cnn on mnist dataset

In [0]:

```
# Credits: https://github.com/keras-team/keras/blob/master/examples/mni
st_cnn.py


from __future__ import print_function
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.layers import Conv2D, MaxPooling2D
from keras import backend as K

batch_size = 128
num_classes = 10
epochs = 12

# input image dimensions
img_rows, img_cols = 28, 28

# the data, split between train and test sets
(x_train, y_train), (x_test, y_test) = mnist.load_data()

if K.image_data_format() == 'channels_first':
    x_train = x_train.reshape(x_train.shape[0], 1, img_rows, img_cols)
    x_test = x_test.reshape(x_test.shape[0], 1, img_rows, img_cols)
    input_shape = (1, img_rows, img_cols)
else:
    x_train = x_train.reshape(x_train.shape[0], img_rows, img_cols, 1)
    x_test = x_test.reshape(x_test.shape[0], img_rows, img_cols, 1)
    input_shape = (img_rows, img_cols, 1)

x_train = x_train.astype('float32')
```

```
x_test = x_test.astype('float32')
x_train /= 255
x_test /= 255
print('x_train shape:', x_train.shape)
print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')

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

model = Sequential()
model.add(Conv2D(32, kernel_size=(5, 5),
                 activation='relu',
                 input_shape=input_shape))
model.add(Conv2D(64, (5, 5), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))

model.compile(loss=keras.losses.categorical_crossentropy,
              optimizer=keras.optimizers.Adadelta(),
              metrics=['accuracy'])

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

```
Using TensorFlow backend.
```

```
Downloading data from https://s3.amazonaws.com/img-datasets/mnist.npz
11493376/11490434 [==============================] - 1s 0us/step
```

```
x_train shape: (60000, 28, 28, 1)
60000 train samples
10000 test samples
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorfl
ow/python/framework/op_def_library.py:263: colocate_with (from tensorfl
ow.python.framework.ops) is deprecated and will be removed in a future
version.
Instructions for updating:
Colocations handled automatically by placer.
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/ba
ckend/tensorflow_backend.py:3445: calling dropout (from tensorflow.pyth
on.ops.nn_ops) with keep_prob is deprecated and will be removed in a fu
ture version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate =
1 - keep_prob`.
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorfl
ow/python/ops/math_ops.py:3066: to_int32 (from tensorflow.python.ops.ma
th_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Train on 60000 samples, validate on 10000 samples
Epoch 1/12
60000/60000 [==============================] - 10s 173us/step - loss:
0.2330 - acc: 0.9267 - val_loss: 0.0524 - val_acc: 0.9839
Epoch 2/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
779 - acc: 0.9768 - val_loss: 0.0435 - val_acc: 0.9864
Epoch 3/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
600 - acc: 0.9822 - val_loss: 0.0293 - val_acc: 0.9899
Epoch 4/12
60000/60000 [==============================] - 5s 77us/step - loss: 0.0
478 - acc: 0.9855 - val_loss: 0.0248 - val_acc: 0.9908
Epoch 5/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
409 - acc: 0.9876 - val_loss: 0.0243 - val_acc: 0.9916
Epoch 6/12
60000/60000 [==============================] - 5s 77us/step - loss: 0.0
```

```
359 - acc: 0.9890 - val_loss: 0.0259 - val_acc: 0.9919
Epoch 7/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
330 - acc: 0.9903 - val_loss: 0.0303 - val_acc: 0.9896
Epoch 8/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
288 - acc: 0.9914 - val_loss: 0.0238 - val_acc: 0.9921
Epoch 9/12
60000/60000 [==============================] - 5s 79us/step - loss: 0.0
272 - acc: 0.9919 - val_loss: 0.0224 - val_acc: 0.9928
Epoch 10/12
60000/60000 [==============================] - 5s 81us/step - loss: 0.0
249 - acc: 0.9921 - val_loss: 0.0213 - val_acc: 0.9930
Epoch 11/12
60000/60000 [==============================] - 5s 81us/step - loss: 0.0
230 - acc: 0.9930 - val_loss: 0.0226 - val_acc: 0.9931
Epoch 12/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
213 - acc: 0.9935 - val_loss: 0.0227 - val_acc: 0.9927
Test loss: 0.022691776645601566
Test accuracy: 0.9927
```

In [0]:

