# jjoy6_assignment_1

February 16, 2025

Assignent_1 Jacob Joy

Loading the IMDB dataset

[1]:

```
#Importing libraries that will be used
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
import os
import random
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.regularizers import l2

#importing IMBD Dataset and setting word count to top 10,000
from tensorflow.keras.datasets import imdb
(train_data, train_labels), (test_data, test_labels) = imdb.
 ↪load_data(num_words=10000)

#Attempting to add some standardisation to RNG for better comparisons
#Setting seed to 113 as this is the default seed used in the IMBD data set
os.environ['PYTHONHASHSEED'] = str(113)
random.seed(113)

# Set the seed for NumPy
np.random.seed(113)

# Set the seed for TensorFlow
tf.random.set_seed(113)

# Enable deterministic operations
tf.config.experimental.enable_op_determinism()

# Setting the seed may not make exactly reproducable results but helps to keep␣
 ↪them as close as can be without more complex coding.
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/imdb.npz
17464789/17464789              0s
```

```
0us/step
```

Multi-hot encoding of data and labels

[2]:

```
# Using manual Multi-hot encoding
# Attempted to use keras to_categorical but would run out of memory
def vectorize_sequences(sequences, dimension=10000):
    results = np.zeros((len(sequences), dimension))
    for i, sequence in enumerate(sequences):
        for j in sequence:
            results[i, j] = 1.
    return results

x_train = vectorize_sequences(train_data)
x_test = vectorize_sequences(test_data)

y_train = np.asarray(train_labels).astype("float32")
y_test = np.asarray(test_labels).astype("float32")
```

Validation Set

[3]:

```
#Creation of validation set from the training data
x_val = x_train[:10000]
partial_x_train = x_train[10000:]
y_val = y_train[:10000]
partial_y_train = y_train[10000:]
```

Building of different models for testing.

[4]:

```
#Experiment 1
"""
model = keras.Sequential([
    layers.Dense(8, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 2
"""
model = keras.Sequential([
    layers.Dense(16, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 3
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 4
"""
model = keras.Sequential([
    layers.Dense(128, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 5
"""
model = keras.Sequential([
    layers.Dense(8, activation="relu"),
    layers.Dense(8, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 6
"""
model = keras.Sequential([
    layers.Dense(16, activation="relu"),
    layers.Dense(16, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 7
"""
model = keras.Sequential([
    layers.Dense(32, activation="relu"),
    layers.Dense(32, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])

"""

#Experiment 8
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
```

```
"""

#Experiment 9
"""
model = keras.Sequential([
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 10
"""
model = keras.Sequential([
    layers.Dense(256, activation="relu"),
    layers.Dense(256, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 11
"""
model = keras.Sequential([
    layers.Dense(8, activation="relu"),
    layers.Dense(8, activation="relu"),
    layers.Dense(8, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 12
"""
model = keras.Sequential([
    layers.Dense(16, activation="relu"),
    layers.Dense(16, activation="relu"),
    layers.Dense(16, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 13
"""
model = keras.Sequential([
    layers.Dense(32, activation="relu"),
    layers.Dense(32, activation="relu"),
    layers.Dense(32, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 14
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 15
"""
model = keras.Sequential([
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 16,19, and 20
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 17
"""
model = keras.Sequential([
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 18
"""
```

```
model = keras.Sequential([
    layers.Dense(64, activation="tanh"),
    layers.Dense(64, activation="tanh"),
    layers.Dense(64, activation="tanh"),
    layers.Dense(64, activation="tanh"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 21 (0.2),22 (0.3), and 23 (0.5)
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.5),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.5),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.5),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.5),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 24 (0.00001), 25 (0.0001), and 26 (0.001)
"""
model = keras.Sequential([
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 27
"""
model = keras.Sequential([
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(1, activation="sigmoid")
])
"""

#Final Model

model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(1, activation="sigmoid")
])
```

Compiling Model

[5]:

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

#Used for Experiment 19
#model.compile(optimizer="rmsprop",loss="mse", metrics=["accuracy"])

#Used for Experiment 20
#model.compile(optimizer='adam', loss="binary_crossentropy",␣
 ↪metrics=["accuracy"])
```

Training Model

[6]:

```
history = model.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))

history_dict = history.history
history_dict.keys()
```

```
Epoch 1/20
30/30                 8s 80ms/step -
accuracy: 0.6169 - loss: 0.6402 - val_accuracy: 0.8332 - val_loss: 0.3948
Epoch 2/20
30/30                 1s 34ms/step -
accuracy: 0.8484 - loss: 0.3768 - val_accuracy: 0.8818 - val_loss: 0.2914
Epoch 3/20
30/30                 1s 33ms/step -
```

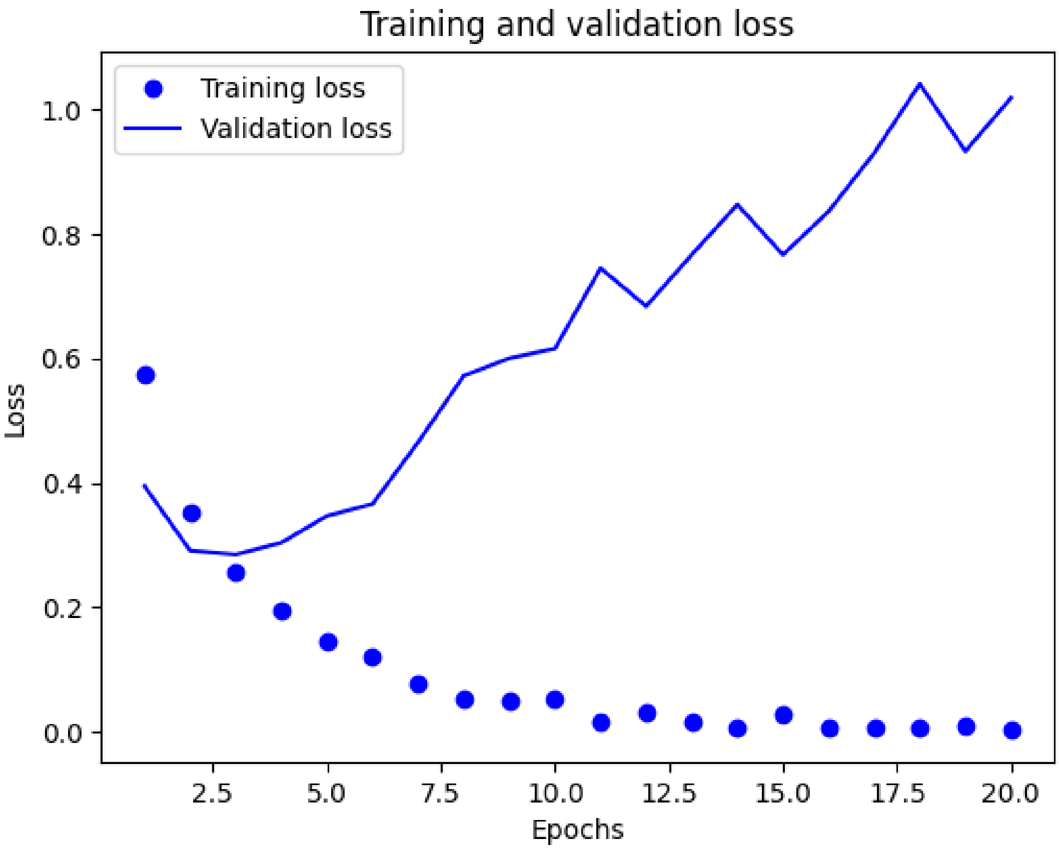
```
accuracy: 0.8990 - loss: 0.2673 - val_accuracy: 0.8883 - val_loss: 0.2850
Epoch 4/20
30/30             1s 30ms/step -
accuracy: 0.9263 - loss: 0.2076 - val_accuracy: 0.8880 - val_loss: 0.3042
Epoch 5/20
30/30             1s 30ms/step -
accuracy: 0.9462 - loss: 0.1565 - val_accuracy: 0.8849 - val_loss: 0.3470
Epoch 6/20
30/30             2s 42ms/step -
accuracy: 0.9559 - loss: 0.1249 - val_accuracy: 0.8864 - val_loss: 0.3662
Epoch 7/20
30/30             2s 30ms/step -
accuracy: 0.9734 - loss: 0.0813 - val_accuracy: 0.8811 - val_loss: 0.4654
Epoch 8/20
30/30             1s 31ms/step -
accuracy: 0.9769 - loss: 0.0674 - val_accuracy: 0.8775 - val_loss: 0.5721
Epoch 9/20
30/30             2s 40ms/step -
accuracy: 0.9801 - loss: 0.0609 - val_accuracy: 0.8773 - val_loss: 0.6001
Epoch 10/20
30/30             1s 39ms/step -
accuracy: 0.9693 - loss: 0.1007 - val_accuracy: 0.8834 - val_loss: 0.6157
Epoch 11/20
30/30             1s 34ms/step -
accuracy: 0.9958 - loss: 0.0139 - val_accuracy: 0.8779 - val_loss: 0.7446
Epoch 12/20
30/30             1s 34ms/step -
accuracy: 0.9901 - loss: 0.0292 - val_accuracy: 0.8827 - val_loss: 0.6836
Epoch 13/20
30/30             1s 30ms/step -
accuracy: 0.9958 - loss: 0.0142 - val_accuracy: 0.8817 - val_loss: 0.7663
Epoch 14/20
30/30             2s 47ms/step -
accuracy: 0.9984 - loss: 0.0057 - val_accuracy: 0.8800 - val_loss: 0.8468
Epoch 15/20
30/30             1s 36ms/step -
accuracy: 0.9962 - loss: 0.0106 - val_accuracy: 0.8744 - val_loss: 0.7662
Epoch 16/20
30/30             1s 36ms/step -
accuracy: 0.9980 - loss: 0.0087 - val_accuracy: 0.8799 - val_loss: 0.8357
Epoch 17/20
30/30             1s 33ms/step -
accuracy: 0.9984 - loss: 0.0052 - val_accuracy: 0.8809 - val_loss: 0.9294
Epoch 18/20
30/30             1s 39ms/step -
accuracy: 0.9980 - loss: 0.0063 - val_accuracy: 0.8777 - val_loss: 1.0403
Epoch 19/20
30/30             1s 43ms/step -
```

```
accuracy: 0.9963 - loss: 0.0171 - val_accuracy: 0.8794 - val_loss: 0.9324
Epoch 20/20
30/30                 2s 28ms/step -
accuracy: 0.9986 - loss: 0.0045 - val_accuracy: 0.8799 - val_loss: 1.0180
```

[6]:
```
dict_keys(['accuracy', 'loss', 'val_accuracy', 'val_loss'])
```

Plotting taining and Validation loss

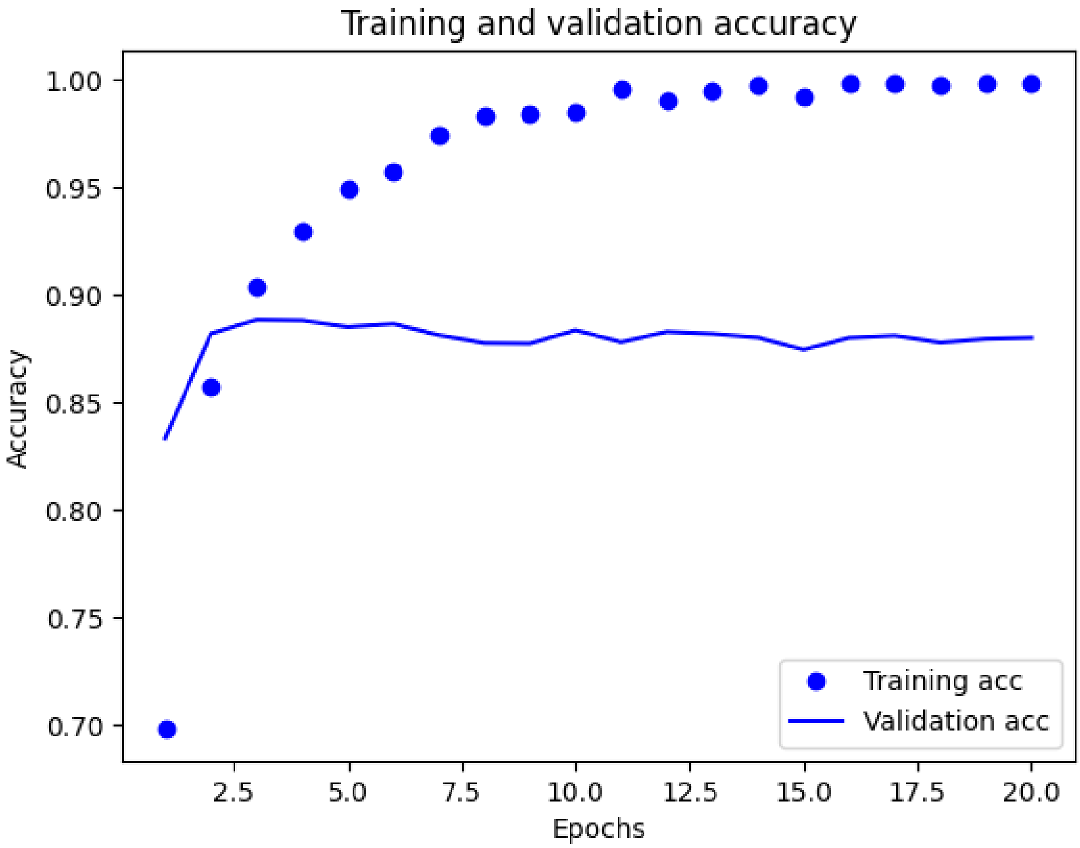
[7]:
```python
import matplotlib.pyplot as plt
history_dict = history.history
loss_values = history_dict["loss"]
val_loss_values = history_dict["val_loss"]
epochs = range(1, len(loss_values) + 1)
plt.plot(epochs, loss_values, "bo", label="Training loss")
plt.plot(epochs, val_loss_values, "b", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
```



Plotting training and Validation acccuracy

[8]:

```
plt.clf()
acc = history_dict["accuracy"]
val_acc = history_dict["val_accuracy"]
plt.plot(epochs, acc, "bo", label="Training acc")
plt.plot(epochs, val_acc, "b", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```



Retraining the model using number of epochs set before validation deteriorates

[10]:

```
#Experiment 1
"""
model = keras.Sequential([
    layers.Dense(8, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 2
"""
model = keras.Sequential([
    layers.Dense(16, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""


#Experiment 3
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 4
"""
model = keras.Sequential([
    layers.Dense(128, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 5
"""
model = keras.Sequential([
    layers.Dense(8, activation="relu"),
    layers.Dense(8, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""
#Experiment 6
"""
model = keras.Sequential([
    layers.Dense(16, activation="relu"),
    layers.Dense(16, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 7
```

```
"""
model = keras.Sequential([
    layers.Dense(32, activation="relu"),
    layers.Dense(32, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 8
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 9
"""
model = keras.Sequential([
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 10
"""
model = keras.Sequential([
    layers.Dense(256, activation="relu"),
    layers.Dense(256, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 11
"""
model = keras.Sequential([
    layers.Dense(8, activation="relu"),
    layers.Dense(8, activation="relu"),
    layers.Dense(8, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 12
"""
```

```
model = keras.Sequential([
    layers.Dense(16, activation="relu"),
    layers.Dense(16, activation="relu"),
    layers.Dense(16, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 13
"""
model = keras.Sequential([
    layers.Dense(32, activation="relu"),
    layers.Dense(32, activation="relu"),
    layers.Dense(32, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 14
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 15
"""
model = keras.Sequential([
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 16,19, and 20
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(64, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
```

```
"""

#Experiment 17
"""
model = keras.Sequential([
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(128, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 18
"""
model = keras.Sequential([
    layers.Dense(64, activation="tanh"),
    layers.Dense(64, activation="tanh"),
    layers.Dense(64, activation="tanh"),
    layers.Dense(64, activation="tanh"),
    layers.Dense(1, activation="sigmoid")
])
"""

#Experiment 21 (0.2),22 (0.3), and 23 (0.5)
"""
model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.5),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.5),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.5),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.5),
    layers.Dense(1, activation="sigmoid")
])
"""
#Experiment 24 (0.00001), 25 (0.0001), and 26 (0.001)
"""
model = keras.Sequential([
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
```

```
"""

#Experiment 27
"""
model = keras.Sequential([
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, kernel_regularizer= l2(0.00001), activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(1, activation="sigmoid")
])
"""

#Final Model

model = keras.Sequential([
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(64, activation="relu"),
    layers.Dropout(0.3),
    layers.Dense(1, activation="sigmoid")
])


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

#Used for Experiment 19
#model.compile(optimizer="rmsprop",loss="mse", metrics=["accuracy"])

#Used for Experiment 20
#model.compile(optimizer=optimizer, loss="binary_crossentropy",␣
 ↪metrics=["accuracy"])

model.fit(x_train, y_train, epochs=3, batch_size=512)
results_test = model.evaluate(x_test, y_test)
results_val = model.evaluate(x_val, y_val)
results_train = model.evaluate(x_train, y_train)
print('Training results (loss,Acc)')
```

```python
print(results_train)
print('Val results (loss,Acc)')
print(results_val)
print('Test results (loss,Acc)')
print(results_test)
```

```
Epoch 1/3
49/49                 3s 17ms/step -
accuracy: 0.6625 - loss: 0.5996
Epoch 2/3
49/49                 1s 21ms/step -
accuracy: 0.8784 - loss: 0.3153
Epoch 3/3
49/49                 2s 29ms/step -
accuracy: 0.9156 - loss: 0.2265
782/782                 3s 3ms/step -
accuracy: 0.8874 - loss: 0.2966
313/313                 1s 3ms/step -
accuracy: 0.9579 - loss: 0.1184
782/782                 3s 3ms/step -
accuracy: 0.9578 - loss: 0.1203
Training results (loss,Acc)
[0.12189925462007523, 0.957319974899292]
Val results (loss,Acc)
[0.1203325092792511, 0.9587000012397766]
Test results (loss,Acc)
[0.29753419756889343, 0.8867200016975403]
```

Predict

```
[11]: model.predict(x_test)
```

```
782/782                 2s 2ms/step
```

```
[11]: array([[0.07631286],
              [0.9999299 ],
              [0.908958  ],
              …,
              [0.06250498],
              [0.03814842],
              [0.79949695]], dtype=float32)
```

```
[ ]: !pip
```