IT350 DA Assignment 5

MNIST Dataset

Submitted by: Harsh Agarwal (181IT117)

In [1]:
```
# Import Libraries
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
import matplotlib.pyplot as plt
np.random.seed(2017)
```

In [2]:
```
# the data, split between train and test sets
(x_train, y_train), (x_test, y_test) = mnist.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz
11493376/11490434 [==============================] - 0s 0us/step
```

In [3]:
```
#Flatten image
x_train = x_train.reshape(60000, 784)
x_test = x_test.reshape(10000, 784)
x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
#Normalize pixel data
x_train /= 255
x_test /= 255
print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')
```

```
60000 train samples
10000 test samples
```

In [4]:
```
# convert class vectors 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)
```

In [5]:
```
batch_size = 128
epochs = 20
```

In [6]:
```
#Initialise model
model = Sequential()
#Add input and 1st hidden layer
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
#Add 2nd hidden layer
model.add(Dense(512, activation='sigmoid'))
#Add output layer
model.add(Dense(num_classes, activation='sigmoid'))
```

In [7]:
```
#Print model information
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 512)               401920
_________________________________________________________________
dense_1 (Dense)              (None, 512)               262656
_________________________________________________________________
dense_2 (Dense)              (None, 10)                5130
=================================================================
Total params: 669,706
Trainable params: 669,706
Non-trainable params: 0
_________________________________________________________________
```

In [8]:
```
#Compiling model: Using categorical crossentropy loss function and sgd optimizer
model.compile(loss='categorical_crossentropy',
              optimizer=keras.optimizers.SGD(lr=0.1, momentum=0.0, nesterov=False),
              metrics=['accuracy'])
```

In [9]:
```
#Training model
history = model.fit(x_train, y_train,
                    batch_size=batch_size,
                    epochs=epochs,
                    verbose=1,
                    validation_data=(x_test, y_test))
#Evaluating model
score = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
Epoch 1/20
469/469 [==============================] - 5s 5ms/step - loss: 2.0702 - accuracy: 0.2696 - val_loss: 0.8628 - val_accuracy: 0.7363
Epoch 2/20
469/469 [==============================] - 2s 4ms/step - loss: 0.6864 - accuracy: 0.8133 - val_loss: 0.4591 - val_accuracy: 0.8733
Epoch 3/20
469/469 [==============================] - 2s 4ms/step - loss: 0.4458 - accuracy: 0.8734 - val_loss: 0.3792 - val_accuracy: 0.8905
Epoch 4/20
469/469 [==============================] - 2s 4ms/step - loss: 0.3847 - accuracy: 0.8892 - val_loss: 0.3415 - val_accuracy: 0.9010
Epoch 5/20
469/469 [==============================] - 2s 4ms/step - loss: 0.3508 - accuracy: 0.8978 - val_loss: 0.3167 - val_accuracy: 0.9060
Epoch 6/20
469/469 [==============================] - 2s 4ms/step - loss: 0.3288 - accuracy: 0.9035 - val_loss: 0.3075 - val_accuracy: 0.9105
Epoch 7/20
469/469 [==============================] - 2s 4ms/step - loss: 0.3124 - accuracy: 0.9080 - val_loss: 0.2991 - val_accuracy: 0.9143
Epoch 8/20
469/469 [==============================] - 2s 4ms/step - loss: 0.3109 - accuracy: 0.9099 - val_loss: 0.2927 - val_accuracy: 0.9150
Epoch 9/20
469/469 [==============================] - 2s 4ms/step - loss: 0.3025 - accuracy: 0.9119 - val_loss: 0.2886 - val_accuracy: 0.9140
Epoch 10/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2856 - accuracy: 0.9155 - val_loss: 0.2794 - val_accuracy: 0.9201
Epoch 11/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2796 - accuracy: 0.9196 - val_loss: 0.2903 - val_accuracy: 0.9144
Epoch 12/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2800 - accuracy: 0.9203 - val_loss: 0.2689 - val_accuracy: 0.9221
Epoch 13/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2753 - accuracy: 0.9193 - val_loss: 0.2621 - val_accuracy: 0.9223
Epoch 14/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2652 - accuracy: 0.9241 - val_loss: 0.2573 - val_accuracy: 0.9264
Epoch 15/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2592 - accuracy: 0.9234 - val_loss: 0.2511 - val_accuracy: 0.9277
Epoch 16/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2572 - accuracy: 0.9256 - val_loss: 0.2484 - val_accuracy: 0.9270
Epoch 17/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2529 - accuracy: 0.9277 - val_loss: 0.2462 - val_accuracy: 0.9284
Epoch 18/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2460 - accuracy: 0.9293 - val_loss: 0.2410 - val_accuracy: 0.9316
Epoch 19/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2394 - accuracy: 0.9329 - val_loss: 0.2280 - val_accuracy: 0.9349
Epoch 20/20
469/469 [==============================] - 2s 4ms/step - loss: 0.2282 - accuracy: 0.9332 - val_loss: 0.2272 - val_accuracy: 0.9349
Test loss: 0.22717602599692343
Test accuracy: 0.9348999857902527
```

In [10]:
```
print(model.summary())
```

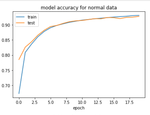
```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 512)               401920
_________________________________________________________________
dense_1 (Dense)              (None, 512)               262656
_________________________________________________________________
dense_2 (Dense)              (None, 10)                5130
=================================================================
Total params: 669,706
Trainable params: 669,706
Non-trainable params: 0
_________________________________________________________________
None
```

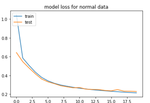
In [11]:
```
score = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
Test loss: 0.22717602599692343
Test accuracy: 0.9348999857902527
```

In [22]:
```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('model accuracy for normal data')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss for normal data')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```





Dimensionality Reduction using PCA

In [12]:
```
x_train, x_train, x_valid, y_valid, x_test , y_test = [], [], [], [], [], []
(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train = x_train.reshape(60000,28,28)
x_test = x_test.reshape(10000,28,28)
```

In [13]:
```
from sklearn.model_selection import train_test_split
from sklearn.decomposition import PCA
x_train, x_valid, y_train, y_valid = train_test_split(x_train, y_train, test_size=0.2)

x_train = x_train.astype('float32')
x_valid = x_valid.astype('float32')
x_test = x_test.astype('float32')
x_train /= 255
x_valid /= 255
x_test /= 255

x_train = x_train.reshape(len(x_train),28,28)
x_test = x_test.reshape(10000,28,28)
y_train = keras.utils.to_categorical(y_train, 10)
y_valid = keras.utils.to_categorical(y_valid, 10)
y_test = keras.utils.to_categorical(y_test, 10)
```

In [14]:
```
pca = PCA(n_components=10)
x_train = x_train.reshape(48000,784)
x_train_reduced = pca.fit_transform(x_train)
print("Explained variance = ",(100*np.sum(pca.explained_variance_ratio_))))
print("The number of features are reduced to ",pca.n_components_)
```

```
Explained variance = 48.81797134782251
The number of features are reduced to  10
```

In [15]:
```
X_test = x_test.reshape(10000,784)
x_test_reduced = pca.transform(X_test)
x_valid = x_valid.reshape(12000,784)
x_valid_reduced = pca.transform(x_valid)
```

In [16]:
```
optim = keras.optimizers.SGD(lr=0.1)
```

In [17]:
```
PCAmodel = Sequential()
PCAmodel.add(Dense(256, activation='sigmoid',kernel_initializer = 'he_normal'))
#PCAmodel.add(Dropout(0.4))
PCAmodel.add(Dense(128, activation='sigmoid'))
#PCAmodel.add(Dropout(0.4))
PCAmodel.add(Dense(100, activation='sigmoid'))
#PCAmodel.add(Dropout(0.4))
PCAmodel.add(Dense(10, activation='sigmoid'))
optim = keras.optimizers.SGD(lr=0.1)
```

In [18]:
```
PCAmodel.compile(loss='categorical_crossentropy',
                 optimizer=keras.optimizers.SGD(lr=0.1, momentum=0.0, nesterov=False),
                 metrics=['accuracy'])
```

In [19]:
```
history = PCAmodel.fit(x_train_reduced, y_train,batch_size=32,epochs=20,verbose=2,validation_data=(x_valid_reduced,y_valid))
```

```
Epoch 1/20
1500/1500 - 4s - loss: 1.0462 - accuracy: 0.6733 - val_loss: 0.6432 - val_accuracy: 0.7853
Epoch 2/20
1500/1500 - 3s - loss: 0.5849 - accuracy: 0.8087 - val_loss: 0.5459 - val_accuracy: 0.8261
Epoch 3/20
1500/1500 - 3s - loss: 0.5058 - accuracy: 0.8363 - val_loss: 0.4786 - val_accuracy: 0.8438
Epoch 4/20
1500/1500 - 3s - loss: 0.4342 - accuracy: 0.8603 - val_loss: 0.4162 - val_accuracy: 0.8657
Epoch 5/20
1500/1500 - 3s - loss: 0.3781 - accuracy: 0.8778 - val_loss: 0.3606 - val_accuracy: 0.8817
Epoch 6/20
1500/1500 - 3s - loss: 0.3415 - accuracy: 0.8900 - val_loss: 0.3308 - val_accuracy: 0.8940
Epoch 7/20
1500/1500 - 3s - loss: 0.3156 - accuracy: 0.8978 - val_loss: 0.3118 - val_accuracy: 0.8977
Epoch 8/20
1500/1500 - 3s - loss: 0.2972 - accuracy: 0.9030 - val_loss: 0.2898 - val_accuracy: 0.9044
Epoch 9/20
1500/1500 - 3s - loss: 0.2844 - accuracy: 0.9080 - val_loss: 0.2781 - val_accuracy: 0.9099
Epoch 10/20
1500/1500 - 3s - loss: 0.2726 - accuracy: 0.9116 - val_loss: 0.2676 - val_accuracy: 0.9128
Epoch 11/20
1500/1500 - 3s - loss: 0.2627 - accuracy: 0.9152 - val_loss: 0.2703 - val_accuracy: 0.9141
Epoch 12/20
1500/1500 - 3s - loss: 0.2555 - accuracy: 0.9173 - val_loss: 0.2530 - val_accuracy: 0.9171
Epoch 13/20
1500/1500 - 3s - loss: 0.2470 - accuracy: 0.9197 - val_loss: 0.2499 - val_accuracy: 0.9200
Epoch 14/20
1500/1500 - 3s - loss: 0.2410 - accuracy: 0.9216 - val_loss: 0.2408 - val_accuracy: 0.9197
Epoch 15/20
1500/1500 - 3s - loss: 0.2358 - accuracy: 0.9234 - val_loss: 0.2393 - val_accuracy: 0.9238
Epoch 16/20
1500/1500 - 3s - loss: 0.2303 - accuracy: 0.9252 - val_loss: 0.2349 - val_accuracy: 0.9233
Epoch 17/20
1500/1500 - 3s - loss: 0.2260 - accuracy: 0.9268 - val_loss: 0.2407 - val_accuracy: 0.9202
Epoch 18/20
1500/1500 - 3s - loss: 0.2206 - accuracy: 0.9279 - val_loss: 0.2316 - val_accuracy: 0.9242
Epoch 19/20
1500/1500 - 3s - loss: 0.2171 - accuracy: 0.9301 - val_loss: 0.2311 - val_accuracy: 0.9250
Epoch 20/20
1500/1500 - 3s - loss: 0.2137 - accuracy: 0.9308 - val_loss: 0.2280 - val_accuracy: 0.9275
```

In [20]:
```
print(model.summary())
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 512)               401920
_________________________________________________________________
dense_1 (Dense)              (None, 512)               262656
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dense_2 (Dense)              (None, 10)                5130
=================================================================
Total params: 669,706
Trainable params: 669,706
Non-trainable params: 0
_________________________________________________________________
None
```
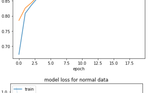
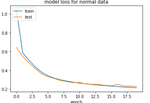

In [21]:
```
score = PCAmodel.evaluate(x_test_reduced, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
Test loss: 0.22815966606140137
Test accuracy: 0.9283000230789185
```

In [22]:
```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('model accuracy for normal data')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss for normal data')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```





In [ ]:
```

```