Write a program to implement feed forward neural network, Alexnet, Lnet and VGG16 on mnist dataset compare result in terms of time and Accuracy, split=80 and 20

In [ ]:
```
import pandas as pd
```

In [ ]:
```
df=pd.read_csv('/content/train.csv')
df.head()
```

Out[ ]:

	label	pixel0	pixel1	pixel2	pixel3	pixel4	pixel5	pixel6	pixel7	pixel8	...	pixel774	pixel775	pixel776	pixel777	pixel778	pixel779	pixel780	pixe
0	1	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
2	1	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
3	4	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	

5 rows × 785 columns

In [ ]:
```
X = df.drop('label',axis=1)
y = df['label']
X.shape
```

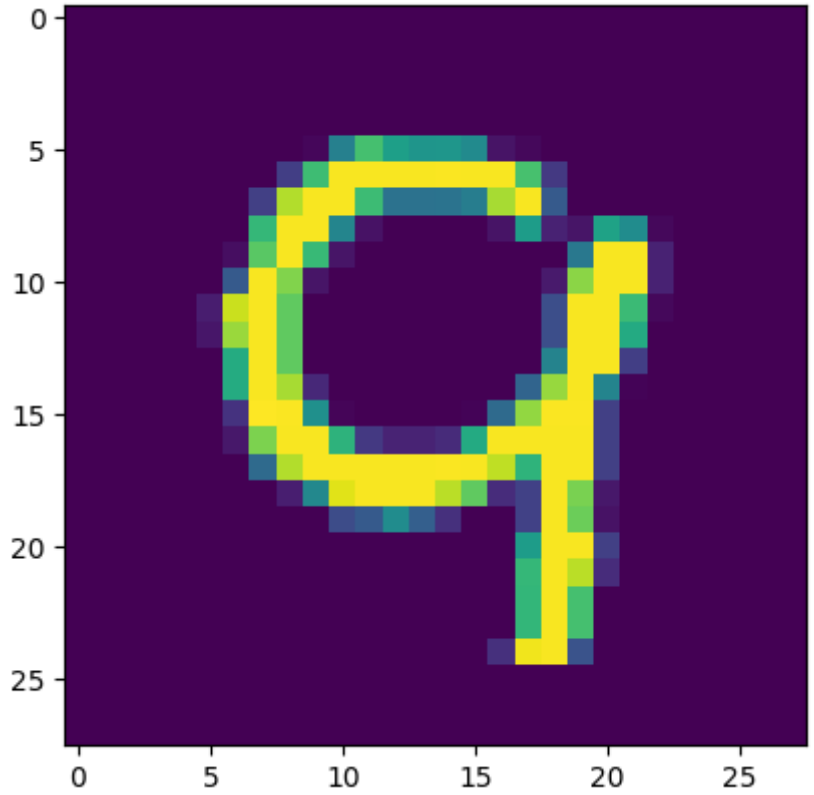
Out[ ]:
```
(42000, 784)
```

In [ ]:
```
import matplotlib.pyplot as plt
import seaborn as sns
import sklearn
from sklearn.model_selection import train_test_split
```

In [ ]:
```
x_train,x_test,y_train,y_test = train_test_split(X,y,train_size=0.7,random_state=42)
```

In [ ]:
```
import numpy as np
plt.imshow(np.array(x_train.iloc[1]).reshape(28,28))
```

