Computational Intelligence
Course Project
Spring 1399

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Below are the packages used in this project.

```
[1]: import numpy as np
     import keras
     import matplotlib.pyplot as plt
     from keras.models import Sequential
     from sklearn.preprocessing import StandardScaler
     from keras.layers import Dense, Dropout
     from keras.layers.normalization import BatchNormalization
     import pandas as pd
```

```
Using TensorFlow backend.
```

```
[2]: input_path = 'data/Elearning-Data-cut.xls'
     train_data_count = 640
```

The data is split into train and test sets. the data is read using `pandas` and tha `NaN` values are replaced with 0. also the student No. column is dropped since we don't need it.

```
[3]: def read_input():
         input = pd.read_excel(input_path, 0)
         input = input.drop(['STUDENTN'], axis=1)
         input = input.fillna(0)
         output_gpa = pd.read_excel(input_path, 1)
         output_fail = pd.read_excel(input_path, 2)[['OUT_IN']]
         return input, output_gpa, output_fail
```

Here the data is converted from `pandas` `datafram` to `numpy` `array`. For the second part of the project (Classfication), Because the data is not balanced and there are lots more `passed` classes than `failed` classes, we duplicate rows belonging to `failed` classes. And then the data is split into train and test sets. Finally all the data are normalized using `StandardScaler().fit_transform`.

```
[4]: input, output_gpa, output_fail = read_input()
     input = input.to_numpy()
     output_gpa = output_gpa.to_numpy()
```

```python
output_fail = output_fail.to_numpy()
input2 = []
output_fail2 = []

for i in range(len(input)):
    if output_fail[i] == 0:
        input2.append(input[i])
        input2.append(input[i])
        output_fail2.append([output_fail[i][0]])
        output_fail2.append([output_fail[i][0]])
    else:
        input2.append(input[i])
        output_fail2.append([output_fail[i][0]])

input2 = np.array(input2)
output_fail2 = np.array(output_fail2)

X_train = input[:train_data_count]
X_train2 = input2[:train_data_count]

Y_train = output_gpa[:train_data_count]
Y_train2 = output_fail2[:train_data_count]

X_test = input[train_data_count:]
X_test2 = input2[train_data_count:]

Y_test = output_gpa[train_data_count:]
Y_test2 = output_fail2[train_data_count:]
Y_test22 = output_fail[train_data_count:]

ss = StandardScaler()
X_train = ss.fit_transform(X_train)
X_test = ss.fit_transform(X_test)
X_test2 = ss.fit_transform(X_test2)
X_train2 = ss.fit_transform(X_train2)
```

1   Regression

For this part, we design a `sequential` model having 2 hidden layers with 250 and 150 neurons respectively. The output layer has 1 nueron. Also all the layers are using `relu` as their activation function. `Nadam` is used as the optimizer and `mse` is used as loss function and the metric. These are obtained by trial and error. Also there's a batch normalizer layer between each of the layers that normalizes the current batch which is being fed to the network. finally the data is shuffled and the network is trained for 800 epochs.

```
[5]: model = Sequential()
     model.add(BatchNormalization())
     model.add(Dense(250, activation='relu'))
     model.add(BatchNormalization())
     model.add(Dense(150, activation='relu'))
     model.add(BatchNormalization())
     model.add(Dense(1))
     model.compile(optimizer='Nadam', loss='mse', metrics=['mse'])
     result = model.fit(X_train, Y_train,batch_size=32, epochs=400)
```

```
Epoch 1/400
640/640 [==============================] - 1s 1ms/step - loss: 195.2816 - mse:
195.2816
Epoch 2/400
640/640 [==============================] - 0s 83us/step - loss: 171.0429 - mse:
171.0429
Epoch 3/400
640/640 [==============================] - 0s 73us/step - loss: 130.3741 - mse:
130.3741
Epoch 4/400
640/640 [==============================] - 0s 80us/step - loss: 80.4407 - mse:
80.4407
Epoch 5/400
640/640 [==============================] - 0s 81us/step - loss: 37.5905 - mse:
37.5905
Epoch 6/400
640/640 [==============================] - 0s 85us/step - loss: 12.9863 - mse:
12.9863
Epoch 7/400
640/640 [==============================] - 0s 84us/step - loss: 4.6627 - mse:
4.6627
Epoch 8/400
640/640 [==============================] - 0s 91us/step - loss: 2.4559 - mse:
2.4559
Epoch 9/400
640/640 [==============================] - 0s 98us/step - loss: 2.2705 - mse:
2.2705
Epoch 10/400
640/640 [==============================] - 0s 81us/step - loss: 2.1992 - mse:
2.1992
Epoch 11/400
640/640 [==============================] - 0s 78us/step - loss: 1.9381 - mse:
1.9381
Epoch 12/400
640/640 [==============================] - 0s 79us/step - loss: 1.5955 - mse:
1.5955
Epoch 13/400
```

```
640/640 [==============================] - 0s 66us/step - loss: 1.2960 - mse:
1.2960
Epoch 14/400
640/640 [==============================] - 0s 68us/step - loss: 1.3618 - mse:
1.3618
Epoch 15/400
640/640 [==============================] - 0s 85us/step - loss: 1.3501 - mse:
1.3501
Epoch 16/400
640/640 [==============================] - 0s 80us/step - loss: 1.3853 - mse:
1.3853
Epoch 17/400
640/640 [==============================] - 0s 71us/step - loss: 1.5006 - mse:
1.5006
Epoch 18/400
640/640 [==============================] - 0s 62us/step - loss: 1.2418 - mse:
1.2418
Epoch 19/400
640/640 [==============================] - 0s 74us/step - loss: 1.0689 - mse:
1.0689
Epoch 20/400
640/640 [==============================] - 0s 67us/step - loss: 1.2547 - mse:
1.2547
Epoch 21/400
640/640 [==============================] - 0s 67us/step - loss: 1.0406 - mse:
1.0406
Epoch 22/400
640/640 [==============================] - 0s 72us/step - loss: 1.1682 - mse:
1.1682
Epoch 23/400
640/640 [==============================] - 0s 97us/step - loss: 1.0527 - mse:
1.0527
Epoch 24/400
640/640 [==============================] - 0s 112us/step - loss: 0.8363 - mse:
0.8363
Epoch 25/400
640/640 [==============================] - 0s 107us/step - loss: 0.8688 - mse:
0.8688
Epoch 26/400
640/640 [==============================] - 0s 104us/step - loss: 0.9281 - mse:
0.9281
Epoch 27/400
640/640 [==============================] - 0s 112us/step - loss: 0.8867 - mse:
0.8867
Epoch 28/400
640/640 [==============================] - 0s 96us/step - loss: 0.8568 - mse:
0.8568
Epoch 29/400
```

```
640/640 [==============================] - 0s 78us/step - loss: 0.9928 - mse:
0.9928
Epoch 30/400
640/640 [==============================] - 0s 82us/step - loss: 0.9319 - mse:
0.9319
Epoch 31/400
640/640 [==============================] - 0s 75us/step - loss: 0.8107 - mse:
0.8107
Epoch 32/400
640/640 [==============================] - 0s 71us/step - loss: 0.7831 - mse:
0.7831
Epoch 33/400
640/640 [==============================] - 0s 74us/step - loss: 0.7366 - mse:
0.7366
Epoch 34/400
640/640 [==============================] - 0s 80us/step - loss: 0.7335 - mse:
0.7335
Epoch 35/400
640/640 [==============================] - 0s 82us/step - loss: 0.6919 - mse:
0.6919
Epoch 36/400
640/640 [==============================] - 0s 63us/step - loss: 0.8376 - mse:
0.8376
Epoch 37/400
640/640 [==============================] - 0s 81us/step - loss: 0.8762 - mse:
0.8762
Epoch 38/400
640/640 [==============================] - 0s 118us/step - loss: 0.7700 - mse:
0.7700
Epoch 39/400
640/640 [==============================] - 0s 113us/step - loss: 0.7460 - mse:
0.7460
Epoch 40/400
640/640 [==============================] - 0s 97us/step - loss: 0.8032 - mse:
0.8032
Epoch 41/400
640/640 [==============================] - 0s 88us/step - loss: 1.0118 - mse:
1.0118
Epoch 42/400
640/640 [==============================] - 0s 90us/step - loss: 0.7800 - mse:
0.7800
Epoch 43/400
640/640 [==============================] - 0s 80us/step - loss: 0.8010 - mse:
0.8010
Epoch 44/400
640/640 [==============================] - 0s 73us/step - loss: 0.6135 - mse:
0.6135
Epoch 45/400
```

```
640/640 [==============================] - 0s 72us/step - loss: 0.8734 - mse:
0.8734
Epoch 46/400
640/640 [==============================] - 0s 78us/step - loss: 0.7039 - mse:
0.7039
Epoch 47/400
640/640 [==============================] - 0s 83us/step - loss: 0.6767 - mse:
0.6767
Epoch 48/400
640/640 [==============================] - 0s 76us/step - loss: 0.7645 - mse:
0.7645
Epoch 49/400
640/640 [==============================] - 0s 90us/step - loss: 0.6361 - mse:
0.6361
Epoch 50/400
640/640 [==============================] - 0s 79us/step - loss: 0.7036 - mse:
0.7036
Epoch 51/400
640/640 [==============================] - 0s 97us/step - loss: 0.7228 - mse:
0.7228
Epoch 52/400
640/640 [==============================] - 0s 89us/step - loss: 0.7744 - mse:
0.7744
Epoch 53/400
640/640 [==============================] - 0s 91us/step - loss: 0.6930 - mse:
0.6930
Epoch 54/400
640/640 [==============================] - 0s 80us/step - loss: 0.5111 - mse:
0.5111
Epoch 55/400
640/640 [==============================] - 0s 64us/step - loss: 0.8187 - mse:
0.8187
Epoch 56/400
640/640 [==============================] - 0s 60us/step - loss: 0.6219 - mse:
0.6219
Epoch 57/400
640/640 [==============================] - 0s 62us/step - loss: 0.6732 - mse:
0.6732
Epoch 58/400
640/640 [==============================] - 0s 59us/step - loss: 0.5999 - mse:
0.5999
Epoch 59/400
640/640 [==============================] - 0s 61us/step - loss: 0.5927 - mse:
0.5927
Epoch 60/400
640/640 [==============================] - 0s 68us/step - loss: 0.6565 - mse:
0.6565
Epoch 61/400
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640/640 [==============================] - 0s 67us/step - loss: 0.5583 - mse:
0.5583
Epoch 62/400
640/640 [==============================] - 0s 65us/step - loss: 0.6749 - mse:
0.6749
Epoch 63/400
640/640 [==============================] - 0s 68us/step - loss: 0.7847 - mse:
0.7847
Epoch 64/400
640/640 [==============================] - 0s 69us/step - loss: 0.5961 - mse:
0.5961
Epoch 65/400
640/640 [==============================] - 0s 81us/step - loss: 0.6109 - mse:
0.6109
Epoch 66/400
640/640 [==============================] - 0s 80us/step - loss: 0.9075 - mse:
0.9075
Epoch 67/400
640/640 [==============================] - 0s 82us/step - loss: 0.6595 - mse:
0.6595
Epoch 68/400
640/640 [==============================] - 0s 95us/step - loss: 0.7680 - mse:
0.7680
Epoch 69/400
640/640 [==============================] - 0s 73us/step - loss: 0.6373 - mse:
0.6373
Epoch 70/400
640/640 [==============================] - 0s 68us/step - loss: 0.6932 - mse:
0.6932
Epoch 71/400
640/640 [==============================] - 0s 86us/step - loss: 0.6996 - mse:
0.6996
Epoch 72/400
640/640 [==============================] - 0s 78us/step - loss: 0.7339 - mse:
0.7339
Epoch 73/400
640/640 [==============================] - 0s 77us/step - loss: 0.6508 - mse:
0.6508
Epoch 74/400
640/640 [==============================] - 0s 68us/step - loss: 0.6871 - mse:
0.6871
Epoch 75/400
640/640 [==============================] - 0s 67us/step - loss: 0.7960 - mse:
0.7960
Epoch 76/400
640/640 [==============================] - 0s 74us/step - loss: 0.6158 - mse:
0.6158
Epoch 77/400
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640/640 [==============================] - 0s 69us/step - loss: 0.5133 - mse:
0.5133
Epoch 78/400
640/640 [==============================] - 0s 68us/step - loss: 0.6267 - mse:
0.6267
Epoch 79/400
640/640 [==============================] - 0s 64us/step - loss: 0.4714 - mse:
0.4714
Epoch 80/400
640/640 [==============================] - 0s 71us/step - loss: 0.5836 - mse:
0.5836
Epoch 81/400
640/640 [==============================] - 0s 66us/step - loss: 0.5959 - mse:
0.5959
Epoch 82/400
640/640 [==============================] - 0s 68us/step - loss: 0.5602 - mse:
0.5602
Epoch 83/400
640/640 [==============================] - 0s 71us/step - loss: 0.4210 - mse:
0.4210
Epoch 84/400
640/640 [==============================] - 0s 72us/step - loss: 0.7371 - mse:
0.7371
Epoch 85/400
640/640 [==============================] - 0s 72us/step - loss: 0.6839 - mse:
0.6839
Epoch 86/400
640/640 [==============================] - 0s 75us/step - loss: 0.8328 - mse:
0.8328
Epoch 87/400
640/640 [==============================] - 0s 74us/step - loss: 0.6442 - mse:
0.6442
Epoch 88/400
640/640 [==============================] - 0s 74us/step - loss: 0.5691 - mse:
0.5691
Epoch 89/400
640/640 [==============================] - 0s 74us/step - loss: 0.6019 - mse:
0.6019
Epoch 90/400
640/640 [==============================] - 0s 66us/step - loss: 0.5932 - mse:
0.5932
Epoch 91/400
640/640 [==============================] - 0s 64us/step - loss: 0.5887 - mse:
0.5887
Epoch 92/400
640/640 [==============================] - 0s 72us/step - loss: 0.6236 - mse:
0.6236
Epoch 93/400
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640/640 [==============================] - 0s 75us/step - loss: 0.6302 - mse:
0.6302
Epoch 94/400
640/640 [==============================] - 0s 73us/step - loss: 0.4722 - mse:
0.4722
Epoch 95/400
640/640 [==============================] - 0s 66us/step - loss: 0.5833 - mse:
0.5833
Epoch 96/400
640/640 [==============================] - 0s 63us/step - loss: 0.5144 - mse:
0.5144
Epoch 97/400
640/640 [==============================] - 0s 69us/step - loss: 0.7952 - mse:
0.7952
Epoch 98/400
640/640 [==============================] - 0s 68us/step - loss: 0.5349 - mse:
0.5349
Epoch 99/400
640/640 [==============================] - 0s 66us/step - loss: 0.6835 - mse:
0.6835
Epoch 100/400
640/640 [==============================] - 0s 63us/step - loss: 0.4561 - mse:
0.4561
Epoch 101/400
640/640 [==============================] - 0s 62us/step - loss: 0.5265 - mse:
0.5265
Epoch 102/400
640/640 [==============================] - 0s 63us/step - loss: 0.5366 - mse:
0.5366
Epoch 103/400
640/640 [==============================] - 0s 65us/step - loss: 0.5675 - mse:
0.5675
Epoch 104/400
640/640 [==============================] - 0s 70us/step - loss: 0.3779 - mse:
0.3779
Epoch 105/400
640/640 [==============================] - 0s 71us/step - loss: 0.5246 - mse:
0.5246
Epoch 106/400
640/640 [==============================] - 0s 69us/step - loss: 0.3732 - mse:
0.3732
Epoch 107/400
640/640 [==============================] - 0s 70us/step - loss: 0.5546 - mse:
0.5546
Epoch 108/400
640/640 [==============================] - 0s 82us/step - loss: 0.4738 - mse:
0.4738
Epoch 109/400
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640/640 [==============================] - 0s 104us/step - loss: 0.6577 - mse:
0.6577
Epoch 110/400
640/640 [==============================] - 0s 97us/step - loss: 0.6806 - mse:
0.6806
Epoch 111/400
640/640 [==============================] - 0s 81us/step - loss: 0.5416 - mse:
0.5416
Epoch 112/400
640/640 [==============================] - 0s 74us/step - loss: 0.4652 - mse:
0.4652
Epoch 113/400
640/640 [==============================] - 0s 76us/step - loss: 0.4023 - mse:
0.4023
Epoch 114/400
640/640 [==============================] - 0s 73us/step - loss: 0.5503 - mse:
0.5503
Epoch 115/400
640/640 [==============================] - 0s 62us/step - loss: 0.5649 - mse:
0.5649
Epoch 116/400
640/640 [==============================] - 0s 57us/step - loss: 0.4386 - mse:
0.4386
Epoch 117/400
640/640 [==============================] - 0s 57us/step - loss: 0.5442 - mse:
0.5442
Epoch 118/400
640/640 [==============================] - 0s 66us/step - loss: 0.4824 - mse:
0.4824
Epoch 119/400
640/640 [==============================] - 0s 60us/step - loss: 0.5432 - mse:
0.5432
Epoch 120/400
640/640 [==============================] - 0s 59us/step - loss: 0.5504 - mse:
0.5504
Epoch 121/400
640/640 [==============================] - 0s 60us/step - loss: 0.4369 - mse:
0.4369
Epoch 122/400
640/640 [==============================] - 0s 62us/step - loss: 0.4537 - mse:
0.4537
Epoch 123/400
640/640 [==============================] - 0s 64us/step - loss: 0.4550 - mse:
0.4550
Epoch 124/400
640/640 [==============================] - 0s 58us/step - loss: 0.6031 - mse:
0.6031
Epoch 125/400
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640/640 [==============================] - 0s 60us/step - loss: 0.4876 - mse:
0.4876
Epoch 126/400
640/640 [==============================] - 0s 62us/step - loss: 0.4250 - mse:
0.4250
Epoch 127/400
640/640 [==============================] - 0s 65us/step - loss: 0.4614 - mse:
0.4614
Epoch 128/400
640/640 [==============================] - 0s 63us/step - loss: 0.4644 - mse:
0.4644
Epoch 129/400
640/640 [==============================] - 0s 73us/step - loss: 0.6168 - mse:
0.6168
Epoch 130/400
640/640 [==============================] - 0s 78us/step - loss: 0.5291 - mse:
0.5291
Epoch 131/400
640/640 [==============================] - 0s 75us/step - loss: 0.3988 - mse:
0.3988
Epoch 132/400
640/640 [==============================] - 0s 76us/step - loss: 0.4402 - mse:
0.4402
Epoch 133/400
640/640 [==============================] - 0s 74us/step - loss: 0.4999 - mse:
0.4999
Epoch 134/400
640/640 [==============================] - 0s 70us/step - loss: 0.4584 - mse:
0.4584
Epoch 135/400
640/640 [==============================] - 0s 61us/step - loss: 0.4197 - mse:
0.4197
Epoch 136/400
640/640 [==============================] - 0s 71us/step - loss: 0.4693 - mse:
0.4693
Epoch 137/400
640/640 [==============================] - 0s 69us/step - loss: 0.5158 - mse:
0.5158
Epoch 138/400
640/640 [==============================] - 0s 69us/step - loss: 0.5386 - mse:
0.5386
Epoch 139/400
640/640 [==============================] - 0s 63us/step - loss: 0.5591 - mse:
0.5591
Epoch 140/400
640/640 [==============================] - 0s 61us/step - loss: 0.4721 - mse:
0.4721
Epoch 141/400
```