```
%matplotlib inline
import matplotlib.pyplot as plt
import numpy as np
import time
# https://gist.github.com/greydanus/f6eee59eaf1d90fcb3b534a25362cea4
# https://stackoverflow.com/a/14434334
# this function is used to update the plots for each epoch and error
def plt_dynamic(x, vy, ty, ax, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation Loss")
    ax.plot(x, ty, 'r', label="Train Loss")
    plt.legend()
    plt.grid()
    fig.canvas.draw()
```

In [0]:

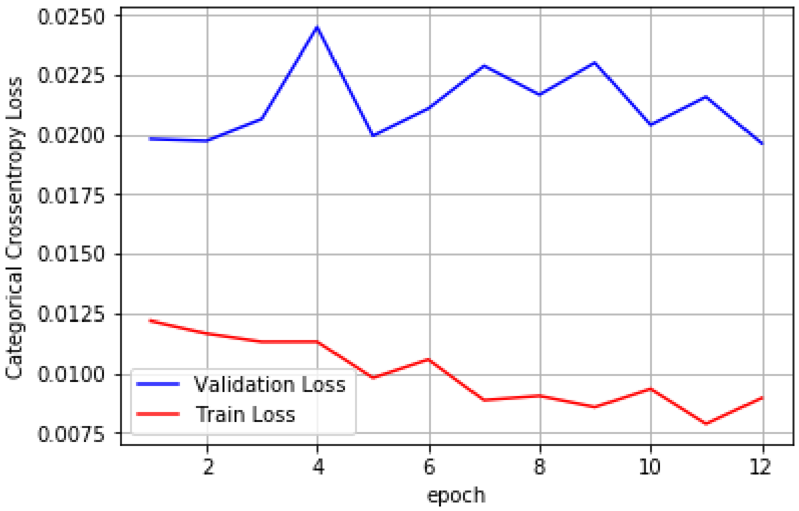
```
history = model.fit(x_train, y_train, batch_size=batch_size, epochs=12,
 verbose=1, validation_data=(x_test, y_test))
```

```
Train on 60000 samples, validate on 10000 samples
Epoch 1/12
60000/60000 [==============================] - 5s 81us/step - loss: 0.0
122 - acc: 0.9962 - val_loss: 0.0198 - val_acc: 0.9953
Epoch 2/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
117 - acc: 0.9965 - val_loss: 0.0197 - val_acc: 0.9944
Epoch 3/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
113 - acc: 0.9962 - val_loss: 0.0206 - val_acc: 0.9945
Epoch 4/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
113 - acc: 0.9961 - val_loss: 0.0245 - val_acc: 0.9945
Epoch 5/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
098 - acc: 0.9968 - val_loss: 0.0199 - val_acc: 0.9948
Epoch 6/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
106 - acc: 0.9968 - val_loss: 0.0211 - val_acc: 0.9945
Epoch 7/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
089 - acc: 0.9969 - val_loss: 0.0229 - val_acc: 0.9940
Epoch 8/12
60000/60000 [==============================] - 5s 80us/step - loss: 0.0
090 - acc: 0.9971 - val_loss: 0.0217 - val_acc: 0.9954
Epoch 9/12
60000/60000 [==============================] - 5s 80us/step - loss: 0.0
086 - acc: 0.9972 - val_loss: 0.0230 - val_acc: 0.9950
Epoch 10/12
60000/60000 [==============================] - 5s 77us/step - loss: 0.0
093 - acc: 0.9971 - val_loss: 0.0204 - val_acc: 0.9953
Epoch 11/12
60000/60000 [==============================] - 5s 77us/step - loss: 0.0
079 - acc: 0.9975 - val_loss: 0.0216 - val_acc: 0.9949
Epoch 12/12
60000/60000 [==============================] - 5s 77us/step - loss: 0.0
089 - acc: 0.9972 - val_loss: 0.0196 - val_acc: 0.9953
```

