Assignment No. 4

November 10, 2022

[1]:
```
import matplotlib.pyplot as plt
import pandas as pd
import tensorflow as tf
import seaborn as sns
from tensorflow.keras.models import Model
from sklearn.metrics import accuracy_score, precision_score, recall_score
from sklearn.model_selection import train_test_split
from keras import Sequential
sns.set()
import numpy as np
from tensorflow.keras import layers, losses
```

[2]:
```
df = pd.read_csv('http://storage.googleapis.com/download.tensorflow.org/data/
 ↪ecg.csv', header=None)
raw_data = df.values
df.head()
```

[2]:

	0	1	2	3	4	5	6	…	131	132	133	134	135	136	137	138	139	140
0	-0.112522	-2.827204	-3.773897	-4.349751	-4.376041	-3.474986	-2.181408	…	0.792168	0.933541	0.796958	0.578621	0.257740	0.228077	0.123431	0.925286	0.193137	1.0
1	-1.100878	-3.996840	-4.285843	-4.506579	-4.022377	-3.234368	-1.566126	…	0.538356	0.656881	0.787490	0.724046	0.555784	0.476333	0.773820	1.119621	-1.436250	1.0
2	-0.567088	-2.593450	-3.874230	-4.584095	-4.187449	-3.151462	-1.742940	…	0.886073	0.531452	0.311377	-0.021919	-0.713683	-0.532197	0.321097	0.904227	-0.421797	1.0
3	0.490473	-1.914407	-3.616364	-4.318823	-4.268016	-3.881110	-2.993280	…	0.350816	0.499111	0.600345	0.842069	0.952074	0.990133	1.086798	1.403011	-0.383564	1.0
4	0.800232	-0.874252	-2.384761	-3.973292	-4.338224	-3.802422	-2.534510	…	1.148884	0.958434	1.059025	1.371682	1.277392	0.960304	0.971020	1.614392	1.421456	1.0

```
[5 rows x 141 columns]
```

[3]:
```
labels = raw_data[:, -1]

data = raw_data[:, 0:-1]
```

[4]:
```
pd.Series(labels).value_counts()
```

[4]:
```
1.0    2919
0.0    2079
dtype: int64
```

[5]:
```
train_data,test_data, train_labels,test_labels = train_test_split(
    data, labels, test_size = 0.2, random_state=21
)
```

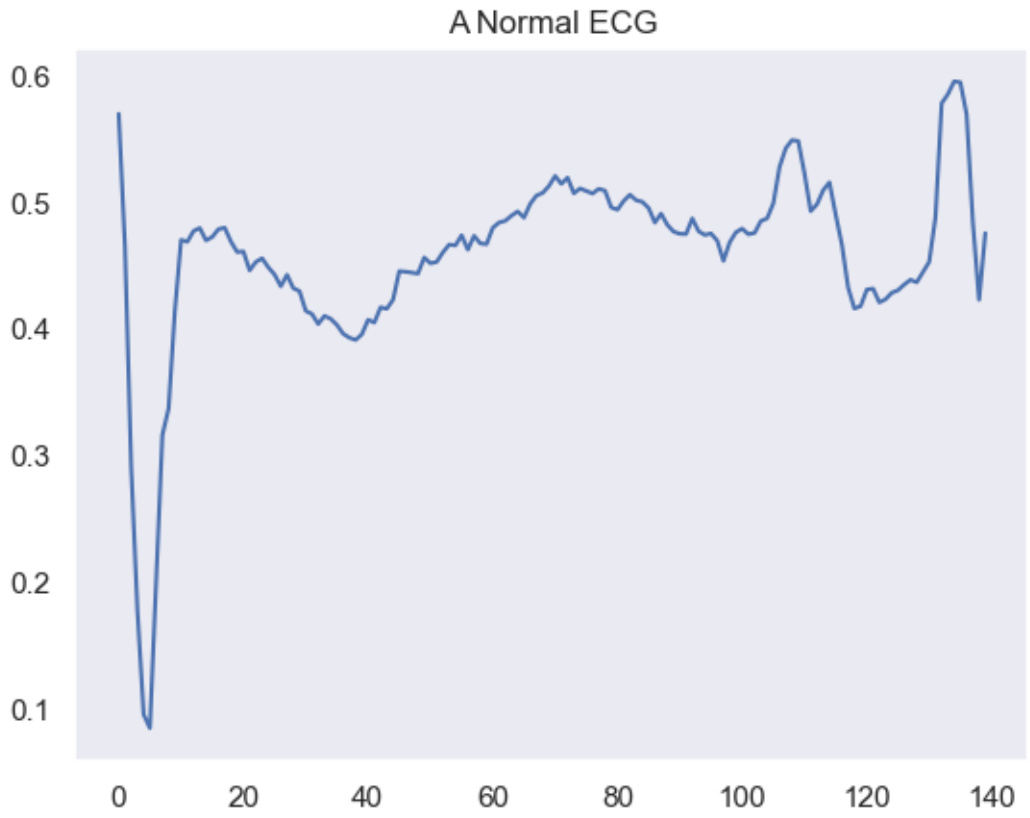
[6]:
```
min = np.min(train_data)
max = np.max(train_data)

train_data = ( train_data - min ) / ( max - min )
test_data = ( test_data - min ) / ( max - min )
```

