untitled

November 19, 2023

```
[1]: pip install numpy
```

```
Requirement already satisfied: numpy in c:\users\vaishnavi\anaconda3\lib\site-
packages (1.24.3)
Note: you may need to restart the kernel to use updated packages.
```

```
[2]: pip install pandas
```

```
Requirement already satisfied: pandas in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (1.5.1)
Requirement already satisfied: python-dateutil>=2.8.1 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from pandas)
(2.8.2)
Requirement already satisfied: pytz>=2020.1 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from pandas)
(2022.6)
Requirement already satisfied: numpy>=1.21.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from pandas) (1.24.3)
Requirement already satisfied: six>=1.5 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from python-
dateutil>=2.8.1->pandas) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

```
[3]: pip install tensorflow
```

```
Requirement already satisfied: tensorflow in
c:\users\vaishnavi\anaconda3\lib\site-packages (2.14.0)Note: you may need to
restart the kernel to use updated packages.

Requirement already satisfied: tensorflow-intel==2.14.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow) (2.14.0)
Requirement already satisfied: absl-py>=1.0.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-
intel==2.14.0->tensorflow) (2.0.0)
Requirement already satisfied: astunparse>=1.6.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-
intel==2.14.0->tensorflow) (1.6.3)
Requirement already satisfied: flatbuffers>=23.5.26 in
```

c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (23.5.26)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (0.5.4)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (0.2.0)
Requirement already satisfied: h5py>=2.9.0 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (3.9.0)
Requirement already satisfied: libclang>=13.0.0 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (16.0.6)
Requirement already satisfied: ml-dtypes==0.2.0 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (0.2.0)
Requirement already satisfied: numpy>=1.23.5 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (1.24.3)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (3.3.0)
Requirement already satisfied: packaging in c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from tensorflow-intel==2.14.0->tensorflow) (21.3)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<5.0.0dev,>=3.20.3 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (4.25.0)
Requirement already satisfied: setuptools in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (68.0.0)
Requirement already satisfied: six>=1.12.0 in c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from tensorflow-intel==2.14.0->tensorflow) (1.16.0)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (2.3.0)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (4.7.1)
Requirement already satisfied: wrapt<1.15,>=1.11.0 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (1.14.1)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (0.31.0)

Requirement already satisfied: grpcio<2.0,>=1.24.3 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-
intel==2.14.0->tensorflow) (1.59.2)
Requirement already satisfied: tensorboard<2.15,>=2.14 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-
intel==2.14.0->tensorflow) (2.14.1)
Requirement already satisfied: tensorflow-estimator<2.15,>=2.14.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-
intel==2.14.0->tensorflow) (2.14.0)
Requirement already satisfied: keras<2.15,>=2.14.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from tensorflow-
intel==2.14.0->tensorflow) (2.14.0)
Requirement already satisfied: wheel<1.0,>=0.23.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
astunparse>=1.6.0->tensorflow-intel==2.14.0->tensorflow) (0.38.4)
Requirement already satisfied: google-auth<3,>=1.6.3 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (2.23.4)
Requirement already satisfied: google-auth-oauthlib<1.1,>=0.5 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (1.0.0)
Requirement already satisfied: markdown>=2.6.8 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (3.4.1)
Requirement already satisfied: requests<3,>=2.21.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (2.31.0)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (0.7.2)
Requirement already satisfied: werkzeug>=1.0.1 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (2.2.3)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from
packaging->tensorflow-intel==2.14.0->tensorflow) (3.0.9)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from google-
auth<3,>=1.6.3->tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow)
(5.3.2)
Requirement already satisfied: pyasn1-modules>=0.2.1 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from google-
auth<3,>=1.6.3->tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow)
(0.2.8)
Requirement already satisfied: rsa<5,>=3.1.4 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from google-
auth<3,>=1.6.3->tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow)
(4.9)

Requirement already satisfied: requests-oauthlib>=0.7.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from google-auth-
oauthlib<1.1,>=0.5->tensorboard<2.15,>=2.14->tensorflow-
intel==2.14.0->tensorflow) (1.3.1)
Requirement already satisfied: charset-normalizer<4,>=2 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
requests<3,>=2.21.0->tensorboard<2.15,>=2.14->tensorflow-
intel==2.14.0->tensorflow) (2.0.4)
Requirement already satisfied: idna<4,>=2.5 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
requests<3,>=2.21.0->tensorboard<2.15,>=2.14->tensorflow-
intel==2.14.0->tensorflow) (3.4)
Requirement already satisfied: urllib3<3,>=1.21.1 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
requests<3,>=2.21.0->tensorboard<2.15,>=2.14->tensorflow-
intel==2.14.0->tensorflow) (1.26.16)
Requirement already satisfied: certifi>=2017.4.17 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
requests<3,>=2.21.0->tensorboard<2.15,>=2.14->tensorflow-
intel==2.14.0->tensorflow) (2023.7.22)
Requirement already satisfied: MarkupSafe>=2.1.1 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
werkzeug>=1.0.1->tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow)
(2.1.1)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from
pyasn1-modules>=0.2.1->google-
auth<3,>=1.6.3->tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow)
(0.4.8)
Requirement already satisfied: oauthlib>=3.0.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from requests-
oauthlib>=0.7.0->google-auth-
oauthlib<1.1,>=0.5->tensorboard<2.15,>=2.14->tensorflow-
intel==2.14.0->tensorflow) (3.2.2)

[4]: `pip install keras`

Requirement already satisfied: keras in c:\users\vaishnavi\anaconda3\lib\site-
packages (2.14.0)
Note: you may need to restart the kernel to use updated packages.

[5]: `pip install matplotlib`

Requirement already satisfied: matplotlib in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (3.6.2)
Requirement already satisfied: contourpy>=1.0.1 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from
matplotlib) (1.0.6)

