GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

NNDL ASSIGNMENT 6

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1. Use the use case in the class:

a. Add more Dense layers to the existing code and check how the accuracy changes.

```
[ ]: #read the data
     data = pd.read_csv('sample_data/diabetes.csv')

[59]: path_to_csv = 'sample_data/diabetes.csv'

[63]: import keras
      import pandas
      from keras.models import Sequential
      from keras.layers.core import Dense, Activation

      # load dataset
      from sklearn.model_selection import train_test_split
      import pandas as pd
      import numpy as np

      dataset = pd.read_csv(path_to_csv, header=None).values

      X_train, X_test, Y_train, Y_test = train_test_split(dataset[:,0:8], dataset[:,8],
                                                          test_size=0.25, random_state=87)
      np.random.seed(155)
      my_first_nn = Sequential() # create model
      my_first_nn.add(Dense(20, input_dim=8, activation='relu')) # hidden layer
      my_first_nn.add(Dense(4, activation='relu')) # hidden layer
      my_first_nn.add(Dense(1, activation='sigmoid')) # output layer
      my_first_nn.compile(loss='binary_crossentropy', optimizer='adam', metrics=['acc'])
      my_first_nn_fitted = my_first_nn.fit(X_train, Y_train, epochs=100,
                                           initial_epoch=0)
      print(my_first_nn.summary())
      print(my_first_nn.evaluate(X_test, Y_test))
```

Output:

```
Epoch 1/100
18/18 [==============================] - 1s 2ms/step - loss: 18.2141 - acc: 0.3385
Epoch 2/100
18/18 [==============================] - 0s 2ms/step - loss: 8.1899 - acc: 0.3438
Epoch 3/100
18/18 [==============================] - 0s 3ms/step - loss: 1.7616 - acc: 0.3924
Epoch 4/100
18/18 [==============================] - 0s 2ms/step - loss: 0.8124 - acc: 0.5278
Epoch 5/100
18/18 [==============================] - 0s 3ms/step - loss: 0.7466 - acc: 0.5972
Epoch 6/100
18/18 [==============================] - 0s 2ms/step - loss: 0.7242 - acc: 0.6181
Epoch 7/100
18/18 [==============================] - 0s 3ms/step - loss: 0.7203 - acc: 0.6319
Epoch 8/100
18/18 [==============================] - 0s 2ms/step - loss: 0.7132 - acc: 0.6458
Epoch 9/100
18/18 [==============================] - 0s 3ms/step - loss: 0.7066 - acc: 0.6458
Epoch 10/100
18/18 [==============================] - 0s 2ms/step - loss: 0.7044 - acc: 0.6441
Epoch 11/100
18/18 [==============================] - 0s 2ms/step - loss: 0.7018 - acc: 0.6545
Epoch 12/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6989 - acc: 0.6545
Epoch 13/100
18/18 [==============================] - 0s 2ms/step - loss: 0.7013 - acc: 0.6580
Epoch 14/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6929 - acc: 0.6493
Epoch 15/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6911 - acc: 0.6528
Epoch 16/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6882 - acc: 0.6545
```

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```
Epoch 17/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6849 - acc: 0.6528
Epoch 18/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6877 - acc: 0.6545
Epoch 19/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6785 - acc: 0.6615
Epoch 20/100
18/18 [==============================] - 0s 4ms/step - loss: 0.6775 - acc: 0.6649
Epoch 21/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6738 - acc: 0.6615
Epoch 22/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6761 - acc: 0.6632
Epoch 23/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6763 - acc: 0.6597
Epoch 24/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6713 - acc: 0.6632
Epoch 25/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6719 - acc: 0.6632
Epoch 26/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6687 - acc: 0.6632
Epoch 27/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6654 - acc: 0.6649
Epoch 28/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6669 - acc: 0.6684
Epoch 29/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6644 - acc: 0.6597
Epoch 30/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6656 - acc: 0.6684
Epoch 31/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6611 - acc: 0.6632
Epoch 32/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6615 - acc: 0.6632
```

```
Epoch 33/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6592 - acc: 0.6684
Epoch 34/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6585 - acc: 0.6632
Epoch 35/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6564 - acc: 0.6701
Epoch 36/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6569 - acc: 0.6580
Epoch 37/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6594 - acc: 0.6667
Epoch 38/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6690 - acc: 0.6649
Epoch 39/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6554 - acc: 0.6701
Epoch 40/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6519 - acc: 0.6684
Epoch 41/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6506 - acc: 0.6667
Epoch 42/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6493 - acc: 0.6701
Epoch 43/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6495 - acc: 0.6719
Epoch 44/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6639 - acc: 0.6649
Epoch 45/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6552 - acc: 0.6736
Epoch 46/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6501 - acc: 0.6719
Epoch 47/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6461 - acc: 0.6736
Epoch 48/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6469 - acc: 0.6667
```

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```
Epoch 49/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6464 - acc: 0.6719
Epoch 50/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6409 - acc: 0.6736
Epoch 51/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6433 - acc: 0.6736
Epoch 52/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6428 - acc: 0.6719
Epoch 53/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6420 - acc: 0.6736
Epoch 54/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6409 - acc: 0.6719
Epoch 55/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6403 - acc: 0.6719
Epoch 56/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6408 - acc: 0.6719
Epoch 57/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6408 - acc: 0.6684
Epoch 58/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6404 - acc: 0.6719
Epoch 59/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6404 - acc: 0.6701
Epoch 60/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6390 - acc: 0.6736
Epoch 61/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6389 - acc: 0.6753
Epoch 62/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6370 - acc: 0.6719
Epoch 63/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6382 - acc: 0.6771
Epoch 64/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6370 - acc: 0.6736
```

```
18/18 [==============================] - 0s 3ms/step - loss: 0.6370 - acc: 0.6736
Epoch 65/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6363 - acc: 0.6771
Epoch 66/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6374 - acc: 0.6753
Epoch 67/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6361 - acc: 0.6736
Epoch 68/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6359 - acc: 0.6719
Epoch 69/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6351 - acc: 0.6701
Epoch 70/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6340 - acc: 0.6788
Epoch 71/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6333 - acc: 0.6771
Epoch 72/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6397 - acc: 0.6701
Epoch 73/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6341 - acc: 0.6649
Epoch 74/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6338 - acc: 0.6771
Epoch 75/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6360 - acc: 0.6753
Epoch 76/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6339 - acc: 0.6753
Epoch 77/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6329 - acc: 0.6788
Epoch 78/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6326 - acc: 0.6771
Epoch 79/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6370 - acc: 0.6771
Epoch 80/100
```

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```
Epoch 81/100
18/18 [==============================] - 0s 2ms/step - loss: 0.6310 - acc: 0.6771
Epoch 82/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6299 - acc: 0.6806
Epoch 83/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6293 - acc: 0.6823
Epoch 84/100
18/18 [==============================] - 0s 4ms/step - loss: 0.6298 - acc: 0.6753
Epoch 85/100
18/18 [==============================] - 0s 4ms/step - loss: 0.6306 - acc: 0.6753
Epoch 86/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6328 - acc: 0.6719
Epoch 87/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6326 - acc: 0.6771
Epoch 88/100
18/18 [==============================] - 0s 4ms/step - loss: 0.6301 - acc: 0.6771
Epoch 89/100
18/18 [==============================] - 0s 4ms/step - loss: 0.6287 - acc: 0.6788
Epoch 90/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6293 - acc: 0.6719
Epoch 91/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6261 - acc: 0.6771
Epoch 92/100
18/18 [==============================] - 0s 4ms/step - loss: 0.6234 - acc: 0.6823
Epoch 93/100
18/18 [==============================] - 0s 4ms/step - loss: 0.6268 - acc: 0.6753
Epoch 94/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6275 - acc: 0.6823
Epoch 95/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6320 - acc: 0.6806
Epoch 96/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6425 - acc: 0.6771
```


```
Epoch 94/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6275 - acc: 0.6823
Epoch 95/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6320 - acc: 0.6806
Epoch 96/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6425 - acc: 0.6771
```


```
Epoch 97/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6370 - acc: 0.6823
Epoch 98/100
18/18 [==============================] - 0s 4ms/step - loss: 0.6220 - acc: 0.6806
Epoch 99/100
18/18 [==============================] - 0s 4ms/step - loss: 0.6210 - acc: 0.6858
Epoch 100/100
18/18 [==============================] - 0s 3ms/step - loss: 0.6212 - acc: 0.6823
Model: "sequential_38"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_89 (Dense)            (None, 20)                180

 dense_90 (Dense)            (None, 4)                 84

 dense_91 (Dense)            (None, 1)                 5

=================================================================
Total params: 269
Trainable params: 269
Non-trainable params: 0
_________________________________________________________________
None
6/6 [==============================] - 0s 4ms/step - loss: 0.7119 - acc: 0.5833
[0.7118666172027588, 0.5833333134651184]
```

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2. Change the data source to Breast Cancer dataset * available in the source code folder and make required changes. Report accuracy of the model.

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Code JupyterLab Python 3 (ipykernel)

```
[72]: #read the data
      data = pd.read_csv('sample_data/breastcancer.csv')

[73]: path_to_csv = 'sample_data/breastcancer.csv'

[75]: import keras
      import pandas as pd
      import numpy as np
      from keras.models import Sequential
      from keras.layers.core import Dense, Activation
      from sklearn.datasets import load_breast_cancer
      from sklearn.model_selection import train_test_split

      # load dataset
      cancer_data = load_breast_cancer()
      X_train, X_test, Y_train, Y_test = train_test_split(cancer_data.data, cancer_data.target,
                                                          test_size=0.25, random_state=87)
      np.random.seed(155)
      my_nn = Sequential() # create model
      my_nn.add(Dense(20, input_dim=30, activation='relu')) # hidden layer 1
      my_nn.add(Dense(1, activation='sigmoid')) # output layer
      my_nn.compile(loss='binary_crossentropy', optimizer='adam', metrics=['acc'])
      my_nn_fitted = my_nn.fit(X_train, Y_train, epochs=100,
                               initial_epoch=0)
      print(my_nn.summary())
      print(my_nn.evaluate(X_test, Y_test))
```

Output:

Code JupyterLab Python 3 (ipykernel)

```
my_nn.add(Dense(1, activation='sigmoid')) # output layer
my_nn.compile(loss='binary_crossentropy', optimizer='adam', metrics=['acc'])
my_nn_fitted = my_nn.fit(X_train, Y_train, epochs=100,
                         initial_epoch=0)
print(my_nn.summary())
print(my_nn.evaluate(X_test, Y_test))
```

```
Epoch 96/100
14/14 [==============================] - 0s 2ms/step - loss: 0.1522 - acc: 0.9390
Epoch 97/100
14/14 [==============================] - 0s 2ms/step - loss: 0.1466 - acc: 0.9343
Epoch 98/100
14/14 [==============================] - 0s 2ms/step - loss: 0.1683 - acc: 0.9319
Epoch 99/100
14/14 [==============================] - 0s 3ms/step - loss: 0.2092 - acc: 0.9178
Epoch 100/100
14/14 [==============================] - 0s 2ms/step - loss: 0.1453 - acc: 0.9484
Model: "sequential_42"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_98 (Dense)            (None, 20)                620

 dense_99 (Dense)            (None, 1)                 21

=================================================================
Total params: 641
Trainable params: 641
Non-trainable params: 0
_________________________________________________________________
None
5/5 [==============================] - 0s 4ms/step - loss: 0.3893 - acc: 0.8881
[0.3892970681190491, 0.8881118893623352]
```

GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

3. Normalize the data before feeding the data to the model and check how the normalization change your accuracy (code given below). from sklearn.preprocessing import StandardScaler sc = StandardScaler() Breast Cancer dataset is designated to predict if a patient has Malignant (M) or Benign = B cancer

```
[76]: #read the data
      data = pd.read_csv('sample_data/breastcancer.csv')

[77]: path_to_csv = 'sample_data/breastcancer.csv'

[81]: from sklearn.preprocessing import StandardScaler
      sc = StandardScaler()

[82]: import keras
      import pandas as pd
      import numpy as np
      from keras.models import Sequential
      from keras.layers.core import Dense, Activation
      from sklearn.datasets import load_breast_cancer
      from sklearn.model_selection import train_test_split

      # load dataset
      cancer_data = load_breast_cancer()
      X_train, X_test, Y_train, Y_test = train_test_split(cancer_data.data, cancer_data.target,
                                                          test_size=0.25, random_state=87)
      np.random.seed(155)
      my_nn = Sequential() # create model
      my_nn.add(Dense(20, input_dim=30, activation='relu')) # hidden layer 1
      my_nn.add(Dense(1, activation='sigmoid')) # output layer
      my_nn.compile(loss='binary_crossentropy', optimizer='adam', metrics=['acc'])
      my_nn_fitted = my_nn.fit(X_train, Y_train, epochs=100,
                               initial_epoch=0)
      print(my_nn.summary())
      print(my_nn.evaluate(X_test, Y_test))
```

Output:

```
14/14 [==============================] - 0s 2ms/step - loss: 0.6664 - acc: 0.9061
Epoch 93/100
14/14 [==============================] - 0s 2ms/step - loss: 0.4741 - acc: 0.9296
Epoch 94/100
14/14 [==============================] - 0s 3ms/step - loss: 0.4954 - acc: 0.9155
Epoch 95/100
14/14 [==============================] - 0s 3ms/step - loss: 0.4736 - acc: 0.9225
Epoch 96/100
14/14 [==============================] - 0s 2ms/step - loss: 0.4443 - acc: 0.9343
Epoch 97/100
14/14 [==============================] - 0s 3ms/step - loss: 0.4802 - acc: 0.9202
Epoch 98/100
14/14 [==============================] - 0s 2ms/step - loss: 0.4229 - acc: 0.9225
Epoch 99/100
14/14 [==============================] - 0s 3ms/step - loss: 0.5408 - acc: 0.9131
Epoch 100/100
14/14 [==============================] - 0s 3ms/step - loss: 0.3975 - acc: 0.9272
Model: "sequential_45"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_104 (Dense)           (None, 20)                620

 dense_105 (Dense)           (None, 1)                 21

=================================================================
Total params: 641
Trainable params: 641
Non-trainable params: 0
_________________________________________________________________
None
5/5 [==============================] - 0s 3ms/step - loss: 1.3143 - acc: 0.7902
[1.314283013343811, 0.7902097702026367]
```

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Use Image Classification on the hand written digits data set (mnist)

1. Plot the loss and accuracy for both training data and validation data using the history object in the source code.

[84]:
```python
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt

# load MNIST dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()

# normalize pixel values to range [0, 1]
x_train = x_train.astype('float32') / 255
x_test = x_test.astype('float32') / 255

# convert class labels to binary class matrices
num_classes = 10
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)

# create a simple neural network model
model = Sequential()
model.add(Dense(512, activation='relu', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='relu'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))

model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])

# train the model and record the training history
history = model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
```

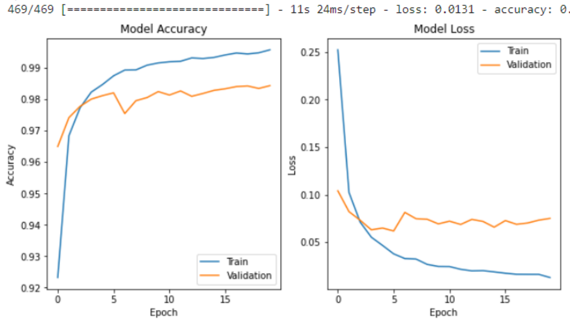
```python
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])

# train the model and record the training history
history = model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
                    epochs=20, batch_size=128)

# plot the training and validation accuracy and loss curves
plt.figure(figsize=(10, 5))
plt.subplot(1, 2, 1)
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='lower right')

plt.subplot(1, 2, 2)
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper right')

plt.show()
```

Output:

GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

Code JupyterLab Python 3 (ipykernel)

```
Epoch 11/20
469/469 [==============================] - 14s 31ms/step - loss: 0.0246 - accuracy: 0.9920 - val_loss: 0.0723 - val_accuracy: 0.9814
Epoch 12/20
469/469 [==============================] - 12s 26ms/step - loss: 0.0217 - accuracy: 0.9922 - val_loss: 0.0688 - val_accuracy: 0.9827
Epoch 13/20
469/469 [==============================] - 16s 35ms/step - loss: 0.0201 - accuracy: 0.9932 - val_loss: 0.0741 - val_accuracy: 0.9810
Epoch 14/20
469/469 [==============================] - 12s 26ms/step - loss: 0.0203 - accuracy: 0.9930 - val_loss: 0.0720 - val_accuracy: 0.9819
Epoch 15/20
469/469 [==============================] - 11s 24ms/step - loss: 0.0190 - accuracy: 0.9934 - val_loss: 0.0660 - val_accuracy: 0.9829
Epoch 16/20
469/469 [==============================] - 11s 23ms/step - loss: 0.0176 - accuracy: 0.9942 - val_loss: 0.0729 - val_accuracy: 0.9834
Epoch 17/20
469/469 [==============================] - 11s 23ms/step - loss: 0.0165 - accuracy: 0.9948 - val_loss: 0.0690 - val_accuracy: 0.9841
Epoch 18/20
469/469 [==============================] - 11s 24ms/step - loss: 0.0164 - accuracy: 0.9945 - val_loss: 0.0704 - val_accuracy: 0.9843
Epoch 19/20
469/469 [==============================] - 12s 26ms/step - loss: 0.0164 - accuracy: 0.9949 - val_loss: 0.0734 - val_accuracy: 0.9835
Epoch 20/20
469/469 [==============================] - 11s 24ms/step - loss: 0.0131 - accuracy: 0.9958 - val_loss: 0.0752 - val_accuracy: 0.9844
```



2. Plot one of the images in the test data, and then do inferencing to check what is the prediction of the model on that single image.

```
[85]: import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt
import numpy as np

# load MNIST dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()

# normalize pixel values to range [0, 1]
x_train = x_train.astype('float32') / 255
x_test = x_test.astype('float32') / 255

# convert class labels to binary class matrices
num_classes = 10
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)

# create a simple neural network model
model = Sequential()
model.add(Dense(512, activation='relu', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='relu'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))

model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])

# train the model
model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
          epochs=20, batch_size=128)

# plot one of the images in the test data
plt.imshow(x_test[0], cmap='gray')
plt.show()

# make a prediction on the image using the trained model
prediction = model.predict(x_test[0].reshape(1, -1))
print('Model prediction:', np.argmax(prediction))
```

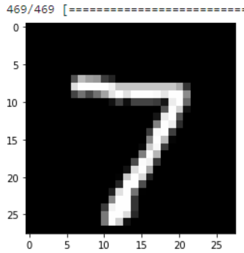
GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

Output:

File Edit View Run Kernel Settings Help Not Trusted

Code JupyterLab Python 3 (ipykernel)

```
469/469 [==============================] - 11s 24ms/step - loss: 0.0381 - accuracy: 0.9873 - val_loss: 0.0648 - val_accuracy: 0.9818
Epoch 7/20
469/469 [==============================] - 11s 24ms/step - loss: 0.0337 - accuracy: 0.9891 - val_loss: 0.0732 - val_accuracy: 0.9810
Epoch 8/20
469/469 [==============================] - 12s 25ms/step - loss: 0.0296 - accuracy: 0.9905 - val_loss: 0.0675 - val_accuracy: 0.9811
Epoch 9/20
469/469 [==============================] - 12s 25ms/step - loss: 0.0279 - accuracy: 0.9905 - val_loss: 0.0756 - val_accuracy: 0.9799
Epoch 10/20
469/469 [==============================] - 12s 26ms/step - loss: 0.0248 - accuracy: 0.9915 - val_loss: 0.0804 - val_accuracy: 0.9806
Epoch 11/20
469/469 [==============================] - 11s 23ms/step - loss: 0.0238 - accuracy: 0.9918 - val_loss: 0.0753 - val_accuracy: 0.9807
Epoch 12/20
469/469 [==============================] - 12s 25ms/step - loss: 0.0237 - accuracy: 0.9923 - val_loss: 0.0743 - val_accuracy: 0.9814
Epoch 13/20
469/469 [==============================] - 12s 25ms/step - loss: 0.0211 - accuracy: 0.9929 - val_loss: 0.0785 - val_accuracy: 0.9803
Epoch 14/20
469/469 [==============================] - 11s 24ms/step - loss: 0.0168 - accuracy: 0.9945 - val_loss: 0.0694 - val_accuracy: 0.9838
Epoch 15/20
469/469 [==============================] - 11s 24ms/step - loss: 0.0192 - accuracy: 0.9934 - val_loss: 0.0786 - val_accuracy: 0.9820
Epoch 16/20
469/469 [==============================] - 11s 23ms/step - loss: 0.0184 - accuracy: 0.9938 - val_loss: 0.0768 - val_accuracy: 0.9827
Epoch 17/20
469/469 [==============================] - 11s 23ms/step - loss: 0.0164 - accuracy: 0.9948 - val_loss: 0.0775 - val_accuracy: 0.9823
Epoch 18/20
469/469 [==============================] - 10s 22ms/step - loss: 0.0162 - accuracy: 0.9948 - val_loss: 0.0800 - val_accuracy: 0.9822
Epoch 19/20
469/469 [==============================] - 11s 24ms/step - loss: 0.0145 - accuracy: 0.9951 - val_loss: 0.0873 - val_accuracy: 0.9820
Epoch 20/20
469/469 [==============================] - 11s 24ms/step - loss: 0.0140 - accuracy: 0.9957 - val_loss: 0.0807 - val_accuracy: 0.9841
```




```
1/1 [==============================] - 0s 120ms/step
Model prediction: 7
```

3. We had used 2 hidden layers and Relu activation. Try to change the number of hidden layer and the activation to tanh or sigmoid and see what happens.

GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

[88]:
```python
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt
import numpy as np

# load MNIST dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()

# normalize pixel values to range [0, 1]
x_train = x_train.astype('float32') / 255
x_test = x_test.astype('float32') / 255

# convert class labels to binary class matrices
num_classes = 10
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)

# create a list of models to train
models = []

# model with 1 hidden layer and tanh activation
model = Sequential()
model.add(Dense(512, activation='tanh', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('1 hidden layer with tanh', model))

# model with 1 hidden layer and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('1 hidden layer with sigmoid', model))
```

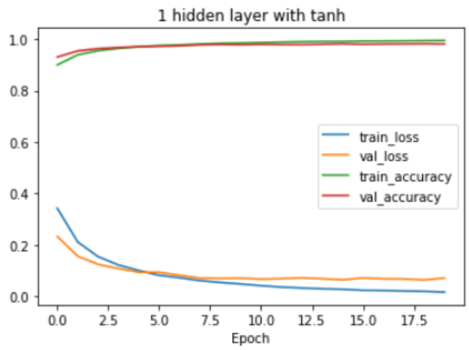
JupyterLab Python 3 (ipykernel) Code

```python
# model with 2 hidden layers and tanh activation
model = Sequential()
model.add(Dense(512, activation='tanh', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='tanh'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with tanh', model))

# model with 2 hidden layers and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='sigmoid'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with sigmoid', model))

# train each model and plot loss and accuracy curves
for name, model in models:
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
    history = model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
                        epochs=20, batch_size=128, verbose=0)
    # plot loss and accuracy curves
    plt.plot(history.history['loss'], label='train_loss')
    plt.plot(history.history['val_loss'], label='val_loss')
    plt.plot(history.history['accuracy'], label='train_accuracy')
    plt.plot(history.history['val_accuracy'], label='val_accuracy')
    plt.title(name)
    plt.xlabel('Epoch')
    plt.legend()
    plt.show()

    # evaluate the model on test data
    loss, accuracy = model.evaluate(x_test.reshape(-1, 784), y_test, verbose=0)
    print('{} - Test loss: {:.4f}, Test accuracy: {:.4f}'.format(name, loss, accuracy))
```

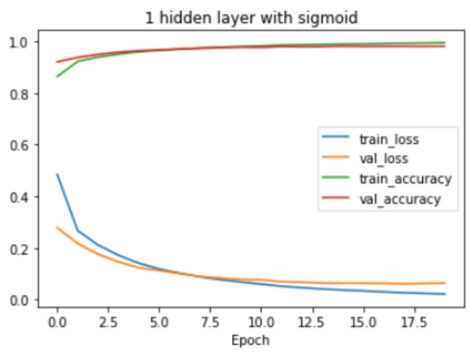
Output:

GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

```
print('{} - Test loss: {:.4f}, Test accuracy: {:.4f}'.format(name, loss, accuracy))
```



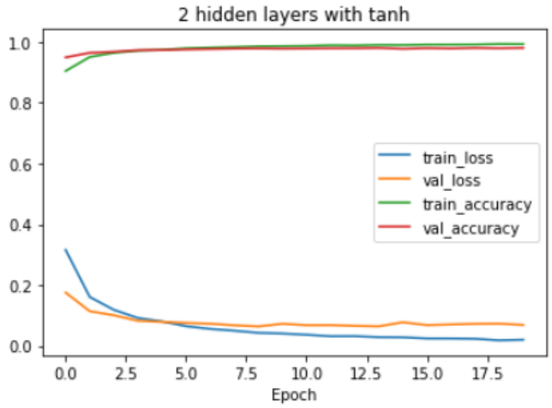

```
1 hidden layer with tanh - Test loss: 0.0716, Test accuracy: 0.9809
```



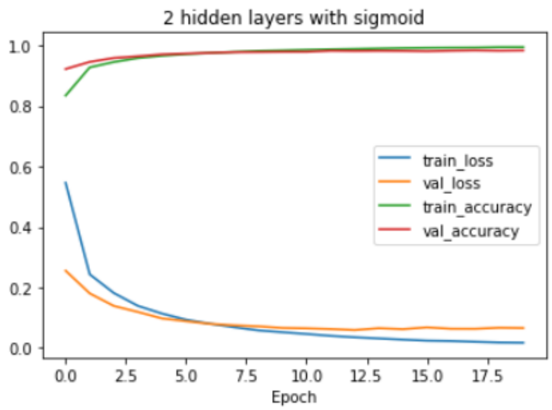

```
1 hidden layer with sigmoid - Test loss: 0.0642, Test accuracy: 0.9809
```

GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

```
1 hidden layer with sigmoid - Test loss: 0.0642, Test accuracy: 0.9809
```




```
2 hidden layers with tanh - Test loss: 0.0686, Test accuracy: 0.9808
```




```
2 hidden layers with sigmoid - Test loss: 0.0663, Test accuracy: 0.9830
```

4. Run the same code without scaling the images and check the performance?

[89]:
```
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt
import numpy as np

# load MNIST dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()

# convert class labels to binary class matrices
num_classes = 10
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)

# create a list of models to train
models = []

# model with 1 hidden layer and tanh activation
model = Sequential()
model.add(Dense(512, activation='tanh', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('1 hidden layer with tanh', model))

# model with 1 hidden layer and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
```

GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

Code | JupyterLab | Python 3 (

```
# model with 1 hidden layer and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('1 hidden layer with sigmoid', model))

# model with 2 hidden layers and tanh activation
model = Sequential()
model.add(Dense(512, activation='tanh', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='tanh'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with tanh', model))

# model with 2 hidden layers and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='sigmoid'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with sigmoid', model))

# train each model and plot loss and accuracy curves
for name, model in models:
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
    history = model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
                        epochs=20, batch_size=128, verbose=0)
    # plot loss and accuracy curves
```

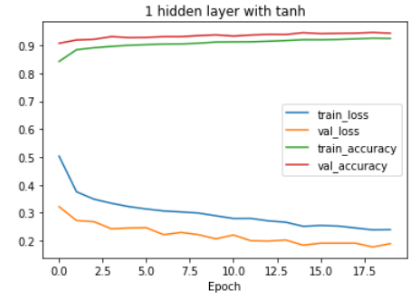
Code | JupyterLab | Python 3 (ipykernel)

```
# model with 2 hidden layers and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='sigmoid'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with sigmoid', model))

# train each model and plot loss and accuracy curves
for name, model in models:
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
    history = model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
                        epochs=20, batch_size=128, verbose=0)
    # plot loss and accuracy curves
    plt.plot(history.history['loss'], label='train_loss')
    plt.plot(history.history['val_loss'], label='val_loss')
    plt.plot(history.history['accuracy'], label='train_accuracy')
    plt.plot(history.history['val_accuracy'], label='val_accuracy')
    plt.title(name)
    plt.xlabel('Epoch')
    plt.legend()
    plt.show()

    # evaluate the model on test data
    loss, accuracy = model.evaluate(x_test.reshape(-1, 784), y_test, verbose=0)
    print('{} - Test loss: {:.4f}, Test accuracy: {:.4f}'.format(name, loss, accuracy))
```

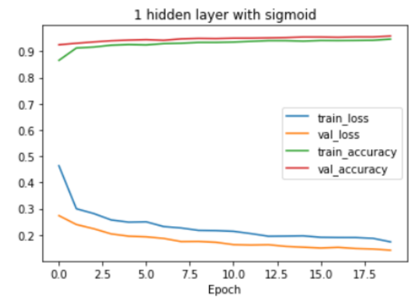
1 hidden layer with tanh

GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

Output:



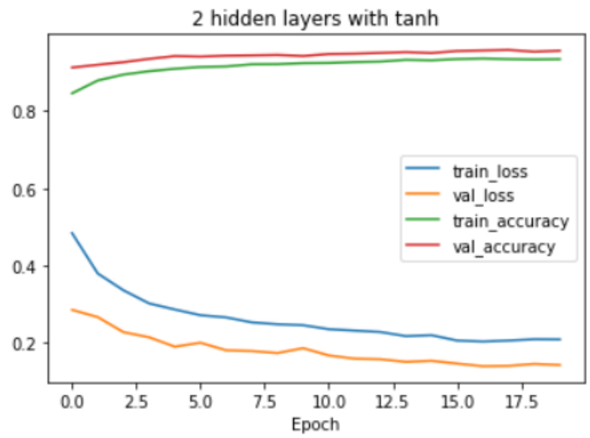
1 hidden layer with tanh - Test loss: 0.1895, Test accuracy: 0.9439



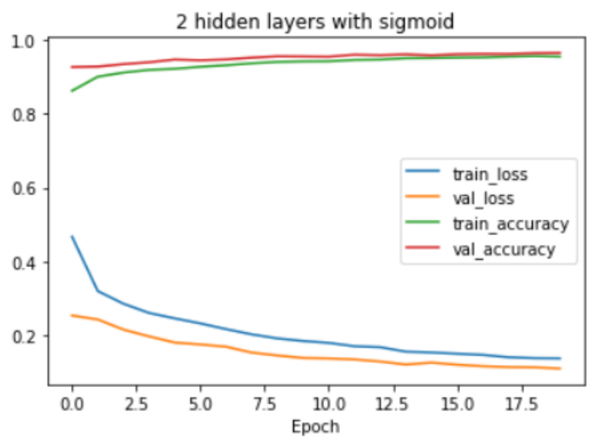
1 hidden layer with sigmoid - Test loss: 0.1420, Test accuracy: 0.9582

GitHub Link:
https://github.com/HemanthLakkimsetti76/NN_Assignment6/blob/main/Assignment6.ipynb

```
1 hidden layer with sigmoid - Test loss: 0.1420, Test accuracy: 0.9582
```




```
2 hidden layers with tanh - Test loss: 0.1422, Test accuracy: 0.9563
```




```
2 hidden layers with sigmoid - Test loss: 0.1095, Test accuracy: 0.9652
```