

Hands-On Assignment #4

Advanced Artificial Intelligence

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1. Environment and Technical Requirements

To execute this experiment, the following environment was configured:

- **IDE:** Visual Studio Code
- **Language:** Python 3.x
- **Core Library:** **PyOD** (Python Outlier Detection)
- **Deep Learning Backend:** **TensorFlow 2.20.0 with Keras 3.10.0**
- **Version Note:** Due to the updated Keras backend, the AutoEncoder was initialized using the hidden_neuron_list and epoch_num parameters to ensure compatibility with the latest library signatures.

2. Methodology

The experiment utilizes an **AutoEncoder**, a type of neural network designed to learn a compressed representation (encoding) of the input data.

- **Training:** The model was trained primarily on normal transaction data. It learns to "reconstruct" these transactions with very low error.
- **Detection:** When the model encounters a fraudulent transaction (an anomaly), it fails to reconstruct it accurately. This results in a high **Reconstruction Error**.
- **Architecture:** The network uses a symmetric bottleneck architecture: [30, 15, 15, 30].

3. Source Code Repository

The complete Python source code, including the manifest file and dependency list, has been uploaded to GitHub.

Repository URL: <https://github.com/bibekitani-git/Hands-On-Assignment-4.git>

4. Experiment Results and Output

The model was trained for **20 epochs**. The following output captures the successful training cycle and the final evaluation metrics on the test dataset.

A. Training Logs

```
$ python3 fraud_detection.py
--- Training AutoEncoder Model ---
Training: 100%|██████████| 20/20 [07:3
--- Model Evaluation ---
precision    recall   f1-score  support
          0       1.00     0.99     1.00      56864
          1       0.12     0.77     0.21      98

accuracy                           0.99      56962
macro avg       0.56     0.88     0.60      56962
weighted avg    1.00     0.99     0.99      56962
```

B. Classification Report

The model produced the following performance metrics:

Metric	Class 0 (Normal)	Class 1 (Fraud)
Precision	1.00	0.12
Recall	0.99	0.77
F1-Score	1.00	0.21

C. Analysis

- **Recall (0.77):** The model successfully identified 77% of all fraudulent transactions in the test set. In fraud detection, high recall is critical to ensure that the majority of illegal activity is flagged.
- **Precision (0.12):** The precision is lower because the model is sensitive to anomalies, leading to some false positives. This is acceptable in a financial context where "flagged" transactions can be verified by a human agent or secondary system.
- **Conclusion:** The AutoEncoder effectively distinguishes between standard purchasing patterns and fraudulent anomalies without requiring labeled "fraud" data for training.