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Exercise 2.2
Complex Machine Learning Models

1. CNN (Convolution Neural Network)
    - With the continuous change in hyperparameters. I settled with
      Epoch: 30
      Batch_size = 32
      N_hidden = 124
    - This gave an accuracy of 13%
    - The loss grows quite a lot through each epoch processing.
    - The activation ' Softmax' works the best when accurately predicting

```
# Create a Keras leyered model. Use initial hyperparameters: 30, 32, 124, softtmax

epochs = 30
batch_size = 32
n_hidden = 124

timesteps = len(X_train[0])
input_dim = len(X_train[0][0])
n_classes = len(y_train[0])

model = Sequential()
model.add(Conv1D(n_hidden, kernel_size=2, activation='relu', input_shape=(timesteps, input_dim)))
model.add(Dense(16, activation='relu'))
model.add(MaxPooling1D())
model.add(Flatten())
model.add(Dense(n_classes, activation='softmax')) #softmax
```

```
Epoch 1/30
574/574 - 2s - 3ms/step - accuracy: 0.1122 - loss: 3322.4768
Epoch 2/30
574/574 - 1s - 1ms/step - accuracy: 0.1092 - loss: 28904.5176
Epoch 3/30
574/574 - 1s - 1ms/step - accuracy: 0.1135 - loss: 98123.7734
Epoch 4/30
574/574 - 1s - 1ms/step - accuracy: 0.1121 - loss: 222794.7344
Epoch 5/30
574/574 - 1s - 1ms/step - accuracy: 0.1141 - loss: 410069.5938
Epoch 6/30
574/574 - 1s - 1ms/step - accuracy: 0.1163 - loss: 655449.1250
Epoch 7/30
574/574 - 1s - 1ms/step - accuracy: 0.1168 - loss: 940525.8125
Epoch 8/30
574/574 - 1s - 1ms/step - accuracy: 0.1156 - loss: 1340234.1250
Epoch 9/30
574/574 - 1s - 1ms/step - accuracy: 0.1181 - loss: 1748423.5000
Epoch 10/30
574/574 - 1s - 1ms/step - accuracy: 0.1207 - loss: 2288331.7500
Epoch 11/30
574/574 - 1s - 1ms/step - accuracy: 0.1216 - loss: 2831586.5000
Epoch 12/30
574/574 - 1s - 1ms/step - accuracy: 0.1241 - loss: 3477688.0000
Epoch 13/30
574/574 - 1s - 1ms/step - accuracy: 0.1247 - loss: 4270880.5000
Epoch 14/30
574/574 - 1s - 1ms/step - accuracy: 0.1194 - loss: 5063831.0000
Epoch 15/30
574/574 - 1s - 1ms/step - accuracy: 0.1204 - loss: 5912756.5000
Epoch 16/30
574/574 - 1s - 1ms/step - accuracy: 0.1223 - loss: 6972762.0000
Epoch 17/30
574/574 - 1s - 1ms/step - accuracy: 0.1271 - loss: 8045972.5000
Epoch 18/30
574/574 - 1s - 1ms/step - accuracy: 0.1256 - loss: 9142060.0000
Epoch 19/30
574/574 - 1s - 1ms/step - accuracy: 0.1254 - loss: 10471365.0000
Epoch 20/30
574/574 - 1s - 1ms/step - accuracy: 0.1259 - loss: 11748533.0000
Epoch 21/30
574/574 - 1s - 1ms/step - accuracy: 0.1204 - loss: 13204114.0000
Epoch 22/30
574/574 - 1s - 1ms/step - accuracy: 0.1226 - loss: 14752302.0000
Epoch 23/30
574/574 - 1s - 1ms/step - accuracy: 0.1211 - loss: 16408173.0000
Epoch 24/30
574/574 - 1s - 1ms/step - accuracy: 0.1192 - loss: 18075764.0000
Epoch 25/30
574/574 - 1s - 1ms/step - accuracy: 0.1179 - loss: 19963706.0000
Epoch 26/30
574/574 - 1s - 1ms/step - accuracy: 0.1209 - loss: 21850274.0000
Epoch 27/30
574/574 - 1s - 1ms/step - accuracy: 0.1153 - loss: 24054456.0000
Epoch 28/30
574/574 - 1s - 1ms/step - accuracy: 0.1162 - loss: 26270816.0000
Epoch 29/30
574/574 - 1s - 1ms/step - accuracy: 0.1191 - loss: 28510532.0000
Epoch 30/30
574/574 - 1s - 1ms/step - accuracy: 0.1158 - loss: 31055964.0000
```

Pred	LJUBLJANA	MAASTRICHT	MADRID	OSLO	SONNBLICK	STOCKHOLM	\
True							
BASEL	344	76	1090	107	3	16	
BELGRADE	27	0	380	22	0	3	
BUDAPEST	2	0	82	9	0	0	
DEBILT	1	0	27	5	0	0	
DUSSELDORF	1	0	15	1	0	0	
HEATHROW	1	0	39	9	0	0	
KASSEL	0	0	5	0	0	0	
LJUBLJANA	4	0	24	3	0	0	
MAASTRICHT	0	0	4	0	0	0	
MADRID	10	0	212	24	0	0	
MUNCHENB	0	0	4	0	0	0	
OSLO	0	0	2	0	0	0	
STOCKHOLM	0	0	1	1	0	0	
VALENTIA	0	0	2	0	0	0	

