.1559918</td> <td>0.04962389</td> <td>0.2384251</td> <td>0.0091287</td> <td>0.99671021</td> <td>-0.7873148</td>	-0.558848	0.3097539	-0.2591158	-0.3281432	-0.000467	0.36283237	0.5289038	-0.128468	-0.089789	0.3599639	0.7078633	0.1559918	0.04962389	0.2384251	0.0091287	0.99671021	-0.7873148
12		10	1.2498974	1.221038	0.3830915	1.2348987 <td>-1.4854195</td> <td>-0.7632302</td> <td>-0.089465</td> <td>0.2374872</td> <td>-0.0404106</td> <td>1.3272727</td> <td>0.2376623</td> <td>-0.242082</td> <td>1.2054181</td> <td>-0.3176303</td> <td>0.7256749</td> <td>-0.815412</td> <td>0.8730845</td> <td>0.8477888</td> <td>-0.6831828</td> <td>-0.107359</td> <td>-0.2118902</td> <td>-0.4823853</td> <td>0.04646789</td> <td>0.3203389</td> <td>0.6113465</td>	-1.4854195	-0.7632302	-0.089465	0.2374872	-0.0404106	1.3272727	0.2376623	-0.242082	1.2054181	-0.3176303	0.7256749	-0.815412	0.8730845	0.8477888	-0.6831828	-0.107359	-0.2118902	-0.4823853	0.04646789	0.3203389	0.6113465
13		11	1.0897359	0.2877213	0.8261273	2.7123043 <td>-0.178398</td> <td>0.33754373</td> <td>-0.0967169</td> <td>0.11588174</td> <td>-0.2210308</td> <td>0.46523044</td> <td>-0.776566</td> <td>0.2333875</td> <td>-0.011759</td> <td>-0.1748852</td> <td>-0.655643</td> <td>-0.199252</td> <td>1.2140542</td> <td>-0.980482</td> <td>-0.8828161</td> <td>-0.1533372</td> <td>-0.5988755</td> <td>0.0744234</td> <td>-0.0714074</td> <td>0.15474375</td> <td>0.0485473</td>	-0.178398	0.33754373	-0.0967169	0.11588174	-0.2210308	0.46523044	-0.776566	0.2333875	-0.011759	-0.1748852	-0.655643	-0.199252	1.2140542	-0.980482	-0.8828161	-0.1533372	-0.5988755	0.0744234	-0.0714074	0.15474375	0.0485473
14		12	-0.7918548	-0.3277708	1.64715018	1.76747274	-0.1393884	0.89798647	-0.4229114	1.8071075	0.75571291	1.1510889	0.8445547	0.7924395	0.3744409	-0.7497751	0.4087957	-0.3030578	-0.1558887	0.77820546	2.22186801	-1.582122	1.15169305	0.22218197	0.020962	0.02831865	-0.2327463
15		12	-0.7421417	0.34545452	2.0273221	1.4864631	-1.158397	-0.0778488	-0.068914	0.0308404	-0.428167	0.4773983	-0.7890606	-0.7184967	1.047327	1.0669371	1.0885348	1.6011356	-0.2780814	-0.4199941	0.4235335	0.3263486	-0.4990435	1.3336489	-0.2567373	-0.656837	0.0391244
16		11	1.0897359	0.2877213	0.8261273	2.7123043	-0.178398	0.33754373	-0.0967169	0.11588174	-0.2210308	0.46523044	-0.776566	0.2333875	-0.011759	-0.1748852	-0.655643	-0.199252	1.2140542	-0.980482	-0.8828161	-0.1533372	-0.5988755	0.0744234	-0.0714074	0.15474375	0.0485473
17		12	-0.7918548	-0.3277708	1.64715018	1.76747274	-0.1393884	0.89798647	-0.4229114	1.8071075	0.75571291	1.1510889	0.8445547	0.7924395	0.3744409	-0.7497751	0.4087957	-0.3030578	-0.1558887	0.77820546	2.22186801	-1.582122	1.15169305	0.22218197	0.020962	0.02831865	-0.2327463
18		14	-0.4012577	-0.4501478	1.1883643	1.786208	0.3491598	-1.7634556	1.5593777	0.16884175	1.2335874	0.34517283	0.9172297	0.9701672	-0.1666878	-0.791299	-0.5286895	0.7200411	-0.2548019	0.0758215	-0.409895	-2.198448	-0.5036933	0.0846979	2.6556558	0.4212119	-0.4416306
19		12	1.0321544	-0.0402962	1.2673529	1.2809147	-0.7359927	0.28880916	-0.0680684	0.08377951	0.78233289	-0.2679751	-0.4503313	0.9367771	0.7083841	-0.4864743	0.3547406	-0.2466347	-0.0092124	-0.5099124	-0.5756818	-0.1139102	-0.204612	0.1906189	0.01380165	0.13275833	0.36429574
