Import Modules

```
import numpy as np
import tensorflow as tf
from tensorflow.keras.datasets import mnist
from tensorflow.keras import layers
from tensorflow.keras.models import Model
from tensorflow.keras.utils import to_categorical     #One-Hot Encoding
```

Read Dataset and Normalization

```
#Read Dataset
(X_train, y_train), (X_test, y_test) = mnist.load_data()

#Normalization
X_train = X_train.astype("float32")/255.0        #shape = (60000, 28, 28)
X_test = X_test.astype("float32")/255.0          #shape = (10000, 28, 28)

#Batch size
X_train = np.expand_dims(X_train, axis = -1)    #shape = (60000, 28, 28, 1)
X_test = np.expand_dims(X_test, axis = -1)      #shape = (10000, 28, 28, 1)


#One-Hot Encoding

# Befor t0_categorical: y_train equals to [5 0 4 ..... 5 6 8]
#After to_categorical: y_train = [1 0 0 0 ... 0],.....

#convert class vectors to binary class matrices
y_train_one_hot = to_categorical(y_train)
y_test_one_hot = to_categorical(y_test)
```

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

Main part of network - CNN

```
#Start defining the input tensor
#we define input_1 beacause keras ducument say:"When using Conv2D as the first layer in a
input_1 = layers.Input(shape=(28, 28, 1))

#Define layers

x = layers.Conv2D(32, (5, 5))(input_1)    #number of filter = 32 , dimension of filter = (
x = layers.BatchNormalization()(x)
```

```
    x = layers.PReLU()(x)

    x = layers.Conv2D(32, (5, 5))(x)          #number of filter = 32 , dimension of filter = (
    x = layers.BatchNormalization()(x)
    x = layers.PReLU()(x)

    x = layers.Conv2D(64, (5, 5))(x)          #number of filter = 64 , dimension of filter = (
    x = layers.BatchNormalization()(x)
    x = layers.PReLU()(x)

    x = layers.Conv2D(64, (5, 5))(x)          #number of filter = 64 , dimension of filter = (
    x = layers.BatchNormalization()(x)
    x = layers.PReLU()(x)

    x = layers.Conv2D(128, (5, 5))(x)         #number of filter = 128 , dimension of filter =
    x = layers.BatchNormalization()(x)
    x = layers.PReLU()(x)

    x = layers.Conv2D(128, (5, 5))(x)        #number of filter = 128 , dimension of filter = (
    x = layers.BatchNormalization()(x)
    x = layers.PReLU()(x)

    #Make data to Flatten
    x = layers.Flatten()(x)

    #We choose 2 for visualizing in x-y (2D plane)
    x = layers.Dense(2)(x)

    out_1 = layers.PReLU(name= "out_1")(x)    #Output of 2 neurons we define

    out_2 = layers.Dense(10, activation= "softmax")(out_1)   #this is main output for mnist da
```

Center Loss network

```
#Lambda_c is a constant for center loss function
lambda_c = 1
input_2 = layers.Input(shape=(1,))          # This is input number[0, 1, ....,9]

#Turns positive integers (indexes) into dense vectors of fixed size with Embedding

centers = layers.Embedding(10, 2)(input_2)    #Embeddding convert number to vector

# 10 is type of input for this layer[0, 1, 2, ... ,9] : input_dim
# 2 is the number of output for compare with 2 output in main network : output_dim

#Define center-loss function
def custom_layer(x):
  out_1 = x[0]
  centers = x[1]

  return tf.sqrt(tf.reduce_sum(tf.square(out_1 - centers[:, 0]), axis = 1, keepdims = True
print(out_1.shape)
```

```
print(centers.shape)
print(centers[:,0])
intra_loss = layers.Lambda(custom_layer)([out_1, centers])
```

```
(None, 2)
(None, 1, 2)
KerasTensor(type_spec=TensorSpec(shape=(None, 2), dtype=tf.float32, name=None), name=
```

Complete Model and Compile

```
model_center_loss = Model([input_1, input_2], [out_2, intra_loss])

#Compile Model

#If the model has multiple outputs, you can use a different loss on each output by passing
def custom_loss(y_true, y_pred):
  # y_pred equals to loss because we calculate loss in output of custom_layer
  return y_pred



model_center_loss.compile(optimizer= "sgd",
                          loss = ["categorical_crossentropy", custom_loss],  #An objective
                          loss_weights = [1, lambda_c/2],                    # scalar coef
                          metrics=  ["accuracy"])


dummy_matrix1 = np.zeros((X_train.shape[0], 1))     #X_train.shape[0] = 60000
dummy_matrix2 = np.zeros((X_test.shape[0], 1))      #X_test.shape[0] = 10000

model_center_loss.fit(x = [X_train, y_train], y = [y_train_one_hot, dummy_matrix1],
                        batch_size = 32, epochs = 5, verbose = 1,
                        validation_data=([X_test, y_test], [y_test_one_hot, dummy_matrix2]

#print(model_center_loss.summary())
```

```
oss: 0.1357 - dense_7_accuracy: 0.1889 - lambda_3_accuracy: 0.9259 - val_loss: 2.1526

oss: 0.1473 - dense_7_accuracy: 0.2357 - lambda_3_accuracy: 0.9031 - val_loss: 1.9597

oss: 0.2912 - dense_7_accuracy: 0.4391 - lambda_3_accuracy: 0.8130 - val_loss: 1.5882

oss: 0.2434 - dense_7_accuracy: 0.5199 - lambda_3_accuracy: 0.8391 - val_loss: 1.3519

oss: 0.2006 - dense_7_accuracy: 0.6016 - lambda_3_accuracy: 0.9086 - val_loss: 1.1961
```

Plot Model

```
from keras import backend as K
```

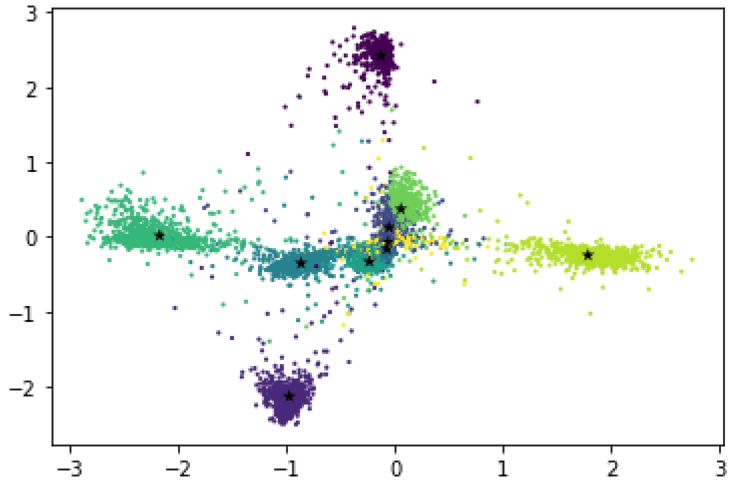
```
model=Model(input_1,out_2)

func = K.function([model.input],[model.get_layer('out_1').output])
test_features= func([X_test])[0]
print(test_features.shape)

test_centers = np.dot(np.transpose(y_test_one_hot),test_features)
test_centers_count = np.sum(np.transpose(y_test_one_hot),axis=1,keepdims=True)
test_centers /= test_centers_count
print(test_centers.shape)

from matplotlib import pyplot as plt
%matplotlib inline
plt.scatter(test_features[:,0],test_features[:,1],c=y_test,edgecolor="none",s=5)
plt.scatter(test_centers[:,0],test_centers[:,1],c="black",marker="*",edgecolor="none",s=50
plt.show()
```

```
(10000, 2)
(10, 2)
```



✓ 0s completed at 5:41 PM