[7]:
```
train_labels = train_labels.astype(bool)
test_labels = test_labels.astype(bool)



normal_train_data = train_data[train_labels]
normal_test_data = test_data[test_labels]

anamalous_train_data = train_data[~train_labels]
anamalous_test_data = test_data[~test_labels]
```

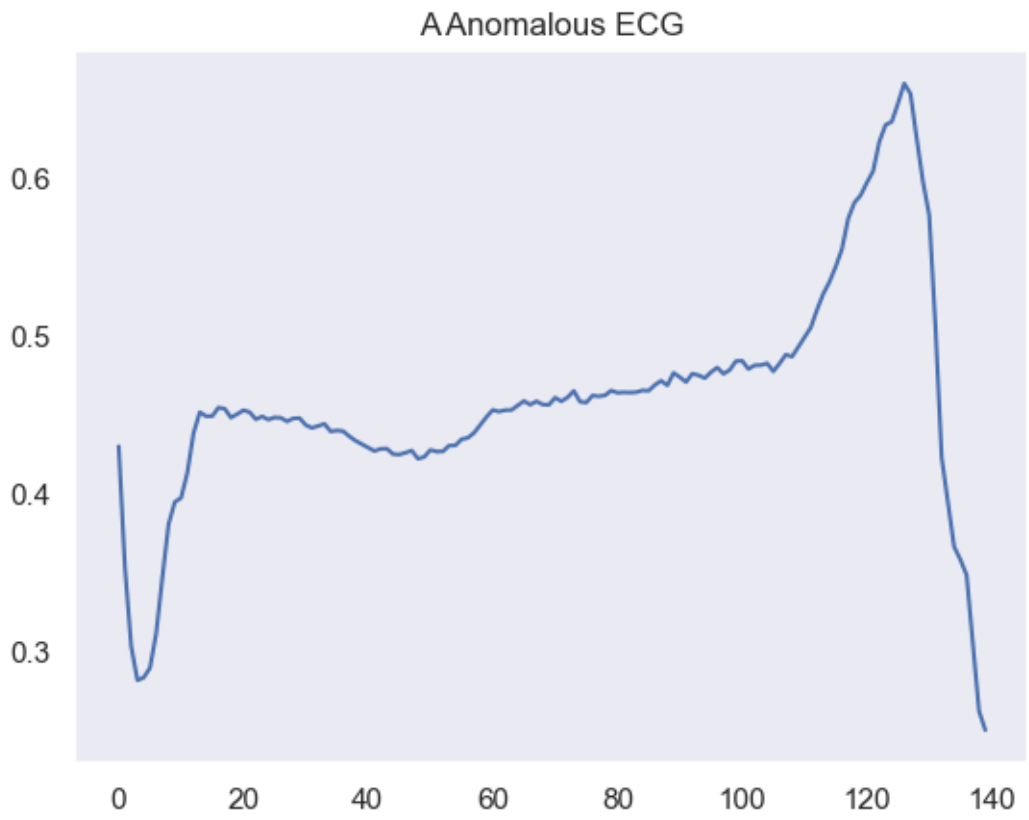
[8]:
```
~train_labels
```

[8]:
```
array([False, False, False, …, False, False, False])
```

[9]:
```
plt.grid()
plt.plot(np.arange(140),normal_train_data[0])
plt.title('A Normal ECG')
plt.show()
```



[10]:
```
plt.grid()
plt.plot(np.arange(140),anamalous_train_data[0])
plt.title('A Anomalous ECG')
plt.show()
```



[11]:
```
class AnomalyDetector(Model):
  def __init__(self):
    super(AnomalyDetector, self).__init__()
    self.encoder = Sequential([
                                        layers.Dense(32, activation='relu'),
                                        layers.Dense(16, activation='relu'),
                                        layers.Dense(8, activation='relu')
    ])
    self.decoder = tf.keras.Sequential([
                                        layers.Dense(16, activation='relu'),
                                        layers.Dense(32, activation='relu'),
                                        layers.Dense(140, activation='sigmoid')
    ])

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

autoencoder = AnomalyDetector()
```

[12]:
```
autoencoder.compile(optimizer='adam', loss='mae')
```