20		13	-0.4389051	0.9189621	0.9249077	-0.7272191	0.9156782	-0.1278874	0.7076141	0.0876236	-0.6652714	-0.7377998	0.32409781	0.27719211	0.2524262	-0.2918985	-0.1845202	1.14317371	-0.9287083	0.68046959	0.02543648	-0.0470213	-0.1947898	-0.072388	-0.1588575	-0.8883863	-0.3424312
21		14	-0.4012577	-0.4501478	1.1883643	1.786208	0.3491598	-1.7634556	1.5593777	0.16884175	1.2335874	0.34517283	0.9172297	0.9701672	-0.1666878	-0.791299	-0.5286895	0.7200411	-0.2548019	0.0758215	-0.409895	-2.198448	-0.5036933	0.0846979	2.6556558	0.4212119	-0.4416306
22		15	1.4829358	-0.0295467	0.6454793	1.4382059	-1.5554341	-0.7206611	1.0896641	-0.053127	-0.7898816	1.8380784	1.0774541	-0.632465	-0.4169872	0.05201052	-0.0429788	-0.1564525	0.3042442	-0.5544325	0.05422962	-0.2958136	-0.177648	-0.0587958	0.1375878	0.0286136	0.3370001
23		16	0.8848478	-1.3618191	1.0222314	0.8341593	-1.1912088	1.39510882	-0.8758889	0.45529183	-0.461358	0.5685204	1.01915081	1.2883287	-0.0480827	-0.727851	-0.8079795	-0.0445575	0.51568347	0.6258473	-1.3004892	-0.188339	-0.175785	-0.0088087	-0.304245	0.0720011	-0.1
24		17	0.9049897	0.2846103	-0.1714781	1.0302047	1.1295557	1.8603769	0.10771165	0.5125216	-1.193111	0.71429621	0.0602292	0.4067759	-0.2064219	0.8787962	0.7109777	-0.0022219	0.64048438	-0.0470213	-0.207123	-0.20821	1.0409742	-0.0485292	-0.1718953	0.3906139	-0.1
25		18	1.6865163	0.5021209	-0.057803	0.26166584	0.4288943	0.08847352	0.24114658	0.1388817	-0.8891624	0.52571487	-0.7447769	-0.531373	-0.1053465	1.188781	0.6037532	0.0442461	-0.4544753	0.0986786	-0.2073885	-0.161970187	-0.0519722	-0.103849	-0.249436	0.6020034	-0.1
26		18	0.24748113	0.2770663	1.5847084	0.6062025	-1.3134394	-0.150118	-0.043638	-1.6179331	1.5440714	-0.2589806	0.5893232	0.483373	0.8139399	-1.5502402	-1.398849	0.7831084	0.43062121	2.17788717	-0.209881	0.5818036	0.2040849	-0.185325	0.42670715	0.82096126	-0.1
27		22	1.9465251	-0.044005	-0.405701	1.0135673	1.8149677	2.9555534	-0.003633	0.0554831	0.048969	0.57174251	-0.0812555	-0.215745	0.0414903	0.0289778	1.007179	0.7584548	-0.07967	0.0446262	0.4889287	-0.2187153	-0.5759229	-0.709229	0.0700322	0.96342149	0.32210113
28		22	0.2742947	-0.121418	1.3202063	0.4100751	0.2931795	-0.6656372	0.5408549	-0.104867	0.7566462	0.1845062	-0.856564	-1.051252	-0.855239	-0.277999	-0.3333206	0.9187519	-0.484477	0.5057103	-0.2666396	-0.483635	-0.227644	-0.1024487	-0.0589404	-0.1589913	-0.1
29		23	1.7238481	0.3534788	0.2899007	1.1336632	-0.127572	-0.8160337	0.36902485	-0.3278602	-0.246651	-0.5461393	-0.145418	0.7930388	1.4822844	0.1014173	0.7514775	-0.0148841	-0.5116401	-0.3250564	-0.3908338	0.2577791	-0.08				

[Screenshot: Classification Report & Confusion Matrix Output]

```
ROC-AUC Score: 0.9498
(venv) /Users/mac/Sandesh_Cumberlands_Assignments/Advanced_Artificial_Intelligence/MSCS-633-Assignment4 % open ./.
(venv) /Users/mac/Sandesh_Cumberlands_Assignments/Advanced_Artificial_Intelligence/MSCS-633-Assignment4 %
```

The model showed a strong ROC-AUC score of approximately 0.95, indicating good separation between fraud and non-fraud cases. However, due to class imbalance, the recall for fraud detection was relatively low. This is expected behavior in anomaly detection setups.

All source code, README, and manifest files have been pushed to the following GitHub repository:

<https://github.com/sanspokharel26677/MSCS-633-Assignment4>