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640/640 [==============================] - 0s 76us/step - loss: 0.5138 - mse:
0.5138
Epoch 142/400
640/640 [==============================] - 0s 72us/step - loss: 0.6017 - mse:
0.6017
Epoch 143/400
640/640 [==============================] - 0s 66us/step - loss: 0.5052 - mse:
0.5052
Epoch 144/400
640/640 [==============================] - 0s 55us/step - loss: 0.5714 - mse:
0.5714
Epoch 145/400
640/640 [==============================] - 0s 55us/step - loss: 0.5793 - mse:
0.5793
Epoch 146/400
640/640 [==============================] - 0s 63us/step - loss: 0.6520 - mse:
0.6520
Epoch 147/400
640/640 [==============================] - 0s 63us/step - loss: 0.7044 - mse:
0.7044
Epoch 148/400
640/640 [==============================] - 0s 61us/step - loss: 0.6093 - mse:
0.6093
Epoch 149/400
640/640 [==============================] - 0s 58us/step - loss: 0.4154 - mse:
0.4154
Epoch 150/400
640/640 [==============================] - 0s 64us/step - loss: 0.4091 - mse:
0.4091
Epoch 151/400
640/640 [==============================] - 0s 63us/step - loss: 0.5765 - mse:
0.5765
Epoch 152/400
640/640 [==============================] - 0s 71us/step - loss: 0.4806 - mse:
0.4806
Epoch 153/400
640/640 [==============================] - 0s 71us/step - loss: 0.4547 - mse:
0.4547
Epoch 154/400
640/640 [==============================] - 0s 71us/step - loss: 0.5213 - mse:
0.5213
Epoch 155/400
640/640 [==============================] - 0s 73us/step - loss: 0.6227 - mse:
0.6227
Epoch 156/400
640/640 [==============================] - 0s 74us/step - loss: 0.6539 - mse:
0.6539
Epoch 157/400
```

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640/640 [==============================] - 0s 63us/step - loss: 0.4391 - mse:
0.4391
Epoch 158/400
640/640 [==============================] - 0s 62us/step - loss: 0.5262 - mse:
0.5262
Epoch 159/400
640/640 [==============================] - 0s 71us/step - loss: 0.5114 - mse:
0.5114
Epoch 160/400
640/640 [==============================] - 0s 90us/step - loss: 0.5156 - mse:
0.5156
Epoch 161/400
640/640 [==============================] - 0s 118us/step - loss: 0.5390 - mse:
0.5390
Epoch 162/400
640/640 [==============================] - 0s 103us/step - loss: 0.5184 - mse:
0.5184
Epoch 163/400
640/640 [==============================] - 0s 102us/step - loss: 0.6504 - mse:
0.6504
Epoch 164/400
640/640 [==============================] - 0s 96us/step - loss: 0.4801 - mse:
0.4801
Epoch 165/400
640/640 [==============================] - 0s 97us/step - loss: 0.4709 - mse:
0.4709
Epoch 166/400
640/640 [==============================] - 0s 128us/step - loss: 0.4178 - mse:
0.4178
Epoch 167/400
640/640 [==============================] - 0s 152us/step - loss: 0.4509 - mse:
0.4509
Epoch 168/400
640/640 [==============================] - 0s 213us/step - loss: 0.3910 - mse:
0.3910
Epoch 169/400
640/640 [==============================] - 0s 166us/step - loss: 0.4272 - mse:
0.4272
Epoch 170/400
640/640 [==============================] - 0s 131us/step - loss: 0.5176 - mse:
0.5176
Epoch 171/400
640/640 [==============================] - 0s 155us/step - loss: 0.6255 - mse:
0.6255
Epoch 172/400
640/640 [==============================] - 0s 308us/step - loss: 0.5471 - mse:
0.5471
Epoch 173/400
```

```
640/640 [==============================] - 0s 163us/step - loss: 0.6517 - mse:
0.6517
Epoch 174/400
640/640 [==============================] - 0s 157us/step - loss: 0.4971 - mse:
0.4971
Epoch 175/400
640/640 [==============================] - 0s 114us/step - loss: 0.4771 - mse:
0.4771
Epoch 176/400
640/640 [==============================] - 0s 98us/step - loss: 0.3247 - mse:
0.3247
Epoch 177/400
640/640 [==============================] - 0s 71us/step - loss: 0.4652 - mse:
0.4652
Epoch 178/400
640/640 [==============================] - 0s 71us/step - loss: 0.4141 - mse:
0.4141
Epoch 179/400
640/640 [==============================] - 0s 85us/step - loss: 0.4845 - mse:
0.4845
Epoch 180/400
640/640 [==============================] - 0s 80us/step - loss: 0.5354 - mse:
0.5354
Epoch 181/400
640/640 [==============================] - 0s 90us/step - loss: 0.5216 - mse:
0.5216
Epoch 182/400
640/640 [==============================] - 0s 103us/step - loss: 0.6243 - mse:
0.6243
Epoch 183/400
640/640 [==============================] - 0s 81us/step - loss: 0.4611 - mse:
0.4611
Epoch 184/400
640/640 [==============================] - 0s 91us/step - loss: 0.3919 - mse:
0.3919
Epoch 185/400
640/640 [==============================] - 0s 86us/step - loss: 0.6254 - mse:
0.6254
Epoch 186/400
640/640 [==============================] - 0s 86us/step - loss: 0.4606 - mse:
0.4606
Epoch 187/400
640/640 [==============================] - 0s 74us/step - loss: 0.3850 - mse:
0.3850
Epoch 188/400
640/640 [==============================] - 0s 69us/step - loss: 0.3392 - mse:
0.3392
Epoch 189/400
```