```
In [0]: print('Test score:', score[0])
```

```
print('Test accuracy:', score[1])

fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('Categorical Crossentropy Loss')

# list of epoch numbers
x = list(range(1,13))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epo
chs=nb_epoch, verbose=1, validation_data=(X_test, Y_test))

# we will get val_loss and val_acc only when you pass the paramter vali
dation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal
 to number of epochs


vy = history.history['val_loss']
ty = history.history['loss']
plt_dynamic(x, vy, ty, ax)
```

```
Test score: 0.022691776645601566
Test accuracy: 0.9927
```



Three Diff convnets

M1:Three conv layers-(max-pool,batch-norm,drop-out)

In [0]:

```
from keras.layers.normalization import BatchNormalization

model1 = Sequential()
model1.add(Conv2D(32, kernel_size=(3, 3),
                 activation='relu',
                 input_shape=input_shape))
model1.add(MaxPooling2D(pool_size=(2, 2)))
model1.add(Conv2D(64, (3, 3), activation='relu'))
model1.add(Conv2D(32, (3, 3), activation='relu'))
model1.add(MaxPooling2D(pool_size=(2, 2)))

model1.add(Dropout(0.25))
model1.add(Flatten())
```

```
model1.add(Dense(128, activation='relu'))
model1.add(BatchNormalization())
model1.add(Dropout(0.5))
model1.add(Dense(num_classes, activation='softmax'))

print(model1.summary())

model1.compile(loss=keras.losses.categorical_crossentropy,
              optimizer=keras.optimizers.Adadelta(),
              metrics=['accuracy'])

history=model1.fit(x_train, y_train,batch_size=batch_size,epochs=epochs
,verbose=1,validation_data=(x_test, y_test))
score = model1.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_51 (Conv2D)           (None, 26, 26, 32)        320       
_________________________________________________________________
max_pooling2d_27 (MaxPooling (None, 13, 13, 32)        0         
_________________________________________________________________
conv2d_52 (Conv2D)           (None, 11, 11, 64)        18496     
_________________________________________________________________
conv2d_53 (Conv2D)           (None, 9, 9, 32)          18464     
_________________________________________________________________
max_pooling2d_28 (MaxPooling (None, 4, 4, 32)          0         
_________________________________________________________________
dropout_18 (Dropout)         (None, 4, 4, 32)          0         
_________________________________________________________________
flatten_7 (Flatten)          (None, 512)               0         
_________________________________________________________________
dense_11 (Dense)             (None, 128)               65664     
_________________________________________________________________
batch_normalization_5 (Batch (None, 128)               512       
_________________________________________________________________
dropout_19 (Dropout)         (None, 128)               0         
_________________________________________________________________
```

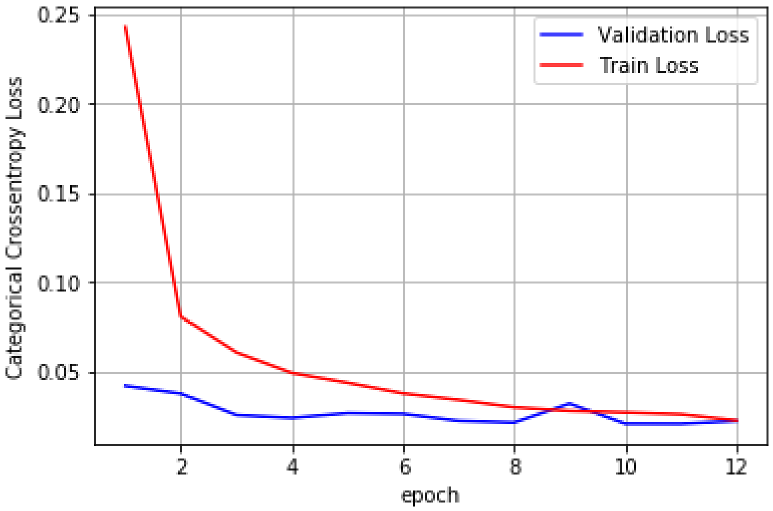
```
dense_12 (Dense)             (None, 10)                1290
=================================================================
Total params: 104,746
Trainable params: 104,490
Non-trainable params: 256
_________________________________________________________________
None
Train on 60000 samples, validate on 10000 samples
Epoch 1/12
60000/60000 [==============================] - 5s 87us/step - loss: 0.2
426 - acc: 0.9259 - val_loss: 0.0420 - val_acc: 0.9864
Epoch 2/12
60000/60000 [==============================] - 4s 65us/step - loss: 0.0
807 - acc: 0.9753 - val_loss: 0.0377 - val_acc: 0.9885
Epoch 3/12
60000/60000 [==============================] - 4s 64us/step - loss: 0.0
607 - acc: 0.9815 - val_loss: 0.0256 - val_acc: 0.9911
Epoch 4/12
60000/60000 [==============================] - 4s 65us/step - loss: 0.0
492 - acc: 0.9846 - val_loss: 0.0240 - val_acc: 0.9923
Epoch 5/12
60000/60000 [==============================] - 4s 64us/step - loss: 0.0
437 - acc: 0.9864 - val_loss: 0.0267 - val_acc: 0.9903
Epoch 6/12
60000/60000 [==============================] - 4s 64us/step - loss: 0.0
378 - acc: 0.9879 - val_loss: 0.0263 - val_acc: 0.9916
Epoch 7/12
60000/60000 [==============================] - 4s 64us/step - loss: 0.0
341 - acc: 0.9890 - val_loss: 0.0223 - val_acc: 0.9934
Epoch 8/12
60000/60000 [==============================] - 4s 68us/step - loss: 0.0
300 - acc: 0.9909 - val_loss: 0.0214 - val_acc: 0.9940
Epoch 9/12
60000/60000 [==============================] - 4s 71us/step - loss: 0.0
279 - acc: 0.9914 - val_loss: 0.0320 - val_acc: 0.9911
Epoch 10/12
60000/60000 [==============================] - 4s 68us/step - loss: 0.0
271 - acc: 0.9914 - val_loss: 0.0207 - val_acc: 0.9940
Epoch 11/12
```

```
60000/60000 [==============================] - 4s 64us/step - loss: 0.0
261 - acc: 0.9917 - val_loss: 0.0207 - val_acc: 0.9935
Epoch 12/12
60000/60000 [==============================] - 4s 64us/step - loss: 0.0
226 - acc: 0.9927 - val_loss: 0.0223 - val_acc: 0.9937
Test loss: 0.022268649872068273
Test accuracy: 0.9937
```

In [0]:

```
print('Test score:', score[0])
print('Test accuracy:', score[1])

fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('Categorical Crossentropy Loss')

# list of epoch numbers
x = list(range(1,13))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epo
chs=nb_epoch, verbose=1, validation_data=(X_test, Y_test))

# we will get val_loss and val_acc only when you pass the paramter vali
dation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal
 to number of epochs


vy = history.history['val_loss']
ty = history.history['loss']
plt_dynamic(x, vy, ty, ax)
```

```
Test score: 0.022268649872068273
Test accuracy: 0.9937
```



M2:Five conv layers-(max-pool,drop-out,batch-norm)

In [0]:

```
model2 = Sequential()
model2.add(Conv2D(8, kernel_size=(5, 5),padding='same',activation='relu',input_shape=input_shape))
model2.add(MaxPooling2D(pool_size=(2, 2),padding='same'))
model2.add(Conv2D(16, (5, 5),padding='same', activation='relu'))
model2.add(Conv2D(32, (5, 5), activation='relu'))
model2.add(MaxPooling2D(pool_size=(2, 2),padding='same'))
model2.add(Dropout(0.25))
model2.add(Conv2D(64, (5, 5), activation='relu',padding='same'))
model2.add(Conv2D(64, (5, 5), activation='relu'))
model2.add(MaxPooling2D(pool_size=(2, 2),padding='same'))

model2.add(Dropout(0.25))
model2.add(Flatten())
model2.add(Dense(128, activation='relu'))
model2.add(BatchNormalization())
model2.add(Dropout(0.5))
model2.add(Dense(num_classes, activation='softmax'))
```