```
Requirement already satisfied: cycler>=0.10 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from
matplotlib) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from
matplotlib) (4.38.0)
Requirement already satisfied: kiwisolver>=1.0.1 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from
matplotlib) (1.4.4)
Requirement already satisfied: numpy>=1.19 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from matplotlib) (1.24.3)
Requirement already satisfied: packaging>=20.0 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from
matplotlib) (21.3)
Requirement already satisfied: pillow>=6.2.0 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from
matplotlib) (9.3.0)
Requirement already satisfied: pyparsing>=2.2.1 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from
matplotlib) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from
matplotlib) (2.8.2)
Requirement already satisfied: six>=1.5 in
c:\users\vaishnavi\appdata\roaming\python\python311\site-packages (from python-
dateutil>=2.7->matplotlib) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

[6]:
```
pip install scikit-learn
```

```
Requirement already satisfied: scikit-learn in
c:\users\vaishnavi\anaconda3\lib\site-packages (1.3.0)
Requirement already satisfied: numpy>=1.17.3 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from scikit-learn) (1.24.3)
Requirement already satisfied: scipy>=1.5.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from scikit-learn) (1.11.1)
Requirement already satisfied: joblib>=1.1.1 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from scikit-learn) (1.2.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in
c:\users\vaishnavi\anaconda3\lib\site-packages (from scikit-learn) (2.2.0)
Note: you may need to restart the kernel to use updated packages.
```

[7]:
```python
import numpy as np
import pandas as pd
import tensorflow as tf
import matplotlib.pyplot as plt
from sklearn.metrics import accuracy_score
```
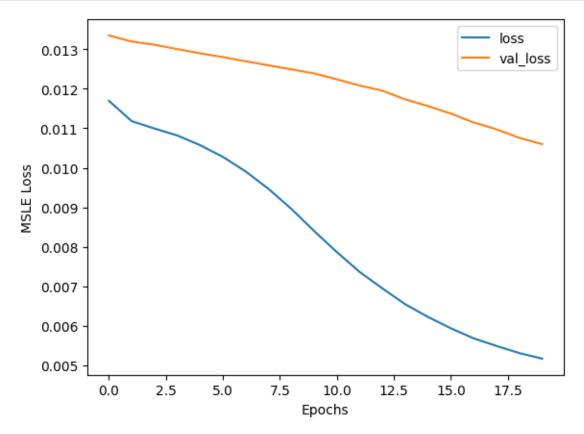
```python
from tensorflow.keras.optimizers import Adam
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras import Model, Sequential
from tensorflow.keras.layers import Dense, Dropout
from sklearn.model_selection import train_test_split
from tensorflow.keras.losses import MeanSquaredLogarithmicError
```

```python
[8]: DATA = 'http://storage.googleapis.com/download.tensorflow.org/data/ecg.csv'
data = pd.read_csv(DATA, header=None)
data.head()
```

```
[8]:         0         1         2         3         4         5         6  \
0 -0.112522 -2.827204 -3.773897 -4.349751 -4.376041 -3.474986 -2.181408
1 -1.100878 -3.996840 -4.285843 -4.506579 -4.022377 -3.234368 -1.566126
2 -0.567088 -2.593450 -3.874230 -4.584095 -4.187449 -3.151462 -1.742940
3  0.490473 -1.914407 -3.616364 -4.318823 -4.268016 -3.881110 -2.993280
4  0.800232 -0.874252 -2.384761 -3.973292 -4.338224 -3.802422 -2.534510

          7         8         9  ...       131       132       133       134  \
0 -1.818286 -1.250522 -0.477492  ...  0.792168  0.933541  0.796958  0.578621
1 -0.992258 -0.754680  0.042321  ...  0.538356  0.656881  0.787490  0.724046
2 -1.490659 -1.183580 -0.394229  ...  0.886073  0.531452  0.311377 -0.021919
3 -1.671131 -1.333884 -0.965629  ...  0.350816  0.499111  0.600345  0.842069
4 -1.783423 -1.594450 -0.753199  ...  1.148884  0.958434  1.059025  1.371682

        135       136       137       138       139  140
0  0.257740  0.228077  0.123431  0.925286  0.193137  1.0
1  0.555784  0.476333  0.773820  1.119621 -1.436250  1.0
2 -0.713683 -0.532197  0.321097  0.904227 -0.421797  1.0
3  0.952074  0.990133  1.086798  1.403011 -0.383564  1.0
4  1.277392  0.960304  0.971020  1.614392  1.421456  1.0

[5 rows x 141 columns]
```

```python
[9]: data.shape
```

```
[9]: (4998, 141)
```

```python
[10]: features = data.drop(140, axis=1)
target = data[140]
x_train, x_test, y_train, y_test = train_test_split(
features, target, test_size=0.2, stratify=target
)
train_index = y_train[y_train == 1].index
train_data = x_train.loc[train_index]
min_max_scaler = MinMaxScaler(feature_range=(0, 1))
x_train_scaled = min_max_scaler.fit_transform(train_data.copy())
```

```
x_test_scaled = min_max_scaler.transform(x_test.copy())
```

[12]:
```python
class AutoEncoder(Model):
    def __init__(self, output_unit, ldim=8):
        super().__init__()
        self.encoder = Sequential([
            Dense(16, activation='relu'),
            Dropout(0.1),
            Dense(ldim, activation='relu')
        ])
        self.decoder = Sequential([
            Dense(16, activation='relu'),
            Dropout(0.1),
            Dense(output_unit, activation='sigmoid')
        ])

    def call(self, inputs):
        encoded = self.encoder(inputs)
        decoded = self.decoder(encoded)
        return decoded
```