Out[ ]:
```
<matplotlib.image.AxesImage at 0x7ff0014c32b0>
```



In [ ]:
```
import numpy as np
import tensorflow as tf
from tensorflow import keras
(x_train, _), (x_test, _) = keras.datasets.mnist.load_data()
x_train = x_train.astype('float32') / 255.
x_test = x_test.astype('float32') / 255.
x_train = x_train.reshape((len(x_train), np.prod(x_train.shape[1:])))
x_test = x_test.reshape((len(x_test), np.prod(x_test.shape[1:])))
input_size = 784
encoding_dim = 32
```

```
input_img = keras.Input(shape=(input_size,))
encoded = keras.layers.Dense(encoding_dim, activation='relu')(input_img)
decoded = keras.layers.Dense(input_size, activation='sigmoid')(encoded)

autoencoder = keras.Model(input_img, decoded)
autoencoder.compile(optimizer='adam', loss='binary_crossentropy',metrics=['accuracy'])
autoencoder.fit(x_train, x_train,
                epochs=10,
                batch_size=256,
                shuffle=True,
                validation_data=(x_test, x_test))
loss, accuracy = autoencoder.evaluate(x_test, x_test)
print("The loss is : ",loss)
print("The accuracy is: ",accuracy)
```

```
Epoch 1/10
235/235 [==============================] - 5s 17ms/step - loss: 0.2744 - accuracy: 0.0144 - val_loss: 0.1869 - val_accuracy: 0.014
0
Epoch 2/10
235/235 [==============================] - 3s 13ms/step - loss: 0.1690 - accuracy: 0.0119 - val_loss: 0.1522 - val_accuracy: 0.011
3
Epoch 3/10
235/235 [==============================] - 3s 12ms/step - loss: 0.1438 - accuracy: 0.0115 - val_loss: 0.1333 - val_accuracy: 0.009
8
Epoch 4/10
235/235 [==============================] - 3s 12ms/step - loss: 0.1282 - accuracy: 0.0109 - val_loss: 0.1206 - val_accuracy: 0.009
7
Epoch 5/10
235/235 [==============================] - 4s 15ms/step - loss: 0.1178 - accuracy: 0.0107 - val_loss: 0.1123 - val_accuracy: 0.010
5
Epoch 6/10
235/235 [==============================] - 3s 14ms/step - loss: 0.1109 - accuracy: 0.0109 - val_loss: 0.1066 - val_accuracy: 0.013
3
Epoch 7/10
235/235 [==============================] - 3s 12ms/step - loss: 0.1058 - accuracy: 0.0112 - val_loss: 0.1025 - val_accuracy: 0.015
4
Epoch 8/10
235/235 [==============================] - 3s 12ms/step - loss: 0.1021 - accuracy: 0.0113 - val_loss: 0.0995 - val_accuracy: 0.014
8
Epoch 9/10
235/235 [==============================] - 3s 14ms/step - loss: 0.0994 - accuracy: 0.0118 - val_loss: 0.0971 - val_accuracy: 0.013
8
Epoch 10/10
```

```
235/235 [==============================] - 4s 15ms/step - loss: 0.0975 - accuracy: 0.0121 - val_loss: 0.0956 - val_accuracy: 0.013
5
313/313 [==============================] - 1s 2ms/step - loss: 0.0956 - accuracy: 0.0135
The loss is :  0.09558252990245819
The accuracy is:  0.013500000350177288
```

In [ ]:
```
decoded_imgs = autoencoder.predict(x_test)
```

```
313/313 [==============================] - 1s 1ms/step
```

In [ ]:
```
decoded_imgs
```

Out[ ]:
```
array([[7.8738296e-09, 7.4654638e-09, 7.7409270e-09, ..., 7.3403497e-09,
        2.7544009e-09, 1.3647015e-08],
       [1.0379384e-09, 8.2345366e-08, 1.2986355e-08, ..., 1.1101036e-09,
        1.3471355e-09, 4.2482928e-09],
       [3.1553395e-06, 7.9852807e-06, 8.6544951e-06, ..., 7.9739193e-06,
        4.6467276e-06, 4.5928764e-06],
       ...,
       [3.1120972e-13, 4.9353761e-13, 3.9814050e-13, ..., 1.4934057e-13,
        2.5434326e-13, 1.0919302e-13],
       [4.7266363e-10, 5.0536669e-10, 1.7544977e-09, ..., 1.3492170e-11,
        7.6990567e-11, 7.9319142e-11],
       [4.3974872e-15, 4.5305372e-13, 5.8339665e-14, ..., 5.7260046e-15,
        1.4299443e-15, 1.4965100e-14]], dtype=float32)
```

Alexnet

In [ ]:
```
import keras
from keras.datasets import mnist
from keras.models import Sequential,Model
from keras.layers import Dense, Dropout, Flatten,Input,MaxPooling2D
from keras.layers import Conv2D, MaxPooling2D
import numpy as np
```

In [ ]:
```
import tensorflow as tf
(x_train,y_train),(x_test,y_test)=keras.datasets.mnist.load_data()
```

In [ ]:
```
x_train = x_train.astype('float32') / 255.
x_test = x_test.astype('float32') / 255.
y_train = keras.utils.to_categorical(y_train, 10)
y_test = keras.utils.to_categorical(y_test, 10)
```