```
print(model2.summary())

model2.compile(loss=keras.losses.categorical_crossentropy,optimizer=ker
as.optimizers.Adadelta(),metrics=['accuracy'])

history=model2.fit(x_train, y_train,batch_size=batch_size,epochs=epochs
,verbose=1,validation_data=(x_test, y_test))
score = model2.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

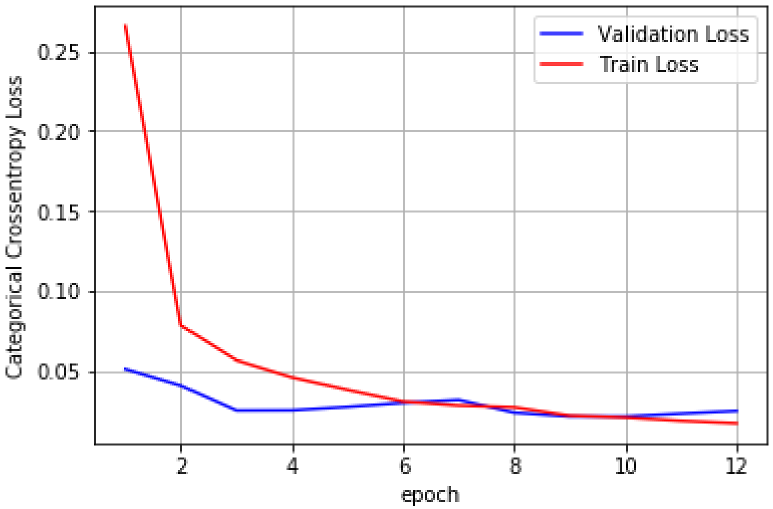
```
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_54 (Conv2D)           (None, 28, 28, 8)         208       
_________________________________________________________________
max_pooling2d_29 (MaxPooling (None, 14, 14, 8)         0         
_________________________________________________________________
conv2d_55 (Conv2D)           (None, 14, 14, 16)        3216      
_________________________________________________________________
conv2d_56 (Conv2D)           (None, 10, 10, 32)        12832     
_________________________________________________________________
max_pooling2d_30 (MaxPooling (None, 5, 5, 32)          0         
_________________________________________________________________
dropout_20 (Dropout)         (None, 5, 5, 32)          0         
_________________________________________________________________
conv2d_57 (Conv2D)           (None, 5, 5, 64)          51264     
_________________________________________________________________
conv2d_58 (Conv2D)           (None, 1, 1, 64)          102464    
_________________________________________________________________
max_pooling2d_31 (MaxPooling (None, 1, 1, 64)          0         
_________________________________________________________________
dropout_21 (Dropout)         (None, 1, 1, 64)          0         
_________________________________________________________________
flatten_8 (Flatten)          (None, 64)                0         
_________________________________________________________________
dense_13 (Dense)             (None, 128)               8320      
_________________________________________________________________
batch_normalization_6 (Batch (None, 128)               512       
_________________________________________________________________
dropout_22 (Dropout)         (None, 128)               0
_________________________________________________________________
dense_14 (Dense)             (None, 10)                1290
=================================================================
Total params: 180,106
Trainable params: 179,850
Non-trainable params: 256
_________________________________________________________________
None
Train on 60000 samples, validate on 10000 samples
Epoch 1/12
60000/60000 [==============================] - 6s 99us/step - loss: 0.2
656 - acc: 0.9190 - val_loss: 0.0511 - val_acc: 0.9848
Epoch 2/12
60000/60000 [==============================] - 4s 71us/step - loss: 0.0
784 - acc: 0.9787 - val_loss: 0.0408 - val_acc: 0.9878
Epoch 3/12
60000/60000 [==============================] - 5s 78us/step - loss: 0.0
565 - acc: 0.9844 - val_loss: 0.0251 - val_acc: 0.9909
Epoch 4/12
60000/60000 [==============================] - 4s 72us/step - loss: 0.0
459 - acc: 0.9875 - val_loss: 0.0252 - val_acc: 0.9923
Epoch 5/12
60000/60000 [==============================] - 4s 70us/step - loss: 0.0
381 - acc: 0.9895 - val_loss: 0.0274 - val_acc: 0.9924
Epoch 6/12
60000/60000 [==============================] - 4s 70us/step - loss: 0.0
308 - acc: 0.9914 - val_loss: 0.0299 - val_acc: 0.9909
Epoch 7/12
60000/60000 [==============================] - 4s 70us/step - loss: 0.0
283 - acc: 0.9918 - val_loss: 0.0318 - val_acc: 0.9912
Epoch 8/12
60000/60000 [==============================] - 4s 70us/step - loss: 0.0
272 - acc: 0.9927 - val_loss: 0.0238 - val_acc: 0.9926
Epoch 9/12
60000/60000 [==============================] - 4s 70us/step - loss: 0.0
219 - acc: 0.9938 - val_loss: 0.0214 - val_acc: 0.9929
Epoch 10/12
```

```
60000/60000 [==============================] - 4s 69us/step - loss: 0.0
207 - acc: 0.9942 - val_loss: 0.0214 - val_acc: 0.9938
Epoch 11/12
60000/60000 [==============================] - 4s 69us/step - loss: 0.0
186 - acc: 0.9950 - val_loss: 0.0232 - val_acc: 0.9943
Epoch 12/12
60000/60000 [==============================] - 4s 72us/step - loss: 0.0
171 - acc: 0.9952 - val_loss: 0.0248 - val_acc: 0.9932
Test loss: 0.024832504260356155
Test accuracy: 0.9932
```

In [0]:

```
print('Test score:', score[0])
print('Test accuracy:', score[1])

fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('Categorical Crossentropy Loss')

# list of epoch numbers
x = list(range(1,13))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epo
chs=nb_epoch, verbose=1, validation_data=(X_test, Y_test))

# we will get val_loss and val_acc only when you pass the paramter vali
dation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal
 to number of epochs


vy = history.history['val_loss']
ty = history.history['loss']
plt_dynamic(x, vy, ty, ax)
```

```
Test score: 0.024832504260356155
Test accuracy: 0.9932
```



M3:seven conv layers-(max-pool,drop-out,batch-norm) kernel 7*7

In [0]:

```
model3 = Sequential()
model3.add(Conv2D(32, kernel_size=(7, 7),padding='same',activation='relu',input_shape=input_shape))
model3.add(Conv2D(32, (7, 7), activation='relu',padding='same'))
model3.add(MaxPooling2D(pool_size=(3, 3),padding='same'))
model3.add(Dropout(0.25))
model3.add(Conv2D(64, (7, 7), activation='relu',padding='same'))
model3.add(MaxPooling2D(pool_size=(2, 2),padding='same'))
model3.add(Conv2D(64, (7, 7), activation='relu',padding='same'))
model3.add(Conv2D(128, (7, 7), activation='relu',padding='same'))
model3.add(MaxPooling2D(pool_size=(2, 2),padding='same'))
model3.add(Dropout(0.25))
model3.add(Conv2D(128, (7, 7), activation='relu',padding='same'))
model3.add(Conv2D(256, (7, 7), activation='relu',padding='same'))
model3.add(MaxPooling2D(pool_size=(2, 2),padding='same'))
```

```
model3.add(Dropout(0.25))
model3.add(Flatten())
model3.add(Dense(128, activation='relu'))
model3.add(BatchNormalization())
model3.add(Dropout(0.5))
model3.add(Dense(num_classes, activation='softmax'))

print(model3.summary())

model3.compile(loss=keras.losses.categorical_crossentropy,optimizer=ker
as.optimizers.Adadelta(),metrics=['accuracy'])

history=model3.fit(x_train, y_train,batch_size=batch_size,epochs=epochs
,verbose=1,validation_data=(x_test, y_test))
score = model3.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

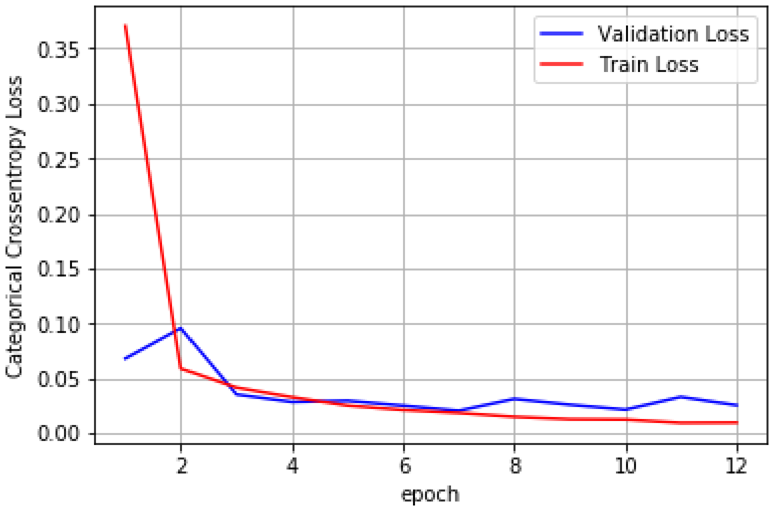
```
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_44 (Conv2D)           (None, 28, 28, 32)        1600      
_________________________________________________________________
conv2d_45 (Conv2D)           (None, 28, 28, 32)        50208     
_________________________________________________________________
max_pooling2d_23 (MaxPooling (None, 10, 10, 32)        0         
_________________________________________________________________
dropout_14 (Dropout)         (None, 10, 10, 32)        0         
_________________________________________________________________
conv2d_46 (Conv2D)           (None, 10, 10, 64)        100416    
_________________________________________________________________
max_pooling2d_24 (MaxPooling (None, 5, 5, 64)          0         
_________________________________________________________________
conv2d_47 (Conv2D)           (None, 5, 5, 64)          200768    
_________________________________________________________________
conv2d_48 (Conv2D)           (None, 5, 5, 128)         401536    
_________________________________________________________________
max_pooling2d_25 (MaxPooling (None, 3, 3, 128)         0         
_________________________________________________________________
dropout_15 (Dropout)         (None, 3, 3, 128)         0
_________________________________________________________________
conv2d_49 (Conv2D)           (None, 3, 3, 128)         802944
_________________________________________________________________
conv2d_50 (Conv2D)           (None, 3, 3, 256)         1605888
_________________________________________________________________
max_pooling2d_26 (MaxPooling (None, 2, 2, 256)         0
_________________________________________________________________
dropout_16 (Dropout)         (None, 2, 2, 256)         0
_________________________________________________________________
flatten_6 (Flatten)          (None, 1024)              0
_________________________________________________________________
dense_9 (Dense)              (None, 128)               131200
_________________________________________________________________
batch_normalization_4 (Batch (None, 128)               512
_________________________________________________________________
dropout_17 (Dropout)         (None, 128)               0
_________________________________________________________________
dense_10 (Dense)             (None, 10)                1290
=================================================================
Total params: 3,296,362
Trainable params: 3,296,106
Non-trainable params: 256
_________________________________________________________________
None
Train on 60000 samples, validate on 10000 samples
Epoch 1/12
60000/60000 [==============================] - 17s 290us/step - loss:
0.3705 - acc: 0.8747 - val_loss: 0.0681 - val_acc: 0.9814
Epoch 2/12
60000/60000 [==============================] - 15s 252us/step - loss:
0.0589 - acc: 0.9842 - val_loss: 0.0957 - val_acc: 0.9729
Epoch 3/12
60000/60000 [==============================] - 15s 253us/step - loss:
0.0415 - acc: 0.9886 - val_loss: 0.0352 - val_acc: 0.9896
Epoch 4/12
60000/60000 [==============================] - 15s 253us/step - loss:
0.0328 - acc: 0.9908 - val_loss: 0.0283 - val_acc: 0.9924
```