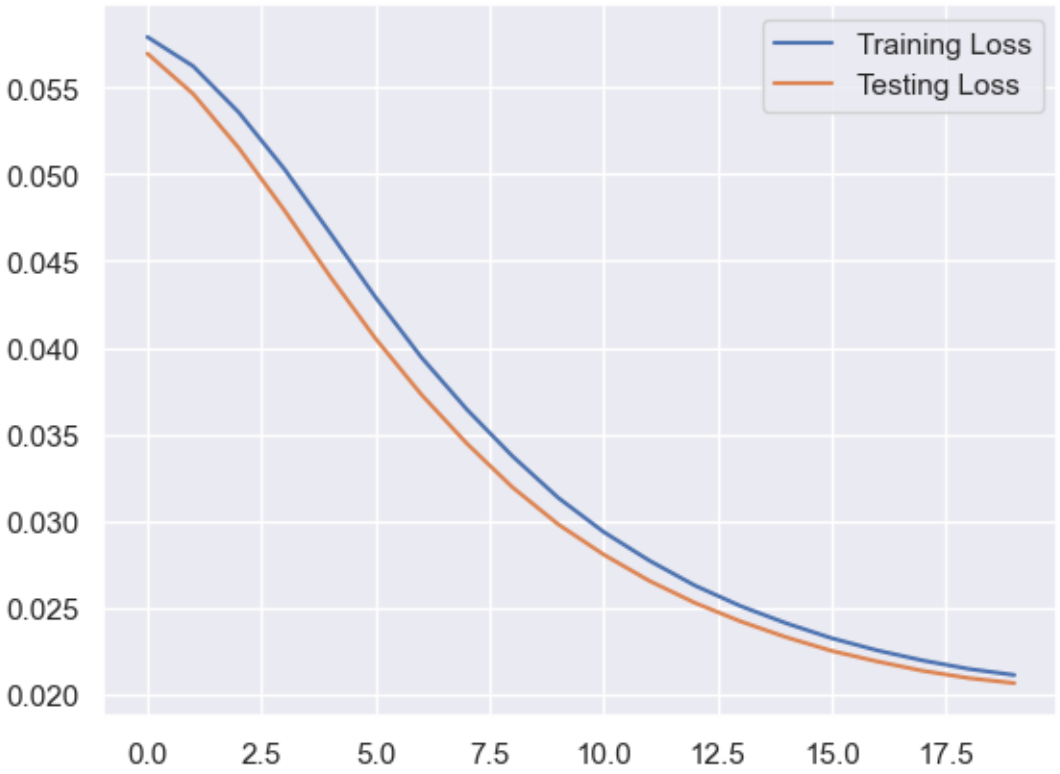
[13]:
```
history = autoencoder.fit(normal_train_data, normal_train_data,
                          epochs = 20,
                          batch_size=512,
                          validation_data=(normal_test_data, normal_test_data),
                          shuffle=True)
```

```
Epoch 1/20
5/5 [==============================] - 1s 45ms/step - loss: 0.0579 - val_loss:
0.0570
Epoch 2/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0562 - val_loss:
0.0546
Epoch 3/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0536 - val_loss:
0.0515
Epoch 4/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0503 - val_loss:
0.0479
Epoch 5/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0466 - val_loss:
0.0441
Epoch 6/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0429 - val_loss:
0.0405
Epoch 7/20
5/5 [==============================] - 0s 11ms/step - loss: 0.0395 - val_loss:
0.0373
Epoch 8/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0364 - val_loss:
0.0345
Epoch 9/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0337 - val_loss:
0.0319
Epoch 10/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0314 - val_loss:
0.0298
Epoch 11/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0294 - val_loss:
0.0281
Epoch 12/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0277 - val_loss:
0.0266
Epoch 13/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0263 - val_loss:
0.0253
Epoch 14/20
```