In [ ]:
```
model=Sequential()
model.add(Conv2D(filters=96, kernel_size=(11, 11), strides=(4, 4), activation='relu', input_shape=(28,28,1)))
model.add(MaxPooling2D(pool_size=(3, 3), strides=(2, 2)))
model.add(Conv2D(filters=256, kernel_size=(5, 5), strides=(1, 1), activation='relu', padding="same"))
# model.add(MaxPooling2D(pool_size=(3, 3), strides=(2, 2)))
model.add(Conv2D(filters=384, kernel_size=(3, 3), strides=(1, 1), activation='relu', padding="same"))
model.add(Conv2D(filters=384, kernel_size=(3, 3), strides=(1, 1), activation='relu', padding="same"))
model.add(Conv2D(filters=256, kernel_size=(3, 3), strides=(1, 1), activation='relu', padding="same"))
model.add(Flatten())
model.add(Dense(4096,activation='relu'))
model.add(Dense(4096,activation='relu'))
model.add(Dense(10,activation='softmax'))
```

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

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

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 5, 5, 96)          11712

 max_pooling2d (MaxPooling2D  (None, 2, 2, 96)         0
 )

 conv2d_1 (Conv2D)           (None, 2, 2, 256)         614656

 conv2d_2 (Conv2D)           (None, 2, 2, 384)         885120

 conv2d_3 (Conv2D)           (None, 2, 2, 384)         1327488

 conv2d_4 (Conv2D)           (None, 2, 2, 256)         884992
```

```
 flatten (Flatten)           (None, 1024)              0

 dense (Dense)               (None, 4096)              4198400

 dense_1 (Dense)             (None, 4096)              16781312

 dense_2 (Dense)             (None, 10)                40970

=================================================================
Total params: 24,744,650
Trainable params: 24,744,650
Non-trainable params: 0
_________________________________________________________________
```

In [ ]:

```
model.fit(x_train,y_train,validation_data=(x_test,y_test),epochs=20,batch_size=32)
```

```
Epoch 1/20
1875/1875 [==============================] - 36s 11ms/step - loss: 0.4395 - accuracy: 0.8518 - val_loss: 0.1389 - val_accuracy: 0.
9654
Epoch 2/20
1875/1875 [==============================] - 21s 11ms/step - loss: 0.1455 - accuracy: 0.9639 - val_loss: 0.1255 - val_accuracy: 0.
9691
Epoch 3/20
1875/1875 [==============================] - 22s 12ms/step - loss: 0.1115 - accuracy: 0.9720 - val_loss: 0.1413 - val_accuracy: 0.
9657
Epoch 4/20
1875/1875 [==============================] - 21s 11ms/step - loss: 0.0929 - accuracy: 0.9760 - val_loss: 0.0858 - val_accuracy: 0.
9781
Epoch 5/20
1875/1875 [==============================] - 23s 12ms/step - loss: 0.0772 - accuracy: 0.9796 - val_loss: 0.0923 - val_accuracy: 0.
9720
Epoch 6/20
1875/1875 [==============================] - 22s 12ms/step - loss: 0.0715 - accuracy: 0.9809 - val_loss: 0.0622 - val_accuracy: 0.
9817
Epoch 7/20
1875/1875 [==============================] - 21s 11ms/step - loss: 0.0659 - accuracy: 0.9822 - val_loss: 0.0738 - val_accuracy: 0.
9797
Epoch 8/20
1875/1875 [==============================] - 21s 11ms/step - loss: 0.0583 - accuracy: 0.9843 - val_loss: 0.0706 - val_accuracy: 0.
9814
Epoch 9/20
1875/1875 [==============================] - 21s 11ms/step - loss: 0.0539 - accuracy: 0.9859 - val_loss: 0.0640 - val_accuracy: 0.
```

