Assignment 6.1: Anomaly Detection with a Deep Autoencoder

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Results

The results from experimenting with different number of layers, encoding dimensions, and learning rates in the deep autoencoder are summarized in the tables that follow (TensorFlow, 2023). From Table 1 it can be seen that the performance of the models improved with the addition of a new layer until the fifth layer which performed similar to the model with only 4 layers. The precision of the model is consistent with the accuracy for all iterations and the recall is consistently slightly higher.

Table 1

Exploration of the number of layers

Performance Metric	1	2	3	4	5
Accuracy	0.1299	0.2768	0.3446	0.4124	0.4181
Precision	0.1237	0.2844	0.3394	0.4109	0.4167
Recall	0.1481	0.3827	0.4568	0.6543	0.6790

Table 2 summarizes the results from experimenting with different encoding dimensions. Since the previous exploration showed the ideal number of layers is 4, that is used for this exploration. Each layer of the encoder has a dimension that is half of the previous layer. The maximum encoding dimensions analyzed are 25, 50, 100, 200, and 500. It can be seen that the number of encoding dimensions does not drastically influence the performance of the model as the accuracy, precision, and recall have similar results for every model iteration.

Table 2

Exploration of encoding dimensions

Performance Metric	25	50	100	200	500
Accuracy	0.4746	0.3729	0.4124	0.4463	0.3390
Precision	0.4559	0.3863	0.4109	0.4361	0.3500
Recall	0.7654	0.6296	0.6543	0.7160	0.5185

Table 3 summarizes the results from experimenting with different learning rates. This parameter has the most influence on the model's performance; however still does not obtain great accuracy or precision.

Table 3

Exploration of learning rates

Performance Metric	0.1	0.01	0.001	0.0001	0.00001
Accuracy	0.1243	0.1243	0.3616	0.5085	0.5141
Precision	0.1146	0.1224	0.3769	0.4810	0.4842
Recall	0.1358	0.1481	0.6049	0.9383	0.9506

The final model uses the findings from the layer, encoding dimension, and learning rate exploration to optimize the performance. The model consists of 4 layers, an encoding dimension of 100, and a learning rate of 0.00001. The model performance on the testing dataset is summarized in Table 4.

Table 4

Final model performance metrics on test dataset

Performance Metric	Test Dataset
Accuracy	0.5859
Precision	0.5604
Recall	0.9808

Discussion

From the results gathered in the previous section it can be seen that deep autoencoders are an alright solution for anomaly detection in credit card transactions. The accuracy of the models stays between 10-60% regardless of the parameter tuning that is done. The precision has a similar poor performance indicating a small proportion of the identified anomalies are true anomalies. The recall has the best performance with the test dataset obtaining a result of 98%. This indicates that the network is able to identify a large proportion of the true anomalies. These metrics imply that the autoencoder will classify

more transactions as fraud than really are, which for this application is beneficial since the impact of misclassifying a true transaction as fraud is not large but the opposite situation is.

A limitation of applying deep autoencoders to anomaly detection in credit card transactions is the limited datasets available. The number of fraudulent transactions is significantly less than the true transactions creating a very imbalanced dataset. To balance it, a large portion of the true transactions are removed resulting in a smaller dataset. In the event that a large, balanced dataset is available, the model requires a considerable amount of time to train (Goodfellow et al., 2016).

References

Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. *MIT Press*.

TensorFlow. (2023, August 3). Intro to Autoencoders. https://www.tensorflow.org/tutorials/generative/autoencoder#third_example_anomaly_detection