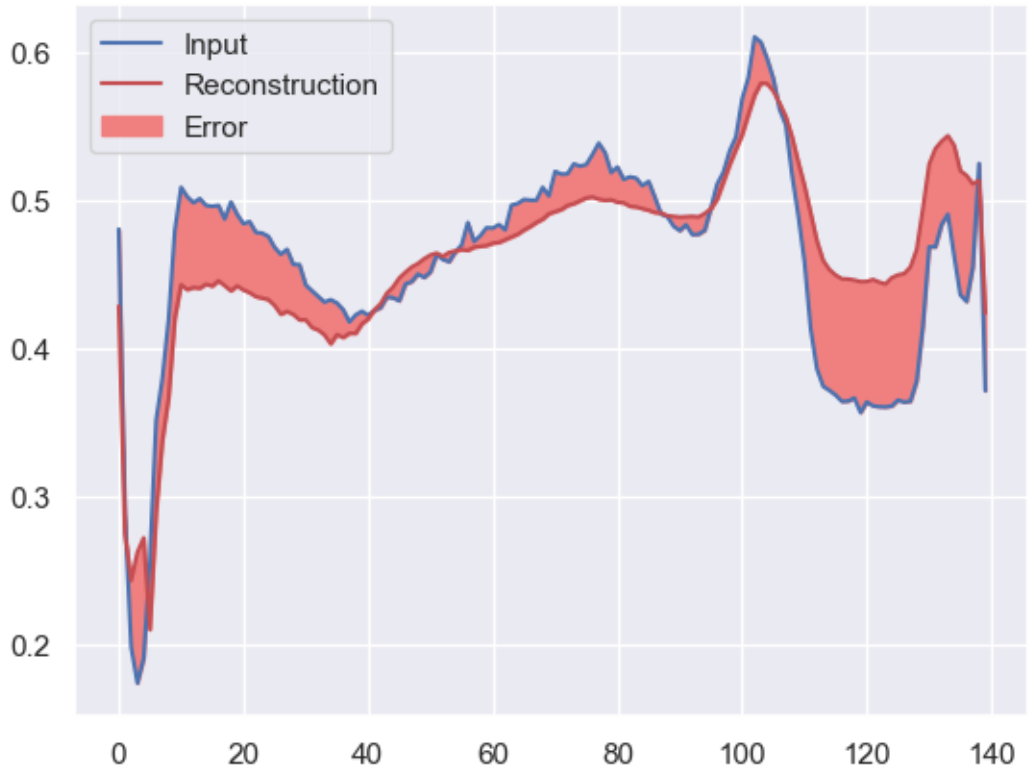
```
5/5 [==============================] - 0s 10ms/step - loss: 0.0251 - val_loss:
0.0242
Epoch 15/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0241 - val_loss:
0.0233
Epoch 16/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0232 - val_loss:
0.0225
Epoch 17/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0225 - val_loss:
0.0219
Epoch 18/20
5/5 [==============================] - 0s 10ms/step - loss: 0.0220 - val_loss:
0.0214
Epoch 19/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0215 - val_loss:
0.0209
Epoch 20/20
5/5 [==============================] - 0s 9ms/step - loss: 0.0211 - val_loss:
0.0207
```

[14]:
```
plt.plot(history.history['loss'],label='Training Loss')
plt.plot(history.history['val_loss'],label='Testing Loss')
plt.legend()
```

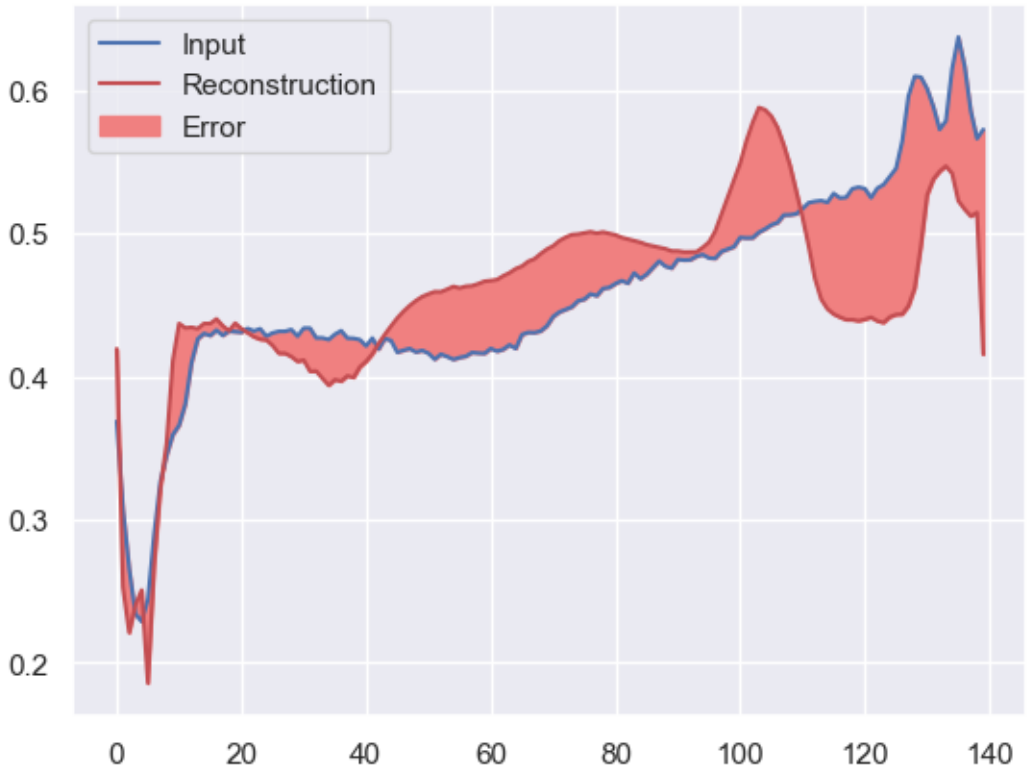
[14]:
```
<matplotlib.legend.Legend at 0x1513413e5e0>
```



[15]:
```
encoded_image = autoencoder.encoder(normal_test_data).numpy()
decoded_image = autoencoder.decoder(encoded_image).numpy()

plt.plot(normal_test_data[0],'b')
plt.plot(decoded_image[0],'r')
plt.fill_between(np.
 ↪arange(140),decoded_image[0],normal_test_data[0],color='lightcoral')
plt.legend(labels=['Input',"Reconstruction","Error"])
plt.show()
```