```
9839
Epoch 10/20
1875/1875 [==============================] - 21s 11ms/step - loss: 0.0467 - accuracy: 0.9877 - val_loss: 0.0804 - val_accuracy: 0.
9815
Epoch 11/20
1875/1875 [==============================] - 22s 12ms/step - loss: 0.0501 - accuracy: 0.9869 - val_loss: 0.0843 - val_accuracy: 0.
9774
Epoch 12/20
1875/1875 [==============================] - 26s 14ms/step - loss: 0.0375 - accuracy: 0.9889 - val_loss: 0.0760 - val_accuracy: 0.
9821
Epoch 13/20
1875/1875 [==============================] - 24s 13ms/step - loss: 0.0378 - accuracy: 0.9901 - val_loss: 0.0902 - val_accuracy: 0.
9831
Epoch 14/20
1875/1875 [==============================] - 22s 12ms/step - loss: 0.0405 - accuracy: 0.9894 - val_loss: 0.1138 - val_accuracy: 0.
9790
Epoch 15/20
1875/1875 [==============================] - 23s 12ms/step - loss: 0.0332 - accuracy: 0.9909 - val_loss: 0.1038 - val_accuracy: 0.
9800
Epoch 16/20
1875/1875 [==============================] - 22s 12ms/step - loss: 0.0375 - accuracy: 0.9900 - val_loss: 0.1118 - val_accuracy: 0.
9718
Epoch 17/20
1875/1875 [==============================] - 21s 11ms/step - loss: 0.0334 - accuracy: 0.9909 - val_loss: 0.0753 - val_accuracy: 0.
9845
Epoch 18/20
1875/1875 [==============================] - 21s 11ms/step - loss: 0.0298 - accuracy: 0.9918 - val_loss: 0.1126 - val_accuracy: 0.
9772
Epoch 19/20
1875/1875 [==============================] - 22s 11ms/step - loss: 0.0289 - accuracy: 0.9929 - val_loss: 0.0679 - val_accuracy: 0.
9833
Epoch 20/20
1875/1875 [==============================] - 22s 12ms/step - loss: 0.0284 - accuracy: 0.9921 - val_loss: 0.0786 - val_accuracy: 0.
9810
```

Out[ ]: <keras.callbacks.History at 0x7fb01c208430>

Lnet

In [ ]:
```
model1 = Sequential()
model1.add(Conv2D(8, kernel_size=(5, 5), activation='relu', input_shape=(28, 28, 1)))
model1.add(MaxPooling2D(pool_size=(2, 2)))
model1.add(Conv2D(16, kernel_size=(5, 5), activation='relu'))
```

```
model1.add(Conv2D(32, kernel_size=(5, 5), activation='relu'))
model1.add(Flatten())
model1.add(Dense(120, activation='relu'))
model1.add(Dense(10, activation='softmax'))
model1.compile(loss=keras.metrics.categorical_crossentropy, optimizer=keras.optimizers.Adam(), metrics=['accuracy'])
```

In [ ]:

```
model1.summary()
```

```
Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_16 (Conv2D)          (None, 24, 24, 8)         208

 max_pooling2d_6 (MaxPooling  (None, 12, 12, 8)        0
 2D)

 conv2d_17 (Conv2D)          (None, 8, 8, 16)          3216

 conv2d_18 (Conv2D)          (None, 4, 4, 32)          12832

 flatten_3 (Flatten)         (None, 512)               0

 dense_7 (Dense)             (None, 120)               61560

 dense_8 (Dense)             (None, 10)                1210

=================================================================
Total params: 79,026
Trainable params: 79,026
Non-trainable params: 0
_________________________________________________________________
```

In [ ]:

```
model1.fit(x_train,y_train,validation_data=(x_test,y_test),epochs=20,batch_size=32)
```

```
Epoch 1/20
1875/1875 [==============================] - 9s 4ms/step - loss: 0.1839 - accuracy: 0.9430 - val_loss: 0.0805 - val_accuracy: 0.97
40
Epoch 2/20
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0643 - accuracy: 0.9800 - val_loss: 0.0437 - val_accuracy: 0.98
66
Epoch 3/20
```

```
Epoch 18/20
1875/1875 [==============================] - 9s 5ms/step - loss: 0.0089 - accuracy: 0.9974 - val_loss: 0.0426 - val_accuracy: 0.99
13
Epoch 19/20
1875/1875 [==============================] - 9s 5ms/step - loss: 0.0081 - accuracy: 0.9976 - val_loss: 0.0511 - val_accuracy: 0.98
93
Epoch 20/20
1875/1875 [==============================] - 8s 4ms/step - loss: 0.0079 - accuracy: 0.9974 - val_loss: 0.0464 - val_accuracy: 0.99
06
```

Out[ ]: <keras.callbacks.History at 0x7faf72d99d30>

VGG-16

In [ ]:
```
from skimage.transform import resize
num_samples, img_height, img_width = x_train.shape
new_img_height, new_img_width = 224, 224
x_train = x_train.reshape(num_samples, img_height, img_width, 1)
x_train_resized = np.zeros((num_samples, new_img_height, new_img_width, 1))
for i in range(num_samples):
    x_train_resized[i] = resize(x_train[i], (new_img_height, new_img_width))
x_train_resized = x_train_resized.reshape(num_samples, new_img_height, new_img_width)
```

In [ ]:
```
model2=Sequential()
model2.add(Conv2D(64, kernel_size=(5, 5), activation='relu', input_shape=(28, 28, 1)))
model2.add(Conv2D(64, kernel_size=(5, 5), activation='relu'))
model2.add(MaxPooling2D(pool_size=(2, 2)))
model2.add(Conv2D(128, kernel_size=(5, 5), activation='relu'))
model2.add(Conv2D(128, kernel_size=(5, 5), activation='relu'))
# model2.add(MaxPooling2D(pool_size=(2, 2)))
# model2.add(Conv2D(256, kernel_size=(5, 5), activation='relu'))
# model2.add(Conv2D(256, kernel_size=(5, 5), activation='relu'))
# model2.add(Conv2D(256, kernel_size=(5, 5), activation='relu'))
# model2.add(MaxPooling2D(pool_size=(2, 2)))
# model2.add(Conv2D(512, kernel_size=(5, 5), activation='relu'))
# model2.add(Conv2D(512, kernel_size=(5, 5), activation='relu'))
# model2.add(Conv2D(512, kernel_size=(5, 5), activation='relu'))
# model2.add(Conv2D(512, kernel_size=(5, 5), activation='relu'))
# model2.add(Conv2D(512, kernel_size=(5, 5), activation='relu'))
# model2.add(Conv2D(512, kernel_size=(5, 5), activation='relu'))
# model2.add(MaxPooling2D(pool_size=(2, 2)))
model2.add(Flatten())
```

```
model2.add(Dense(4096,activation='relu'))
model2.add(Dense(4096,activation='relu'))
model2.add(Dense(10,activation='softmax'))
```

In [ ]:
```
model2.compile(loss=keras.metrics.categorical_crossentropy, optimizer=keras.optimizers.Adam(), metrics=['accuracy'])
```

In [ ]:
```
model2.summary()
```

```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_18 (Conv2D)          (None, 24, 24, 64)        1664

 conv2d_19 (Conv2D)          (None, 20, 20, 64)        102464

 max_pooling2d_8 (MaxPooling  (None, 10, 10, 64)       0
 2D)

 conv2d_20 (Conv2D)          (None, 6, 6, 128)         204928

 conv2d_21 (Conv2D)          (None, 2, 2, 128)         409728

 flatten_1 (Flatten)         (None, 512)               0

 dense_3 (Dense)             (None, 4096)              2101248

 dense_4 (Dense)             (None, 4096)              16781312

 dense_5 (Dense)             (None, 10)                40970

=================================================================
Total params: 19,642,314
Trainable params: 19,642,314
Non-trainable params: 0
_________________________________________________________________
```

In [ ]:
```
model2.fit(x_train,y_train,validation_data=(x_test,y_test),epochs=20,batch_size=32)
```

```
Epoch 1/20
1875/1875 [==============================] - 27s 10ms/step - loss: 0.1588 - accuracy: 0.9538 - val_loss: 0.0849 - val_accuracy: 0.
```

```
1875/1875 [==============================] - 19s 10ms/step - loss: 0.0227 - accuracy: 0.9952 - val_loss: 0.0576 - val_accuracy: 0.
9906
Epoch 17/20
1875/1875 [==============================] - 19s 10ms/step - loss: 0.0152 - accuracy: 0.9967 - val_loss: 0.0625 - val_accuracy: 0.
9901
Epoch 18/20
1875/1875 [==============================] - 19s 10ms/step - loss: 0.0194 - accuracy: 0.9965 - val_loss: 0.0624 - val_accuracy: 0.
9911
Epoch 19/20
1875/1875 [==============================] - 19s 10ms/step - loss: 0.0177 - accuracy: 0.9969 - val_loss: 0.0741 - val_accuracy: 0.
9916
Epoch 20/20
1875/1875 [==============================] - 19s 10ms/step - loss: 0.0133 - accuracy: 0.9972 - val_loss: 0.0529 - val_accuracy: 0.
9920
```

Out[ ]: <keras.callbacks.History at 0x7f8370ae8eb0>

In [ ]: