```
%matplotlib inline
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
from scipy.io import loadmat

# If you are NOT using google colab, you need to take this part out starting from here
from google.colab import files

uploaded=files.upload()
# till here

data = loadmat('notMNIST_small.mat')
X_temp = data['images']/255

#for i in range(X_temp.shape[2]):

X = np.empty(shape=[X_temp.shape[2]] + [784], dtype='float32')
for i in range(X_temp.shape[2]):
    X[i,:] = X_temp[:,:,i].flatten()

y = pd.get_dummies(data['labels']).to_numpy()

print(X_temp.shape)
print(X.shape)
print(y.shape)
X[1,:]
```

Choose Files notMNIST_small.mat

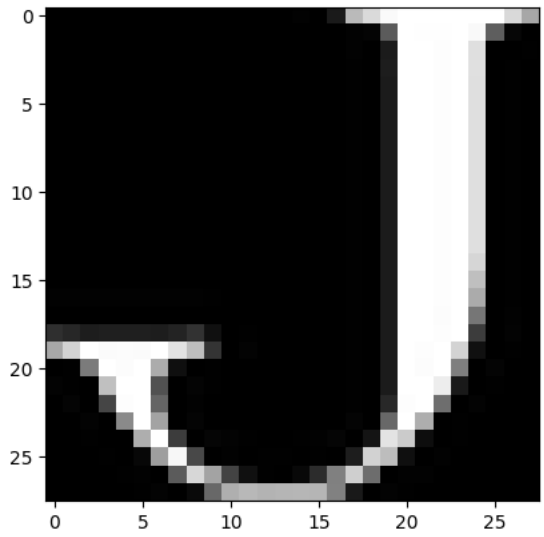
- **notMNIST_small.mat**(n/a) - 117586976 bytes, last modified: 10/1/2023 - 100% done

```
Saving notMNIST_small.mat to notMNIST_small.mat
(28, 28, 18724)
(18724, 784)
(18724, 10)
array([0.        , 0.00392157, 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.03137255, 0.16078432, 0.38039216, 0.6509804 , 0.87058824,
       0.9764706 , 0.90588236, 0.6627451 , 0.4       , 0.11764706,
       0.        , 0.00784314, 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.07450981,
       0.3647059 , 0.44313726, 0.42745098, 0.4627451 , 0.5019608 ,
       0.54509807, 0.6392157 , 0.77254903, 0.8627451 , 0.9607843 ,
       1.        , 1.        , 1.        , 1.        , 1.        ,
       0.99607843, 1.        , 0.94509804, 0.42352942, 0.        ,
       0.00392157, 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.01176471, 0.654902  , 1.        , 0.9843137 ,
       1.        , 1.        , 1.        , 1.        , 1.        ,
       1.        , 1.        , 0.99607843, 0.98039216, 0.972549  ,
       0.99215686, 1.        , 0.99607843, 0.9882353 , 0.99215686,
       0.99215686, 1.        , 0.21568628, 0.        , 0.00784314,
       0.        , 0.        , 0.        , 0.        , 0.05882353,
       0.7529412 , 1.        , 0.98039216, 0.9764706 , 0.96862745,
       0.96862745, 0.98039216, 0.99607843, 1.        , 1.        ,
       1.        , 1.        , 1.        , 0.99607843, 1.        ,
       1.        , 1.        , 1.        , 0.9843137 , 1.        ,
       0.5372549 , 0.        , 0.00392157, 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.18039216, 0.74509805,
       0.96862745, 1.        , 1.        , 1.        , 1.        ,
       0.98039216, 0.9372549 , 0.85882354, 0.76862746, 0.6666667 ,
       0.6627451 , 0.9372549 , 1.        , 0.99607843, 1.        ,
       1.        , 0.99607843, 1.        , 0.85882354, 0.00392157,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.1254902 , 0.2784314 ,
       0.3372549 , 0.3372549 , 0.24705882, 0.15294118, 0.07058824,
       0.01960784, 0.        , 0.01568628, 0.        , 0.3764706 ,
       1.        , 1.        , 0.99607843, 1.        , 1.        ,
       1.        , 0.9764706 , 0.24705882, 0.        , 0.00784314,
       0.        , 0.        , 0.        , 0.        , 0.00784314,
       0.00392157, 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.00392157,
       0.01176471, 0.01568628, 0.        , 0.8117647 , 1.        ,
       0.99607843, 1.        , 1.        , 0.99215686, 1.        ,
       0.58431375, 0.        , 0.01568628, 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.00392157, 0.00392157,
       0.01176471, 0.01568628, 0.01568628, 0.01176471, 0.00784314,
       0.00392157, 0.00392157, 0.        , 0.        , 0.00784314,
       0.        , 0.45882353, 1.        , 0.99607843, 1.        ,
       1.        , 0.9882353 , 1.        , 0.8       , 0.03137255,
       0.        , 0.00392157, 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.00392157, 0.        , 0.13725491,
       0.9882353 , 1.        , 1.        , 1.        , 0.99607843,
       1.        , 0.9764706 , 0.2901961 , 0.        , 0.01568628,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.00392157, 0.        , 0.01960784, 0.6901961 , 1.        ,
       0.9882353 , 1.        , 1.        , 0.98039216, 1.        ,
       0.52156866, 0.        , 0.01568628, 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.01176471,
       0.        , 0.36862746, 1.        , 0.9843137 , 1.        ,
       1.        , 0.9882353 , 1.        , 0.8       , 0.07450981,
       0.        , 0.00392157, 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.00784314, 0.        , 0.15294118,
       0.88235295, 1.        , 0.99215686, 1.        , 1.        ,
       0.99215686, 1.        , 0.21960784, 0.        , 0.00784314,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.00392157, 0.01176471, 0.        , 0.6666667 , 1.        ,
       0.9843137 , 1.        , 1.        , 0.99215686, 1.        ,
       0.5176471 , 0.        , 0.00392157, 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.01568628,
       0.        , 0.41568628, 1.        , 0.99607843, 0.99607843,
       1.        , 0.99607843, 1.        , 0.85490197, 0.01176471,
```

```
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.00392157, 0.01176471, 0.01960784, 0.        , 0.20392157,
0.93333334, 1.        , 0.99607843, 1.        , 1.        ,
1.        , 0.98039216, 0.23137255, 0.        , 0.00392157,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.00392157, 0.00784314,
0.01568628, 0.01176471, 0.00392157, 0.        , 0.        ,
0.        , 0.00784314, 0.        , 0.8352941 , 1.        ,
0.99215686, 1.        , 1.        , 0.99215686, 1.        ,
0.5803922 , 0.        , 0.01568628, 0.        , 0.        ,
0.        , 0.        , 0.        , 0.00392157, 0.01176471,
0.01176471, 0.        , 0.        , 0.        , 0.        ,
0.00392157, 0.08235294, 0.2       , 0.31764707, 0.41960785,
0.43529412, 0.8666667 , 1.        , 0.99607843, 1.        ,
1.        , 0.9882353 , 1.        , 0.80784315, 0.01960784,
0.        , 0.        , 0.        , 0.        , 0.00392157,
0.01176471, 0.        , 0.        , 0.        , 0.01568628,
0.16862746, 0.3764706 , 0.5803922 , 0.7764706 , 0.92941177,
1.        , 1.        , 1.        , 1.        , 1.        ,
1.        , 0.99607843, 1.        , 1.        , 0.99607843,
1.        , 0.96862745, 0.28235295, 0.        , 0.        ,
0.00392157, 0.01568628, 0.00392157, 0.        , 0.03529412,
0.24705882, 0.5568628 , 0.8235294 , 0.98039216, 1.        ,
1.        , 1.        , 1.        , 1.        , 0.99607843,
1.        , 0.9411765 , 0.8235294 , 0.87058824, 1.        ,
```

