credit-card-fraud-detection

January 23, 2024

[2]:
```
import numpy as np
import pandas as pd
import os
for dirname, _, filenames in os.walk('/content/creditcard.csv'):
    for filename in filenames:
        print(os.path.join(dirname, filename))
```

[3]:
```
df=pd.read_csv("/content/creditcard.csv")
df
```

[3]:

	Time	V1	V2	V3	V4	V5	V6	\
0	0	-1.359807	-0.072781	2.536347	1.378155	-0.338321	0.462388	
1	0	1.191857	0.266151	0.166480	0.448154	0.060018	-0.082361	
2	1	-1.358354	-1.340163	1.773209	0.379780	-0.503198	1.800499	
3	1	-0.966272	-0.185226	1.792993	-0.863291	-0.010309	1.247203	
4	2	-1.158233	0.877737	1.548718	0.403034	-0.407193	0.095921	
…	…	…	…	…	…	…	…	
13949	24754	1.252924	-0.182189	-0.802716	-0.210981	1.916713	3.643624	
13950	24756	-0.346979	-2.103284	-0.685061	1.961605	-0.401125	0.473632	
13951	24759	-6.053652	-5.988723	0.810413	-0.011811	1.308135	-0.590803	
13952	24759	1.169121	-1.284945	0.032717	-0.681670	0.660598	4.412578	
13953	24759	-6.917152	5.854171	-1.652458	-1.488884	-0.833891	-0.344418	

	V7	V8	V9	…	V21	V22	V23	\
0	0.239599	0.098698	0.363787	…	-0.018307	0.277838	-0.110474	
1	-0.078803	0.085102	-0.255425	…	-0.225775	-0.638672	0.101288	
2	0.791461	0.247676	-1.514654	…	0.247998	0.771679	0.909412	
3	0.237609	0.377436	-1.387024	…	-0.108300	0.005274	-0.190321	
4	0.592941	-0.270533	0.817739	…	-0.009431	0.798278	-0.137458	
…	…	…	…	…	…	…	…	
13949	-0.778711	0.818295	1.706962	…	-0.497088	-1.211285	0.043809	
13950	1.133816	-0.256528	0.893409	…	0.359662	-0.316275	-0.864259	
13951	-0.725838	-0.234840	1.624646	…	-0.771970	1.474668	3.176363	
13952	-1.913115	1.076592	1.501230	…	-0.557596	-0.882435	-0.041523	
13953	0.393789	0.379968	6.133597	…	-1.404681	-1.124694	0.174333	

	V24	V25	V26	V27	V28	Amount	Class

```
0      0.066928  0.128539 -0.189115  0.133558 -0.021053  149.62    0.0
1     -0.339846  0.167170  0.125895 -0.008983  0.014724    2.69    0.0
2     -0.689281 -0.327642 -0.139097 -0.055353 -0.059752  378.66    0.0
3     -1.175575  0.647376 -0.221929  0.062723  0.061458  123.50    0.0
4      0.141267 -0.206010  0.502292  0.219422  0.215153   69.99    0.0
…           …         …         …         …         …      …     …
13949  0.964159  0.442030  0.261483 -0.051402  0.005112   23.74    0.0
13950 -0.279881  0.491802 -0.353996 -0.149931  0.129795  794.20    0.0
13951 -0.302410  0.052529 -0.373871 -0.700463  2.508443   60.00    0.0
13952  0.975445  0.297229  0.550515  0.015029  0.032067   90.00    0.0
13953 -0.528234  0.990685 -0.035875  1.071374 -0.168831     NaN    NaN

[13954 rows x 31 columns]
```

[4]:
```
df.shape
```

[4]:
```
(13954, 31)
```

[5]:
```
df.columns
```

[5]:
```
Index(['Time', 'V1', 'V2', 'V3', 'V4', 'V5', 'V6', 'V7', 'V8', 'V9', 'V10',
       'V11', 'V12', 'V13', 'V14', 'V15', 'V16', 'V17', 'V18', 'V19', 'V20',
       'V21', 'V22', 'V23', 'V24', 'V25', 'V26', 'V27', 'V28', 'Amount',
       'Class'],
      dtype='object')
```

[6]:
```
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout
from tensorflow.keras.callbacks import ModelCheckpoint
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report

y = df['Class']
X = df.drop('Class', axis=1)

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪random_state=42)

model = Sequential()

model.add(Dense(512, input_dim=X_train.shape[1], activation='relu'))
model.add(Dropout(0.2))

model.add(Dense(256, activation='relu'))
model.add(Dropout(0.2))
```

```
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.2))

model.add(Dense(64, activation='relu'))
model.add(Dropout(0.2))

model.add(Dense(32, activation='relu'))
model.add(Dropout(0.2))

model.add(Dense(32, activation='relu'))
model.add(Dropout(0.2))

model.add(Dense(1, activation='sigmoid'))

model.compile(loss='binary_crossentropy', optimizer='adam',␣
 ↪metrics=['accuracy'])

checkpoint = ModelCheckpoint('best_model.h5', monitor='val_accuracy',␣
 ↪mode='max', save_best_only=True, verbose=1)

model.fit(X_train, y_train, epochs=100, batch_size=2000, validation_split=0.1,␣
 ↪callbacks=[checkpoint], verbose=1)

best_model = tf.keras.models.load_model('best_model.h5')
```

```
Epoch 1/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9063
Epoch 1: val_accuracy improved from -inf to 0.99642, saving model to
best_model.h5
6/6 [==============================] - 4s 143ms/step - loss: nan - accuracy:
0.9067 - val_loss: nan - val_accuracy: 0.9964
Epoch 2/100
1/6 [====>…] - ETA: 0s - loss: nan - accuracy: 0.9950

/usr/local/lib/python3.10/dist-packages/keras/src/engine/training.py:3103:
UserWarning: You are saving your model as an HDF5 file via `model.save()`. This
file format is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')`.
  saving_api.save_model(

5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 2: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 69ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 3/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 3: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 74ms/step - loss: nan - accuracy:
```

```
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 4/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 4: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 79ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 5/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 5: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 74ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 6/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 6: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 78ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 7/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 7: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 79ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 8/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 8: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 78ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 9/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 9: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 10/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 10: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 70ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 11/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 11: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 63ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 12/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 12: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 66ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 13/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
```

```
Epoch 13: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 74ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 14/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9959
Epoch 14: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 68ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 15/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 15: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 16/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 16: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 96ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 17/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 17: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 75ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 18/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 18: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 19/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 19: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 77ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 20/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 20: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 77ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 21/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 21: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 115ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 22/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 22: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 125ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
```

```
Epoch 23/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 23: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 117ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 24/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 24: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 114ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 25/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 25: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 105ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 26/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 26: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 85ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 27/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 27: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 72ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 28/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 28: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 29/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 29: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 30/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 30: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 68ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 31/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 31: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 66ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 32/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 32: val_accuracy did not improve from 0.99642
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6/6 [==============================] - 0s 64ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 33/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 33: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 68ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 34/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 34: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 67ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 35/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 35: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 68ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 36/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 36: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 68ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 37/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 37: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 68ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 38/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 38: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 75ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 39/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 39: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 40/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 40: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 41/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 41: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 42/100
```

```
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 42: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 43/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 43: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 44/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 44: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 45/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 45: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 46/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 46: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 47/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 47: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 48/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 48: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 49/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 49: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 114ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 50/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 50: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 118ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 51/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 51: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 108ms/step - loss: nan - accuracy:
```

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0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 52/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 52: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 117ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 53/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 53: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 109ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 54/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 54: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 103ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 55/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 55: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 56/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 56: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 57/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 57: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 77ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 58/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 58: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 75ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 59/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 59: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 77ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 60/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 60: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 75ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 61/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
```

```
Epoch 61: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 72ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 62/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 62: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 63/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 63: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 72ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 64/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 64: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 65/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 65: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 66/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 66: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 67/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 67: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 75ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 68/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 68: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 74ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 69/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 69: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 75ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 70/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 70: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 75ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
```

```
Epoch 71/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 71: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 72/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 72: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 73/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 73: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 74/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 74: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 75/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 75: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 76/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 76: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 82ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 77/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9959
Epoch 77: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 113ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 78/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 78: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 129ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 79/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 79: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 115ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 80/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 80: val_accuracy did not improve from 0.99642
```

```
6/6 [==============================] - 1s 113ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 81/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 81: val_accuracy did not improve from 0.99642
6/6 [==============================] - 1s 115ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 82/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 82: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 83/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 83: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 84/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 84: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 71ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 85/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 85: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 75ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 86/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 86: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 72ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 87/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 87: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 79ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 88/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 88: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 89/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 89: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 74ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 90/100
```

```
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 90: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 74ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 91/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 91: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 73ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 92/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 92: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 93/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 93: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 72ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 94/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 94: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 76ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 95/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9958
Epoch 95: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 75ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 96/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 96: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 80ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 97/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 97: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 74ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 98/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 98: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 80ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 99/100
5/6 [=======================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 99: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 74ms/step - loss: nan - accuracy:
```

```
0.9957 - val_loss: nan - val_accuracy: 0.9964
Epoch 100/100
5/6 [========================>…] - ETA: 0s - loss: nan - accuracy: 0.9957
Epoch 100: val_accuracy did not improve from 0.99642
6/6 [==============================] - 0s 69ms/step - loss: nan - accuracy:
0.9957 - val_loss: nan - val_accuracy: 0.9964
```

[7]:
```
best_model = tf.keras.models.load_model('best_model.h5')
```

[8]:
```
probabilities = best_model.predict(X_test)

threshold = 0.5

binary_predictions = np.where(probabilities > threshold, 1, 0)


print("Classification Report:")
print(classification_report(y_test, binary_predictions))
```

```
88/88 [==============================] - 0s 2ms/step
Classification Report:
              precision    recall  f1-score   support

         0.0       1.00      1.00      1.00      2781
         1.0       0.00      0.00      0.00        10

    accuracy                           1.00      2791
   macro avg       0.50      0.50      0.50      2791
weighted avg       0.99      1.00      0.99      2791

/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

[9]:
```
print(binary_predictions)
```

```
[[0]
 [0]
 [0]
 …
 [0]
 [0]
 [0]]
```

[10]:
```
print(y_test)
```

```
2019     0.0
9438     0.0
5709     0.0
12264    0.0
5403     0.0
        …
6113     0.0
4842     0.0
6930     0.0
10067    0.0
12643    0.0
Name: Class, Length: 2791, dtype: float64
```