[14]:
```python
model = AutoEncoder(output_unit=x_train_scaled.shape[1])
model.compile(loss='msle', metrics=['mse'], optimizer='adam')
epochs = 20
history = model.fit(
x_train_scaled,
x_train_scaled,
epochs=epochs,
batch_size=512,
validation_data=(x_test_scaled, x_test_scaled)
)
```

```
Epoch 1/20
5/5 [==============================] - 1s 58ms/step - loss: 0.0117 - mse: 0.0262
- val_loss: 0.0133 - val_mse: 0.0307
Epoch 2/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0112 - mse: 0.0250
- val_loss: 0.0132 - val_mse: 0.0303
Epoch 3/20
5/5 [==============================] - 0s 14ms/step - loss: 0.0110 - mse: 0.0246
- val_loss: 0.0131 - val_mse: 0.0302
Epoch 4/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0108 - mse: 0.0242
- val_loss: 0.0130 - val_mse: 0.0299
Epoch 5/20
5/5 [==============================] - 0s 11ms/step - loss: 0.0106 - mse: 0.0237
- val_loss: 0.0129 - val_mse: 0.0297
```

```
Epoch 6/20
5/5 [==============================] - 0s 11ms/step - loss: 0.0103 - mse: 0.0230
- val_loss: 0.0128 - val_mse: 0.0295
Epoch 7/20
5/5 [==============================] - 0s 13ms/step - loss: 0.0099 - mse: 0.0222
- val_loss: 0.0127 - val_mse: 0.0292
Epoch 8/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0095 - mse: 0.0212
- val_loss: 0.0126 - val_mse: 0.0290
Epoch 9/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0090 - mse: 0.0201
- val_loss: 0.0125 - val_mse: 0.0287
Epoch 10/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0084 - mse: 0.0188
- val_loss: 0.0124 - val_mse: 0.0285
Epoch 11/20
5/5 [==============================] - 0s 14ms/step - loss: 0.0079 - mse: 0.0176
- val_loss: 0.0122 - val_mse: 0.0281
Epoch 12/20
5/5 [==============================] - 0s 13ms/step - loss: 0.0074 - mse: 0.0165
- val_loss: 0.0121 - val_mse: 0.0277
Epoch 13/20
5/5 [==============================] - 0s 17ms/step - loss: 0.0069 - mse: 0.0155
- val_loss: 0.0119 - val_mse: 0.0274
Epoch 14/20
5/5 [==============================] - 0s 13ms/step - loss: 0.0065 - mse: 0.0146
- val_loss: 0.0117 - val_mse: 0.0269
Epoch 15/20
5/5 [==============================] - 0s 12ms/step - loss: 0.0062 - mse: 0.0139
- val_loss: 0.0116 - val_mse: 0.0265
Epoch 16/20
5/5 [==============================] - 0s 12ms/step - loss: 0.0059 - mse: 0.0132
- val_loss: 0.0114 - val_mse: 0.0261
Epoch 17/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0057 - mse: 0.0127
- val_loss: 0.0111 - val_mse: 0.0256
Epoch 18/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0055 - mse: 0.0122
- val_loss: 0.0110 - val_mse: 0.0252
Epoch 19/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0053 - mse: 0.0118
- val_loss: 0.0108 - val_mse: 0.0247
Epoch 20/20
5/5 [==============================] - 0s 11ms/step - loss: 0.0052 - mse: 0.0115
- val_loss: 0.0106 - val_mse: 0.0244
```

```
[15]: plt.plot(history.history['loss'])
      plt.plot(history.history['val_loss'])
      plt.xlabel('Epochs')
      plt.ylabel('MSLE Loss')
      plt.legend(['loss', 'val_loss'])
      plt.show()
```



```
[19]: def find_threshold(model, x_train_scaled):
          reconstructions = model.predict(x_train_scaled)
          reconstruction_errors = tf.keras.losses.msle(reconstructions,
      ↪x_train_scaled)
          threshold = np.mean(reconstruction_errors.numpy()) + np.
      ↪std(reconstruction_errors.numpy())
          return threshold

      def get_predictions(model, x_test_scaled, threshold):
          predictions = model.predict(x_test_scaled)
          errors = tf.keras.losses.msle(predictions, x_test_scaled)
          anomaly_mask = pd.Series(errors) > threshold
          preds = anomaly_mask.map(lambda x: 0.0 if x == True else 1.0)
          return preds
```

```python
# Assuming you have already defined 'model' and 'x_train_scaled'
threshold = find_threshold(model, x_train_scaled)
print(f"Threshold: {threshold}")
```

```
73/73 [==============================] - 0s 1ms/step
Threshold: 0.01007491388611868
```

[20]:
```python
predictions = get_predictions(model, x_test_scaled, threshold)
accuracy_score(predictions, y_test)
```

```
32/32 [==============================] - 0s 1ms/step
```

[20]: 0.943