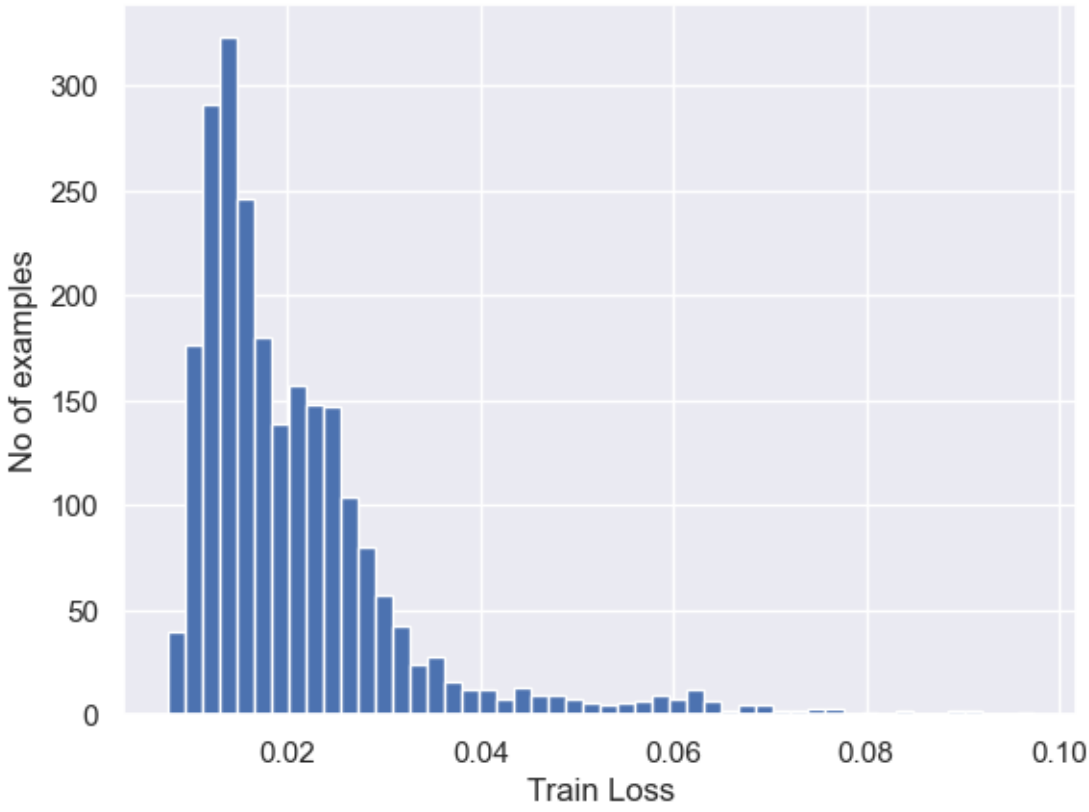


[16]:
```
encoded_image = autoencoder.encoder(anamalous_test_data).numpy()
decoded_image = autoencoder.decoder(encoded_image).numpy()

plt.plot(anamalous_test_data[0],'b')
plt.plot(decoded_image[0],'r')
plt.fill_between(np.
 ↪arange(140),decoded_image[0],anamalous_test_data[0],color='lightcoral')
plt.legend(labels=['Input',"Reconstruction","Error"])
plt.show()
```



[17]:
```
reconstructions = autoencoder.predict(normal_train_data)
train_loss = tf.keras.losses.mae(reconstructions, normal_train_data)

plt.hist(train_loss[None,:],bins=50)
plt.xlabel("Train Loss")
plt.ylabel("No of examples")
plt.show()
```

```
74/74 [==============================] - 0s 1ms/step
```