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640/640 [==============================] - 0s 58us/step - loss: 0.4280 - mse:
0.4280
Epoch 190/400
640/640 [==============================] - 0s 61us/step - loss: 0.4200 - mse:
0.4200
Epoch 191/400
640/640 [==============================] - 0s 55us/step - loss: 0.5494 - mse:
0.5494
Epoch 192/400
640/640 [==============================] - 0s 58us/step - loss: 0.4489 - mse:
0.4489
Epoch 193/400
640/640 [==============================] - 0s 63us/step - loss: 0.4278 - mse:
0.4278
Epoch 194/400
640/640 [==============================] - 0s 56us/step - loss: 0.5221 - mse:
0.5221
Epoch 195/400
640/640 [==============================] - 0s 58us/step - loss: 0.3433 - mse:
0.3433
Epoch 196/400
640/640 [==============================] - 0s 62us/step - loss: 0.4833 - mse:
0.4833
Epoch 197/400
640/640 [==============================] - 0s 65us/step - loss: 0.4848 - mse:
0.4848
Epoch 198/400
640/640 [==============================] - 0s 62us/step - loss: 0.5027 - mse:
0.5027
Epoch 199/400
640/640 [==============================] - 0s 69us/step - loss: 0.4216 - mse:
0.4216
Epoch 200/400
640/640 [==============================] - 0s 73us/step - loss: 0.4525 - mse:
0.4525
Epoch 201/400
640/640 [==============================] - 0s 78us/step - loss: 0.4119 - mse:
0.4119
Epoch 202/400
640/640 [==============================] - 0s 122us/step - loss: 0.4047 - mse:
0.4047
Epoch 203/400
640/640 [==============================] - 0s 110us/step - loss: 0.6396 - mse:
0.6396
Epoch 204/400
640/640 [==============================] - 0s 111us/step - loss: 0.4083 - mse:
0.4083
Epoch 205/400
```

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640/640 [==============================] - 0s 120us/step - loss: 0.5504 - mse:
0.5504
Epoch 206/400
640/640 [==============================] - 0s 140us/step - loss: 0.5262 - mse:
0.5262
Epoch 207/400
640/640 [==============================] - 0s 142us/step - loss: 0.4403 - mse:
0.4403
Epoch 208/400
640/640 [==============================] - 0s 114us/step - loss: 0.5963 - mse:
0.5963
Epoch 209/400
640/640 [==============================] - 0s 69us/step - loss: 0.3513 - mse:
0.3513
Epoch 210/400
640/640 [==============================] - 0s 73us/step - loss: 0.3906 - mse:
0.3906
Epoch 211/400
640/640 [==============================] - 0s 64us/step - loss: 0.4415 - mse:
0.4415
Epoch 212/400
640/640 [==============================] - 0s 58us/step - loss: 0.4088 - mse:
0.4088
Epoch 213/400
640/640 [==============================] - 0s 71us/step - loss: 0.3692 - mse:
0.3692
Epoch 214/400
640/640 [==============================] - 0s 78us/step - loss: 0.4959 - mse:
0.4959
Epoch 215/400
640/640 [==============================] - 0s 86us/step - loss: 0.6028 - mse:
0.6028
Epoch 216/400
640/640 [==============================] - 0s 86us/step - loss: 0.5457 - mse:
0.5457
Epoch 217/400
640/640 [==============================] - 0s 80us/step - loss: 0.4896 - mse:
0.4896
Epoch 218/400
640/640 [==============================] - 0s 81us/step - loss: 0.5013 - mse:
0.5013
Epoch 219/400
640/640 [==============================] - 0s 74us/step - loss: 0.4245 - mse:
0.4245
Epoch 220/400
640/640 [==============================] - 0s 76us/step - loss: 0.3599 - mse:
0.3599
Epoch 221/400
```

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640/640 [==============================] - 0s 85us/step - loss: 0.4199 - mse:
0.4199
Epoch 222/400
640/640 [==============================] - 0s 94us/step - loss: 0.4627 - mse:
0.4627
Epoch 223/400
640/640 [==============================] - 0s 74us/step - loss: 0.4877 - mse:
0.4877
Epoch 224/400
640/640 [==============================] - 0s 69us/step - loss: 0.4949 - mse:
0.4949
Epoch 225/400
640/640 [==============================] - 0s 82us/step - loss: 0.4465 - mse:
0.4465
Epoch 226/400
640/640 [==============================] - 0s 88us/step - loss: 0.3610 - mse:
0.3610
Epoch 227/400
640/640 [==============================] - 0s 68us/step - loss: 0.4683 - mse:
0.4683
Epoch 228/400
640/640 [==============================] - 0s 68us/step - loss: 0.4128 - mse:
0.4128
Epoch 229/400
640/640 [==============================] - 0s 66us/step - loss: 0.5949 - mse:
0.5949
Epoch 230/400
640/640 [==============================] - 0s 68us/step - loss: 0.3338 - mse:
0.3338
Epoch 231/400
640/640 [==============================] - 0s 67us/step - loss: 0.3897 - mse:
0.3897
Epoch 232/400
640/640 [==============================] - 0s 120us/step - loss: 0.4451 - mse:
0.4451
Epoch 233/400
640/640 [==============================] - 0s 117us/step - loss: 0.4270 - mse:
0.4270
Epoch 234/400
640/640 [==============================] - 0s 126us/step - loss: 0.3643 - mse:
0.3643
Epoch 235/400
640/640 [==============================] - 0s 106us/step - loss: 0.4987 - mse:
0.4987
Epoch 236/400
640/640 [==============================] - 0s 99us/step - loss: 0.3600 - mse:
0.3600
Epoch 237/400
```

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640/640 [==============================] - 0s 126us/step - loss: 0.3880 - mse:
0.3880
Epoch 238/400
640/640 [==============================] - 0s 150us/step - loss: 0.4138 - mse:
0.4138
Epoch 239/400
640/640 [==============================] - 0s 153us/step - loss: 0.5214 - mse:
0.5214
Epoch 240/400
640/640 [==============================] - 0s 150us/step - loss: 0.4058 - mse:
0.4058
Epoch 241/400
640/640 [==============================] - 0s 138us/step - loss: 0.3471 - mse:
0.3471
Epoch 242/400
640/640 [==============================] - 0s 129us/step - loss: 0.3800 - mse:
0.3800
Epoch 243/400
640/640 [==============================] - 0s 117us/step - loss: 0.5907 - mse:
0.5907
Epoch 244/400
640/640 [==============================] - 0s 116us/step - loss: 0.4395 - mse:
0.4395
Epoch 245/400
640/640 [==============================] - 0s 184us/step - loss: 0.4722 - mse:
0.4722
Epoch 246/400
640/640 [==============================] - 0s 129us/step - loss: 0.4882 - mse:
0.4882
Epoch 247/400
640/640 [==============================] - 0s 112us/step - loss: 0.3647 - mse:
0.3647
Epoch 248/400
640/640 [==============================] - 0s 136us/step - loss: 0.4760 - mse:
0.4760
Epoch 249/400
640/640 [==============================] - 0s 105us/step - loss: 0.4398 - mse:
0.4398
Epoch 250/400
640/640 [==============================] - 0s 107us/step - loss: 0.3303 - mse:
0.3303
Epoch 251/400
640/640 [==============================] - 0s 138us/step - loss: 0.3419 - mse:
0.3419
Epoch 252/400
640/640 [==============================] - 0s 133us/step - loss: 0.4275 - mse:
0.4275
Epoch 253/400
```

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640/640 [==============================] - 0s 122us/step - loss: 0.3788 - mse:
0.3788
Epoch 254/400
640/640 [==============================] - 0s 116us/step - loss: 0.4566 - mse:
0.4566
Epoch 255/400
640/640 [==============================] - 0s 112us/step - loss: 0.3935 - mse:
0.3935
Epoch 256/400
640/640 [==============================] - 0s 77us/step - loss: 0.4693 - mse:
0.4693
Epoch 257/400
640/640 [==============================] - 0s 95us/step - loss: 0.5260 - mse:
0.5260
Epoch 258/400
640/640 [==============================] - 0s 133us/step - loss: 0.5338 - mse:
0.5338
Epoch 259/400
640/640 [==============================] - 0s 114us/step - loss: 0.5539 - mse:
0.5539
Epoch 260/400
640/640 [==============================] - 0s 108us/step - loss: 0.4785 - mse:
0.4785
Epoch 261/400
640/640 [==============================] - 0s 115us/step - loss: 0.4754 - mse:
0.4754
Epoch 262/400
640/640 [==============================] - 0s 102us/step - loss: 0.3422 - mse:
0.3422
Epoch 263/400
640/640 [==============================] - 0s 93us/step - loss: 0.4118 - mse:
0.4118
Epoch 264/400
640/640 [==============================] - 0s 84us/step - loss: 0.4949 - mse:
0.4949
Epoch 265/400
640/640 [==============================] - 0s 96us/step - loss: 0.5105 - mse:
0.5105
Epoch 266/400
640/640 [==============================] - 0s 105us/step - loss: 0.5355 - mse:
0.5355
Epoch 267/400
640/640 [==============================] - 0s 92us/step - loss: 0.3388 - mse:
0.3388
Epoch 268/400
640/640 [==============================] - 0s 87us/step - loss: 0.5284 - mse:
0.5284
Epoch 269/400
```

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640/640 [==============================] - 0s 75us/step - loss: 0.3962 - mse:
0.3962
Epoch 270/400
640/640 [==============================] - 0s 76us/step - loss: 0.4454 - mse:
0.4454
Epoch 271/400
640/640 [==============================] - 0s 71us/step - loss: 0.5003 - mse:
0.5003
Epoch 272/400
640/640 [==============================] - 0s 93us/step - loss: 0.3784 - mse:
0.3784
Epoch 273/400
640/640 [==============================] - 0s 92us/step - loss: 0.3704 - mse:
0.3704
Epoch 274/400
640/640 [==============================] - 0s 85us/step - loss: 0.3915 - mse:
0.3915
Epoch 275/400
640/640 [==============================] - 0s 108us/step - loss: 0.4681 - mse:
0.4681
Epoch 276/400
640/640 [==============================] - 0s 113us/step - loss: 0.5507 - mse:
0.5507
Epoch 277/400
640/640 [==============================] - 0s 92us/step - loss: 0.3324 - mse:
0.3324
Epoch 278/400
640/640 [==============================] - 0s 112us/step - loss: 0.4883 - mse:
0.4883
Epoch 279/400
640/640 [==============================] - 0s 79us/step - loss: 0.5128 - mse:
0.5128
Epoch 280/400
640/640 [==============================] - 0s 73us/step - loss: 0.5134 - mse:
0.5134
Epoch 281/400
640/640 [==============================] - 0s 91us/step - loss: 0.4225 - mse:
0.4225
Epoch 282/400
640/640 [==============================] - 0s 94us/step - loss: 0.5154 - mse:
0.5154
Epoch 283/400
640/640 [==============================] - 0s 90us/step - loss: 0.5000 - mse:
0.5000
Epoch 284/400
640/640 [==============================] - 0s 75us/step - loss: 0.5422 - mse:
0.5422
Epoch 285/400
```

```
640/640 [==============================] - 0s 75us/step - loss: 0.4057 - mse:
0.4057
Epoch 286/400
640/640 [==============================] - 0s 72us/step - loss: 0.4629 - mse:
0.4629
Epoch 287/400
640/640 [==============================] - 0s 79us/step - loss: 0.3808 - mse:
0.3808
Epoch 288/400
640/640 [==============================] - 0s 69us/step - loss: 0.4395 - mse:
0.4395
Epoch 289/400
640/640 [==============================] - 0s 78us/step - loss: 0.3742 - mse:
0.3742
Epoch 290/400
640/640 [==============================] - 0s 86us/step - loss: 0.4655 - mse:
0.4655
Epoch 291/400
640/640 [==============================] - 0s 99us/step - loss: 0.5637 - mse:
0.5637
Epoch 292/400
640/640 [==============================] - 0s 86us/step - loss: 0.3570 - mse:
0.3570
Epoch 293/400
640/640 [==============================] - 0s 83us/step - loss: 0.3200 - mse:
0.3200
Epoch 294/400
640/640 [==============================] - 0s 90us/step - loss: 0.4146 - mse:
0.4146
Epoch 295/400
640/640 [==============================] - 0s 98us/step - loss: 0.3897 - mse:
0.3897
Epoch 296/400
640/640 [==============================] - 0s 82us/step - loss: 0.4116 - mse:
0.4116
Epoch 297/400
640/640 [==============================] - 0s 75us/step - loss: 0.3387 - mse:
0.3387
Epoch 298/400
640/640 [==============================] - 0s 102us/step - loss: 0.5658 - mse:
0.5658
Epoch 299/400
640/640 [==============================] - 0s 102us/step - loss: 0.3643 - mse:
0.3643
Epoch 300/400
640/640 [==============================] - 0s 99us/step - loss: 0.3901 - mse:
0.3901
Epoch 301/400
```

```
640/640 [==============================] - 0s 100us/step - loss: 0.3657 - mse:
0.3657
Epoch 302/400
640/640 [==============================] - 0s 93us/step - loss: 0.5815 - mse:
0.5815
Epoch 303/400
640/640 [==============================] - 0s 71us/step - loss: 0.4115 - mse:
0.4115
Epoch 304/400
640/640 [==============================] - 0s 72us/step - loss: 0.3831 - mse:
0.3831
Epoch 305/400
640/640 [==============================] - 0s 80us/step - loss: 0.3471 - mse:
0.3471
Epoch 306/400
640/640 [==============================] - 0s 75us/step - loss: 0.3723 - mse:
0.3723
Epoch 307/400
640/640 [==============================] - 0s 82us/step - loss: 0.4474 - mse:
0.4474
Epoch 308/400
640/640 [==============================] - 0s 101us/step - loss: 0.3540 - mse:
0.3540
Epoch 309/400
640/640 [==============================] - 0s 97us/step - loss: 0.4465 - mse:
0.4465
Epoch 310/400
640/640 [==============================] - 0s 103us/step - loss: 0.3202 - mse:
0.3202
Epoch 311/400
640/640 [==============================] - 0s 100us/step - loss: 0.4505 - mse:
0.4505
Epoch 312/400
640/640 [==============================] - 0s 87us/step - loss: 0.2303 - mse:
0.2303
Epoch 313/400
640/640 [==============================] - 0s 83us/step - loss: 0.2836 - mse:
0.2836
Epoch 314/400
640/640 [==============================] - 0s 73us/step - loss: 0.2936 - mse:
0.2936
Epoch 315/400
640/640 [==============================] - 0s 104us/step - loss: 0.3823 - mse:
0.3823
Epoch 316/400
640/640 [==============================] - 0s 107us/step - loss: 0.3597 - mse:
0.3597
Epoch 317/400
```

```
640/640 [==============================] - 0s 83us/step - loss: 0.4189 - mse:
0.4189
Epoch 318/400
640/640 [==============================] - 0s 78us/step - loss: 0.3856 - mse:
0.3856
Epoch 319/400
640/640 [==============================] - 0s 76us/step - loss: 0.4468 - mse:
0.4468
Epoch 320/400
640/640 [==============================] - 0s 70us/step - loss: 0.3048 - mse:
0.3048
Epoch 321/400
640/640 [==============================] - 0s 62us/step - loss: 0.3777 - mse:
0.3777
Epoch 322/400
640/640 [==============================] - 0s 67us/step - loss: 0.4469 - mse:
0.4469
Epoch 323/400
640/640 [==============================] - 0s 69us/step - loss: 0.3103 - mse:
0.3103
Epoch 324/400
640/640 [==============================] - 0s 70us/step - loss: 0.4350 - mse:
0.4350
Epoch 325/400
640/640 [==============================] - 0s 83us/step - loss: 0.4397 - mse:
0.4397
Epoch 326/400
640/640 [==============================] - 0s 94us/step - loss: 0.4019 - mse:
0.4019
Epoch 327/400
640/640 [==============================] - 0s 90us/step - loss: 0.5710 - mse:
0.5710
Epoch 328/400
640/640 [==============================] - 0s 96us/step - loss: 0.3629 - mse:
0.3629
Epoch 329/400
640/640 [==============================] - 0s 80us/step - loss: 0.3832 - mse:
0.3832
Epoch 330/400
640/640 [==============================] - 0s 94us/step - loss: 0.3931 - mse:
0.3931
Epoch 331/400
640/640 [==============================] - 0s 81us/step - loss: 0.5326 - mse:
0.5326
Epoch 332/400
640/640 [==============================] - 0s 68us/step - loss: 0.3311 - mse:
0.3311
Epoch 333/400
```

```
640/640 [==============================] - 0s 80us/step - loss: 0.4074 - mse:
0.4074
Epoch 334/400
640/640 [==============================] - 0s 85us/step - loss: 0.3581 - mse:
0.3581
Epoch 335/400
640/640 [==============================] - 0s 83us/step - loss: 0.4030 - mse:
0.4030
Epoch 336/400
640/640 [==============================] - 0s 72us/step - loss: 0.4532 - mse:
0.4532
Epoch 337/400
640/640 [==============================] - 0s 106us/step - loss: 0.3479 - mse:
0.3479
Epoch 338/400
640/640 [==============================] - 0s 112us/step - loss: 0.4240 - mse:
0.4240
Epoch 339/400
640/640 [==============================] - 0s 93us/step - loss: 0.3852 - mse:
0.3852
Epoch 340/400
640/640 [==============================] - 0s 82us/step - loss: 0.5516 - mse:
0.5516
Epoch 341/400
640/640 [==============================] - 0s 92us/step - loss: 0.4327 - mse:
0.4327
Epoch 342/400
640/640 [==============================] - 0s 87us/step - loss: 0.5037 - mse:
0.5037
Epoch 343/400
640/640 [==============================] - 0s 89us/step - loss: 0.4786 - mse:
0.4786
Epoch 344/400
640/640 [==============================] - 0s 79us/step - loss: 0.4136 - mse:
0.4136
Epoch 345/400
640/640 [==============================] - 0s 84us/step - loss: 0.3667 - mse:
0.3667
Epoch 346/400
640/640 [==============================] - 0s 74us/step - loss: 0.4105 - mse:
0.4105
Epoch 347/400
640/640 [==============================] - 0s 98us/step - loss: 0.4132 - mse:
0.4132
Epoch 348/400
640/640 [==============================] - 0s 111us/step - loss: 0.4141 - mse:
0.4141
Epoch 349/400
```

```
640/640 [==============================] - 0s 95us/step - loss: 0.4086 - mse:
0.4086
Epoch 350/400
640/640 [==============================] - 0s 137us/step - loss: 0.4303 - mse:
0.4303
Epoch 351/400
640/640 [==============================] - 0s 154us/step - loss: 0.2346 - mse:
0.2346
Epoch 352/400
640/640 [==============================] - 0s 176us/step - loss: 0.4871 - mse:
0.4871
Epoch 353/400
640/640 [==============================] - 0s 116us/step - loss: 0.4023 - mse:
0.4023
Epoch 354/400
640/640 [==============================] - 0s 139us/step - loss: 0.3254 - mse:
0.3254
Epoch 355/400
640/640 [==============================] - 0s 131us/step - loss: 0.5272 - mse:
0.5272
Epoch 356/400
640/640 [==============================] - 0s 117us/step - loss: 0.4390 - mse:
0.4390
Epoch 357/400
640/640 [==============================] - 0s 94us/step - loss: 0.4176 - mse:
0.4176
Epoch 358/400
640/640 [==============================] - 0s 92us/step - loss: 0.4788 - mse:
0.4788
Epoch 359/400
640/640 [==============================] - 0s 75us/step - loss: 0.3402 - mse:
0.3402
Epoch 360/400
640/640 [==============================] - 0s 71us/step - loss: 0.3108 - mse:
0.3108
Epoch 361/400
640/640 [==============================] - 0s 73us/step - loss: 0.4429 - mse:
0.4429
Epoch 362/400
640/640 [==============================] - 0s 67us/step - loss: 0.4598 - mse:
0.4598
Epoch 363/400
640/640 [==============================] - 0s 75us/step - loss: 0.5152 - mse:
0.5152
Epoch 364/400
640/640 [==============================] - 0s 127us/step - loss: 0.4818 - mse:
0.4818
Epoch 365/400
```

```
640/640 [==============================] - 0s 147us/step - loss: 0.3695 - mse:
0.3695
Epoch 366/400
640/640 [==============================] - 0s 132us/step - loss: 0.4116 - mse:
0.4116
Epoch 367/400
640/640 [==============================] - 0s 136us/step - loss: 0.4998 - mse:
0.4998
Epoch 368/400
640/640 [==============================] - 0s 135us/step - loss: 0.4310 - mse:
0.4310
Epoch 369/400
640/640 [==============================] - 0s 115us/step - loss: 0.4412 - mse:
0.4412
Epoch 370/400
640/640 [==============================] - 0s 110us/step - loss: 0.6379 - mse:
0.6379
Epoch 371/400
640/640 [==============================] - 0s 147us/step - loss: 0.3628 - mse:
0.3628
Epoch 372/400
640/640 [==============================] - 0s 110us/step - loss: 0.4431 - mse:
0.4431
Epoch 373/400
640/640 [==============================] - 0s 121us/step - loss: 0.3628 - mse:
0.3628
Epoch 374/400
640/640 [==============================] - 0s 132us/step - loss: 0.3484 - mse:
0.3484
Epoch 375/400
640/640 [==============================] - 0s 125us/step - loss: 0.3617 - mse:
0.3617
Epoch 376/400
640/640 [==============================] - 0s 124us/step - loss: 0.3901 - mse:
0.3901
Epoch 377/400
640/640 [==============================] - 0s 163us/step - loss: 0.4841 - mse:
0.4841
Epoch 378/400
640/640 [==============================] - 0s 129us/step - loss: 0.4366 - mse:
0.4366
Epoch 379/400
640/640 [==============================] - 0s 103us/step - loss: 0.4640 - mse:
0.4640
Epoch 380/400
640/640 [==============================] - 0s 68us/step - loss: 0.3299 - mse:
0.3299
Epoch 381/400
```

```
640/640 [==============================] - 0s 59us/step - loss: 0.4290 - mse:
0.4290
Epoch 382/400
640/640 [==============================] - 0s 65us/step - loss: 0.3009 - mse:
0.3009
Epoch 383/400
640/640 [==============================] - 0s 73us/step - loss: 0.3900 - mse:
0.3900
Epoch 384/400
640/640 [==============================] - 0s 72us/step - loss: 0.4111 - mse:
0.4111
Epoch 385/400
640/640 [==============================] - 0s 71us/step - loss: 0.5051 - mse:
0.5051
Epoch 386/400
640/640 [==============================] - 0s 95us/step - loss: 0.3731 - mse:
0.3731
Epoch 387/400
640/640 [==============================] - 0s 99us/step - loss: 0.3483 - mse:
0.3483
Epoch 388/400
640/640 [==============================] - 0s 107us/step - loss: 0.3858 - mse:
0.3858
Epoch 389/400
640/640 [==============================] - 0s 120us/step - loss: 0.2469 - mse:
0.2469
Epoch 390/400
640/640 [==============================] - 0s 121us/step - loss: 0.3520 - mse:
0.3520
Epoch 391/400
640/640 [==============================] - 0s 111us/step - loss: 0.3424 - mse:
0.3424
Epoch 392/400
640/640 [==============================] - 0s 118us/step - loss: 0.3921 - mse:
0.3921
Epoch 393/400
640/640 [==============================] - 0s 112us/step - loss: 0.3836 - mse:
0.3836
Epoch 394/400
640/640 [==============================] - 0s 101us/step - loss: 0.4511 - mse:
0.4511
Epoch 395/400
640/640 [==============================] - 0s 86us/step - loss: 0.4256 - mse:
0.4256
Epoch 396/400
640/640 [==============================] - 0s 82us/step - loss: 0.3336 - mse:
0.3336
Epoch 397/400
```

```
640/640 [==============================] - 0s 84us/step - loss: 0.3536 - mse:
0.3536
Epoch 398/400
640/640 [==============================] - 0s 90us/step - loss: 0.4270 - mse:
0.4270
Epoch 399/400
640/640 [==============================] - 0s 85us/step - loss: 0.5540 - mse:
0.5540
Epoch 400/400
640/640 [==============================] - 0s 84us/step - loss: 0.4918 - mse:
0.4918
```

[6]:
```python
plt.plot(result.history['mse'][9:], label='Error')
plt.title("Error per Epoch")
plt.ylabel("Error")
plt.xlabel("Epoch")
plt.show()
```
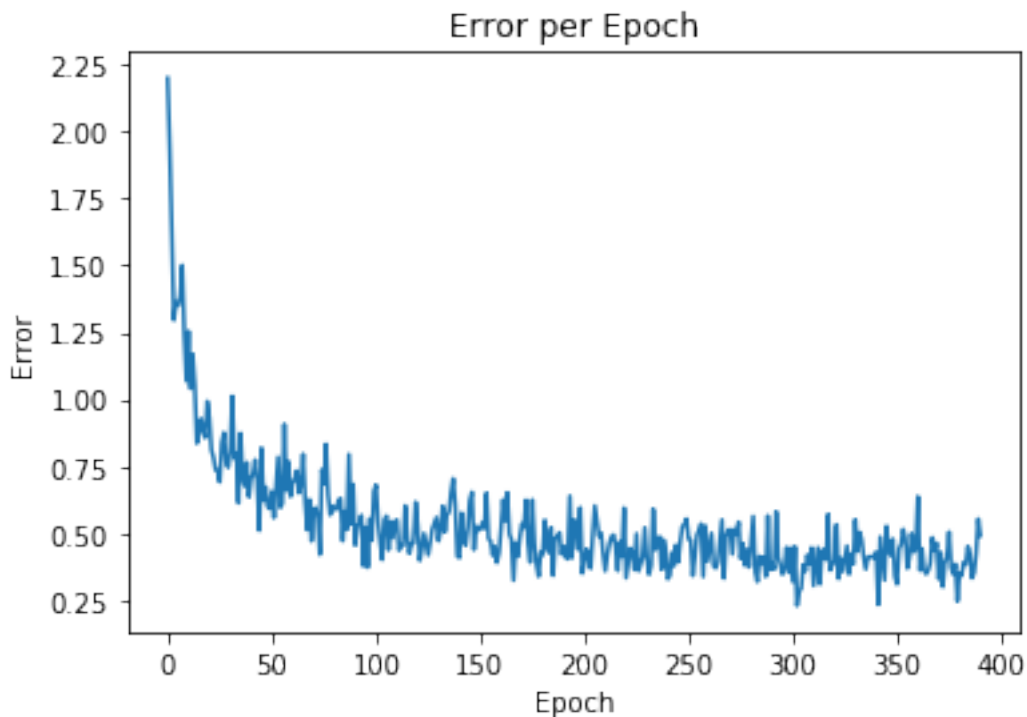

Below are the evaluation and prediction of the test data.

[7]:
```python
model.evaluate(X_test,Y_test)
```

```
100/100 [==============================] - 0s 868us/step
```

28

[7]: [2.239789342880249, 2.2397892475128174]

[8]: `model.predict(X_test)`

[8]: array([[16.066086],
        [15.98393],
        [11.870772],
        [12.667431],
        [13.573432],
        [9.863728],
        [11.944125],
        [12.73495],
        [10.266866],
        [10.733826],
        [11.250207],
        [11.349945],
        [12.134901],
        [10.847218],
        [15.681121],
        [10.969329],
        [11.385669],
        [14.39683],
        [17.971432],
        [12.48136],
        [11.440838],
        [16.00816],
        [14.516333],
        [16.691385],
        [13.32311],
        [11.829491],
        [13.055396],
        [14.968102],
        [10.799687],
        [12.107593],
        [17.106564],
        [14.672067],
        [14.521335],
        [15.66048],
        [16.555681],
        [16.140974],
        [13.721002],
        [14.027346],
        [16.178965],
        [14.742581],
        [17.239153],
        [16.202415],
        [15.156428],

```
[12.744971 ],
[12.250231 ],
[12.929467 ],
[12.152541 ],
[13.43007  ],
[13.23071  ],
[11.864444 ],
[12.834146 ],
[13.166191 ],
[12.937608 ],
[17.727953 ],
[11.552488 ],
[11.1039   ],
[11.717118 ],
[12.875093 ],
[10.829951 ],
[12.348716 ],
[11.54097  ],
[13.630561 ],
[13.920239 ],
[17.285248 ],
[16.258028 ],
[15.760074 ],
[16.725489 ],
[11.452701 ],
[14.409041 ],
[17.252888 ],
[12.58702  ],
[14.398694 ],
[16.390593 ],
[16.250315 ],
[12.951282 ],
[14.656769 ],
[16.84159  ],
[16.614618 ],
[16.754156 ],
[15.919413 ],
[16.406979 ],
[16.297445 ],
[12.895689 ],
[15.435889 ],
[15.8416815],
[17.175055 ],
[14.358504 ],
[16.414505 ],
[15.16162  ],
[14.263532 ],
```

```
            [14.263532 ],
            [16.734726 ],
            [17.18942  ],
            [16.884193 ],
            [13.684597 ],
            [17.30677  ],
            [17.564352 ],
            [13.62445  ],
            [13.782347 ],
            [18.745096 ]], dtype=float32)
```

2 Classification

For the second part we had to classify the data into 2 categories. Same architecture is used as the previous model with the exception that the output layer's activation function is `sigmoid` instead of `relu`. `binary_crossentropy` is used as loss function and `accuracy` is used as metric. The final result of the network's training is and accuracy between 70% and 80% on the train data.

```
[9]: model2 = Sequential()
     model2.add(BatchNormalization())
     model.add(Dense(100, activation='relu'))
     model.add(Dropout(0.01))
     model.add(Dense(50, activation='relu'))
     model.add(Dropout(0.01))
     model2.add(Dense(1, activation='sigmoid'))
     sgd = keras.optimizers.sgd(lr=0.05, decay=1e-6, momentum=0.9, nesterov=True)
     model2.compile(optimizer='Nadam', loss='binary_crossentropy',␣
      ↪metrics=['accuracy'])
     result2 = model2.fit(X_train2, Y_train2,batch_size=32,validation_data=(X_test2,␣
      ↪Y_test2),shuffle = True, epochs=150)
```

```
Train on 640 samples, validate on 222 samples
Epoch 1/150
640/640 [==============================] - 0s 422us/step - loss: 0.7881 -
accuracy: 0.5453 - val_loss: 0.7396 - val_accuracy: 0.5811
Epoch 2/150
640/640 [==============================] - 0s 50us/step - loss: 0.7137 -
accuracy: 0.6031 - val_loss: 0.6582 - val_accuracy: 0.6532
Epoch 3/150
640/640 [==============================] - 0s 44us/step - loss: 0.6406 -
accuracy: 0.6438 - val_loss: 0.6032 - val_accuracy: 0.6847
Epoch 4/150
640/640 [==============================] - 0s 47us/step - loss: 0.6090 -
accuracy: 0.6734 - val_loss: 0.5666 - val_accuracy: 0.7162
Epoch 5/150
640/640 [==============================] - 0s 46us/step - loss: 0.5821 -
accuracy: 0.6828 - val_loss: 0.5416 - val_accuracy: 0.7387
```

```
Epoch 6/150
640/640 [==============================] - 0s 42us/step - loss: 0.5615 -
accuracy: 0.6844 - val_loss: 0.5242 - val_accuracy: 0.7658
Epoch 7/150
640/640 [==============================] - 0s 40us/step - loss: 0.5305 -
accuracy: 0.7156 - val_loss: 0.5113 - val_accuracy: 0.7793
Epoch 8/150
640/640 [==============================] - 0s 40us/step - loss: 0.5322 -
accuracy: 0.7219 - val_loss: 0.5007 - val_accuracy: 0.7748
Epoch 9/150
640/640 [==============================] - 0s 39us/step - loss: 0.5241 -
accuracy: 0.7234 - val_loss: 0.4928 - val_accuracy: 0.7883
Epoch 10/150
640/640 [==============================] - 0s 39us/step - loss: 0.5023 -
accuracy: 0.7234 - val_loss: 0.4862 - val_accuracy: 0.7928
Epoch 11/150
640/640 [==============================] - 0s 39us/step - loss: 0.4908 -
accuracy: 0.7422 - val_loss: 0.4797 - val_accuracy: 0.7883
Epoch 12/150
640/640 [==============================] - 0s 45us/step - loss: 0.4840 -
accuracy: 0.7437 - val_loss: 0.4748 - val_accuracy: 0.7883
Epoch 13/150
640/640 [==============================] - 0s 66us/step - loss: 0.4798 -
accuracy: 0.7578 - val_loss: 0.4703 - val_accuracy: 0.7793
Epoch 14/150
640/640 [==============================] - 0s 68us/step - loss: 0.4708 -
accuracy: 0.7547 - val_loss: 0.4662 - val_accuracy: 0.7793
Epoch 15/150
640/640 [==============================] - 0s 80us/step - loss: 0.4749 -
accuracy: 0.7688 - val_loss: 0.4627 - val_accuracy: 0.7793
Epoch 16/150
640/640 [==============================] - 0s 118us/step - loss: 0.4699 -
accuracy: 0.7484 - val_loss: 0.4593 - val_accuracy: 0.7748
Epoch 17/150
640/640 [==============================] - 0s 74us/step - loss: 0.4536 -
accuracy: 0.7797 - val_loss: 0.4563 - val_accuracy: 0.7838
Epoch 18/150
640/640 [==============================] - 0s 59us/step - loss: 0.4451 -
accuracy: 0.7797 - val_loss: 0.4542 - val_accuracy: 0.7793
Epoch 19/150
640/640 [==============================] - 0s 45us/step - loss: 0.4350 -
accuracy: 0.7781 - val_loss: 0.4514 - val_accuracy: 0.7883
Epoch 20/150
640/640 [==============================] - 0s 43us/step - loss: 0.4432 -
accuracy: 0.7750 - val_loss: 0.4505 - val_accuracy: 0.7883
Epoch 21/150
640/640 [==============================] - 0s 38us/step - loss: 0.4311 -
accuracy: 0.7891 - val_loss: 0.4483 - val_accuracy: 0.7883
```

```
Epoch 22/150
640/640 [==============================] - 0s 46us/step - loss: 0.4337 -
accuracy: 0.7828 - val_loss: 0.4469 - val_accuracy: 0.7883
Epoch 23/150
640/640 [==============================] - 0s 46us/step - loss: 0.4239 -
accuracy: 0.7953 - val_loss: 0.4443 - val_accuracy: 0.7883
Epoch 24/150
640/640 [==============================] - 0s 45us/step - loss: 0.4242 -
accuracy: 0.7844 - val_loss: 0.4434 - val_accuracy: 0.7883
Epoch 25/150
640/640 [==============================] - 0s 47us/step - loss: 0.4145 -
accuracy: 0.7922 - val_loss: 0.4430 - val_accuracy: 0.7793
Epoch 26/150
640/640 [==============================] - 0s 42us/step - loss: 0.4206 -
accuracy: 0.7859 - val_loss: 0.4430 - val_accuracy: 0.7838
Epoch 27/150
640/640 [==============================] - 0s 44us/step - loss: 0.4004 -
accuracy: 0.8078 - val_loss: 0.4414 - val_accuracy: 0.7838
Epoch 28/150
640/640 [==============================] - 0s 40us/step - loss: 0.4080 -
accuracy: 0.8031 - val_loss: 0.4413 - val_accuracy: 0.7838
Epoch 29/150
640/640 [==============================] - 0s 42us/step - loss: 0.4057 -
accuracy: 0.8016 - val_loss: 0.4406 - val_accuracy: 0.7883
Epoch 30/150
640/640 [==============================] - 0s 41us/step - loss: 0.4005 -
accuracy: 0.8078 - val_loss: 0.4400 - val_accuracy: 0.7883
Epoch 31/150
640/640 [==============================] - 0s 38us/step - loss: 0.4047 -
accuracy: 0.8047 - val_loss: 0.4406 - val_accuracy: 0.7883
Epoch 32/150
640/640 [==============================] - 0s 38us/step - loss: 0.4025 -
accuracy: 0.7875 - val_loss: 0.4399 - val_accuracy: 0.7883
Epoch 33/150
640/640 [==============================] - 0s 38us/step - loss: 0.3978 -
accuracy: 0.8078 - val_loss: 0.4391 - val_accuracy: 0.7928
Epoch 34/150
640/640 [==============================] - 0s 41us/step - loss: 0.3988 -
accuracy: 0.7969 - val_loss: 0.4384 - val_accuracy: 0.8063
Epoch 35/150
640/640 [==============================] - 0s 41us/step - loss: 0.3986 -
accuracy: 0.7922 - val_loss: 0.4374 - val_accuracy: 0.8063
Epoch 36/150
640/640 [==============================] - 0s 48us/step - loss: 0.3976 -
accuracy: 0.8094 - val_loss: 0.4374 - val_accuracy: 0.8018
Epoch 37/150
640/640 [==============================] - 0s 41us/step - loss: 0.3979 -
accuracy: 0.7984 - val_loss: 0.4371 - val_accuracy: 0.7973
```

```
Epoch 38/150
640/640 [==============================] - 0s 43us/step - loss: 0.3856 -
accuracy: 0.8062 - val_loss: 0.4380 - val_accuracy: 0.8153
Epoch 39/150
640/640 [==============================] - 0s 43us/step - loss: 0.3986 -
accuracy: 0.8000 - val_loss: 0.4369 - val_accuracy: 0.8198
Epoch 40/150
640/640 [==============================] - 0s 43us/step - loss: 0.3934 -
accuracy: 0.8000 - val_loss: 0.4377 - val_accuracy: 0.8153
Epoch 41/150
640/640 [==============================] - 0s 43us/step - loss: 0.3929 -
accuracy: 0.8094 - val_loss: 0.4370 - val_accuracy: 0.8153
Epoch 42/150
640/640 [==============================] - 0s 40us/step - loss: 0.4003 -
accuracy: 0.8000 - val_loss: 0.4362 - val_accuracy: 0.8153
Epoch 43/150
640/640 [==============================] - 0s 43us/step - loss: 0.3914 -
accuracy: 0.8109 - val_loss: 0.4362 - val_accuracy: 0.8198
Epoch 44/150
640/640 [==============================] - 0s 43us/step - loss: 0.3966 -
accuracy: 0.7922 - val_loss: 0.4367 - val_accuracy: 0.8198
Epoch 45/150
640/640 [==============================] - 0s 47us/step - loss: 0.4000 -
accuracy: 0.7969 - val_loss: 0.4362 - val_accuracy: 0.8198
Epoch 46/150
640/640 [==============================] - 0s 43us/step - loss: 0.3920 -
accuracy: 0.8109 - val_loss: 0.4368 - val_accuracy: 0.8153
Epoch 47/150
640/640 [==============================] - 0s 41us/step - loss: 0.3861 -
accuracy: 0.8047 - val_loss: 0.4377 - val_accuracy: 0.8153
Epoch 48/150
640/640 [==============================] - 0s 46us/step - loss: 0.3864 -
accuracy: 0.8031 - val_loss: 0.4371 - val_accuracy: 0.8153
Epoch 49/150
640/640 [==============================] - 0s 51us/step - loss: 0.3912 -
accuracy: 0.8078 - val_loss: 0.4358 - val_accuracy: 0.8153
Epoch 50/150
640/640 [==============================] - 0s 44us/step - loss: 0.3836 -
accuracy: 0.8172 - val_loss: 0.4346 - val_accuracy: 0.8153
Epoch 51/150
640/640 [==============================] - 0s 42us/step - loss: 0.3938 -
accuracy: 0.8078 - val_loss: 0.4338 - val_accuracy: 0.8153
Epoch 52/150
640/640 [==============================] - 0s 40us/step - loss: 0.3762 -
accuracy: 0.8125 - val_loss: 0.4330 - val_accuracy: 0.8153
Epoch 53/150
640/640 [==============================] - 0s 44us/step - loss: 0.3721 -
accuracy: 0.8141 - val_loss: 0.4321 - val_accuracy: 0.8153
```

```
Epoch 54/150
640/640 [==============================] - 0s 43us/step - loss: 0.3841 -
accuracy: 0.8109 - val_loss: 0.4318 - val_accuracy: 0.8108
Epoch 55/150
640/640 [==============================] - 0s 47us/step - loss: 0.3808 -
accuracy: 0.8172 - val_loss: 0.4317 - val_accuracy: 0.8153
Epoch 56/150
640/640 [==============================] - 0s 44us/step - loss: 0.3826 -
accuracy: 0.8141 - val_loss: 0.4322 - val_accuracy: 0.8108
Epoch 57/150
640/640 [==============================] - 0s 37us/step - loss: 0.3821 -
accuracy: 0.8062 - val_loss: 0.4315 - val_accuracy: 0.8153
Epoch 58/150
640/640 [==============================] - 0s 40us/step - loss: 0.3961 -
accuracy: 0.7937 - val_loss: 0.4324 - val_accuracy: 0.8153
Epoch 59/150
640/640 [==============================] - 0s 37us/step - loss: 0.3831 -
accuracy: 0.8094 - val_loss: 0.4328 - val_accuracy: 0.8153
Epoch 60/150
640/640 [==============================] - 0s 39us/step - loss: 0.3760 -
accuracy: 0.8250 - val_loss: 0.4323 - val_accuracy: 0.8153
Epoch 61/150
640/640 [==============================] - 0s 39us/step - loss: 0.3896 -
accuracy: 0.8156 - val_loss: 0.4319 - val_accuracy: 0.8153
Epoch 62/150
640/640 [==============================] - 0s 42us/step - loss: 0.3807 -
accuracy: 0.8219 - val_loss: 0.4325 - val_accuracy: 0.8153
Epoch 63/150
640/640 [==============================] - 0s 41us/step - loss: 0.3782 -
accuracy: 0.8172 - val_loss: 0.4332 - val_accuracy: 0.8243
Epoch 64/150
640/640 [==============================] - 0s 42us/step - loss: 0.3882 -
accuracy: 0.8047 - val_loss: 0.4326 - val_accuracy: 0.8198
Epoch 65/150
640/640 [==============================] - 0s 38us/step - loss: 0.3743 -
accuracy: 0.8125 - val_loss: 0.4324 - val_accuracy: 0.8198
Epoch 66/150
640/640 [==============================] - 0s 45us/step - loss: 0.3746 -
accuracy: 0.8125 - val_loss: 0.4321 - val_accuracy: 0.8198
Epoch 67/150
640/640 [==============================] - 0s 59us/step - loss: 0.3750 -
accuracy: 0.8125 - val_loss: 0.4323 - val_accuracy: 0.8198
Epoch 68/150
640/640 [==============================] - 0s 63us/step - loss: 0.3732 -
accuracy: 0.8062 - val_loss: 0.4316 - val_accuracy: 0.8198
Epoch 69/150
640/640 [==============================] - 0s 67us/step - loss: 0.3775 -
accuracy: 0.8141 - val_loss: 0.4330 - val_accuracy: 0.8198
```

```
Epoch 70/150
640/640 [==============================] - 0s 81us/step - loss: 0.3753 -
accuracy: 0.8203 - val_loss: 0.4337 - val_accuracy: 0.8198
Epoch 71/150
640/640 [==============================] - 0s 85us/step - loss: 0.3850 -
accuracy: 0.8078 - val_loss: 0.4344 - val_accuracy: 0.8153
Epoch 72/150
640/640 [==============================] - 0s 56us/step - loss: 0.3754 -
accuracy: 0.8156 - val_loss: 0.4338 - val_accuracy: 0.8108
Epoch 73/150
640/640 [==============================] - 0s 66us/step - loss: 0.3737 -
accuracy: 0.8094 - val_loss: 0.4335 - val_accuracy: 0.8108
Epoch 74/150
640/640 [==============================] - 0s 78us/step - loss: 0.3719 -
accuracy: 0.8125 - val_loss: 0.4335 - val_accuracy: 0.8108
Epoch 75/150
640/640 [==============================] - 0s 79us/step - loss: 0.3684 -
accuracy: 0.8250 - val_loss: 0.4335 - val_accuracy: 0.8153
Epoch 76/150
640/640 [==============================] - 0s 60us/step - loss: 0.3779 -
accuracy: 0.8203 - val_loss: 0.4337 - val_accuracy: 0.8153
Epoch 77/150
640/640 [==============================] - 0s 54us/step - loss: 0.3794 -
accuracy: 0.8172 - val_loss: 0.4327 - val_accuracy: 0.8108
Epoch 78/150
640/640 [==============================] - 0s 63us/step - loss: 0.3791 -
accuracy: 0.8141 - val_loss: 0.4328 - val_accuracy: 0.8108
Epoch 79/150
640/640 [==============================] - 0s 62us/step - loss: 0.3864 -
accuracy: 0.8016 - val_loss: 0.4315 - val_accuracy: 0.8153
Epoch 80/150
640/640 [==============================] - 0s 52us/step - loss: 0.3954 -
accuracy: 0.8062 - val_loss: 0.4317 - val_accuracy: 0.8153
Epoch 81/150
640/640 [==============================] - 0s 41us/step - loss: 0.3803 -
accuracy: 0.8094 - val_loss: 0.4315 - val_accuracy: 0.8153
Epoch 82/150
640/640 [==============================] - 0s 39us/step - loss: 0.3817 -
accuracy: 0.8078 - val_loss: 0.4311 - val_accuracy: 0.8153
Epoch 83/150
640/640 [==============================] - 0s 43us/step - loss: 0.3613 -
accuracy: 0.8250 - val_loss: 0.4320 - val_accuracy: 0.8198
Epoch 84/150
640/640 [==============================] - 0s 47us/step - loss: 0.3848 -
accuracy: 0.8047 - val_loss: 0.4322 - val_accuracy: 0.8198
Epoch 85/150
640/640 [==============================] - 0s 52us/step - loss: 0.3768 -
accuracy: 0.8062 - val_loss: 0.4324 - val_accuracy: 0.8108
```

```
Epoch 86/150
640/640 [==============================] - 0s 62us/step - loss: 0.3603 -
accuracy: 0.8297 - val_loss: 0.4327 - val_accuracy: 0.8198
Epoch 87/150
640/640 [==============================] - 0s 58us/step - loss: 0.3711 -
accuracy: 0.8281 - val_loss: 0.4321 - val_accuracy: 0.8153
Epoch 88/150
640/640 [==============================] - 0s 59us/step - loss: 0.3683 -
accuracy: 0.8359 - val_loss: 0.4318 - val_accuracy: 0.8198
Epoch 89/150
640/640 [==============================] - 0s 40us/step - loss: 0.3726 -
accuracy: 0.8266 - val_loss: 0.4338 - val_accuracy: 0.8198
Epoch 90/150
640/640 [==============================] - 0s 43us/step - loss: 0.3671 -
accuracy: 0.8094 - val_loss: 0.4327 - val_accuracy: 0.8108
Epoch 91/150
640/640 [==============================] - 0s 36us/step - loss: 0.3706 -
accuracy: 0.8297 - val_loss: 0.4332 - val_accuracy: 0.8108
Epoch 92/150
640/640 [==============================] - 0s 46us/step - loss: 0.3680 -
accuracy: 0.8203 - val_loss: 0.4335 - val_accuracy: 0.8063
Epoch 93/150
640/640 [==============================] - 0s 41us/step - loss: 0.3600 -
accuracy: 0.8188 - val_loss: 0.4311 - val_accuracy: 0.8198
Epoch 94/150
640/640 [==============================] - 0s 43us/step - loss: 0.3796 -
accuracy: 0.8078 - val_loss: 0.4297 - val_accuracy: 0.8198
Epoch 95/150
640/640 [==============================] - 0s 51us/step - loss: 0.3772 -
accuracy: 0.8094 - val_loss: 0.4326 - val_accuracy: 0.8153
Epoch 96/150
640/640 [==============================] - 0s 56us/step - loss: 0.3721 -
accuracy: 0.8188 - val_loss: 0.4327 - val_accuracy: 0.8198
Epoch 97/150
640/640 [==============================] - 0s 52us/step - loss: 0.3764 -
accuracy: 0.8078 - val_loss: 0.4322 - val_accuracy: 0.8153
Epoch 98/150
640/640 [==============================] - 0s 54us/step - loss: 0.3678 -
accuracy: 0.8125 - val_loss: 0.4322 - val_accuracy: 0.8153
Epoch 99/150
640/640 [==============================] - 0s 44us/step - loss: 0.3780 -
accuracy: 0.8062 - val_loss: 0.4326 - val_accuracy: 0.8108
Epoch 100/150
640/640 [==============================] - 0s 41us/step - loss: 0.3704 -
accuracy: 0.8219 - val_loss: 0.4320 - val_accuracy: 0.8063
Epoch 101/150
640/640 [==============================] - 0s 40us/step - loss: 0.3610 -
accuracy: 0.8219 - val_loss: 0.4323 - val_accuracy: 0.8108
```

```
Epoch 102/150
640/640 [==============================] - 0s 39us/step - loss: 0.3692 -
accuracy: 0.8094 - val_loss: 0.4331 - val_accuracy: 0.8063
Epoch 103/150
640/640 [==============================] - 0s 37us/step - loss: 0.3637 -
accuracy: 0.8172 - val_loss: 0.4333 - val_accuracy: 0.8108
Epoch 104/150
640/640 [==============================] - 0s 43us/step - loss: 0.3618 -
accuracy: 0.8188 - val_loss: 0.4343 - val_accuracy: 0.8108
Epoch 105/150
640/640 [==============================] - 0s 50us/step - loss: 0.3661 -
accuracy: 0.8188 - val_loss: 0.4343 - val_accuracy: 0.8108
Epoch 106/150
640/640 [==============================] - 0s 47us/step - loss: 0.3573 -
accuracy: 0.8062 - val_loss: 0.4344 - val_accuracy: 0.8108
Epoch 107/150
640/640 [==============================] - 0s 43us/step - loss: 0.3617 -
accuracy: 0.8094 - val_loss: 0.4342 - val_accuracy: 0.8108
Epoch 108/150
640/640 [==============================] - 0s 52us/step - loss: 0.3655 -
accuracy: 0.8125 - val_loss: 0.4347 - val_accuracy: 0.8153
Epoch 109/150
640/640 [==============================] - 0s 47us/step - loss: 0.3728 -
accuracy: 0.8047 - val_loss: 0.4342 - val_accuracy: 0.8108
Epoch 110/150
640/640 [==============================] - 0s 42us/step - loss: 0.3565 -
accuracy: 0.8234 - val_loss: 0.4347 - val_accuracy: 0.8198
Epoch 111/150
640/640 [==============================] - 0s 39us/step - loss: 0.3610 -
accuracy: 0.8266 - val_loss: 0.4339 - val_accuracy: 0.8108
Epoch 112/150
640/640 [==============================] - 0s 41us/step - loss: 0.3721 -
accuracy: 0.8016 - val_loss: 0.4345 - val_accuracy: 0.8108
Epoch 113/150
640/640 [==============================] - 0s 50us/step - loss: 0.3618 -
accuracy: 0.8156 - val_loss: 0.4348 - val_accuracy: 0.8063
Epoch 114/150
640/640 [==============================] - 0s 48us/step - loss: 0.3619 -
accuracy: 0.8172 - val_loss: 0.4347 - val_accuracy: 0.8063
Epoch 115/150
640/640 [==============================] - 0s 52us/step - loss: 0.3705 -
accuracy: 0.8141 - val_loss: 0.4343 - val_accuracy: 0.8108
Epoch 116/150
640/640 [==============================] - 0s 58us/step - loss: 0.3657 -
accuracy: 0.8156 - val_loss: 0.4336 - val_accuracy: 0.8063
Epoch 117/150
640/640 [==============================] - 0s 47us/step - loss: 0.3668 -
accuracy: 0.8203 - val_loss: 0.4348 - val_accuracy: 0.8063
```

```
Epoch 118/150
640/640 [==============================] - 0s 47us/step - loss: 0.3690 -
accuracy: 0.8016 - val_loss: 0.4341 - val_accuracy: 0.8108
Epoch 119/150
640/640 [==============================] - 0s 49us/step - loss: 0.3591 -
accuracy: 0.8266 - val_loss: 0.4371 - val_accuracy: 0.8108
Epoch 120/150
640/640 [==============================] - 0s 47us/step - loss: 0.3611 -
accuracy: 0.8188 - val_loss: 0.4346 - val_accuracy: 0.8108
Epoch 121/150
640/640 [==============================] - 0s 56us/step - loss: 0.3671 -
accuracy: 0.8281 - val_loss: 0.4340 - val_accuracy: 0.8018
Epoch 122/150
640/640 [==============================] - 0s 47us/step - loss: 0.3739 -
accuracy: 0.8047 - val_loss: 0.4355 - val_accuracy: 0.8108
Epoch 123/150
640/640 [==============================] - 0s 44us/step - loss: 0.3565 -
accuracy: 0.8219 - val_loss: 0.4374 - val_accuracy: 0.8108
Epoch 124/150
640/640 [==============================] - 0s 49us/step - loss: 0.3548 -
accuracy: 0.8250 - val_loss: 0.4366 - val_accuracy: 0.8108
Epoch 125/150
640/640 [==============================] - 0s 48us/step - loss: 0.3774 -
accuracy: 0.8109 - val_loss: 0.4366 - val_accuracy: 0.8108
Epoch 126/150
640/640 [==============================] - 0s 45us/step - loss: 0.3712 -
accuracy: 0.8297 - val_loss: 0.4352 - val_accuracy: 0.8108
Epoch 127/150
640/640 [==============================] - 0s 49us/step - loss: 0.3717 -
accuracy: 0.8094 - val_loss: 0.4348 - val_accuracy: 0.8108
Epoch 128/150
640/640 [==============================] - 0s 46us/step - loss: 0.3687 -
accuracy: 0.8141 - val_loss: 0.4352 - val_accuracy: 0.8108
Epoch 129/150
640/640 [==============================] - 0s 44us/step - loss: 0.3737 -
accuracy: 0.8203 - val_loss: 0.4341 - val_accuracy: 0.8063
Epoch 130/150
640/640 [==============================] - 0s 49us/step - loss: 0.3689 -
accuracy: 0.8188 - val_loss: 0.4340 - val_accuracy: 0.8108
Epoch 131/150
640/640 [==============================] - 0s 45us/step - loss: 0.3618 -
accuracy: 0.8156 - val_loss: 0.4343 - val_accuracy: 0.8018
Epoch 132/150
640/640 [==============================] - 0s 48us/step - loss: 0.3678 -
accuracy: 0.8172 - val_loss: 0.4351 - val_accuracy: 0.8018
Epoch 133/150
640/640 [==============================] - 0s 50us/step - loss: 0.3753 -
accuracy: 0.8188 - val_loss: 0.4349 - val_accuracy: 0.7973
```

```
Epoch 134/150
640/640 [==============================] - 0s 48us/step - loss: 0.3641 -
accuracy: 0.8219 - val_loss: 0.4333 - val_accuracy: 0.8018
Epoch 135/150
640/640 [==============================] - 0s 55us/step - loss: 0.3760 -
accuracy: 0.8188 - val_loss: 0.4320 - val_accuracy: 0.8108
Epoch 136/150
640/640 [==============================] - 0s 55us/step - loss: 0.3683 -
accuracy: 0.8156 - val_loss: 0.4316 - val_accuracy: 0.8063
Epoch 137/150
640/640 [==============================] - 0s 53us/step - loss: 0.3566 -
accuracy: 0.8250 - val_loss: 0.4336 - val_accuracy: 0.7973
Epoch 138/150
640/640 [==============================] - 0s 51us/step - loss: 0.3774 -
accuracy: 0.8172 - val_loss: 0.4327 - val_accuracy: 0.7973
Epoch 139/150
640/640 [==============================] - 0s 72us/step - loss: 0.3582 -
accuracy: 0.8266 - val_loss: 0.4320 - val_accuracy: 0.8018
Epoch 140/150
640/640 [==============================] - 0s 61us/step - loss: 0.3691 -
accuracy: 0.8266 - val_loss: 0.4318 - val_accuracy: 0.8018
Epoch 141/150
640/640 [==============================] - 0s 62us/step - loss: 0.3622 -
accuracy: 0.8188 - val_loss: 0.4319 - val_accuracy: 0.8018
Epoch 142/150
640/640 [==============================] - 0s 49us/step - loss: 0.3604 -
accuracy: 0.8250 - val_loss: 0.4318 - val_accuracy: 0.8018
Epoch 143/150
640/640 [==============================] - 0s 52us/step - loss: 0.3607 -
accuracy: 0.8125 - val_loss: 0.4328 - val_accuracy: 0.7928
Epoch 144/150
640/640 [==============================] - 0s 62us/step - loss: 0.3582 -
accuracy: 0.8219 - val_loss: 0.4340 - val_accuracy: 0.7973
Epoch 145/150
640/640 [==============================] - 0s 54us/step - loss: 0.3612 -
accuracy: 0.8375 - val_loss: 0.4346 - val_accuracy: 0.7973
Epoch 146/150
640/640 [==============================] - 0s 51us/step - loss: 0.3668 -
accuracy: 0.8094 - val_loss: 0.4350 - val_accuracy: 0.8018
Epoch 147/150
640/640 [==============================] - 0s 51us/step - loss: 0.3565 -
accuracy: 0.8125 - val_loss: 0.4354 - val_accuracy: 0.7973
Epoch 148/150
640/640 [==============================] - 0s 49us/step - loss: 0.3586 -
accuracy: 0.8281 - val_loss: 0.4367 - val_accuracy: 0.7973
Epoch 149/150
640/640 [==============================] - 0s 46us/step - loss: 0.3750 -
accuracy: 0.8125 - val_loss: 0.4358 - val_accuracy: 0.7928
```
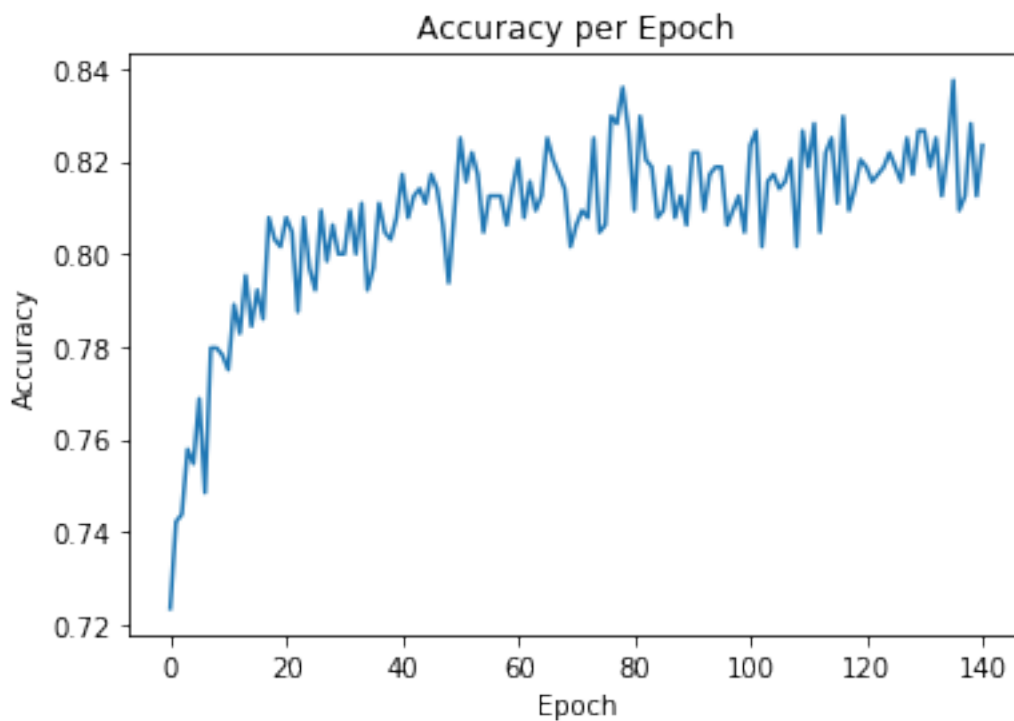
```
Epoch 150/150
640/640 [==============================] - 0s 43us/step - loss: 0.3613 -
accuracy: 0.8234 - val_loss: 0.4349 - val_accuracy: 0.7973
```

The accuracy of the network on the original test data (without duplicating the `failed` class) is also between 80% and 90%.

```
[10]: plt.plot(result2.history['accuracy'][9:], label='Accuracy')
      plt.title("Accuracy per Epoch")
      plt.ylabel("Accuracy")
      plt.xlabel("Epoch")
      plt.show()
```



```
[11]: model2.evaluate(X_test,Y_test22)
```

```
100/100 [==============================] - 0s 40us/step
```

```
[11]: [0.4639051431417465, 0.800000011920929]
```

```
[12]: model2.predict(X_test)
```

```
[12]: array([[0.9981517 ],
             [0.8782023 ],
             [0.15625836],
             [0.36698797],
```

41

```
[0.60959524],
[0.07123813],
[0.53515863],
[0.5419489 ],
[0.13775331],
[0.33504054],
[0.07568375],
[0.36293858],
[0.6074744 ],
[0.037559  ],
[0.9781365 ],
[0.42527306],
[0.47228006],
[0.8232825 ],
[0.9865558 ],
[0.42772606],
[0.48793274],
[0.988801  ],
[0.9614101 ],
[0.98778594],
[0.6143648 ],
[0.15817733],
[0.6557506 ],
[0.96110994],
[0.17132463],
[0.35971868],
[0.99415934],
[0.909128  ],
[0.882218  ],
[0.8987921 ],
[0.88982403],
[0.90994614],
[0.63859236],
[0.91512126],
[0.97896427],
[0.65392053],
[0.9973201 ],
[0.9898011 ],
[0.95916635],
[0.84934795],
[0.37362555],
[0.32621926],
[0.4152782 ],
[0.64420795],
[0.60587376],
[0.41600338],
[0.6552091 ],
```

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[0.659017  ],
[0.69862694],
[0.98076963],
[0.09337808],
[0.11589924],
[0.3060945 ],
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[0.17217705],
[0.62671167],
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[0.9305747 ],
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[0.17926729],
[0.8913601 ],
[0.9844536 ],
[0.3155466 ],
[0.9448713 ],
[0.97725964],
[0.9732246 ],
[0.8292054 ],
[0.8036944 ],
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[0.9871623 ],
[0.9342852 ],
[0.9541438 ],
[0.9868249 ],
[0.9216848 ],
[0.4562843 ],
[0.9852083 ],
[0.8863766 ],
[0.9937504 ],
[0.75724834],
[0.9761401 ],
[0.90395194],
[0.92769206],
[0.92769206],
[0.9934228 ],
[0.9957795 ],
[0.9292013 ],
[0.69706684],
[0.99145657],
[0.9942192 ],
[0.6315681 ],
```

```
        [0.8739621 ],
        [0.99908173]], dtype=float32)
```

[13]:
```
[1 if n > 0.5 else 0 for n in model2.predict(X_test)]
```

[13]:
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