```
Epoch 5/12
60000/60000 [==============================] - 15s 251us/step - loss:
0.0251 - acc: 0.9931 - val_loss: 0.0294 - val_acc: 0.9923
Epoch 6/12
60000/60000 [==============================] - 15s 253us/step - loss:
0.0210 - acc: 0.9942 - val_loss: 0.0250 - val_acc: 0.9925
Epoch 7/12
60000/60000 [==============================] - 15s 252us/step - loss:
0.0183 - acc: 0.9950 - val_loss: 0.0204 - val_acc: 0.9942
Epoch 8/12
60000/60000 [==============================] - 15s 255us/step - loss:
0.0147 - acc: 0.9958 - val_loss: 0.0311 - val_acc: 0.9921
Epoch 9/12
60000/60000 [==============================] - 15s 252us/step - loss:
0.0126 - acc: 0.9966 - val_loss: 0.0258 - val_acc: 0.9939
Epoch 10/12
60000/60000 [==============================] - 15s 252us/step - loss:
0.0123 - acc: 0.9966 - val_loss: 0.0213 - val_acc: 0.9933
Epoch 11/12
60000/60000 [==============================] - 15s 252us/step - loss:
0.0093 - acc: 0.9974 - val_loss: 0.0329 - val_acc: 0.9933
Epoch 12/12
60000/60000 [==============================] - 15s 252us/step - loss:
0.0095 - acc: 0.9976 - val_loss: 0.0254 - val_acc: 0.9940
Test loss: 0.025376197105148914
Test accuracy: 0.994
```

In [0]:

```
print('Test score:', score[0])
print('Test accuracy:', score[1])

fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('Categorical Crossentropy Loss')

# list of epoch numbers
x = list(range(1,13))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epo
chs=nb_epoch, verbose=1, validation_data=(X_test, Y_test))

# we will get val_loss and val_acc only when you pass the paramter vali
dation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal
 to number of epochs


vy = history.history['val_loss']
ty = history.history['loss']
plt_dynamic(x, vy, ty, ax)
```

```
Test score: 0.025376197105148914
Test accuracy: 0.994
```



procedure

```
1.Load MNIST dataset
2.Split the dataset into train and test
3.Normalize the train and test data
4.Convert class variable into categorical data vector
5.Implement Softmax classifier with 3, 5 and 7 conv layers .
6.Use kernel -size (3X3) , (5X5) and (7,7) .
7.Draw Categorical Crossentropy Loss VS No.of Epochs plot .
```

In [0]:

```python
# Creating table using PrettyTable library
from prettytable import PrettyTable

# Names of models
names = ['CNN(3-Conv layers) With Kernel-size = (3,3)','CNN(5-Conv layers) With Kernel-size = (5,5)','CNN(7-Conv layers) With Kernel-size = (7,7)']

# Training accuracies
train_acc = [0.9927,0.9952,0.9976]

# Test accuracies
test_acc = [0.9937,0.9932,0.994]

numbering = [1,2,3]

# Initializing prettytable
ptable = PrettyTable()

# Adding columns
ptable.add_column("S.NO.",numbering)
ptable.add_column("MODEL",names)
ptable.add_column("Training Accuracy",train_acc)
ptable.add_column("Test Accuracy",test_acc)
```

```
# Printing the Table
print(ptable)
```

```
+-------+---------------------------------------------+----------------
---+---------------+
| S.NO. |                    MODEL                    | Training Accura
cy | Test Accuracy |
+-------+---------------------------------------------+----------------
---+---------------+
|   1   | CNN(3-Conv layers) With Kernel-size = (3,3) |       0.9927
   |     0.9937    |
|   2   | CNN(5-Conv layers) With Kernel-size = (5,5) |       0.9952
   |     0.9932    |
|   3   | CNN(7-Conv layers) With Kernel-size = (7,7) |       0.9976
   |     0.994     |
+-------+---------------------------------------------+----------------
---+---------------+
```