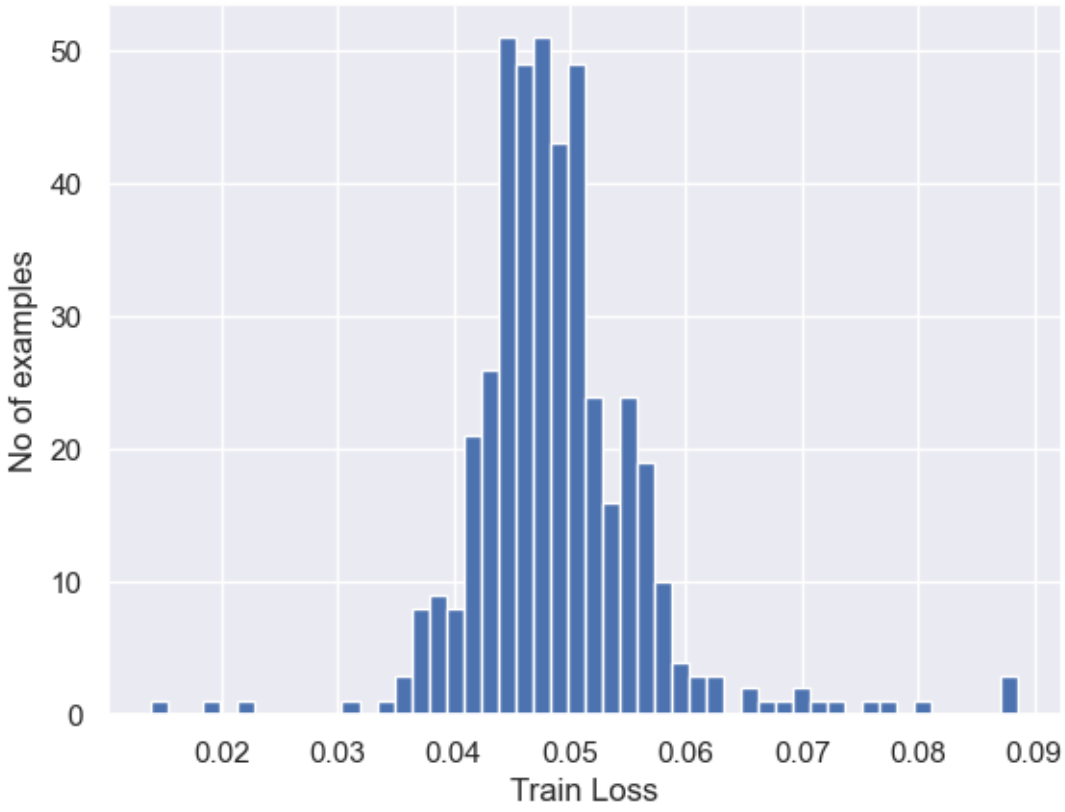


[18]:
```
threshold = np.mean(train_loss) + np.std(train_loss)
print("Threshold: ",threshold)
```

```
Threshold:  0.03266858085789276
```

[19]:
```
reconstructions = autoencoder.predict(anamalous_test_data)
test_loss = tf.keras.losses.mae(reconstructions, anamalous_test_data)

plt.hist(test_loss[None,:],bins=50)
plt.xlabel("Train Loss")
plt.ylabel("No of examples")
plt.show()
```

```
14/14 [==============================] - 0s 1ms/step
```



[20]:
```
def predict(model,data,threshold):
  reconstructions = model(data)
  loss = tf.keras.losses.mae(reconstructions,data)
  return tf.math.less(loss, threshold)

def print_stats(predictions, labels):
  print("Accuracy = {}".format(accuracy_score(labels,preds)))
  print("Precision = {}".format(precision_score(labels,preds)))
  print("Recall = {}".format(recall_score(labels,preds)))
```

[21]:
```
preds = predict(autoencoder, test_data, threshold)
print_stats(preds, test_labels)
```

```
Accuracy = 0.945
Precision = 0.9922027290448343
Recall = 0.9089285714285714
```