Pred	LJUBLJANA	MAASTRICHT	MADRID	OSLO	SONNBLICK	STOCKHOLM	\
True							
BASEL	344	76	1090	107	3	16	
BELGRADE	27	0	380	22	0	3	
BUDAPEST	2	0	82	9	0	0	
DEBILT	1	0	27	5	0	0	
DUSSELDORF	1	0	15	1	0	0	
HEATHROW	1	0	39	9	0	0	
KASSEL	0	0	5	0	0	0	
LJUBLJANA	4	0	24	3	0	0	
MAASTRICHT	0	0	4	0	0	0	
MADRID	10	0	212	24	0	0	
MUNCHENB	0	0	4	0	0	0	
OSLO	0	0	2	0	0	0	
STOCKHOLM	0	0	1	1	0	0	
VALENTIA	0	0	2	0	0	0	

Pred	VALENTIA
True	
BASEL	23
BELGRADE	0
BUDAPEST	0
DEBILT	0
DUSSELDORF	0
HEATHROW	0
KASSEL	0
LJUBLJANA	0
MAASTRICHT	0
MADRID	0
MUNCHENB	0
OSLO	0
STOCKHOLM	0
VALENTIA	0

2. RNN (Recurrent Neural Network)
    - With the continuous change in hyperparameters. I settled with
      Epoch: 20
      Batch_size = 32
      N_hidden = 84
    - This gave an accuracy of 10% and lower
    - The processing time of RNN is significantly slower than the CNN
    - The loss increases with every epoch but is not as large as the CNN
    - The activation 'Sigmoid' gets the best result
    - This model does not recognize all the weather station

```
# Create a Keras leyered model. Change activation type: 30, 32, 64, sigmoid
epochs = 20
batch_size = 32
n_hidden = 84

timesteps = len(X_train[0])
input_dim = len(X_train[0][0])
n_classes = len(y_train[0])

model = Sequential()
model.add(LSTM(n_hidden, input_shape=(timesteps, input_dim)))
model.add(Dropout(0.5))
model.add(Dense(n_classes, activation='sigmoid'))
```

```
Epoch 1/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 4s 5ms/step - accuracy: 0.1087 - loss: 10.8501 - val_accuracy: 0.1887 - val_loss: 9.27
77
Epoch 2/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0982 - loss: 11.6296 - val_accuracy: 0.0519 - val_loss: 9.55
95
Epoch 3/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0911 - loss: 11.5146 - val_accuracy: 0.0420 - val_loss: 10.0
103
Epoch 4/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0994 - loss: 12.0766 - val_accuracy: 0.0298 - val_loss: 10.5
125
Epoch 5/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0887 - loss: 12.3604 - val_accuracy: 0.0479 - val_loss: 10.8
587
Epoch 6/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0863 - loss: 12.5137 - val_accuracy: 0.0538 - val_loss: 11.4
028
Epoch 7/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0909 - loss: 13.0606 - val_accuracy: 0.0453 - val_loss: 11.7
446
Epoch 8/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0888 - loss: 13.1860 - val_accuracy: 0.0418 - val_loss: 11.8
407
Epoch 9/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0909 - loss: 13.4485 - val_accuracy: 0.0318 - val_loss: 12.3
010
Epoch 10/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0884 - loss: 13.8676 - val_accuracy: 0.0305 - val_loss: 12.8
018
Epoch 11/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0818 - loss: 14.1218 - val_accuracy: 0.0366 - val_loss: 13.1
076
Epoch 12/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0797 - loss: 14.3601 - val_accuracy: 0.0327 - val_loss: 13.4
880
Epoch 13/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0828 - loss: 14.8175 - val_accuracy: 0.0451 - val_loss: 13.9
034
Epoch 14/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 6ms/step - accuracy: 0.0825 - loss: 15.1959 - val_accuracy: 0.0418 - val_loss: 14.0
963
```

```
Epoch 15/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0877 - loss: 14.9920 - val_accuracy: 0.0534 - val_loss: 14.3
030
Epoch 16/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 6ms/step - accuracy: 0.0823 - loss: 15.5096 - val_accuracy: 0.0399 - val_loss: 14.8
809
Epoch 17/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 6ms/step - accuracy: 0.0805 - loss: 15.9259 - val_accuracy: 0.0436 - val_loss: 15.1
548
Epoch 18/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0867 - loss: 15.8826 - val_accuracy: 0.0453 - val_loss: 15.4
051
Epoch 19/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0724 - loss: 16.1122 - val_accuracy: 0.0431 - val_loss: 15.6
386
Epoch 20/20
574/574 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.0726 - loss: 16.2900 - val_accuracy: 0.0333 - val_loss: 15.9
253
```

```
144/144 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
```

Pred	BASEL	MADRID
True		
BASEL	2962	0
BELGRADE	882	0
BUDAPEST	160	0
DEBILT	75	0
DUSSELDORF	17	0
HEATHROW	75	0
KASSEL	16	0
LJUBLJANA	41	0
MAASTRICHT	9	0
MADRID	338	2
MUNCHENB	5	0
OSLO	5	0
STOCKHOLM	1	0
VALENTIA	2	0