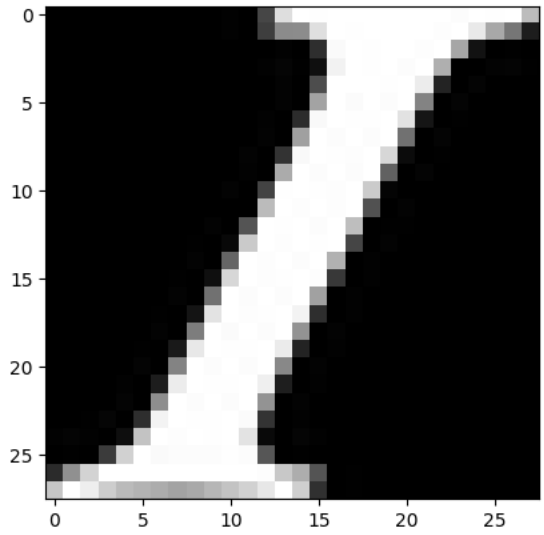
```
print(X_temp[:,:,3].shape)
plt.imshow(X_temp[:,:,3],cmap="gray");
```

```
(28, 28)
```




```
1.        , 0.76980394, 0.1764706 , 0.0784314 , 0.99215686,
```

```
plt.imshow(X_temp[:,:,4504],cmap="gray");
```



```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test =train_test_split(
    X, y, test_size=0.2, random_state=50)
print(X_train.shape)
print(y_train.shape)
```

```
(14979, 784)
(14979, 10)
```

```
print(y_test[7])
```

```
[0 1 0 0 0 0 0 0 0 0]
```

```
from keras.models import Sequential
from keras.layers import Dense
from keras.regularizers import l2, l1
from tensorflow.keras.optimizers import SGD , Adam

model = Sequential()

model.add(Dense(units = 256,  input_shape=[784], activation='sigmoid', kernel_regularizer=l2(0.01)))
model.add(Dense(units = 128,  input_shape=[256], activation='sigmoid', kernel_regularizer=l2(0.01)))
model.add(Dense(units = 10,  input_shape=[128], activation='sigmoid', kernel_regularizer=l2(0.01)))

sgd = SGD(learning_rate=0.1)

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

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 256)               200960

 dense_1 (Dense)             (None, 128)               32896

 dense_2 (Dense)             (None, 10)                1290

=================================================================
Total params: 235146 (918.54 KB)
Trainable params: 235146 (918.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
history = model.fit(X_train, y_train, batch_size = 256,
                    epochs = 100, verbose=0, validation_data=(X_test,y_test))
```

```
%matplotlib inline
import matplotlib.pyplot as plt

fig = plt.figure(figsize=(6,4))

plt.plot(history.history['loss'])

plt.plot(history.history['val_loss'], 'g--')

plt.title('Logistic Regression Model Loss')

plt.ylabel('categorical_crossentropy')

plt.xlabel('Epoch')

plt.legend(['Training Loss', 'Testing Loss'], loc='upper right')

print("Loss after final iteration: ", history.history['val_loss'][-1])

print("Training Loss after final iteration: ", history.history['loss'][-1])

plt.show()
```

```
Loss after final iteration:  1.6950663328170776
Training Loss after final iteration:  1.6902908086776733
```