LSTM ON TimeSeries DATA

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In [1]:

```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
```

In [2]:

```
### Load dataset
from sklearn import datasets
import tensorflow as tf
import keras
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dense
from tensorflow.keras.losses import MeanSquaredLogarithmicError
```

In [3]:

```
# filename =  pd.read_csv("C:\\Users\\praba\\Desktop\\uca1\\M1\\deep learning\\class
# df_1 = pd.read_csv(filename, sep="\t", engine="python", on_bad_lines="skip")

filename = "http://www.i3s.unice.fr/~riveill/dataset/precipitation.csv.zip"
df = pd.read_csv(filename, sep="\t", engine="python", on_bad_lines="skip")
```

In [4]:

```
df.describe()
```

Out[4]:

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	
count	38.000000	38.000000	38.000000	38.000000	38.000000	38.000000	38.000000	38.000000	
mean	1983.500000	0.294368	1.101132	1.677184	12.381237	25.059789	337.096395	430.010395	2
std	11.113055	0.640510	1.741219	2.486516	13.671071	22.451708	171.666565	177.976444	1
min	1965.000000	0.000000	0.000000	0.000000	0.061000	0.508000	94.088000	84.936000	
25%	1974.250000	0.000000	0.000000	0.000000	2.291750	7.005250	226.180250	322.461000	1
50%	1983.500000	0.008000	0.247500	0.596000	5.489500	18.144500	312.100000	415.079500	2
75%	1992.750000	0.248000	1.948500	2.076000	19.796500	33.066000	412.568250	555.284250	4
max	2002.000000	3.013000	8.410000	9.619000	53.266000	80.539000	773.737000	780.006000	5

In [5]:

```
df.head()
```

Out[5]:

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	De
0	1965	0.029	0.069	0.000	21.667	17.859	102.111	606.071	402.521	69.511	5.249	16.232	22.07
1	1966	0.905	0.000	0.000	2.981	63.008	94.088	481.942	59.386	150.624	1.308	41.214	4.13
2	1967	0.248	3.390	1.320	13.482	11.116	251.314	780.006	181.069	183.757	50.404	8.393	37.68
3	1968	0.318	3.035	1.704	23.307	7.441	179.872	379.354	171.979	219.884	73.997	23.326	2.02

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	De
4	1969	0.248	2.524	0.334	4.569	6.213	393.682	678.354	397.335	205.413	24.014	24.385	1.95

In [6]:

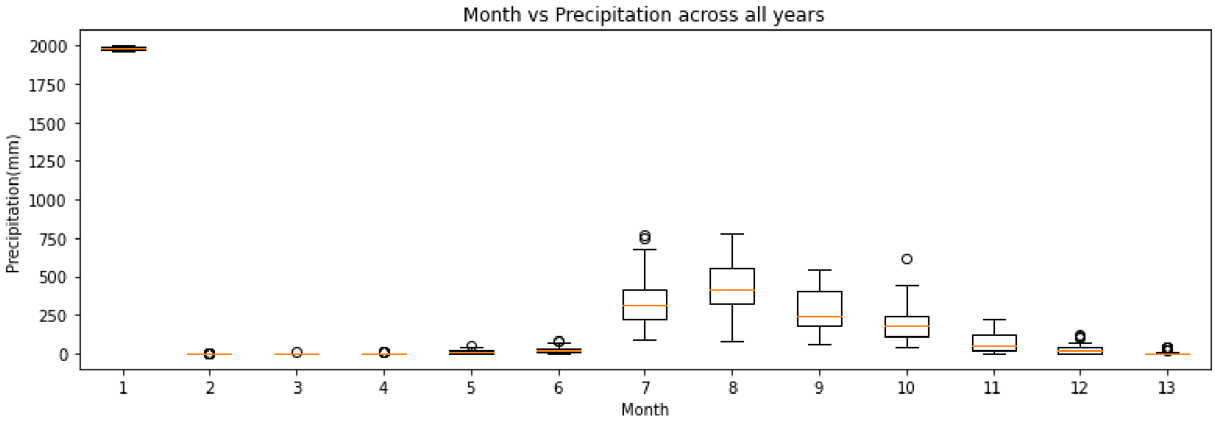
```
import sklearn
from sklearn.model_selection import TimeSeriesSplit
```

In [7]:

```
import matplotlib.pyplot as plt

# df.set_index('Year', inplace=True)
plt.figure(figsize=(13,4))
plt.boxplot(df)
plt.xlabel('Month')
plt.ylabel('Precipitation(mm)')
plt.title('Month vs Precipitation across all years')

data = df.to_numpy().ravel()
```

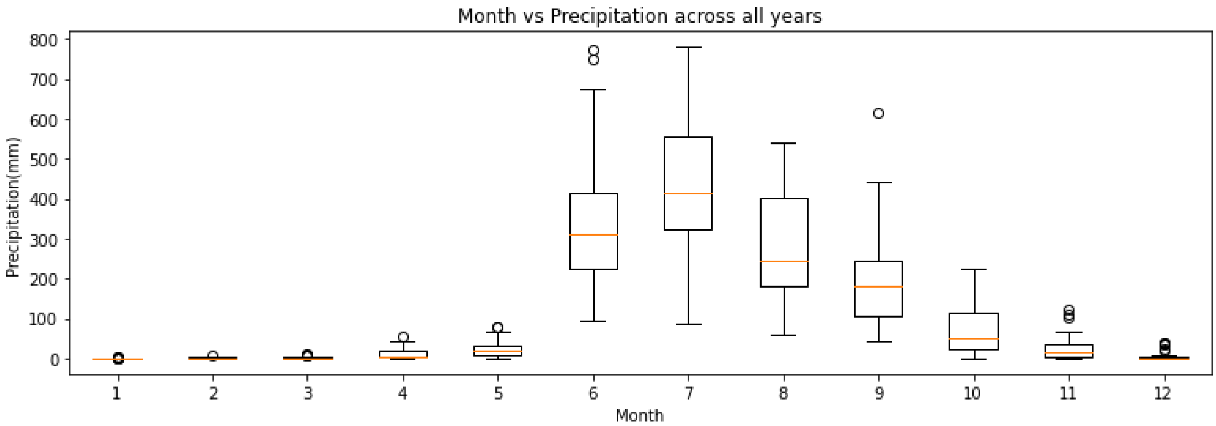


In [8]:

```
import matplotlib.pyplot as plt

df.set_index('Year', inplace=True)
plt.figure(figsize=(13,4))
plt.boxplot(df)
plt.xlabel('Month')
plt.ylabel('Precipitation(mm)')
plt.title('Month vs Precipitation across all years')

data = df.to_numpy().ravel()
```



In [9]:
```
#Prepare X and y
input_with = 24
offset = 0

X = [data[i:i+input_with] for i in range(len(data)-input_with)]
X = np.array(X)

y = [data[i+input_with+offset] for i in range(len(data)-input_with)]
y = np.array(y)
```

In [ ]:

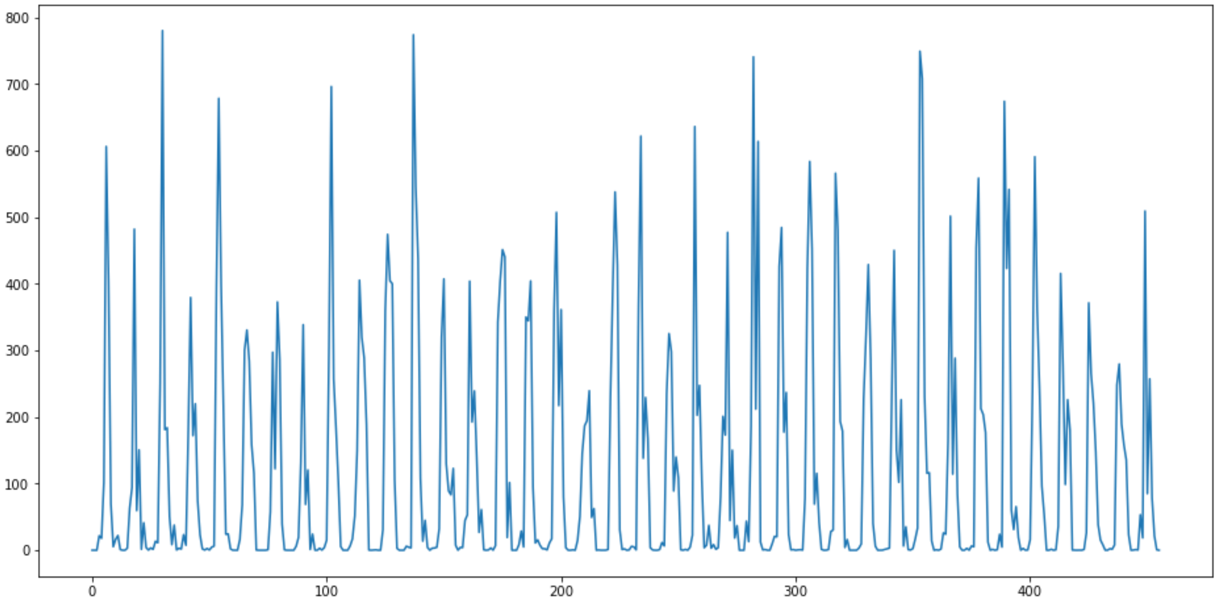
In [10]:
```
X.shape,y.shape
```

Out[10]:
```
((432, 24), (432,))
```

In [11]:
```
plt.figure(figsize=(16,8))

plt.plot(data)
```

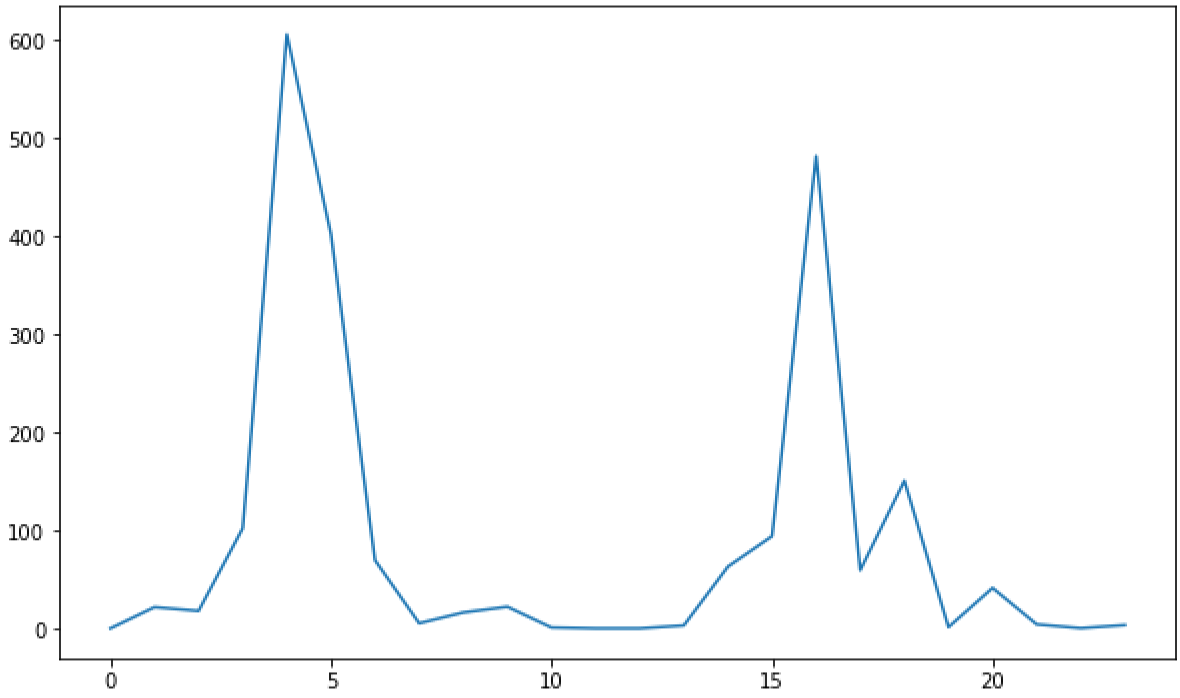
Out[11]:
```
[<matplotlib.lines.Line2D at 0x2688e17e460>]
```



In [12]:
```
plt.figure(figsize=(10,6))

plt.plot(X[2])
```

Out[12]:
```
[<matplotlib.lines.Line2D at 0x268901d65e0>]
```



In [13]:
```
import numpy as np
import tensorflow as tf
import keras
from keras import layers
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dense
%matplotlib inline
```

SOLUTION USING LSTM And CROSS VALIDATION ON TIME SERIES DATA

In [14]:
```
def plot_result(trainY, testY, train_predict, test_predict):
    actual = np.append(trainY, testY)
    predictions = np.append(train_predict, test_predict)
    rows = len(actual)
    plt.figure(figsize=(15, 6), dpi=80)
    plt.plot(range(rows), actual)
    plt.plot(range(rows), predictions)
    plt.axvline(x=len(trainY), color='r')
    plt.legend(['Actual', 'Predictions'])
    plt.xlabel('Observation number after given time steps')
    plt.ylabel('Sunspots scaled')
    plt.title('Actual and Predicted Values. The Red Line Separates The Training And
```

In [15]:
```
# def plot_loss(history):
#     plt.plot(history.history["loss"])
#     plt.plot(history.history["val_loss"])
#     plt.title("validation loss & training loss")
#     plt.xlabel("epochs")
#     plt.ylabel("loss")
#     leg = plt.legend(["training loss", "validation loss"],loc ="upper right");

#     plt.show()
```

In [16]:
```
# from sklearn.metrics import classification_report, confusion_matrix

# def plot_confusion_matrix(y_test,y_pred):
#     conf_matrix = confusion_matrix(y_test,y_pred)
#     plt.figure(figsize=(8, 6))
#     plt.imshow(conf_matrix, cmap=plt.cm.Blues)
#     plt.title('Confusion Matrix')
#     plt.colorbar()
```

In [17]:
```
import numpy as np
from sklearn.model_selection import TimeSeriesSplit
from sklearn.metrics import mean_squared_error
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense
from tensorflow.keras.losses import MeanSquaredLogarithmicError


# Build the LSTM model
def build_model(input_shape):
    inputs =tf.keras.layers.Input(shape=(None,1))    → input size are unknown
    inputs_norm = tf.keras.layers.BatchNormalization()(inputs)
    lstm= tf.keras.layers.LSTM(128, return_sequences=False)(inputs_norm)
    outputs = tf.keras.layers.Dense(1, activation='linear')(lstm)
    model = Model(inputs, outputs)        o/p= 1 Feature      → Regression
    model.summary()
    optimizer = keras.optimizers.Adam(learning_rate=0.1)
    model.compile(optimizer=optimizer, loss=MeanSquaredLogarithmicError())
    return model


#TimeSeriesSplit for cross-validation
tscv = TimeSeriesSplit(n_splits=5)
cv_scores = []
model = build_model(input_shape=(1, X.shape[1]))


# callback = tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=)
print(tscv)
history=[]
for i, (train_index, test_index) in enumerate(tscv.split(X)):
    print(f"Fold {i}:")
    X_train, X_test = X[train_index], X[test_index]
    y_train, y_test = y[train_index], y[test_index]

    history.append(model.fit(X_train, y_train, epochs=100, validation_data=(X_test,y
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, None, 1)]         0

 batch_normalization (BatchN  (None, None, 1)          4
 ormalization)

 lstm (LSTM)                 (None, 128)               66560
```

```
 dense (Dense)               (None, 1)                 129

=================================================================
Total params: 66,693
Trainable params: 66,691
Non-trainable params: 2
_________________________________________________________________
TimeSeriesSplit(gap=0, max_train_size=None, n_splits=5, test_size=None)
Fold 0:
Epoch 1/100
3/3 [==============================] - 3s 269ms/step - loss: 7.6583 - val_loss: 7.907
3
Epoch 2/100
3/3 [==============================] - 0s 38ms/step - loss: 9.6894 - val_loss: 13.564
8
Epoch 3/100
3/3 [==============================] - 0s 42ms/step - loss: 8.9291 - val_loss: 13.395
6
Epoch 4/100
3/3 [==============================] - 0s 45ms/step - loss: 8.3288 - val_loss: 11.435
5
Epoch 5/100
3/3 [==============================] - 0s 43ms/step - loss: 7.0774 - val_loss: 11.282
4
Epoch 6/100
3/3 [==============================] - 0s 44ms/step - loss: 7.6324 - val_loss: 7.0819
Epoch 7/100
3/3 [==============================] - 0s 39ms/step - loss: 6.8049 - val_loss: 5.9387
Epoch 8/100
3/3 [==============================] - 0s 43ms/step - loss: 5.6003 - val_loss: 5.2095
Epoch 9/100
3/3 [==============================] - 0s 48ms/step - loss: 5.1089 - val_loss: 4.4722
Epoch 10/100
3/3 [==============================] - 0s 52ms/step - loss: 4.4699 - val_loss: 3.7650
Epoch 11/100
3/3 [==============================] - 0s 58ms/step - loss: 4.1657 - val_loss: 3.6066
Epoch 12/100
3/3 [==============================] - 0s 47ms/step - loss: 4.1258 - val_loss: 3.3534
Epoch 13/100
3/3 [==============================] - 0s 40ms/step - loss: 3.9706 - val_loss: 3.2843
Epoch 14/100
3/3 [==============================] - 0s 41ms/step - loss: 4.0015 - val_loss: 3.3512
Epoch 15/100
3/3 [==============================] - 0s 56ms/step - loss: 4.0057 - val_loss: 3.3447
Epoch 16/100
3/3 [==============================] - 0s 49ms/step - loss: 3.9149 - val_loss: 3.4111
Epoch 17/100
3/3 [==============================] - 0s 54ms/step - loss: 4.1066 - val_loss: 3.4888
Epoch 18/100
3/3 [==============================] - 0s 42ms/step - loss: 4.0607 - val_loss: 3.5851
Epoch 19/100
3/3 [==============================] - 0s 55ms/step - loss: 4.1620 - val_loss: 3.6067
Epoch 20/100
3/3 [==============================] - 0s 43ms/step - loss: 4.1585 - val_loss: 3.6069
Epoch 21/100
3/3 [==============================] - 0s 39ms/step - loss: 4.1405 - val_loss: 3.6648
Epoch 22/100
3/3 [==============================] - 0s 39ms/step - loss: 4.1906 - val_loss: 3.6970
Epoch 23/100
3/3 [==============================] - 0s 40ms/step - loss: 4.2018 - val_loss: 3.6396
Epoch 24/100
3/3 [==============================] - 0s 38ms/step - loss: 4.1389 - val_loss: 3.4642
Epoch 25/100
3/3 [==============================] - 0s 42ms/step - loss: 4.0479 - val_loss: 3.3948
```

```
Epoch 26/100
3/3 [==============================] - 0s 39ms/step - loss: 4.1725 - val_loss: 3.4145
Epoch 27/100
3/3 [==============================] - 0s 41ms/step - loss: 3.8497 - val_loss: 3.4270
Epoch 28/100
3/3 [==============================] - 0s 53ms/step - loss: 3.6362 - val_loss: 3.1118
Epoch 29/100
3/3 [==============================] - 0s 48ms/step - loss: 3.5881 - val_loss: 3.0643
Epoch 30/100
3/3 [==============================] - 0s 42ms/step - loss: 3.4568 - val_loss: 3.0163
Epoch 31/100
3/3 [==============================] - 0s 45ms/step - loss: 3.5530 - val_loss: 2.8158
Epoch 32/100
3/3 [==============================] - 0s 50ms/step - loss: 3.2357 - val_loss: 3.2757
Epoch 33/100
3/3 [==============================] - 0s 44ms/step - loss: 3.8056 - val_loss: 2.8577
Epoch 34/100
3/3 [==============================] - 0s 43ms/step - loss: 3.1657 - val_loss: 2.7948
Epoch 35/100
3/3 [==============================] - 0s 46ms/step - loss: 2.9210 - val_loss: 2.6341
Epoch 36/100
3/3 [==============================] - 0s 46ms/step - loss: 2.7063 - val_loss: 2.3333
Epoch 37/100
3/3 [==============================] - 0s 51ms/step - loss: 2.5720 - val_loss: 2.3741
Epoch 38/100
3/3 [==============================] - 0s 46ms/step - loss: 2.6366 - val_loss: 2.1130
Epoch 39/100
3/3 [==============================] - 0s 47ms/step - loss: 2.1821 - val_loss: 2.0113
Epoch 40/100
3/3 [==============================] - 0s 46ms/step - loss: 1.8689 - val_loss: 1.8831
Epoch 41/100
3/3 [==============================] - 0s 45ms/step - loss: 1.9566 - val_loss: 2.3255
Epoch 42/100
3/3 [==============================] - 0s 49ms/step - loss: 2.4952 - val_loss: 2.6011
Epoch 43/100
3/3 [==============================] - 0s 46ms/step - loss: 4.5197 - val_loss: 7.2667
Epoch 44/100
3/3 [==============================] - 0s 43ms/step - loss: 7.7865 - val_loss: 7.2214
Epoch 45/100
3/3 [==============================] - 0s 41ms/step - loss: 7.6401 - val_loss: 7.7723
Epoch 46/100
3/3 [==============================] - 0s 41ms/step - loss: 8.3215 - val_loss: 7.5061
Epoch 47/100
3/3 [==============================] - 0s 42ms/step - loss: 7.9534 - val_loss: 6.9655
Epoch 48/100
3/3 [==============================] - 0s 41ms/step - loss: 7.2701 - val_loss: 6.3358
Epoch 49/100
3/3 [==============================] - 0s 42ms/step - loss: 6.5245 - val_loss: 5.7295
Epoch 50/100
3/3 [==============================] - 0s 39ms/step - loss: 5.6215 - val_loss: 5.0673
Epoch 51/100
3/3 [==============================] - 0s 45ms/step - loss: 4.8544 - val_loss: 5.8153
Epoch 52/100
3/3 [==============================] - 0s 46ms/step - loss: 5.5270 - val_loss: 5.1274
Epoch 53/100
3/3 [==============================] - 0s 44ms/step - loss: 4.9612 - val_loss: 5.0970
Epoch 54/100
3/3 [==============================] - 0s 46ms/step - loss: 4.9929 - val_loss: 5.0835
Epoch 55/100
3/3 [==============================] - 0s 45ms/step - loss: 4.9352 - val_loss: 5.0764
Epoch 56/100
3/3 [==============================] - 0s 41ms/step - loss: 4.9036 - val_loss: 5.0624
Epoch 57/100
3/3 [==============================] - 0s 38ms/step - loss: 4.8556 - val_loss: 4.9827
```

```
Epoch 58/100
3/3 [==============================] - 0s 35ms/step - loss: 4.8350 - val_loss: 4.9125
Epoch 59/100
3/3 [==============================] - 0s 35ms/step - loss: 4.7057 - val_loss: 4.9213
Epoch 60/100
3/3 [==============================] - 0s 47ms/step - loss: 4.5747 - val_loss: 4.6313
Epoch 61/100
3/3 [==============================] - 0s 42ms/step - loss: 4.3286 - val_loss: 4.3591
Epoch 62/100
3/3 [==============================] - 0s 49ms/step - loss: 4.1515 - val_loss: 4.1028
Epoch 63/100
3/3 [==============================] - 0s 44ms/step - loss: 3.9019 - val_loss: 3.7232
Epoch 64/100
3/3 [==============================] - 0s 48ms/step - loss: 3.6403 - val_loss: 3.7882
Epoch 65/100
3/3 [==============================] - 0s 50ms/step - loss: 4.2376 - val_loss: 3.7728
Epoch 66/100
3/3 [==============================] - 0s 65ms/step - loss: 3.7905 - val_loss: 3.7848
Epoch 67/100
3/3 [==============================] - 0s 67ms/step - loss: 3.6787 - val_loss: 3.6914
Epoch 68/100
3/3 [==============================] - 0s 51ms/step - loss: 3.6227 - val_loss: 3.5693
Epoch 69/100
3/3 [==============================] - 0s 48ms/step - loss: 3.5150 - val_loss: 3.2814
Epoch 70/100
3/3 [==============================] - 0s 60ms/step - loss: 3.1365 - val_loss: 3.0494
Epoch 71/100
3/3 [==============================] - 0s 52ms/step - loss: 2.8520 - val_loss: 3.0770
Epoch 72/100
3/3 [==============================] - 0s 47ms/step - loss: 2.7796 - val_loss: 5.2750
Epoch 73/100
3/3 [==============================] - 0s 45ms/step - loss: 5.4984 - val_loss: 5.3982
Epoch 74/100
3/3 [==============================] - 0s 46ms/step - loss: 5.5502 - val_loss: 5.4032
Epoch 75/100
3/3 [==============================] - 0s 54ms/step - loss: 5.5283 - val_loss: 5.3536
Epoch 76/100
3/3 [==============================] - 0s 48ms/step - loss: 5.4677 - val_loss: 5.3063
Epoch 77/100
3/3 [==============================] - 0s 51ms/step - loss: 5.3919 - val_loss: 5.2198
Epoch 78/100
3/3 [==============================] - 0s 51ms/step - loss: 5.2443 - val_loss: 5.1013
Epoch 79/100
3/3 [==============================] - 0s 48ms/step - loss: 5.0886 - val_loss: 5.0076
Epoch 80/100
3/3 [==============================] - 0s 43ms/step - loss: 4.8655 - val_loss: 4.9654
Epoch 81/100
3/3 [==============================] - 0s 47ms/step - loss: 4.8111 - val_loss: 4.9529
Epoch 82/100
3/3 [==============================] - 0s 46ms/step - loss: 4.7225 - val_loss: 5.0287
Epoch 83/100
3/3 [==============================] - 0s 47ms/step - loss: 4.7147 - val_loss: 4.8667
Epoch 84/100
3/3 [==============================] - 0s 42ms/step - loss: 4.5382 - val_loss: 5.0342
Epoch 85/100
3/3 [==============================] - 0s 41ms/step - loss: 4.8236 - val_loss: 4.8723
Epoch 86/100
3/3 [==============================] - 0s 37ms/step - loss: 4.7249 - val_loss: 4.9382
Epoch 87/100
3/3 [==============================] - 0s 33ms/step - loss: 4.7453 - val_loss: 4.5940
Epoch 88/100
3/3 [==============================] - 0s 36ms/step - loss: 4.4562 - val_loss: 4.5881
Epoch 89/100
3/3 [==============================] - 0s 35ms/step - loss: 4.4595 - val_loss: 4.4114
```

```
Epoch 90/100
3/3 [==============================] - 0s 40ms/step - loss: 4.1303 - val_loss: 4.1649
Epoch 91/100
3/3 [==============================] - 0s 47ms/step - loss: 3.9167 - val_loss: 4.2727
Epoch 92/100
3/3 [==============================] - 0s 47ms/step - loss: 3.8623 - val_loss: 3.8475
Epoch 93/100
3/3 [==============================] - 0s 45ms/step - loss: 3.4269 - val_loss: 3.9413
Epoch 94/100
3/3 [==============================] - 0s 42ms/step - loss: 3.4394 - val_loss: 3.9813
Epoch 95/100
3/3 [==============================] - 0s 35ms/step - loss: 3.5209 - val_loss: 3.4707
Epoch 96/100
3/3 [==============================] - 0s 38ms/step - loss: 3.1093 - val_loss: 3.2764
Epoch 97/100
3/3 [==============================] - 0s 37ms/step - loss: 3.9212 - val_loss: 3.5875
Epoch 98/100
3/3 [==============================] - 0s 37ms/step - loss: 3.6398 - val_loss: 3.9687
Epoch 99/100
3/3 [==============================] - 0s 44ms/step - loss: 3.9726 - val_loss: 4.0690
Epoch 100/100
3/3 [==============================] - 0s 48ms/step - loss: 4.0620 - val_loss: 3.9497
Fold 1:
Epoch 1/100
5/5 [==============================] - 0s 39ms/step - loss: 3.8936 - val_loss: 3.9651
Epoch 2/100
5/5 [==============================] - 0s 31ms/step - loss: 3.5640 - val_loss: 3.2679
Epoch 3/100
5/5 [==============================] - 0s 31ms/step - loss: 2.9737 - val_loss: 2.5856
Epoch 4/100
5/5 [==============================] - 0s 29ms/step - loss: 2.5543 - val_loss: 2.9232
Epoch 5/100
5/5 [==============================] - 0s 33ms/step - loss: 2.3818 - val_loss: 2.4831
Epoch 6/100
5/5 [==============================] - 0s 30ms/step - loss: 2.4282 - val_loss: 2.7243
Epoch 7/100
5/5 [==============================] - 0s 29ms/step - loss: 2.4159 - val_loss: 2.3802
Epoch 8/100
5/5 [==============================] - 0s 29ms/step - loss: 2.4446 - val_loss: 2.2925
Epoch 9/100
5/5 [==============================] - 0s 30ms/step - loss: 2.5730 - val_loss: 2.6999
Epoch 10/100
5/5 [==============================] - 0s 29ms/step - loss: 2.5609 - val_loss: 2.4358
Epoch 11/100
5/5 [==============================] - 0s 29ms/step - loss: 2.4019 - val_loss: 2.9203
Epoch 12/100
5/5 [==============================] - 0s 30ms/step - loss: 2.4459 - val_loss: 2.3429
Epoch 13/100
5/5 [==============================] - 0s 29ms/step - loss: 2.2247 - val_loss: 2.3740
Epoch 14/100
5/5 [==============================] - 0s 29ms/step - loss: 2.0865 - val_loss: 2.2945
Epoch 15/100
5/5 [==============================] - 0s 30ms/step - loss: 2.3356 - val_loss: 2.7175
Epoch 16/100
5/5 [==============================] - 0s 30ms/step - loss: 2.2383 - val_loss: 2.2072
Epoch 17/100
5/5 [==============================] - 0s 28ms/step - loss: 2.0441 - val_loss: 2.1892
Epoch 18/100
5/5 [==============================] - 0s 29ms/step - loss: 2.0488 - val_loss: 3.0345
Epoch 19/100
5/5 [==============================] - 0s 29ms/step - loss: 2.4376 - val_loss: 2.2681
Epoch 20/100
5/5 [==============================] - 0s 30ms/step - loss: 2.2930 - val_loss: 2.3663
Epoch 21/100
```

```
5/5 [==============================] - 0s 29ms/step - loss: 2.3586 - val_loss: 2.7413
Epoch 22/100
5/5 [==============================] - 0s 29ms/step - loss: 2.1665 - val_loss: 2.5512
Epoch 23/100
5/5 [==============================] - 0s 27ms/step - loss: 2.7323 - val_loss: 3.6878
Epoch 24/100
5/5 [==============================] - 0s 25ms/step - loss: 2.6122 - val_loss: 2.9172
Epoch 25/100
5/5 [==============================] - 0s 29ms/step - loss: 2.3756 - val_loss: 2.2375
Epoch 26/100
5/5 [==============================] - 0s 30ms/step - loss: 2.6184 - val_loss: 3.2392
Epoch 27/100
5/5 [==============================] - 0s 32ms/step - loss: 2.9155 - val_loss: 2.7355
Epoch 28/100
5/5 [==============================] - 0s 28ms/step - loss: 2.7482 - val_loss: 2.9143
Epoch 29/100
5/5 [==============================] - 0s 25ms/step - loss: 2.4228 - val_loss: 2.6835
Epoch 30/100
5/5 [==============================] - 0s 26ms/step - loss: 5.2858 - val_loss: 5.9971
Epoch 31/100
5/5 [==============================] - 0s 27ms/step - loss: 5.6168 - val_loss: 6.3357
Epoch 32/100
5/5 [==============================] - 0s 28ms/step - loss: 5.6447 - val_loss: 5.9107
Epoch 33/100
5/5 [==============================] - 0s 29ms/step - loss: 5.5074 - val_loss: 5.6384
Epoch 34/100
5/5 [==============================] - 0s 28ms/step - loss: 5.1868 - val_loss: 5.5511
Epoch 35/100
5/5 [==============================] - 0s 28ms/step - loss: 5.1477 - val_loss: 5.4953
Epoch 36/100
5/5 [==============================] - 0s 29ms/step - loss: 5.1699 - val_loss: 5.4517
Epoch 37/100
5/5 [==============================] - 0s 27ms/step - loss: 5.0677 - val_loss: 5.4457
Epoch 38/100
5/5 [==============================] - 0s 27ms/step - loss: 5.1378 - val_loss: 5.5050
Epoch 39/100
5/5 [==============================] - 0s 28ms/step - loss: 5.0833 - val_loss: 5.4792
Epoch 40/100
5/5 [==============================] - 0s 30ms/step - loss: 5.0578 - val_loss: 5.4457
Epoch 41/100
5/5 [==============================] - 0s 35ms/step - loss: 5.0536 - val_loss: 5.4285
Epoch 42/100
5/5 [==============================] - 0s 35ms/step - loss: 5.0802 - val_loss: 5.3810
Epoch 43/100
5/5 [==============================] - 0s 34ms/step - loss: 5.0858 - val_loss: 5.3426
Epoch 44/100
5/5 [==============================] - 0s 35ms/step - loss: 4.9881 - val_loss: 5.3923
Epoch 45/100
5/5 [==============================] - 0s 33ms/step - loss: 4.9571 - val_loss: 5.6751
Epoch 46/100
5/5 [==============================] - 0s 33ms/step - loss: 5.1858 - val_loss: 5.3443
Epoch 47/100
5/5 [==============================] - 0s 30ms/step - loss: 4.9448 - val_loss: 5.2768
Epoch 48/100
5/5 [==============================] - 0s 29ms/step - loss: 4.9203 - val_loss: 5.2714
Epoch 49/100
5/5 [==============================] - 0s 27ms/step - loss: 4.8837 - val_loss: 5.2389
Epoch 50/100
5/5 [==============================] - 0s 29ms/step - loss: 4.8303 - val_loss: 5.1841
Epoch 51/100
5/5 [==============================] - 0s 28ms/step - loss: 4.7842 - val_loss: 5.0296
Epoch 52/100
5/5 [==============================] - 0s 28ms/step - loss: 4.8243 - val_loss: 5.2013
Epoch 53/100
```

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5/5 [==============================] - 0s 27ms/step - loss: 4.7941 - val_loss: 5.1996
Epoch 54/100
5/5 [==============================] - 0s 30ms/step - loss: 4.9078 - val_loss: 5.3078
Epoch 55/100
5/5 [==============================] - 0s 31ms/step - loss: 4.8332 - val_loss: 5.1384
Epoch 56/100
5/5 [==============================] - 0s 30ms/step - loss: 4.7739 - val_loss: 5.1289
Epoch 57/100
5/5 [==============================] - 0s 29ms/step - loss: 4.7376 - val_loss: 5.0994
Epoch 58/100
5/5 [==============================] - 0s 30ms/step - loss: 4.7258 - val_loss: 5.0505
Epoch 59/100
5/5 [==============================] - 0s 34ms/step - loss: 4.6905 - val_loss: 5.0129
Epoch 60/100
5/5 [==============================] - 0s 31ms/step - loss: 4.7087 - val_loss: 5.0099
Epoch 61/100
5/5 [==============================] - 0s 29ms/step - loss: 4.6635 - val_loss: 4.9309
Epoch 62/100
5/5 [==============================] - 0s 26ms/step - loss: 4.5815 - val_loss: 4.8925
Epoch 63/100
5/5 [==============================] - 0s 28ms/step - loss: 4.5379 - val_loss: 4.8128
Epoch 64/100
5/5 [==============================] - 0s 30ms/step - loss: 4.4724 - val_loss: 4.7913
Epoch 65/100
5/5 [==============================] - 0s 29ms/step - loss: 4.4715 - val_loss: 4.6409
Epoch 66/100
5/5 [==============================] - 0s 29ms/step - loss: 4.3060 - val_loss: 4.5174
Epoch 67/100
5/5 [==============================] - 0s 29ms/step - loss: 4.2471 - val_loss: 4.4606
Epoch 68/100
5/5 [==============================] - 0s 30ms/step - loss: 4.3227 - val_loss: 4.5835
Epoch 69/100
5/5 [==============================] - 0s 29ms/step - loss: 4.4901 - val_loss: 4.7700
Epoch 70/100
5/5 [==============================] - 0s 28ms/step - loss: 4.3629 - val_loss: 4.5211
Epoch 71/100
5/5 [==============================] - 0s 26ms/step - loss: 4.3511 - val_loss: 4.4503
Epoch 72/100
5/5 [==============================] - 0s 28ms/step - loss: 4.3014 - val_loss: 4.2108
Epoch 73/100
5/5 [==============================] - 0s 33ms/step - loss: 4.1055 - val_loss: 4.4017
Epoch 74/100
5/5 [==============================] - 0s 32ms/step - loss: 4.0197 - val_loss: 4.0267
Epoch 75/100
5/5 [==============================] - 0s 30ms/step - loss: 3.8563 - val_loss: 3.6726
Epoch 76/100
5/5 [==============================] - 0s 29ms/step - loss: 3.4882 - val_loss: 3.8020
Epoch 77/100
5/5 [==============================] - 0s 30ms/step - loss: 3.8619 - val_loss: 3.3459
Epoch 78/100
5/5 [==============================] - 0s 29ms/step - loss: 3.6292 - val_loss: 3.5664
Epoch 79/100
5/5 [==============================] - 0s 29ms/step - loss: 3.5631 - val_loss: 3.1748
Epoch 80/100
5/5 [==============================] - 0s 26ms/step - loss: 3.3105 - val_loss: 3.0307
Epoch 81/100
5/5 [==============================] - 0s 27ms/step - loss: 3.4200 - val_loss: 3.1112
Epoch 82/100
5/5 [==============================] - 0s 30ms/step - loss: 2.8675 - val_loss: 3.1052
Epoch 83/100
5/5 [==============================] - 0s 29ms/step - loss: 2.8224 - val_loss: 2.6419
Epoch 84/100
5/5 [==============================] - 0s 27ms/step - loss: 2.8395 - val_loss: 2.9787
Epoch 85/100
```

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5/5 [==============================] - 0s 28ms/step - loss: 3.5715 - val_loss: 4.7167
Epoch 86/100
5/5 [==============================] - 0s 27ms/step - loss: 4.2993 - val_loss: 4.4631
Epoch 87/100
5/5 [==============================] - 0s 26ms/step - loss: 4.0594 - val_loss: 3.8368
Epoch 88/100
5/5 [==============================] - 0s 27ms/step - loss: 3.7937 - val_loss: 3.6079
Epoch 89/100
5/5 [==============================] - 0s 28ms/step - loss: 3.5125 - val_loss: 4.0239
Epoch 90/100
5/5 [==============================] - 0s 32ms/step - loss: 3.7586 - val_loss: 3.6399
Epoch 91/100
5/5 [==============================] - 0s 30ms/step - loss: 3.3873 - val_loss: 3.0842
Epoch 92/100
5/5 [==============================] - 0s 30ms/step - loss: 3.3885 - val_loss: 3.6399
Epoch 93/100
5/5 [==============================] - 0s 31ms/step - loss: 3.4000 - val_loss: 4.4841
Epoch 94/100
5/5 [==============================] - 0s 32ms/step - loss: 3.3567 - val_loss: 3.0700
Epoch 95/100
5/5 [==============================] - 0s 30ms/step - loss: 2.8885 - val_loss: 2.6758
Epoch 96/100
5/5 [==============================] - 0s 33ms/step - loss: 2.4805 - val_loss: 3.0375
Epoch 97/100
5/5 [==============================] - 0s 32ms/step - loss: 3.3937 - val_loss: 3.5333
Epoch 98/100
5/5 [==============================] - 0s 32ms/step - loss: 3.2631 - val_loss: 3.2215
Epoch 99/100
5/5 [==============================] - 0s 31ms/step - loss: 2.7398 - val_loss: 2.4361
Epoch 100/100
5/5 [==============================] - 0s 30ms/step - loss: 2.7714 - val_loss: 3.0526
Fold 2:
Epoch 1/100
7/7 [==============================] - 0s 32ms/step - loss: 3.0948 - val_loss: 3.2973
Epoch 2/100
7/7 [==============================] - 0s 27ms/step - loss: 3.0683 - val_loss: 2.3011
Epoch 3/100
7/7 [==============================] - 0s 29ms/step - loss: 2.7443 - val_loss: 2.8005
Epoch 4/100
7/7 [==============================] - 0s 28ms/step - loss: 2.6853 - val_loss: 2.2804
Epoch 5/100
7/7 [==============================] - 0s 30ms/step - loss: 2.2625 - val_loss: 2.1454
Epoch 6/100
7/7 [==============================] - 0s 27ms/step - loss: 2.1445 - val_loss: 3.1710
Epoch 7/100
7/7 [==============================] - 0s 27ms/step - loss: 2.8023 - val_loss: 2.4865
Epoch 8/100
7/7 [==============================] - 0s 27ms/step - loss: 2.2422 - val_loss: 2.2137
Epoch 9/100
7/7 [==============================] - 0s 27ms/step - loss: 2.0824 - val_loss: 2.9695
Epoch 10/100
7/7 [==============================] - 0s 26ms/step - loss: 2.9683 - val_loss: 2.8457
Epoch 11/100
7/7 [==============================] - 0s 27ms/step - loss: 2.5426 - val_loss: 2.2180
Epoch 12/100
7/7 [==============================] - 0s 27ms/step - loss: 2.1267 - val_loss: 2.5433
Epoch 13/100
7/7 [==============================] - 0s 27ms/step - loss: 2.2596 - val_loss: 2.7559
Epoch 14/100
7/7 [==============================] - 0s 27ms/step - loss: 2.6882 - val_loss: 2.8341
Epoch 15/100
7/7 [==============================] - 0s 27ms/step - loss: 2.6030 - val_loss: 2.4468
Epoch 16/100
7/7 [==============================] - 0s 27ms/step - loss: 2.1261 - val_loss: 2.6443
```

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Epoch 17/100
7/7 [==============================] - 0s 27ms/step - loss: 2.4896 - val_loss: 2.6332
Epoch 18/100
7/7 [==============================] - 0s 27ms/step - loss: 2.4935 - val_loss: 2.6991
Epoch 19/100
7/7 [==============================] - 0s 28ms/step - loss: 2.6978 - val_loss: 3.3368
Epoch 20/100
7/7 [==============================] - 0s 27ms/step - loss: 2.8214 - val_loss: 2.7079
Epoch 21/100
7/7 [==============================] - 0s 28ms/step - loss: 2.5499 - val_loss: 2.8502
Epoch 22/100
7/7 [==============================] - 0s 25ms/step - loss: 2.5698 - val_loss: 2.4512
Epoch 23/100
7/7 [==============================] - 0s 26ms/step - loss: 2.5324 - val_loss: 2.5072
Epoch 24/100
7/7 [==============================] - 0s 28ms/step - loss: 2.1281 - val_loss: 2.0684
Epoch 25/100
7/7 [==============================] - 0s 31ms/step - loss: 1.9468 - val_loss: 3.3380
Epoch 26/100
7/7 [==============================] - 0s 26ms/step - loss: 2.4315 - val_loss: 2.3507
Epoch 27/100
7/7 [==============================] - 0s 24ms/step - loss: 2.1185 - val_loss: 1.9778
Epoch 28/100
7/7 [==============================] - 0s 24ms/step - loss: 1.9646 - val_loss: 2.1393
Epoch 29/100
7/7 [==============================] - 0s 28ms/step - loss: 2.0008 - val_loss: 2.2421
Epoch 30/100
7/7 [==============================] - 0s 27ms/step - loss: 2.0599 - val_loss: 2.1157
Epoch 31/100
7/7 [==============================] - 0s 28ms/step - loss: 2.0415 - val_loss: 2.8587
Epoch 32/100
7/7 [==============================] - 0s 29ms/step - loss: 2.5469 - val_loss: 2.3986
Epoch 33/100
7/7 [==============================] - 0s 27ms/step - loss: 2.3897 - val_loss: 2.5025
Epoch 34/100
7/7 [==============================] - 0s 27ms/step - loss: 2.2386 - val_loss: 2.3658
Epoch 35/100
7/7 [==============================] - 0s 27ms/step - loss: 2.1192 - val_loss: 2.3291
Epoch 36/100
7/7 [==============================] - 0s 28ms/step - loss: 1.9762 - val_loss: 3.0035
Epoch 37/100
7/7 [==============================] - 0s 27ms/step - loss: 3.5990 - val_loss: 3.0889
Epoch 38/100
7/7 [==============================] - 0s 27ms/step - loss: 2.7957 - val_loss: 3.4747
Epoch 39/100
7/7 [==============================] - 0s 28ms/step - loss: 3.2466 - val_loss: 3.0078
Epoch 40/100
7/7 [==============================] - 0s 27ms/step - loss: 2.9446 - val_loss: 2.9464
Epoch 41/100
7/7 [==============================] - 0s 27ms/step - loss: 2.9410 - val_loss: 2.8565
Epoch 42/100
7/7 [==============================] - 0s 27ms/step - loss: 2.5329 - val_loss: 3.0004
Epoch 43/100
7/7 [==============================] - 0s 28ms/step - loss: 2.4710 - val_loss: 2.8118
Epoch 44/100
7/7 [==============================] - 0s 27ms/step - loss: 2.4794 - val_loss: 2.8455
Epoch 45/100
7/7 [==============================] - 0s 26ms/step - loss: 2.3370 - val_loss: 2.5393
Epoch 46/100
7/7 [==============================] - 0s 27ms/step - loss: 2.2643 - val_loss: 2.6842
Epoch 47/100
7/7 [==============================] - 0s 28ms/step - loss: 2.3742 - val_loss: 2.3956
Epoch 48/100
7/7 [==============================] - 0s 29ms/step - loss: 2.1351 - val_loss: 2.5849
```

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Epoch 49/100
7/7 [==============================] - 0s 27ms/step - loss: 2.0781 - val_loss: 2.2982
Epoch 50/100
7/7 [==============================] - 0s 27ms/step - loss: 2.0757 - val_loss: 2.5739
Epoch 51/100
7/7 [==============================] - 0s 27ms/step - loss: 2.0368 - val_loss: 2.6054
Epoch 52/100
7/7 [==============================] - 0s 30ms/step - loss: 3.1404 - val_loss: 3.4278
Epoch 53/100
7/7 [==============================] - 0s 28ms/step - loss: 3.5039 - val_loss: 2.8397
Epoch 54/100
7/7 [==============================] - 0s 27ms/step - loss: 2.8471 - val_loss: 3.8260
Epoch 55/100
7/7 [==============================] - 0s 27ms/step - loss: 2.4250 - val_loss: 2.2902
Epoch 56/100
7/7 [==============================] - 0s 27ms/step - loss: 1.9254 - val_loss: 2.2315
Epoch 57/100
7/7 [==============================] - 0s 30ms/step - loss: 2.2205 - val_loss: 2.5485
Epoch 58/100
7/7 [==============================] - 0s 30ms/step - loss: 2.6187 - val_loss: 2.6864
Epoch 59/100
7/7 [==============================] - 0s 27ms/step - loss: 2.5918 - val_loss: 2.5176
Epoch 60/100
7/7 [==============================] - 0s 29ms/step - loss: 3.0066 - val_loss: 2.2837
Epoch 61/100
7/7 [==============================] - 0s 27ms/step - loss: 2.5190 - val_loss: 3.2522
Epoch 62/100
7/7 [==============================] - 0s 40ms/step - loss: 3.1531 - val_loss: 2.7940
Epoch 63/100
7/7 [==============================] - 0s 37ms/step - loss: 2.4899 - val_loss: 2.3928
Epoch 64/100
7/7 [==============================] - 0s 29ms/step - loss: 2.9910 - val_loss: 2.9242
Epoch 65/100
7/7 [==============================] - 0s 29ms/step - loss: 2.7111 - val_loss: 2.8194
Epoch 66/100
7/7 [==============================] - 0s 28ms/step - loss: 2.6559 - val_loss: 2.6329
Epoch 67/100
7/7 [==============================] - 0s 28ms/step - loss: 2.3119 - val_loss: 2.7413
Epoch 68/100
7/7 [==============================] - 0s 27ms/step - loss: 2.2795 - val_loss: 3.2950
Epoch 69/100
7/7 [==============================] - 0s 27ms/step - loss: 3.2899 - val_loss: 3.2116
Epoch 70/100
7/7 [==============================] - 0s 26ms/step - loss: 2.6260 - val_loss: 3.5478
Epoch 71/100
7/7 [==============================] - 0s 28ms/step - loss: 2.8592 - val_loss: 3.2732
Epoch 72/100
7/7 [==============================] - 0s 32ms/step - loss: 3.5701 - val_loss: 3.4925
Epoch 73/100
7/7 [==============================] - 0s 27ms/step - loss: 3.2543 - val_loss: 2.6324
Epoch 74/100
7/7 [==============================] - 0s 29ms/step - loss: 2.6384 - val_loss: 6.0407
Epoch 75/100
7/7 [==============================] - 0s 27ms/step - loss: 5.2042 - val_loss: 4.9478
Epoch 76/100
7/7 [==============================] - 0s 26ms/step - loss: 3.5298 - val_loss: 3.6625
Epoch 77/100
7/7 [==============================] - 0s 24ms/step - loss: 3.9782 - val_loss: 3.5687
Epoch 78/100
7/7 [==============================] - 0s 30ms/step - loss: 3.4687 - val_loss: 3.7367
Epoch 79/100
7/7 [==============================] - 0s 26ms/step - loss: 3.2190 - val_loss: 3.0060
Epoch 80/100
7/7 [==============================] - 0s 24ms/step - loss: 2.6691 - val_loss: 3.3269
```

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Epoch 81/100
7/7 [==============================] - 0s 26ms/step - loss: 2.3845 - val_loss: 3.2842
Epoch 82/100
7/7 [==============================] - 0s 27ms/step - loss: 2.2791 - val_loss: 2.7360
Epoch 83/100
7/7 [==============================] - 0s 26ms/step - loss: 2.3414 - val_loss: 2.7522
Epoch 84/100
7/7 [==============================] - 0s 26ms/step - loss: 3.0671 - val_loss: 2.6676
Epoch 85/100
7/7 [==============================] - 0s 24ms/step - loss: 2.2446 - val_loss: 2.7433
Epoch 86/100
7/7 [==============================] - 0s 27ms/step - loss: 2.3732 - val_loss: 2.5512
Epoch 87/100
7/7 [==============================] - 0s 32ms/step - loss: 2.2859 - val_loss: 2.5756
Epoch 88/100
7/7 [==============================] - 0s 26ms/step - loss: 2.1740 - val_loss: 2.6735
Epoch 89/100
7/7 [==============================] - 0s 27ms/step - loss: 2.9110 - val_loss: 2.6771
Epoch 90/100
7/7 [==============================] - 0s 26ms/step - loss: 2.5594 - val_loss: 3.3647
Epoch 91/100
7/7 [==============================] - 0s 25ms/step - loss: 2.6728 - val_loss: 3.1901
Epoch 92/100
7/7 [==============================] - 0s 25ms/step - loss: 2.1615 - val_loss: 2.4087
Epoch 93/100
7/7 [==============================] - 0s 26ms/step - loss: 1.9807 - val_loss: 2.6836
Epoch 94/100
7/7 [==============================] - 0s 27ms/step - loss: 2.0427 - val_loss: 3.0950
Epoch 95/100
7/7 [==============================] - 0s 28ms/step - loss: 2.2485 - val_loss: 2.8673
Epoch 96/100
7/7 [==============================] - 0s 27ms/step - loss: 2.4800 - val_loss: 2.6092
Epoch 97/100
7/7 [==============================] - 0s 26ms/step - loss: 2.3387 - val_loss: 2.4755
Epoch 98/100
7/7 [==============================] - 0s 26ms/step - loss: 2.1373 - val_loss: 2.5074
Epoch 99/100
7/7 [==============================] - 0s 28ms/step - loss: 2.2455 - val_loss: 2.5850
Epoch 100/100
7/7 [==============================] - 0s 28ms/step - loss: 2.0302 - val_loss: 2.7357
Fold 3:
Epoch 1/100
9/9 [==============================] - 0s 31ms/step - loss: 2.4017 - val_loss: 2.7540
Epoch 2/100
9/9 [==============================] - 0s 25ms/step - loss: 2.1853 - val_loss: 2.4017
Epoch 3/100
9/9 [==============================] - 0s 24ms/step - loss: 2.1034 - val_loss: 2.0272
Epoch 4/100
9/9 [==============================] - 0s 25ms/step - loss: 2.3644 - val_loss: 5.7156
Epoch 5/100
9/9 [==============================] - 0s 38ms/step - loss: 5.7082 - val_loss: 5.6067
Epoch 6/100
9/9 [==============================] - 0s 33ms/step - loss: 4.6893 - val_loss: 3.3528
Epoch 7/100
9/9 [==============================] - 0s 30ms/step - loss: 3.2327 - val_loss: 3.4900
Epoch 8/100
9/9 [==============================] - 0s 29ms/step - loss: 2.8862 - val_loss: 2.8901
Epoch 9/100
9/9 [==============================] - 0s 32ms/step - loss: 2.9091 - val_loss: 2.9636
Epoch 10/100
9/9 [==============================] - 0s 31ms/step - loss: 2.4708 - val_loss: 2.6216
Epoch 11/100
9/9 [==============================] - 0s 25ms/step - loss: 1.9505 - val_loss: 1.9725
Epoch 12/100
```

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9/9 [==============================] - 0s 26ms/step - loss: 1.9342 - val_loss: 1.9460
Epoch 13/100
9/9 [==============================] - 0s 24ms/step - loss: 2.2154 - val_loss: 2.8685
Epoch 14/100
9/9 [==============================] - 0s 25ms/step - loss: 2.2410 - val_loss: 1.9680
Epoch 15/100
9/9 [==============================] - 0s 26ms/step - loss: 1.8896 - val_loss: 1.6646
Epoch 16/100
9/9 [==============================] - 0s 23ms/step - loss: 2.1183 - val_loss: 1.9381
Epoch 17/100
9/9 [==============================] - 0s 25ms/step - loss: 1.7313 - val_loss: 1.7857
Epoch 18/100
9/9 [==============================] - 0s 28ms/step - loss: 2.0467 - val_loss: 1.8983
Epoch 19/100
9/9 [==============================] - 0s 28ms/step - loss: 2.6430 - val_loss: 2.9999
Epoch 20/100
9/9 [==============================] - 0s 27ms/step - loss: 2.1987 - val_loss: 2.1931
Epoch 21/100
9/9 [==============================] - 0s 24ms/step - loss: 2.1759 - val_loss: 2.0849
Epoch 22/100
9/9 [==============================] - 0s 27ms/step - loss: 1.7009 - val_loss: 2.2392
Epoch 23/100
9/9 [==============================] - 0s 26ms/step - loss: 1.6289 - val_loss: 2.1308
Epoch 24/100
9/9 [==============================] - 0s 30ms/step - loss: 1.8653 - val_loss: 1.8000
Epoch 25/100
9/9 [==============================] - 0s 28ms/step - loss: 2.4652 - val_loss: 3.0757
Epoch 26/100
9/9 [==============================] - 0s 27ms/step - loss: 2.5600 - val_loss: 1.9881
Epoch 27/100
9/9 [==============================] - 0s 26ms/step - loss: 1.6478 - val_loss: 1.4858
Epoch 28/100
9/9 [==============================] - 0s 26ms/step - loss: 1.5366 - val_loss: 1.8258
Epoch 29/100
9/9 [==============================] - 0s 26ms/step - loss: 2.0490 - val_loss: 2.7516
Epoch 30/100
9/9 [==============================] - 0s 27ms/step - loss: 4.2852 - val_loss: 4.8411
Epoch 31/100
9/9 [==============================] - 0s 25ms/step - loss: 5.4851 - val_loss: 6.3963
Epoch 32/100
9/9 [==============================] - 0s 28ms/step - loss: 5.6154 - val_loss: 5.3128
Epoch 33/100
9/9 [==============================] - 0s 28ms/step - loss: 5.2119 - val_loss: 5.4329
Epoch 34/100
9/9 [==============================] - 0s 25ms/step - loss: 5.2598 - val_loss: 5.4008
Epoch 35/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1727 - val_loss: 5.3255
Epoch 36/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1388 - val_loss: 5.3076
Epoch 37/100
9/9 [==============================] - 0s 30ms/step - loss: 5.1450 - val_loss: 5.3132
Epoch 38/100
9/9 [==============================] - 0s 30ms/step - loss: 5.1436 - val_loss: 5.2801
Epoch 39/100
9/9 [==============================] - 0s 30ms/step - loss: 5.1174 - val_loss: 5.2840
Epoch 40/100
9/9 [==============================] - 0s 27ms/step - loss: 5.1165 - val_loss: 5.3284
Epoch 41/100
9/9 [==============================] - 0s 28ms/step - loss: 5.2018 - val_loss: 5.3490
Epoch 42/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1660 - val_loss: 5.3117
Epoch 43/100
9/9 [==============================] - 0s 25ms/step - loss: 5.1484 - val_loss: 5.3080
Epoch 44/100
```

```
9/9 [==============================] - 0s 26ms/step - loss: 5.1584 - val_loss: 5.3084
Epoch 45/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1480 - val_loss: 5.3025
Epoch 46/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1360 - val_loss: 5.3017
Epoch 47/100
9/9 [==============================] - 0s 25ms/step - loss: 5.1399 - val_loss: 5.3005
Epoch 48/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1364 - val_loss: 5.2899
Epoch 49/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1520 - val_loss: 5.3160
Epoch 50/100
9/9 [==============================] - 0s 25ms/step - loss: 5.1410 - val_loss: 5.3028
Epoch 51/100
9/9 [==============================] - 0s 25ms/step - loss: 5.1423 - val_loss: 5.3021
Epoch 52/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1477 - val_loss: 5.2901
Epoch 53/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1304 - val_loss: 5.2860
Epoch 54/100
9/9 [==============================] - 0s 29ms/step - loss: 5.1230 - val_loss: 5.2748
Epoch 55/100
9/9 [==============================] - 0s 27ms/step - loss: 5.1145 - val_loss: 5.2696
Epoch 56/100
9/9 [==============================] - 0s 25ms/step - loss: 5.1293 - val_loss: 5.2786
Epoch 57/100
9/9 [==============================] - 0s 26ms/step - loss: 5.1153 - val_loss: 5.2740
Epoch 58/100
9/9 [==============================] - 0s 27ms/step - loss: 5.1201 - val_loss: 5.2689
Epoch 59/100
9/9 [==============================] - 0s 27ms/step - loss: 5.1120 - val_loss: 5.2565
Epoch 60/100
9/9 [==============================] - 0s 28ms/step - loss: 5.1152 - val_loss: 5.2644
Epoch 61/100
9/9 [==============================] - 0s 32ms/step - loss: 5.1116 - val_loss: 5.2593
Epoch 62/100
9/9 [==============================] - 0s 32ms/step - loss: 5.1239 - val_loss: 5.2789
Epoch 63/100
9/9 [==============================] - 0s 31ms/step - loss: 5.1149 - val_loss: 5.2620
Epoch 64/100
9/9 [==============================] - 0s 32ms/step - loss: 5.1107 - val_loss: 5.2515
Epoch 65/100
9/9 [==============================] - 0s 32ms/step - loss: 5.1127 - val_loss: 5.2526
Epoch 66/100
9/9 [==============================] - 0s 29ms/step - loss: 5.1020 - val_loss: 5.2515
Epoch 67/100
9/9 [==============================] - 0s 25ms/step - loss: 5.0893 - val_loss: 5.2366
Epoch 68/100
9/9 [==============================] - 0s 28ms/step - loss: 5.0622 - val_loss: 5.2089
Epoch 69/100
9/9 [==============================] - 0s 27ms/step - loss: 5.0606 - val_loss: 5.2192
Epoch 70/100
9/9 [==============================] - 0s 23ms/step - loss: 5.0481 - val_loss: 5.1911
Epoch 71/100
9/9 [==============================] - 0s 25ms/step - loss: 5.0392 - val_loss: 5.0820
Epoch 72/100
9/9 [==============================] - 0s 24ms/step - loss: 5.1428 - val_loss: 5.0311
Epoch 73/100
9/9 [==============================] - 0s 25ms/step - loss: 5.0310 - val_loss: 5.1258
Epoch 74/100
9/9 [==============================] - 0s 25ms/step - loss: 5.1272 - val_loss: 5.3339
Epoch 75/100
9/9 [==============================] - 0s 23ms/step - loss: 5.1155 - val_loss: 5.3320
Epoch 76/100
```

```
9/9 [==============================] - 0s 26ms/step - loss: 5.1521 - val_loss: 5.3128
Epoch 77/100
9/9 [==============================] - 0s 24ms/step - loss: 5.1514 - val_loss: 5.3208
Epoch 78/100
9/9 [==============================] - 0s 23ms/step - loss: 5.1478 - val_loss: 5.3192
Epoch 79/100
9/9 [==============================] - 0s 24ms/step - loss: 5.1560 - val_loss: 5.2844
Epoch 80/100
9/9 [==============================] - 0s 23ms/step - loss: 5.1217 - val_loss: 5.2625
Epoch 81/100
9/9 [==============================] - 0s 22ms/step - loss: 5.1810 - val_loss: 5.2698
Epoch 82/100
9/9 [==============================] - 0s 27ms/step - loss: 5.1123 - val_loss: 5.2723
Epoch 83/100
9/9 [==============================] - 0s 26ms/step - loss: 5.0847 - val_loss: 5.2208
Epoch 84/100
9/9 [==============================] - 0s 29ms/step - loss: 5.0540 - val_loss: 5.2165
Epoch 85/100
9/9 [==============================] - 0s 25ms/step - loss: 5.0191 - val_loss: 5.1395
Epoch 86/100
9/9 [==============================] - 0s 27ms/step - loss: 4.9547 - val_loss: 5.0661
Epoch 87/100
9/9 [==============================] - 0s 25ms/step - loss: 4.9990 - val_loss: 5.2147
Epoch 88/100
9/9 [==============================] - 0s 26ms/step - loss: 4.9560 - val_loss: 5.1980
Epoch 89/100
9/9 [==============================] - 0s 26ms/step - loss: 4.9624 - val_loss: 5.1127
Epoch 90/100
9/9 [==============================] - 0s 29ms/step - loss: 4.9449 - val_loss: 5.0438
Epoch 91/100
9/9 [==============================] - 0s 29ms/step - loss: 5.0549 - val_loss: 5.0202
Epoch 92/100
9/9 [==============================] - 0s 30ms/step - loss: 4.9386 - val_loss: 4.9688
Epoch 93/100
9/9 [==============================] - 0s 28ms/step - loss: 4.8132 - val_loss: 4.8960
Epoch 94/100
9/9 [==============================] - 0s 28ms/step - loss: 4.7394 - val_loss: 4.6838
Epoch 95/100
9/9 [==============================] - 0s 29ms/step - loss: 4.6038 - val_loss: 4.5746
Epoch 96/100
9/9 [==============================] - 0s 29ms/step - loss: 4.5553 - val_loss: 4.7144
Epoch 97/100
9/9 [==============================] - 0s 27ms/step - loss: 4.5992 - val_loss: 4.7457
Epoch 98/100
9/9 [==============================] - 0s 26ms/step - loss: 4.7660 - val_loss: 4.7587
Epoch 99/100
9/9 [==============================] - 0s 26ms/step - loss: 4.5925 - val_loss: 4.7553
Epoch 100/100
9/9 [==============================] - 0s 25ms/step - loss: 4.5928 - val_loss: 4.4966
Fold 4:
Epoch 1/100
12/12 [==============================] - 0s 24ms/step - loss: 4.6592 - val_loss: 4.91
43
Epoch 2/100
12/12 [==============================] - 0s 26ms/step - loss: 4.6827 - val_loss: 4.53
59
Epoch 3/100
12/12 [==============================] - 0s 23ms/step - loss: 4.3504 - val_loss: 4.26
76
Epoch 4/100
12/12 [==============================] - 0s 23ms/step - loss: 4.4785 - val_loss: 4.49
44
Epoch 5/100
12/12 [==============================] - 0s 23ms/step - loss: 4.3281 - val_loss: 4.20
```

```
82
Epoch 6/100
12/12 [==============================] - 0s 23ms/step - loss: 4.2840 - val_loss: 4.63
57
Epoch 7/100
12/12 [==============================] - 0s 22ms/step - loss: 4.5098 - val_loss: 3.93
43
Epoch 8/100
12/12 [==============================] - 0s 24ms/step - loss: 4.0101 - val_loss: 4.09
12
Epoch 9/100
12/12 [==============================] - 0s 25ms/step - loss: 3.8332 - val_loss: 3.88
20
Epoch 10/100
12/12 [==============================] - 0s 26ms/step - loss: 4.3673 - val_loss: 5.27
66
Epoch 11/100
12/12 [==============================] - 0s 26ms/step - loss: 4.4383 - val_loss: 3.69
78
Epoch 12/100
12/12 [==============================] - 0s 22ms/step - loss: 4.3881 - val_loss: 5.17
75
Epoch 13/100
12/12 [==============================] - 0s 24ms/step - loss: 5.0596 - val_loss: 5.10
60
Epoch 14/100
12/12 [==============================] - 0s 25ms/step - loss: 5.0005 - val_loss: 5.01
80
Epoch 15/100
12/12 [==============================] - 0s 23ms/step - loss: 4.9332 - val_loss: 4.99
91
Epoch 16/100
12/12 [==============================] - 0s 24ms/step - loss: 4.9824 - val_loss: 4.95
81
Epoch 17/100
12/12 [==============================] - 0s 27ms/step - loss: 4.8796 - val_loss: 4.87
84
Epoch 18/100
12/12 [==============================] - 0s 25ms/step - loss: 4.8442 - val_loss: 4.84
77
Epoch 19/100
12/12 [==============================] - 0s 23ms/step - loss: 4.7685 - val_loss: 4.69
63
Epoch 20/100
12/12 [==============================] - 0s 22ms/step - loss: 4.6769 - val_loss: 4.63
44
Epoch 21/100
12/12 [==============================] - 0s 23ms/step - loss: 4.5827 - val_loss: 4.50
85
Epoch 22/100
12/12 [==============================] - 0s 22ms/step - loss: 4.4480 - val_loss: 4.32
62
Epoch 23/100
12/12 [==============================] - 0s 22ms/step - loss: 4.2485 - val_loss: 4.03
87
Epoch 24/100
12/12 [==============================] - 0s 23ms/step - loss: 3.9529 - val_loss: 3.61
43
Epoch 25/100
12/12 [==============================] - 0s 25ms/step - loss: 3.7451 - val_loss: 3.46
27
Epoch 26/100
12/12 [==============================] - 0s 24ms/step - loss: 3.4109 - val_loss: 3.44
52
```

```
Epoch 27/100
12/12 [==============================] - 0s 22ms/step - loss: 3.6715 - val_loss: 4.16
11
Epoch 28/100
12/12 [==============================] - 0s 26ms/step - loss: 3.8809 - val_loss: 3.55
56
Epoch 29/100
12/12 [==============================] - 0s 26ms/step - loss: 3.6924 - val_loss: 3.90
33
Epoch 30/100
12/12 [==============================] - 0s 26ms/step - loss: 3.7471 - val_loss: 3.04
22
Epoch 31/100
12/12 [==============================] - 0s 24ms/step - loss: 3.1087 - val_loss: 3.02
64
Epoch 32/100
12/12 [==============================] - 0s 25ms/step - loss: 3.0295 - val_loss: 2.46
05
Epoch 33/100
12/12 [==============================] - 0s 25ms/step - loss: 2.9100 - val_loss: 2.24
77
Epoch 34/100
12/12 [==============================] - 0s 26ms/step - loss: 2.5088 - val_loss: 2.38
96
Epoch 35/100
12/12 [==============================] - 0s 25ms/step - loss: 2.2949 - val_loss: 2.75
73
Epoch 36/100
12/12 [==============================] - 0s 26ms/step - loss: 2.8782 - val_loss: 2.86
02
Epoch 37/100
12/12 [==============================] - 0s 23ms/step - loss: 3.0469 - val_loss: 2.36
82
Epoch 38/100
12/12 [==============================] - 0s 26ms/step - loss: 2.1993 - val_loss: 1.86
22
Epoch 39/100
12/12 [==============================] - 0s 26ms/step - loss: 2.1528 - val_loss: 2.04
12
Epoch 40/100
12/12 [==============================] - 0s 25ms/step - loss: 2.0085 - val_loss: 1.87
33
Epoch 41/100
12/12 [==============================] - 0s 23ms/step - loss: 2.0112 - val_loss: 1.70
87
Epoch 42/100
12/12 [==============================] - 0s 22ms/step - loss: 1.9074 - val_loss: 1.83
35
Epoch 43/100
12/12 [==============================] - 0s 21ms/step - loss: 2.0230 - val_loss: 1.70
21
Epoch 44/100
12/12 [==============================] - 0s 25ms/step - loss: 1.8823 - val_loss: 1.72
42
Epoch 45/100
12/12 [==============================] - 0s 26ms/step - loss: 1.8173 - val_loss: 1.68
84
Epoch 46/100
12/12 [==============================] - 0s 25ms/step - loss: 2.0930 - val_loss: 1.93
20
Epoch 47/100
12/12 [==============================] - 0s 23ms/step - loss: 2.1025 - val_loss: 1.76
61
Epoch 48/100
```

```
12/12 [==============================] - 0s 26ms/step - loss: 2.0238 - val_loss: 1.74
32
Epoch 49/100
12/12 [==============================] - 0s 25ms/step - loss: 2.0960 - val_loss: 1.94
97
Epoch 50/100
12/12 [==============================] - 0s 26ms/step - loss: 2.0303 - val_loss: 1.76
19
Epoch 51/100
12/12 [==============================] - 0s 23ms/step - loss: 2.1250 - val_loss: 1.68
17
Epoch 52/100
12/12 [==============================] - 0s 24ms/step - loss: 1.8031 - val_loss: 1.62
60
Epoch 53/100
12/12 [==============================] - 0s 23ms/step - loss: 1.8117 - val_loss: 1.57
15
Epoch 54/100
12/12 [==============================] - 0s 23ms/step - loss: 1.7414 - val_loss: 1.79
62
Epoch 55/100
12/12 [==============================] - 0s 24ms/step - loss: 1.8101 - val_loss: 1.67
69
Epoch 56/100
12/12 [==============================] - 0s 25ms/step - loss: 1.9173 - val_loss: 2.46
47
Epoch 57/100
12/12 [==============================] - 0s 24ms/step - loss: 2.0689 - val_loss: 2.19
28
Epoch 58/100
12/12 [==============================] - 0s 24ms/step - loss: 1.9949 - val_loss: 1.84
44
Epoch 59/100
12/12 [==============================] - 0s 23ms/step - loss: 2.9907 - val_loss: 5.74
77
Epoch 60/100
12/12 [==============================] - 0s 26ms/step - loss: 5.3134 - val_loss: 5.02
04
Epoch 61/100
12/12 [==============================] - 0s 23ms/step - loss: 4.4646 - val_loss: 3.79
02
Epoch 62/100
12/12 [==============================] - 0s 24ms/step - loss: 3.1368 - val_loss: 4.31
59
Epoch 63/100
12/12 [==============================] - 0s 26ms/step - loss: 3.4261 - val_loss: 3.36
93
Epoch 64/100
12/12 [==============================] - 0s 25ms/step - loss: 2.6629 - val_loss: 2.19
48
Epoch 65/100
12/12 [==============================] - 0s 26ms/step - loss: 2.3760 - val_loss: 2.66
36
Epoch 66/100
12/12 [==============================] - 0s 23ms/step - loss: 2.3578 - val_loss: 2.16
85
Epoch 67/100
12/12 [==============================] - 0s 22ms/step - loss: 5.0846 - val_loss: 6.12
99
Epoch 68/100
12/12 [==============================] - 0s 22ms/step - loss: 5.4155 - val_loss: 4.97
34
Epoch 69/100
12/12 [==============================] - 0s 22ms/step - loss: 4.3836 - val_loss: 3.16
```

```
27
Epoch 70/100
12/12 [==============================] - 0s 23ms/step - loss: 3.8945 - val_loss: 3.60
84
Epoch 71/100
12/12 [==============================] - 0s 21ms/step - loss: 3.6230 - val_loss: 3.69
80
Epoch 72/100
12/12 [==============================] - 0s 23ms/step - loss: 3.7137 - val_loss: 3.38
22
Epoch 73/100
12/12 [==============================] - 0s 23ms/step - loss: 3.5131 - val_loss: 3.72
17
Epoch 74/100
12/12 [==============================] - 0s 23ms/step - loss: 3.7338 - val_loss: 3.37
92
Epoch 75/100
12/12 [==============================] - 0s 24ms/step - loss: 3.4483 - val_loss: 3.03
47
Epoch 76/100
12/12 [==============================] - 0s 23ms/step - loss: 3.0825 - val_loss: 2.71
19
Epoch 77/100
12/12 [==============================] - 0s 24ms/step - loss: 2.9817 - val_loss: 2.78
08
Epoch 78/100
12/12 [==============================] - 0s 26ms/step - loss: 2.9229 - val_loss: 2.61
03
Epoch 79/100
12/12 [==============================] - 0s 26ms/step - loss: 3.1845 - val_loss: 2.97
08
Epoch 80/100
12/12 [==============================] - 0s 25ms/step - loss: 2.9910 - val_loss: 2.75
15
Epoch 81/100
12/12 [==============================] - 0s 24ms/step - loss: 2.7389 - val_loss: 2.52
20
Epoch 82/100
12/12 [==============================] - 0s 24ms/step - loss: 3.0723 - val_loss: 2.68
96
Epoch 83/100
12/12 [==============================] - 0s 25ms/step - loss: 2.7524 - val_loss: 2.42
46
Epoch 84/100
12/12 [==============================] - 0s 26ms/step - loss: 2.6779 - val_loss: 2.49
65
Epoch 85/100
12/12 [==============================] - 0s 26ms/step - loss: 2.6653 - val_loss: 2.54
78
Epoch 86/100
12/12 [==============================] - 0s 25ms/step - loss: 2.6206 - val_loss: 2.38
16
Epoch 87/100
12/12 [==============================] - 0s 24ms/step - loss: 2.5793 - val_loss: 2.32
01
Epoch 88/100
12/12 [==============================] - 0s 25ms/step - loss: 2.4808 - val_loss: 2.25
68
Epoch 89/100
12/12 [==============================] - 0s 24ms/step - loss: 2.4232 - val_loss: 2.10
98
Epoch 90/100
12/12 [==============================] - 0s 22ms/step - loss: 2.4373 - val_loss: 2.28
10
```

```
Epoch 91/100
12/12 [==============================] - 0s 21ms/step - loss: 2.3368 - val_loss: 2.38
22
Epoch 92/100
12/12 [==============================] - 0s 24ms/step - loss: 3.2328 - val_loss: 3.53
56
Epoch 93/100
12/12 [==============================] - 0s 24ms/step - loss: 2.9438 - val_loss: 1.97
75
Epoch 94/100
12/12 [==============================] - 0s 23ms/step - loss: 2.8866 - val_loss: 2.24
08
Epoch 95/100
12/12 [==============================] - 0s 24ms/step - loss: 2.6206 - val_loss: 2.44
83
Epoch 96/100
12/12 [==============================] - 0s 23ms/step - loss: 2.6988 - val_loss: 2.46
67
Epoch 97/100
12/12 [==============================] - 0s 22ms/step - loss: 2.7599 - val_loss: 2.34
26
Epoch 98/100
12/12 [==============================] - 0s 23ms/step - loss: 2.9274 - val_loss: 2.65
92
Epoch 99/100
12/12 [==============================] - 0s 21ms/step - loss: 2.8039 - val_loss: 2.49
74
Epoch 100/100
12/12 [==============================] - 0s 24ms/step - loss: 2.5366 - val_loss: 2.41
13
```

In [18]:

```
history_train_loss=[i.history['loss'] for i in history]
```

In [19]:

```
train_loss= np.mean(history_train_loss,axis=0)
```

→ Mean of train loss

In [20]:

```
history_validation_loss= [i.history['val_loss'] for i in history]
```

In [21]:

```
validation_loss= np.mean(history_validation_loss,axis=0)
```

→ mean of Validation loss

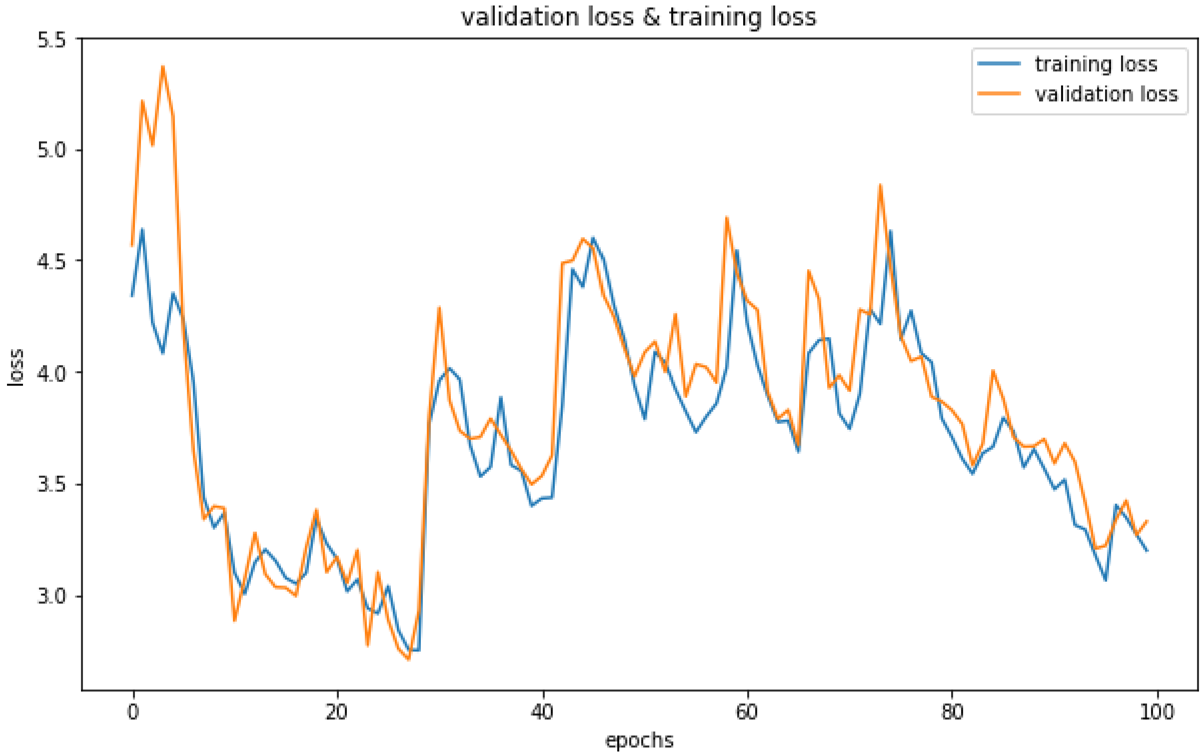
In [40]:

```
def plot_loss(*history):
    plt.figure(figsize=(10,6))
    plt.plot(train_loss)
    plt.plot(validation_loss)
    plt.title("validation loss & training loss")
    plt.xlabel("epochs")
    plt.ylabel("loss")
    leg = plt.legend(["training loss", "validation loss"],loc ="upper right");

    plt.show()
```

In [41]:

```
# loss plot with epochs
plot_loss(train_loss,validation_loss)
```



In [24]:
```
# plt.plot(train_loss)
# plt.plot(validation_loss)
# plt.title("validation loss & training loss")
# plt.xlabel("epochs")
# plt.ylabel("loss")
# leg = plt.legend(["training loss", "validation loss"],loc ="upper right");

# plt.show()
```

In [ ]:

SOLUTION USING Sqquesntial model(LSTM) NEURAL NETWORK

In [25]:
```
multi_step_dense_1_lstm = tf.keras.Sequential(
    [
    tf.keras.layers.Input(shape=(None,1)),
        tf.keras.layers.BatchNormalization(),
 tf.keras.layers.LSTM(128, return_sequences=False),
    tf.keras.layers.Dense(1, activation='linear')
                        ])
```

In [26]:
```
multi_step_dense_1_lstm.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 batch_normalization_1 (Batc  (None, None, 1)          4
 hNormalization)

 lstm_1 (LSTM)               (None, 128)               66560
```

```
 dense_1 (Dense)             (None, 1)                 129

=================================================================
Total params: 66,693
Trainable params: 66,691
Non-trainable params: 2
_________________________________________________________________
```

In [27]:

```
# optimizer = keras.optimizers.Adam(learning_rate=0.09)
# multi_step_dense_1_lstm.compile(optimizer=optimizer, loss=MeanSquaredLogarithmicEr
multi_step_dense_1_lstm.compile(optimizer='adam', loss=MeanSquaredLogarithmicError()
```

In [28]:

```
callback = tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=5)
```

In [29]:

```
history = multi_step_dense_1_lstm.fit(X, y, epochs=500, validation_split=0.2,callbac
```

```
Epoch 1/500
11/11 [==============================] - 3s 78ms/step - loss: 13.2866 - val_loss: 11.
2452
Epoch 2/500
11/11 [==============================] - 0s 25ms/step - loss: 8.1024 - val_loss: 5.56
84
Epoch 3/500
11/11 [==============================] - 0s 28ms/step - loss: 5.4411 - val_loss: 5.32
65
Epoch 4/500
11/11 [==============================] - 0s 26ms/step - loss: 5.2567 - val_loss: 5.28
66
Epoch 5/500
11/11 [==============================] - 0s 27ms/step - loss: 5.2182 - val_loss: 5.27
75
Epoch 6/500
11/11 [==============================] - 0s 24ms/step - loss: 5.1937 - val_loss: 5.27
47
Epoch 7/500
11/11 [==============================] - 0s 24ms/step - loss: 5.1857 - val_loss: 5.27
25
Epoch 8/500
11/11 [==============================] - 0s 25ms/step - loss: 5.1804 - val_loss: 5.27
08
Epoch 9/500
11/11 [==============================] - 0s 28ms/step - loss: 5.1749 - val_loss: 5.26
87
Epoch 10/500
11/11 [==============================] - 0s 29ms/step - loss: 5.1716 - val_loss: 5.26
63
Epoch 11/500
11/11 [==============================] - 0s 28ms/step - loss: 5.1689 - val_loss: 5.26
83
Epoch 12/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1645 - val_loss: 5.26
56
Epoch 13/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1613 - val_loss: 5.26
44
Epoch 14/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1603 - val_loss: 5.26
45
Epoch 15/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1580 - val_loss: 5.26
```

```
04
Epoch 16/500
11/11 [==============================] - 0s 28ms/step - loss: 5.1538 - val_loss: 5.26
17
Epoch 17/500
11/11 [==============================] - 0s 29ms/step - loss: 5.1507 - val_loss: 5.25
71
Epoch 18/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1474 - val_loss: 5.25
30
Epoch 19/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1432 - val_loss: 5.24
89
Epoch 20/500
11/11 [==============================] - 0s 28ms/step - loss: 5.1382 - val_loss: 5.24
04
Epoch 21/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1411 - val_loss: 5.23
05
Epoch 22/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1332 - val_loss: 5.23
90
Epoch 23/500
11/11 [==============================] - 0s 26ms/step - loss: 5.1251 - val_loss: 5.21
80
Epoch 24/500
11/11 [==============================] - 0s 24ms/step - loss: 5.1097 - val_loss: 5.20
12
Epoch 25/500
11/11 [==============================] - 0s 27ms/step - loss: 5.0995 - val_loss: 5.18
70
Epoch 26/500
11/11 [==============================] - 0s 26ms/step - loss: 5.0810 - val_loss: 5.15
63
Epoch 27/500
11/11 [==============================] - 0s 27ms/step - loss: 5.0492 - val_loss: 5.08
58
Epoch 28/500
11/11 [==============================] - 0s 26ms/step - loss: 4.9553 - val_loss: 4.96
86
Epoch 29/500
11/11 [==============================] - 0s 24ms/step - loss: 4.8164 - val_loss: 4.77
37
Epoch 30/500
11/11 [==============================] - 0s 24ms/step - loss: 4.6224 - val_loss: 4.50
77
Epoch 31/500
11/11 [==============================] - 0s 27ms/step - loss: 4.3654 - val_loss: 4.17
82
Epoch 32/500
11/11 [==============================] - 0s 29ms/step - loss: 4.0221 - val_loss: 3.74
04
Epoch 33/500
11/11 [==============================] - 0s 25ms/step - loss: 3.6947 - val_loss: 3.47
18
Epoch 34/500
11/11 [==============================] - 0s 24ms/step - loss: 3.4169 - val_loss: 3.00
33
Epoch 35/500
11/11 [==============================] - 0s 25ms/step - loss: 3.1880 - val_loss: 2.92
81
Epoch 36/500
11/11 [==============================] - 0s 24ms/step - loss: 2.9247 - val_loss: 2.65
26
```

```
Epoch 37/500
11/11 [==============================] - 0s 27ms/step - loss: 2.7623 - val_loss: 2.61
22
Epoch 38/500
11/11 [==============================] - 0s 25ms/step - loss: 2.6760 - val_loss: 2.56
59
Epoch 39/500
11/11 [==============================] - 0s 23ms/step - loss: 2.6729 - val_loss: 2.59
46
Epoch 40/500
11/11 [==============================] - 0s 25ms/step - loss: 2.6252 - val_loss: 2.34
82
Epoch 41/500
11/11 [==============================] - 0s 24ms/step - loss: 2.5087 - val_loss: 2.32
72
Epoch 42/500
11/11 [==============================] - 0s 24ms/step - loss: 2.5139 - val_loss: 2.26
45
Epoch 43/500
11/11 [==============================] - 0s 24ms/step - loss: 2.4949 - val_loss: 2.22
96
Epoch 44/500
11/11 [==============================] - 0s 24ms/step - loss: 2.3907 - val_loss: 2.30
47
Epoch 45/500
11/11 [==============================] - 0s 27ms/step - loss: 2.3562 - val_loss: 2.18
92
Epoch 46/500
11/11 [==============================] - 0s 27ms/step - loss: 2.3460 - val_loss: 2.28
09
Epoch 47/500
11/11 [==============================] - 0s 27ms/step - loss: 2.3588 - val_loss: 2.14
44
Epoch 48/500
11/11 [==============================] - 0s 27ms/step - loss: 2.2317 - val_loss: 2.11
02
Epoch 49/500
11/11 [==============================] - 0s 29ms/step - loss: 2.2085 - val_loss: 1.99
09
Epoch 50/500
11/11 [==============================] - 0s 29ms/step - loss: 2.1753 - val_loss: 1.97
91
Epoch 51/500
11/11 [==============================] - 0s 29ms/step - loss: 2.1359 - val_loss: 2.09
45
Epoch 52/500
11/11 [==============================] - 0s 28ms/step - loss: 2.1326 - val_loss: 1.92
84
Epoch 53/500
11/11 [==============================] - 0s 27ms/step - loss: 2.1017 - val_loss: 1.95
19
Epoch 54/500
11/11 [==============================] - 0s 27ms/step - loss: 2.0985 - val_loss: 1.90
13
Epoch 55/500
11/11 [==============================] - 0s 27ms/step - loss: 2.1007 - val_loss: 1.94
95
Epoch 56/500
11/11 [==============================] - 0s 27ms/step - loss: 2.0429 - val_loss: 1.84
62
Epoch 57/500
11/11 [==============================] - 0s 27ms/step - loss: 2.0260 - val_loss: 1.92
95
Epoch 58/500
```

```
11/11 [==============================] - 0s 25ms/step - loss: 2.0337 - val_loss: 1.92
63
Epoch 59/500
11/11 [==============================] - 0s 24ms/step - loss: 2.0077 - val_loss: 1.86
35
Epoch 60/500
11/11 [==============================] - 0s 24ms/step - loss: 1.9552 - val_loss: 1.91
22
Epoch 61/500
11/11 [==============================] - 0s 24ms/step - loss: 1.9735 - val_loss: 1.78
18
Epoch 62/500
11/11 [==============================] - 0s 26ms/step - loss: 1.9456 - val_loss: 1.76
48
Epoch 63/500
11/11 [==============================] - 0s 26ms/step - loss: 1.8985 - val_loss: 1.76
57
Epoch 64/500
11/11 [==============================] - 0s 26ms/step - loss: 1.9054 - val_loss: 1.75
09
Epoch 65/500
11/11 [==============================] - 0s 25ms/step - loss: 1.9302 - val_loss: 1.82
72
Epoch 66/500
11/11 [==============================] - 0s 27ms/step - loss: 1.8979 - val_loss: 1.74
09
Epoch 67/500
11/11 [==============================] - 0s 27ms/step - loss: 1.9128 - val_loss: 1.87
10
Epoch 68/500
11/11 [==============================] - 0s 27ms/step - loss: 1.8973 - val_loss: 1.71
60
Epoch 69/500
11/11 [==============================] - 0s 27ms/step - loss: 1.8488 - val_loss: 1.72
23
Epoch 70/500
11/11 [==============================] - 0s 26ms/step - loss: 1.8087 - val_loss: 1.65
37
Epoch 71/500
11/11 [==============================] - 0s 24ms/step - loss: 1.8161 - val_loss: 1.64
15
Epoch 72/500
11/11 [==============================] - 0s 25ms/step - loss: 1.8222 - val_loss: 1.75
73
Epoch 73/500
11/11 [==============================] - 0s 24ms/step - loss: 1.7884 - val_loss: 1.61
88
Epoch 74/500
11/11 [==============================] - 0s 25ms/step - loss: 1.7760 - val_loss: 1.62
72
Epoch 75/500
11/11 [==============================] - 0s 24ms/step - loss: 1.7358 - val_loss: 1.64
08
Epoch 76/500
11/11 [==============================] - 0s 24ms/step - loss: 1.7239 - val_loss: 1.60
83
Epoch 77/500
11/11 [==============================] - 0s 25ms/step - loss: 1.7260 - val_loss: 1.61
83
Epoch 78/500
11/11 [==============================] - 0s 24ms/step - loss: 1.7210 - val_loss: 1.60
33
Epoch 79/500
11/11 [==============================] - 0s 23ms/step - loss: 1.7206 - val_loss: 1.63
```

```
76
Epoch 80/500
11/11 [==============================] - 0s 24ms/step - loss: 1.7264 - val_loss: 1.65
47
Epoch 81/500
11/11 [==============================] - 0s 24ms/step - loss: 1.7126 - val_loss: 1.85
33
Epoch 82/500
11/11 [==============================] - 0s 24ms/step - loss: 1.8486 - val_loss: 1.55
00
Epoch 83/500
11/11 [==============================] - 0s 22ms/step - loss: 1.7004 - val_loss: 1.58
19
Epoch 84/500
11/11 [==============================] - 0s 23ms/step - loss: 1.6551 - val_loss: 1.54
17
Epoch 85/500
11/11 [==============================] - 0s 23ms/step - loss: 1.6737 - val_loss: 1.57
50
Epoch 86/500
11/11 [==============================] - 0s 23ms/step - loss: 1.6215 - val_loss: 1.58
76
Epoch 87/500
11/11 [==============================] - 0s 24ms/step - loss: 1.6519 - val_loss: 1.49
43
Epoch 88/500
11/11 [==============================] - 0s 25ms/step - loss: 1.6319 - val_loss: 1.54
71
Epoch 89/500
11/11 [==============================] - 0s 24ms/step - loss: 1.5965 - val_loss: 1.53
50
Epoch 90/500
11/11 [==============================] - 0s 24ms/step - loss: 1.6101 - val_loss: 1.46
40
Epoch 91/500
11/11 [==============================] - 0s 24ms/step - loss: 1.5894 - val_loss: 1.47
99
Epoch 92/500
11/11 [==============================] - 0s 24ms/step - loss: 1.5900 - val_loss: 1.43
32
Epoch 93/500
11/11 [==============================] - 0s 24ms/step - loss: 1.5908 - val_loss: 1.44
67
Epoch 94/500
11/11 [==============================] - 0s 23ms/step - loss: 1.5805 - val_loss: 1.44
37
Epoch 95/500
11/11 [==============================] - 0s 24ms/step - loss: 1.5592 - val_loss: 1.40
49
Epoch 96/500
11/11 [==============================] - 0s 23ms/step - loss: 1.5637 - val_loss: 1.53
77
Epoch 97/500
11/11 [==============================] - 0s 24ms/step - loss: 1.6429 - val_loss: 1.42
22
Epoch 98/500
11/11 [==============================] - 0s 24ms/step - loss: 1.5412 - val_loss: 1.37
21
Epoch 99/500
11/11 [==============================] - 0s 23ms/step - loss: 1.5540 - val_loss: 1.49
87
Epoch 100/500
11/11 [==============================] - 0s 23ms/step - loss: 1.5331 - val_loss: 1.39
14
```

```
Epoch 101/500
11/11 [==============================] - 0s 25ms/step - loss: 1.5406 - val_loss: 1.37
45
Epoch 102/500
11/11 [==============================] - 0s 25ms/step - loss: 1.5386 - val_loss: 1.37
89
Epoch 103/500
11/11 [==============================] - 0s 26ms/step - loss: 1.5081 - val_loss: 1.42
27
```

In [30]:

```
# history.history['loss']
```

In [ ]:

In [31]:

```
plt.figure(figsize=(10,6))

plt.plot(history.history["loss"])
plt.plot(history.history["val_loss"])
plt.title("validation loss & training loss")
plt.xlabel("epochs")
plt.ylabel("loss")
leg = plt.legend(["training loss", "validation loss"],loc ="upper right");

plt.show()
```

In [ ]:

SOLUTION USING LSTM

In [32]:

```
inputs =tf.keras.layers.Input(shape=(None,1))
inputs_norm = tf.keras.layers.BatchNormalization()(inputs)
lstm= tf.keras.layers.LSTM(128, return_sequences=False)(inputs_norm)
```

```
outputs = tf.keras.layers.Dense(1, activation='linear')(lstm)
model = Model(inputs, outputs)
model.summary()
```

```
Model: "model_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 input_3 (InputLayer)        [(None, None, 1)]         0         
                                                                 
 batch_normalization_2 (Batc  (None, None, 1)          4         
 hNormalization)                                                 
                                                                 
 lstm_2 (LSTM)               (None, 128)               66560     
                                                                 
 dense_2 (Dense)             (None, 1)                 129       
                                                                 
=================================================================
Total params: 66,693
Trainable params: 66,691
Non-trainable params: 2
_________________________________________________________________
```

In [33]:

```
from tensorflow.keras.losses import MeanSquaredLogarithmicError

model.compile(optimizer='adam', loss=MeanSquaredLogarithmicError())
```

In [34]:

```
callback = tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=5)
```

In [35]:

```
history = model.fit(X, y, epochs=500, validation_split=0.2,callbacks=[callback])
```

```
Epoch 1/500
11/11 [==============================] - 3s 66ms/step - loss: 13.5424 - val_loss: 11.
9213
Epoch 2/500
11/11 [==============================] - 0s 25ms/step - loss: 8.3341 - val_loss: 5.67
18
Epoch 3/500
11/11 [==============================] - 0s 24ms/step - loss: 5.5016 - val_loss: 5.35
17
Epoch 4/500
11/11 [==============================] - 0s 27ms/step - loss: 5.2729 - val_loss: 5.29
61
Epoch 5/500
11/11 [==============================] - 0s 24ms/step - loss: 5.2238 - val_loss: 5.28
22
Epoch 6/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1993 - val_loss: 5.27
76
Epoch 7/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1893 - val_loss: 5.27
42
Epoch 8/500
11/11 [==============================] - 0s 30ms/step - loss: 5.1816 - val_loss: 5.26
76
Epoch 9/500
11/11 [==============================] - 0s 26ms/step - loss: 5.1750 - val_loss: 5.26
50
Epoch 10/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1703 - val_loss: 5.26
26
```

```
Epoch 11/500
11/11 [==============================] - 0s 26ms/step - loss: 5.1662 - val_loss: 5.26
12
Epoch 12/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1649 - val_loss: 5.26
53
Epoch 13/500
11/11 [==============================] - 0s 28ms/step - loss: 5.1591 - val_loss: 5.25
92
Epoch 14/500
11/11 [==============================] - 0s 25ms/step - loss: 5.1556 - val_loss: 5.25
67
Epoch 15/500
11/11 [==============================] - 0s 24ms/step - loss: 5.1536 - val_loss: 5.25
71
Epoch 16/500
11/11 [==============================] - 0s 23ms/step - loss: 5.1524 - val_loss: 5.25
27
Epoch 17/500
11/11 [==============================] - 0s 24ms/step - loss: 5.1460 - val_loss: 5.25
05
Epoch 18/500
11/11 [==============================] - 0s 26ms/step - loss: 5.1439 - val_loss: 5.24
43
Epoch 19/500
11/11 [==============================] - 0s 27ms/step - loss: 5.1407 - val_loss: 5.23
82
Epoch 20/500
11/11 [==============================] - 0s 26ms/step - loss: 5.1293 - val_loss: 5.22
85
Epoch 21/500
11/11 [==============================] - 0s 26ms/step - loss: 5.1169 - val_loss: 5.20
96
Epoch 22/500
11/11 [==============================] - 0s 26ms/step - loss: 5.0960 - val_loss: 5.16
87
Epoch 23/500
11/11 [==============================] - 0s 26ms/step - loss: 5.0528 - val_loss: 5.11
67
Epoch 24/500
11/11 [==============================] - 0s 27ms/step - loss: 4.9909 - val_loss: 5.02
51
Epoch 25/500
11/11 [==============================] - 0s 27ms/step - loss: 4.9096 - val_loss: 4.91
61
Epoch 26/500
11/11 [==============================] - 0s 29ms/step - loss: 4.7851 - val_loss: 4.73
23
Epoch 27/500
11/11 [==============================] - 0s 28ms/step - loss: 4.6142 - val_loss: 4.50
64
Epoch 28/500
11/11 [==============================] - 0s 27ms/step - loss: 4.3714 - val_loss: 4.16
73
Epoch 29/500
11/11 [==============================] - 0s 27ms/step - loss: 4.0975 - val_loss: 3.80
12
Epoch 30/500
11/11 [==============================] - 0s 27ms/step - loss: 3.8018 - val_loss: 3.51
36
Epoch 31/500
11/11 [==============================] - 0s 28ms/step - loss: 3.4796 - val_loss: 3.15
27
Epoch 32/500
```

```
11/11 [==============================] - 0s 28ms/step - loss: 3.2159 - val_loss: 3.03
34
Epoch 33/500
11/11 [==============================] - 0s 27ms/step - loss: 3.0132 - val_loss: 2.75
57
Epoch 34/500
11/11 [==============================] - 0s 27ms/step - loss: 2.9145 - val_loss: 2.70
59
Epoch 35/500
11/11 [==============================] - 0s 28ms/step - loss: 2.8338 - val_loss: 2.56
56
Epoch 36/500
11/11 [==============================] - 0s 26ms/step - loss: 2.7238 - val_loss: 2.48
38
Epoch 37/500
11/11 [==============================] - 0s 26ms/step - loss: 2.6492 - val_loss: 2.43
79
Epoch 38/500
11/11 [==============================] - 0s 24ms/step - loss: 2.6121 - val_loss: 2.41
39
Epoch 39/500
11/11 [==============================] - 0s 24ms/step - loss: 2.5443 - val_loss: 2.35
46
Epoch 40/500
11/11 [==============================] - 0s 24ms/step - loss: 2.5764 - val_loss: 2.36
40
Epoch 41/500
11/11 [==============================] - 0s 24ms/step - loss: 2.5272 - val_loss: 2.25
72
Epoch 42/500
11/11 [==============================] - 0s 25ms/step - loss: 2.4164 - val_loss: 2.24
82
Epoch 43/500
11/11 [==============================] - 0s 28ms/step - loss: 2.4069 - val_loss: 2.19
22
Epoch 44/500
11/11 [==============================] - 0s 28ms/step - loss: 2.3582 - val_loss: 2.17
54
Epoch 45/500
11/11 [==============================] - 0s 28ms/step - loss: 2.2992 - val_loss: 2.13
08
Epoch 46/500
11/11 [==============================] - 0s 26ms/step - loss: 2.3160 - val_loss: 2.29
26
Epoch 47/500
11/11 [==============================] - 0s 26ms/step - loss: 2.3054 - val_loss: 2.08
76
Epoch 48/500
11/11 [==============================] - 0s 26ms/step - loss: 2.2345 - val_loss: 2.03
86
Epoch 49/500
11/11 [==============================] - 0s 26ms/step - loss: 2.1985 - val_loss: 2.03
01
Epoch 50/500
11/11 [==============================] - 0s 25ms/step - loss: 2.2064 - val_loss: 2.00
18
Epoch 51/500
11/11 [==============================] - 0s 24ms/step - loss: 2.1498 - val_loss: 1.99
34
Epoch 52/500
11/11 [==============================] - 0s 24ms/step - loss: 2.1323 - val_loss: 1.92
68
Epoch 53/500
11/11 [==============================] - 0s 31ms/step - loss: 2.0971 - val_loss: 1.91
```

```
25
Epoch 54/500
11/11 [==============================] - 0s 28ms/step - loss: 2.0758 - val_loss: 1.91
14
Epoch 55/500
11/11 [==============================] - 0s 25ms/step - loss: 2.0504 - val_loss: 2.01
40
Epoch 56/500
11/11 [==============================] - 0s 23ms/step - loss: 2.0435 - val_loss: 1.86
47
Epoch 57/500
11/11 [==============================] - 0s 25ms/step - loss: 1.9979 - val_loss: 1.83
31
Epoch 58/500
11/11 [==============================] - 0s 23ms/step - loss: 2.0117 - val_loss: 2.03
16
Epoch 59/500
11/11 [==============================] - 0s 27ms/step - loss: 1.9923 - val_loss: 1.80
24
Epoch 60/500
11/11 [==============================] - 0s 25ms/step - loss: 1.9711 - val_loss: 1.77
47
Epoch 61/500
11/11 [==============================] - 0s 23ms/step - loss: 1.9471 - val_loss: 1.78
12
Epoch 62/500
11/11 [==============================] - 0s 24ms/step - loss: 1.9139 - val_loss: 1.79
14
Epoch 63/500
11/11 [==============================] - 0s 24ms/step - loss: 1.9005 - val_loss: 1.75
73
Epoch 64/500
11/11 [==============================] - 0s 22ms/step - loss: 1.9256 - val_loss: 1.88
36
Epoch 65/500
11/11 [==============================] - 0s 24ms/step - loss: 1.9129 - val_loss: 1.75
09
Epoch 66/500
11/11 [==============================] - 0s 23ms/step - loss: 1.9182 - val_loss: 1.76
59
Epoch 67/500
11/11 [==============================] - 0s 23ms/step - loss: 1.9040 - val_loss: 1.74
58
Epoch 68/500
11/11 [==============================] - 0s 23ms/step - loss: 1.9317 - val_loss: 1.68
31
Epoch 69/500
11/11 [==============================] - 0s 23ms/step - loss: 1.8513 - val_loss: 1.77
95
Epoch 70/500
11/11 [==============================] - 0s 21ms/step - loss: 1.9850 - val_loss: 1.90
35
Epoch 71/500
11/11 [==============================] - 0s 23ms/step - loss: 1.9023 - val_loss: 1.63
12
Epoch 72/500
11/11 [==============================] - 0s 22ms/step - loss: 1.8126 - val_loss: 1.66
19
Epoch 73/500
11/11 [==============================] - 0s 23ms/step - loss: 1.8081 - val_loss: 1.77
31
Epoch 74/500
11/11 [==============================] - 0s 24ms/step - loss: 1.7855 - val_loss: 1.64
22
```

```
Epoch 75/500
11/11 [==============================] - 0s 27ms/step - loss: 1.8123 - val_loss: 1.67
44
Epoch 76/500
11/11 [==============================] - 0s 24ms/step - loss: 1.7649 - val_loss: 1.65
07
```

In [36]:

```
plt.figure(figsize=(10,6))

plt.plot(history.history["loss"])
plt.plot(history.history["val_loss"])
plt.title("validation loss & training loss")
plt.xlabel("epochs")
plt.ylabel("loss")
leg = plt.legend(["training loss", "validation loss"],loc ="upper right");

plt.show()
```

In [ ]:

SOLUTION USING NORMAL NEURAL NETWORK

In [37]:

```
multi_step_dense = tf.keras.Sequential([
    tf.keras.layers.Input(shape=(24,1)),
    tf.keras.layers.Flatten(),
    tf.keras.layers.BatchNormalization(),

    # Shape: (time, features) => (time*features)
    tf.keras.layers.Dense(units=32, activation='relu'),
    tf.keras.layers.Dense(units=1),
])
```

```
multi_step_dense.summary()

from tensorflow.keras.losses import MeanSquaredLogarithmicError

multi_step_dense.compile(optimizer='adam', loss=MeanSquaredLogarithmicError())
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 flatten (Flatten)           (None, 24)                0         
                                                                 
 batch_normalization_3 (Batc  (None, 24)               96        
 hNormalization)                                                 
                                                                 
 dense_3 (Dense)             (None, 32)                800       
                                                                 
 dense_4 (Dense)             (None, 1)                 33        
                                                                 
=================================================================
Total params: 929
Trainable params: 881
Non-trainable params: 48
_________________________________________________________________
```

In [38]:

```
callback = tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=3)
history = multi_step_dense.fit(X, y, epochs=350, validation_split=0.2,callbacks=[cal
```

```
Epoch 1/350
11/11 [==============================] - 1s 17ms/step - loss: 13.5953 - val_loss: 10.
4769
Epoch 2/350
11/11 [==============================] - 0s 6ms/step - loss: 12.5449 - val_loss: 9.32
44
Epoch 3/350
11/11 [==============================] - 0s 6ms/step - loss: 11.2237 - val_loss: 8.49
08
Epoch 4/350
11/11 [==============================] - 0s 6ms/step - loss: 10.1276 - val_loss: 7.89
16
Epoch 5/350
11/11 [==============================] - 0s 6ms/step - loss: 9.2581 - val_loss: 7.407
5
Epoch 6/350
11/11 [==============================] - 0s 6ms/step - loss: 8.5748 - val_loss: 7.041
6
Epoch 7/350
11/11 [==============================] - 0s 6ms/step - loss: 8.0204 - val_loss: 6.716
4
Epoch 8/350
11/11 [==============================] - 0s 5ms/step - loss: 7.5923 - val_loss: 6.425
0
Epoch 9/350
11/11 [==============================] - 0s 6ms/step - loss: 7.1347 - val_loss: 6.159
7
Epoch 10/350
11/11 [==============================] - 0s 5ms/step - loss: 6.8078 - val_loss: 5.914
2
Epoch 11/350
11/11 [==============================] - 0s 5ms/step - loss: 6.4196 - val_loss: 5.670
8
Epoch 12/350
11/11 [==============================] - 0s 5ms/step - loss: 6.1705 - val_loss: 5.451
```

```
0
Epoch 13/350
11/11 [==============================] - 0s 5ms/step - loss: 5.8852 - val_loss: 5.241
7
Epoch 14/350
11/11 [==============================] - 0s 5ms/step - loss: 5.6271 - val_loss: 5.041
7
Epoch 15/350
11/11 [==============================] - 0s 5ms/step - loss: 5.4059 - val_loss: 4.857
2
Epoch 16/350
11/11 [==============================] - 0s 5ms/step - loss: 5.1700 - val_loss: 4.687
7
Epoch 17/350
11/11 [==============================] - 0s 5ms/step - loss: 4.9974 - val_loss: 4.513
7
Epoch 18/350
11/11 [==============================] - 0s 6ms/step - loss: 4.7486 - val_loss: 4.359
7
Epoch 19/350
11/11 [==============================] - 0s 5ms/step - loss: 4.5804 - val_loss: 4.208
0
Epoch 20/350
11/11 [==============================] - 0s 5ms/step - loss: 4.4259 - val_loss: 4.068
4
Epoch 21/350
11/11 [==============================] - 0s 6ms/step - loss: 4.2773 - val_loss: 3.938
6
Epoch 22/350
11/11 [==============================] - 0s 6ms/step - loss: 4.1789 - val_loss: 3.816
4
Epoch 23/350
11/11 [==============================] - 0s 6ms/step - loss: 3.9548 - val_loss: 3.703
3
Epoch 24/350
11/11 [==============================] - 0s 5ms/step - loss: 3.8323 - val_loss: 3.590
7
Epoch 25/350
11/11 [==============================] - 0s 5ms/step - loss: 3.7165 - val_loss: 3.484
2
Epoch 26/350
11/11 [==============================] - 0s 5ms/step - loss: 3.6225 - val_loss: 3.380
6
Epoch 27/350
11/11 [==============================] - 0s 5ms/step - loss: 3.5362 - val_loss: 3.289
6
Epoch 28/350
11/11 [==============================] - 0s 5ms/step - loss: 3.4121 - val_loss: 3.196
5
Epoch 29/350
11/11 [==============================] - 0s 5ms/step - loss: 3.2984 - val_loss: 3.105
2
Epoch 30/350
11/11 [==============================] - 0s 5ms/step - loss: 3.1845 - val_loss: 3.019
6
Epoch 31/350
11/11 [==============================] - 0s 5ms/step - loss: 3.1377 - val_loss: 2.943
6
Epoch 32/350
11/11 [==============================] - 0s 5ms/step - loss: 3.0547 - val_loss: 2.870
0
Epoch 33/350
11/11 [==============================] - 0s 5ms/step - loss: 2.9572 - val_loss: 2.797
4
```

```
Epoch 34/350
11/11 [==============================] - 0s 6ms/step - loss: 2.9073 - val_loss: 2.730
0
Epoch 35/350
11/11 [==============================] - 0s 5ms/step - loss: 2.9142 - val_loss: 2.663
5
Epoch 36/350
11/11 [==============================] - 0s 5ms/step - loss: 2.7625 - val_loss: 2.607
4
Epoch 37/350
11/11 [==============================] - 0s 5ms/step - loss: 2.6769 - val_loss: 2.547
0
Epoch 38/350
11/11 [==============================] - 0s 5ms/step - loss: 2.6479 - val_loss: 2.496
2
Epoch 39/350
11/11 [==============================] - 0s 5ms/step - loss: 2.5987 - val_loss: 2.448
2
Epoch 40/350
11/11 [==============================] - 0s 5ms/step - loss: 2.5424 - val_loss: 2.397
8
Epoch 41/350
11/11 [==============================] - 0s 6ms/step - loss: 2.4837 - val_loss: 2.346
5
Epoch 42/350
11/11 [==============================] - 0s 5ms/step - loss: 2.3900 - val_loss: 2.297
4
Epoch 43/350
11/11 [==============================] - 0s 6ms/step - loss: 2.3555 - val_loss: 2.251
4
Epoch 44/350
11/11 [==============================] - 0s 6ms/step - loss: 2.3410 - val_loss: 2.205
9
Epoch 45/350
11/11 [==============================] - 0s 5ms/step - loss: 2.2861 - val_loss: 2.164
6
Epoch 46/350
11/11 [==============================] - 0s 5ms/step - loss: 2.2295 - val_loss: 2.125
3
Epoch 47/350
11/11 [==============================] - 0s 5ms/step - loss: 2.2191 - val_loss: 2.089
5
Epoch 48/350
11/11 [==============================] - 0s 5ms/step - loss: 2.1807 - val_loss: 2.057
0
Epoch 49/350
11/11 [==============================] - 0s 5ms/step - loss: 2.1469 - val_loss: 2.022
4
Epoch 50/350
11/11 [==============================] - 0s 5ms/step - loss: 2.0561 - val_loss: 1.992
7
Epoch 51/350
11/11 [==============================] - 0s 5ms/step - loss: 2.0357 - val_loss: 1.961
1
Epoch 52/350
11/11 [==============================] - 0s 5ms/step - loss: 2.0087 - val_loss: 1.934
5
Epoch 53/350
11/11 [==============================] - 0s 5ms/step - loss: 2.0173 - val_loss: 1.903
8
Epoch 54/350
11/11 [==============================] - 0s 5ms/step - loss: 1.9822 - val_loss: 1.876
3
Epoch 55/350
```

```
11/11 [==============================] - 0s 4ms/step - loss: 2.0159 - val_loss: 1.849
3
Epoch 56/350
11/11 [==============================] - 0s 4ms/step - loss: 1.9065 - val_loss: 1.826
4
Epoch 57/350
11/11 [==============================] - 0s 5ms/step - loss: 1.9622 - val_loss: 1.800
5
Epoch 58/350
11/11 [==============================] - 0s 9ms/step - loss: 1.8812 - val_loss: 1.777
8
Epoch 59/350
11/11 [==============================] - 0s 8ms/step - loss: 1.8360 - val_loss: 1.748
6
Epoch 60/350
11/11 [==============================] - 0s 5ms/step - loss: 1.7934 - val_loss: 1.726
3
Epoch 61/350
11/11 [==============================] - 0s 5ms/step - loss: 1.7642 - val_loss: 1.709
7
Epoch 62/350
11/11 [==============================] - 0s 5ms/step - loss: 1.7485 - val_loss: 1.693
7
Epoch 63/350
11/11 [==============================] - 0s 5ms/step - loss: 1.7339 - val_loss: 1.677
8
Epoch 64/350
11/11 [==============================] - 0s 5ms/step - loss: 1.7368 - val_loss: 1.658
2
Epoch 65/350
11/11 [==============================] - 0s 5ms/step - loss: 1.7315 - val_loss: 1.636
7
Epoch 66/350
11/11 [==============================] - 0s 5ms/step - loss: 1.7296 - val_loss: 1.619
1
Epoch 67/350
11/11 [==============================] - 0s 5ms/step - loss: 1.6282 - val_loss: 1.602
4
Epoch 68/350
11/11 [==============================] - 0s 5ms/step - loss: 1.5853 - val_loss: 1.588
7
Epoch 69/350
11/11 [==============================] - 0s 4ms/step - loss: 1.6612 - val_loss: 1.574
2
Epoch 70/350
11/11 [==============================] - 0s 4ms/step - loss: 1.6413 - val_loss: 1.560
1
Epoch 71/350
11/11 [==============================] - 0s 4ms/step - loss: 1.5875 - val_loss: 1.546
0
Epoch 72/350
11/11 [==============================] - 0s 5ms/step - loss: 1.6060 - val_loss: 1.530
4
Epoch 73/350
11/11 [==============================] - 0s 5ms/step - loss: 1.5427 - val_loss: 1.514
9
Epoch 74/350
11/11 [==============================] - 0s 5ms/step - loss: 1.5323 - val_loss: 1.499
8
Epoch 75/350
11/11 [==============================] - 0s 4ms/step - loss: 1.5647 - val_loss: 1.487
3
Epoch 76/350
11/11 [==============================] - 0s 4ms/step - loss: 1.5520 - val_loss: 1.476
```

```
4
Epoch 77/350
11/11 [==============================] - 0s 5ms/step - loss: 1.4995 - val_loss: 1.463
8
Epoch 78/350
11/11 [==============================] - 0s 5ms/step - loss: 1.4861 - val_loss: 1.450
3
Epoch 79/350
11/11 [==============================] - 0s 5ms/step - loss: 1.4698 - val_loss: 1.438
6
Epoch 80/350
11/11 [==============================] - 0s 5ms/step - loss: 1.5441 - val_loss: 1.430
2
Epoch 81/350
11/11 [==============================] - 0s 5ms/step - loss: 1.4869 - val_loss: 1.422
7
Epoch 82/350
11/11 [==============================] - 0s 5ms/step - loss: 1.4458 - val_loss: 1.417
4
Epoch 83/350
11/11 [==============================] - 0s 5ms/step - loss: 1.3808 - val_loss: 1.407
1
Epoch 84/350
11/11 [==============================] - 0s 5ms/step - loss: 1.4340 - val_loss: 1.395
9
Epoch 85/350
11/11 [==============================] - 0s 4ms/step - loss: 1.4352 - val_loss: 1.384
0
Epoch 86/350
11/11 [==============================] - 0s 5ms/step - loss: 1.4651 - val_loss: 1.373
2
Epoch 87/350
11/11 [==============================] - 0s 4ms/step - loss: 1.4430 - val_loss: 1.361
2
Epoch 88/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3673 - val_loss: 1.353
3
Epoch 89/350
11/11 [==============================] - 0s 4ms/step - loss: 1.4529 - val_loss: 1.343
1
Epoch 90/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3913 - val_loss: 1.332
9
Epoch 91/350
11/11 [==============================] - 0s 4ms/step - loss: 1.4317 - val_loss: 1.323
3
Epoch 92/350
11/11 [==============================] - 0s 4ms/step - loss: 1.4761 - val_loss: 1.315
3
Epoch 93/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3553 - val_loss: 1.305
1
Epoch 94/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3633 - val_loss: 1.298
0
Epoch 95/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3727 - val_loss: 1.293
1
Epoch 96/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3016 - val_loss: 1.286
7
Epoch 97/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3697 - val_loss: 1.278
9
```

```
Epoch 98/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3664 - val_loss: 1.268
4
Epoch 99/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3446 - val_loss: 1.263
9
Epoch 100/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2658 - val_loss: 1.256
9
Epoch 101/350
11/11 [==============================] - 0s 4ms/step - loss: 1.3319 - val_loss: 1.250
8
Epoch 102/350
11/11 [==============================] - 0s 5ms/step - loss: 1.2627 - val_loss: 1.247
6
Epoch 103/350
11/11 [==============================] - 0s 5ms/step - loss: 1.3490 - val_loss: 1.244
3
Epoch 104/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2383 - val_loss: 1.237
5
Epoch 105/350
11/11 [==============================] - 0s 5ms/step - loss: 1.3086 - val_loss: 1.231
6
Epoch 106/350
11/11 [==============================] - 0s 5ms/step - loss: 1.2864 - val_loss: 1.220
7
Epoch 107/350
11/11 [==============================] - 0s 6ms/step - loss: 1.3562 - val_loss: 1.215
0
Epoch 108/350
11/11 [==============================] - 0s 5ms/step - loss: 1.2313 - val_loss: 1.210
8
Epoch 109/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2610 - val_loss: 1.203
5
Epoch 110/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2168 - val_loss: 1.197
0
Epoch 111/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2878 - val_loss: 1.191
5
Epoch 112/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1886 - val_loss: 1.185
3
Epoch 113/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2036 - val_loss: 1.183
0
Epoch 114/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2511 - val_loss: 1.175
7
Epoch 115/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2048 - val_loss: 1.168
0
Epoch 116/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2353 - val_loss: 1.164
6
Epoch 117/350
11/11 [==============================] - 0s 4ms/step - loss: 1.2628 - val_loss: 1.158
6
Epoch 118/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1599 - val_loss: 1.156
5
Epoch 119/350
```

```
11/11 [==============================] - 0s 4ms/step - loss: 1.2839 - val_loss: 1.150
3
Epoch 120/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1752 - val_loss: 1.144
5
Epoch 121/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1318 - val_loss: 1.140
1
Epoch 122/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1649 - val_loss: 1.135
4
Epoch 123/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1526 - val_loss: 1.128
8
Epoch 124/350
11/11 [==============================] - 0s 5ms/step - loss: 1.2035 - val_loss: 1.124
4
Epoch 125/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1672 - val_loss: 1.124
7
Epoch 126/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1008 - val_loss: 1.125
0
Epoch 127/350
11/11 [==============================] - 0s 6ms/step - loss: 1.1739 - val_loss: 1.123
2
Epoch 128/350
11/11 [==============================] - 0s 5ms/step - loss: 1.2029 - val_loss: 1.121
3
Epoch 129/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1380 - val_loss: 1.116
0
Epoch 130/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1162 - val_loss: 1.108
8
Epoch 131/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1391 - val_loss: 1.104
8
Epoch 132/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1020 - val_loss: 1.102
1
Epoch 133/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1566 - val_loss: 1.104
7
Epoch 134/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1465 - val_loss: 1.104
4
Epoch 135/350
11/11 [==============================] - 0s 5ms/step - loss: 1.0628 - val_loss: 1.097
9
Epoch 136/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1077 - val_loss: 1.089
8
Epoch 137/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1317 - val_loss: 1.082
3
Epoch 138/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1774 - val_loss: 1.078
4
Epoch 139/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1041 - val_loss: 1.075
6
Epoch 140/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1547 - val_loss: 1.073
```

```
4
Epoch 141/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1458 - val_loss: 1.068
0
Epoch 142/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1010 - val_loss: 1.065
7
Epoch 143/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1266 - val_loss: 1.065
4
Epoch 144/350
11/11 [==============================] - 0s 4ms/step - loss: 1.0925 - val_loss: 1.060
3
Epoch 145/350
11/11 [==============================] - 0s 4ms/step - loss: 1.0734 - val_loss: 1.054
9
Epoch 146/350
11/11 [==============================] - 0s 4ms/step - loss: 1.0745 - val_loss: 1.050
3
Epoch 147/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1582 - val_loss: 1.049
5
Epoch 148/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1003 - val_loss: 1.047
3
Epoch 149/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1564 - val_loss: 1.047
6
Epoch 150/350
11/11 [==============================] - 0s 4ms/step - loss: 1.0315 - val_loss: 1.048
6
Epoch 151/350
11/11 [==============================] - 0s 4ms/step - loss: 1.0430 - val_loss: 1.046
6
Epoch 152/350
11/11 [==============================] - 0s 4ms/step - loss: 1.1252 - val_loss: 1.041
9
Epoch 153/350
11/11 [==============================] - 0s 5ms/step - loss: 1.0859 - val_loss: 1.036
9
Epoch 154/350
11/11 [==============================] - 0s 5ms/step - loss: 1.0733 - val_loss: 1.035
5
Epoch 155/350
11/11 [==============================] - 0s 5ms/step - loss: 1.0699 - val_loss: 1.030
5
Epoch 156/350
11/11 [==============================] - 0s 5ms/step - loss: 0.9967 - val_loss: 1.029
4
Epoch 157/350
11/11 [==============================] - 0s 5ms/step - loss: 1.0342 - val_loss: 1.025
6
Epoch 158/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1022 - val_loss: 1.022
6
Epoch 159/350
11/11 [==============================] - 0s 5ms/step - loss: 1.0636 - val_loss: 1.023
2
Epoch 160/350
11/11 [==============================] - 0s 5ms/step - loss: 1.0603 - val_loss: 1.026
3
Epoch 161/350
11/11 [==============================] - 0s 6ms/step - loss: 1.1588 - val_loss: 1.019
7
```

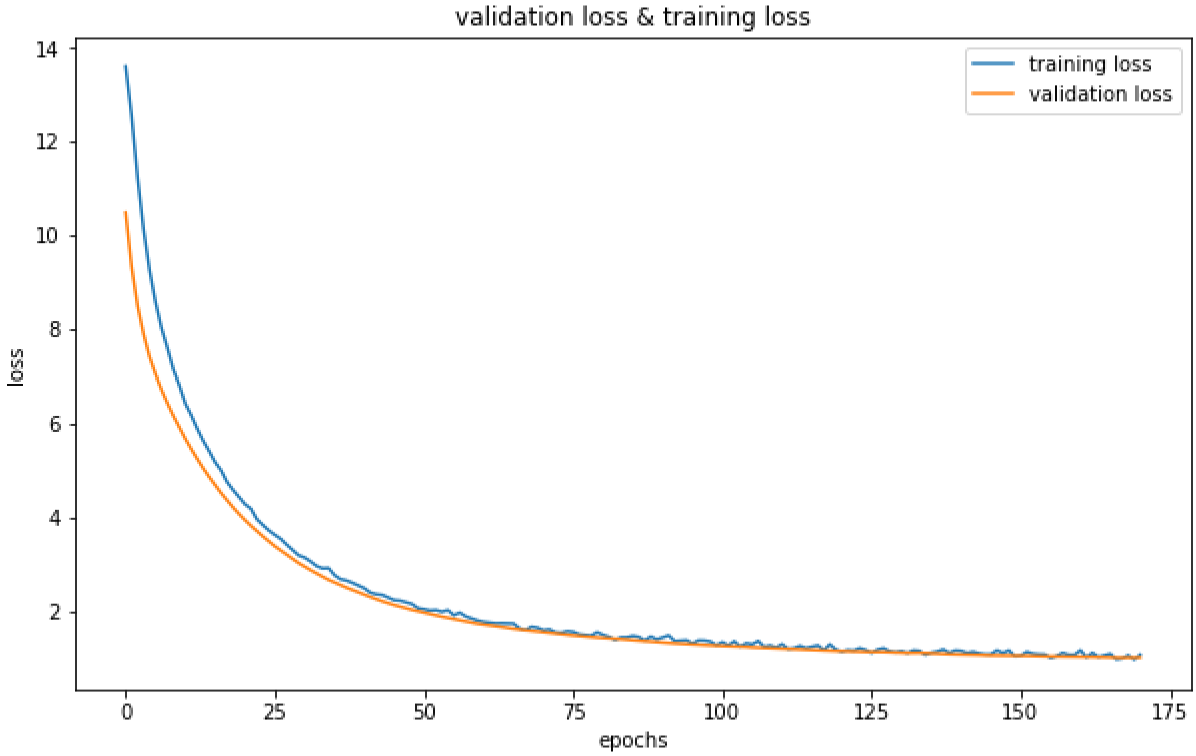
```
Epoch 162/350
11/11 [==============================] - 0s 5ms/step - loss: 1.0088 - val_loss: 1.020
1
Epoch 163/350
11/11 [==============================] - 0s 5ms/step - loss: 1.1033 - val_loss: 1.018
3
Epoch 164/350
11/11 [==============================] - 0s 5ms/step - loss: 1.0183 - val_loss: 1.013
8
Epoch 165/350
11/11 [==============================] - 0s 4ms/step - loss: 1.0522 - val_loss: 1.011
4
Epoch 166/350
11/11 [==============================] - 0s 4ms/step - loss: 1.0824 - val_loss: 1.007
8
Epoch 167/350
11/11 [==============================] - 0s 4ms/step - loss: 0.9675 - val_loss: 1.002
5
Epoch 168/350
11/11 [==============================] - 0s 4ms/step - loss: 0.9868 - val_loss: 1.000
5
Epoch 169/350
11/11 [==============================] - 0s 4ms/step - loss: 1.0515 - val_loss: 1.000
5
Epoch 170/350
11/11 [==============================] - 0s 4ms/step - loss: 0.9623 - val_loss: 1.000
5
Epoch 171/350
11/11 [==============================] - 0s 4ms/step - loss: 1.0621 - val_loss: 1.005
1
```

In [39]:

```
plt.figure(figsize=(10,6))

plt.plot(history.history["loss"])
plt.plot(history.history["val_loss"])
plt.title("validation loss & training loss")
plt.xlabel("epochs")
plt.ylabel("loss")
leg = plt.legend(["training loss", "validation loss"],loc ="upper right");

plt.show()
```


validation loss & training loss
training loss
validation loss
loss
epochs
14
12
10
8
6
4
2
0
25
50
75
100
125
150
175

In [ ]: