In [1]:
```
!pip install tensorflow
```

```
Requirement already satisfied: tensorflow in c:\users\lenovo\anaconda3\lib\site-packages (2.14.0)
Requirement already satisfied: tensorflow-intel==2.14.0 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow) (2.14.
0)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==
2.14.0->tensorflow) (4.4.0)
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\len
ovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (4.24.4)
Requirement already satisfied: numpy>=1.23.5 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->ten
sorflow) (1.23.5)
Requirement already satisfied: tensorflow-estimator<2.15,>=2.14.0 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorfl
ow-intel==2.14.0->tensorflow) (2.14.0)
Requirement already satisfied: six>=1.12.0 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tenso
rflow) (1.16.0)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorf
low-intel==2.14.0->tensorflow) (0.5.4)
Requirement already satisfied: astunparse>=1.6.0 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0-
>tensorflow) (1.6.3)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->
tensorflow) (2.3.0)
Requirement already satisfied: libclang>=13.0.0 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->
tensorflow) (16.0.6)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\users\lenovo\anaconda3\lib\site-packages (from tensor
flow-intel==2.14.0->tensorflow) (0.31.0)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.
0->tensorflow) (0.2.0)
Requirement already satisfied: tensorboard<2.15,>=2.14 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==
2.14.0->tensorflow) (2.14.1)
Requirement already satisfied: keras<2.15,>=2.14.0 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.
0->tensorflow) (2.14.0)
Requirement already satisfied: packaging in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorf
low) (22.0)
Requirement already satisfied: wrapt<1.15,>=1.11.0 in c:\users\lenovo\anaconda3\lib\site-packages (from tensorflow-intel==2.14.
```

In [2]:
```
pip install keras
```

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

In [3]:
```
import numpy as np
import pandas as pd
import tensorflow as tf
import matplotlib.pyplot as plt
from sklearn.metrics import accuracy_score
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
```

In [4]:
```
data = pd.read_csv("ecg.csv", header=None)
data.head()
```

Out[4]:

	0	1	2	3	4	5	6	7	8	9	...	131	132	133	134	
0	-0.112522	-2.827204	-3.773897	-4.349751	-4.376041	-3.474986	-2.181408	-1.818286	-1.250522	-0.477492	...	0.792168	0.933541	0.796958	0.578621	0.257
1	-1.100878	-3.996840	-4.285843	-4.506579	-4.022377	-3.234368	-1.566126	-0.992258	-0.754680	0.042321	...	0.538356	0.656881	0.787490	0.724046	0.555
2	-0.567088	-2.593450	-3.874230	-4.584095	-4.187449	-3.151462	-1.742940	-1.490659	-1.183580	-0.394229	...	0.886073	0.531452	0.311377	-0.021919	-0.713
3	0.490473	-1.914407	-3.616364	-4.318823	-4.268016	-3.881110	-2.993280	-1.671131	-1.333884	-0.965629	...	0.350816	0.499111	0.600345	0.842069	0.952
4	0.800232	-0.874252	-2.384761	-3.973292	-4.338224	-3.802422	-2.534510	-1.783423	-1.594450	-0.753199	...	1.148884	0.958434	1.059025	1.371682	1.277

5 rows × 141 columns

In [5]:
```
#data shape
data.shape
```

Out[5]:
```
(4998, 141)
```

In [6]:
```
# last column is the target
# 0 = anomaly, 1 = normal
TARGET = 140

features = data.drop(TARGET, axis=1)
target = data[TARGET]

x_train, x_test, y_train, y_test = train_test_split(
    features, target, test_size=0.2, stratify=target
)
```

In [7]:
```
# use case is novelty detection so use only the normal data
# for training
train_index = y_train[y_train == 1].index
train_data = x_train.loc[train_index]
```

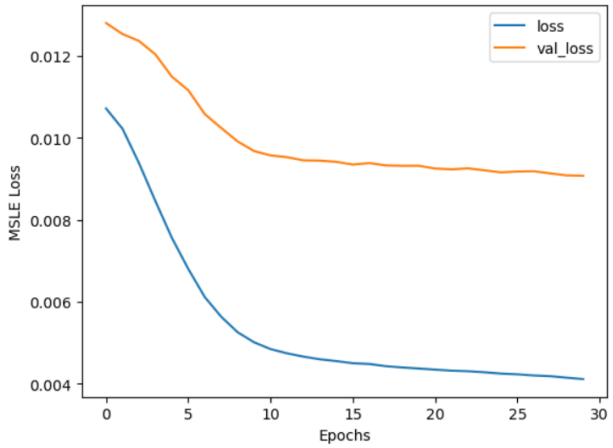
In [8]:
```
# min max scale the input data
min_max_scaler = MinMaxScaler(feature_range=(0, 1))
x_train_scaled = min_max_scaler.fit_transform(train_data.copy())
x_test_scaled = min_max_scaler.transform(x_test.copy())
```

In [9]:
```
# create a model by subclassing Model class in tensorflow
class AutoEncoder(Model):
  """
  Parameters
  ----------
  output_units: int
    Number of output units

  code size: int
```

In [10]:
```
# configurations of model
model.compile(loss='msle', metrics=['mse'], optimizer='adam')

history = model.fit(
    x_train_scaled,
    x_train_scaled,
    epochs=30,
    batch_size=512,
    validation_data=(x_test_scaled, x_test_scaled)
)
```

```
Epoch 1/30
5/5 [==============================] - 2s 63ms/step - loss: 0.0107 - mse: 0.0241 - val_loss: 0.0128 - val_mse: 0.0298
Epoch 2/30
5/5 [==============================] - 0s 16ms/step - loss: 0.0102 - mse: 0.0231 - val_loss: 0.0125 - val_mse: 0.0292
Epoch 3/30
5/5 [==============================] - 0s 16ms/step - loss: 0.0094 - mse: 0.0212 - val_loss: 0.0124 - val_mse: 0.0288
Epoch 4/30
5/5 [==============================] - 0s 16ms/step - loss: 0.0085 - mse: 0.0191 - val_loss: 0.0120 - val_mse: 0.0280
Epoch 5/30
5/5 [==============================] - 0s 17ms/step - loss: 0.0076 - mse: 0.0171 - val_loss: 0.0115 - val_mse: 0.0268
Epoch 6/30
5/5 [==============================] - 0s 16ms/step - loss: 0.0068 - mse: 0.0153 - val_loss: 0.0112 - val_mse: 0.0260
Epoch 7/30
5/5 [==============================] - 0s 17ms/step - loss: 0.0061 - mse: 0.0138 - val_loss: 0.0106 - val_mse: 0.0247
Epoch 8/30
5/5 [==============================] - 0s 17ms/step - loss: 0.0056 - mse: 0.0127 - val_loss: 0.0102 - val_mse: 0.0239
Epoch 9/30
5/5 [==============================] - 0s 16ms/step - loss: 0.0053 - mse: 0.0118 - val_loss: 0.0099 - val_mse: 0.0231
Epoch 10/30
5/5 [==============================] - 0s 16ms/step - loss: 0.0050 - mse: 0.0112 - val_loss: 0.0097 - val_mse: 0.0226
Epoch 11/30
5/5 [==============================] - 0s 16ms/step - loss: 0.0048 - mse: 0.0109 - val_loss: 0.0096 - val_mse: 0.0223
Epoch 12/30
5/5 [==============================] - 0s 15ms/step - loss: 0.0047 - mse: 0.0106 - val_loss: 0.0095 - val_mse: 0.0223
Epoch 13/30
```

In [11]:
```
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()
```



In [12]:
```
def find_threshold(model, x_train_scaled):
  reconstructions = model.predict(x_train_scaled)
  # provides losses of individual instances
  reconstruction_errors = tf.keras.losses.msle(reconstructions, x_train_scaled)
  # threshold for anomaly scores
  threshold = np.mean(reconstruction_errors.numpy()) \
      + np.std(reconstruction_errors.numpy())
  return threshold
```

In [13]:
```
def get_predictions(model, x_test_scaled, threshold):
  predictions = model.predict(x_test_scaled)
  # provides losses of individual instances
  errors = tf.keras.losses.msle(predictions, x_test_scaled)
  # 0 = anomaly, 1 = normal
  anomaly_mask = pd.Series(errors) > threshold
  preds = anomaly_mask.map(lambda x: 0.0 if x == True else 1.0)
  return preds
```

In [15]:
```
threshold = find_threshold(model, x_train_scaled)
print(f"Threshold: {threshold}")

predictions = get_predictions(model, x_test_scaled, threshold)
accuracy_score(predictions, y_test)
```

```
73/73 [==============================] - 0s 2ms/step
Threshold: 0.009049083038145889
32/32 [==============================] - 0s 2ms/step
```

Out[15]: 0.952

In [ ]: