Import Data

```
import warnings
warnings.filterwarnings('ignore')
```

```
from keras.datasets import mnist
```

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

```
from keras import backend as K
K.image_data_format()
```

```
'channels_last'
```

```
# 'channels_last' data format
x_train = x_train.reshape(x_train.shape[0], 28, 28, 1)
x_test = x_test.reshape(x_test.shape[0], 28, 28, 1)
```

```
input_shape = (28, 28, 1)
```

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

```
# convert class vectors to binary class matrices
from keras.utils import to_categorical
y_train = to_categorical(y_train, 10)
y_test = to_categorical(y_test, 10)
```

Create CNN Model

Saved successfully!

```
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten, Conv2D, MaxPooling2D
```

```
model = Sequential()
model.add(Conv2D(32, kernel_size=(3, 3),
                 activation='relu',
                 input_shape=(28, 28, 1)))
model.add(Conv2D(64, (3, 3), 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(10, activation='softmax'))
```

```
model.summary()
```

```
Model: "sequential_5"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_9 (Conv2D)            (None, 26, 26, 32)        320       
_________________________________________________________________
conv2d_10 (Conv2D)           (None, 24, 24, 64)        18496     
_________________________________________________________________
max_pooling2d_5 (MaxPooling2 (None, 12, 12, 64)        0         
_________________________________________________________________
dropout_9 (Dropout)          (None, 12, 12, 64)        0         
_________________________________________________________________
flatten_5 (Flatten)          (None, 9216)              0         
_________________________________________________________________
dense_9 (Dense)              (None, 128)               1179776   
_________________________________________________________________
dropout_10 (Dropout)         (None, 128)               0         
_________________________________________________________________
dense_10 (Dense)             (None, 10)                1290      
=================================================================
Total params: 1,199,882
Trainable params: 1,199,882
Non-trainable params: 0
_________________________________________________________________
```

Compile CNN Model

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

Train CNN Model

Saved successfully!

```
                                    rain,

          epochs=20,
          verbose=1,
          validation_split=0.2)
```

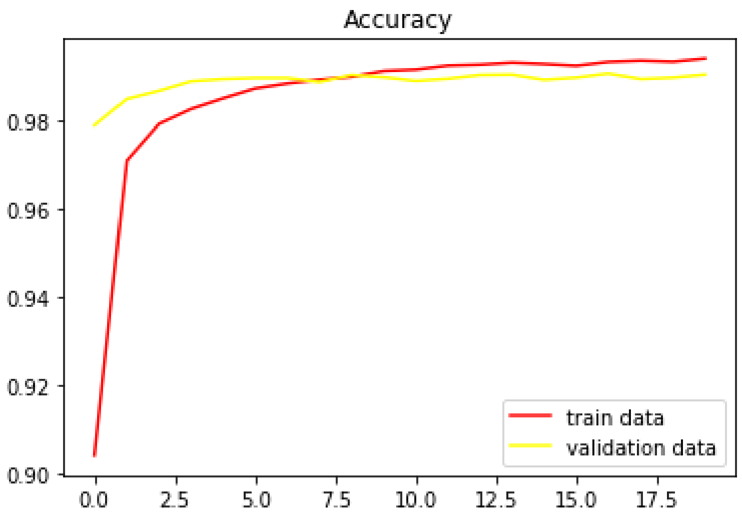
```
Train on 48000 samples, validate on 12000 samples
Epoch 1/20
48000/48000 [==============================] - 8s 168us/step - loss: 0.3058 - acc: 0.
Epoch 2/20
48000/48000 [==============================] - 7s 150us/step - loss: 0.0991 - acc: 0.
Epoch 3/20
48000/48000 [==============================] - 7s 151us/step - loss: 0.0702 - acc: 0.
Epoch 4/20
48000/48000 [==============================] - 7s 151us/step - loss: 0.0569 - acc: 0.
Epoch 5/20
48000/48000 [==============================] - 7s 151us/step - loss: 0.0498 - acc: 0.
Epoch 6/20
48000/48000 [==============================] - 7s 150us/step - loss: 0.0427 - acc: 0.
Epoch 7/20
48000/48000 [==============================] - 7s 150us/step - loss: 0.0376 - acc: 0.
Epoch 8/20
48000/48000 [==============================] - 7s 150us/step - loss: 0.0347 - acc: 0.
Epoch 9/20
48000/48000 [==============================] - 7s 150us/step - loss: 0.0318 - acc: 0.
Epoch 10/20
48000/48000 [==============================] - 7s 150us/step - loss: 0.0285 - acc: 0.
Epoch 11/20
48000/48000 [==============================] - 7s 151us/step - loss: 0.0279 - acc: 0.
Epoch 12/20
48000/48000 [==============================] - 7s 151us/step - loss: 0.0258 - acc: 0.
Epoch 13/20
48000/48000 [==============================] - 7s 155us/step - loss: 0.0243 - acc: 0.
Epoch 14/20
48000/48000 [==============================] - 7s 152us/step - loss: 0.0223 - acc: 0.
Epoch 15/20
48000/48000 [==============================] - 7s 151us/step - loss: 0.0231 - acc: 0.
Epoch 16/20
48000/48000 [==============================] - 7s 150us/step - loss: 0.0225 - acc: 0.
Epoch 17/20
48000/48000 [==============================] - 7s 149us/step - loss: 0.0208 - acc: 0.
Epoch 18/20
48000/48000 [==============================] - 7s 150us/step - loss: 0.0198 - acc: 0.
Epoch 19/20
48000/48000 [==============================] - 7s 150us/step - loss: 0.0197 - acc: 0.
Epoch 20/20
48000/48000 [==============================] - 7s 149us/step - loss: 0.0185 - acc: 0.
```

Saved successfully!

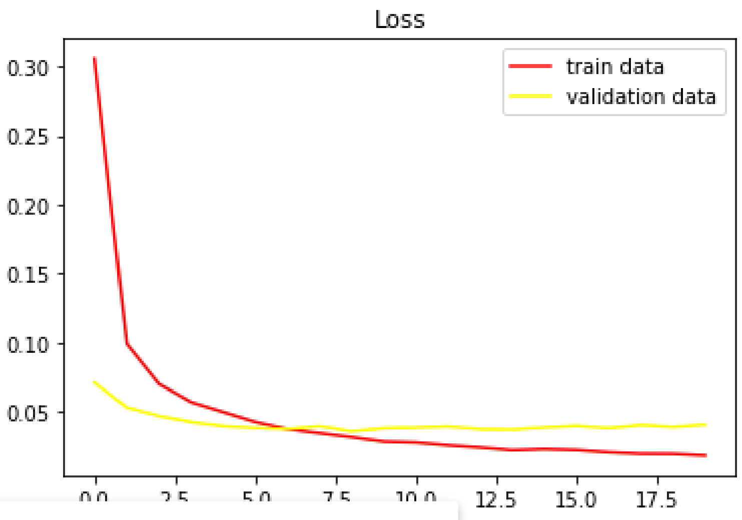
```
model.evaluate(x_test, y_test, verbose=0)
```

```
[0.025763151499420656, 0.9918]
```

```
from matplotlib import pyplot as plt
epochs = history.epoch
acc = history.history['acc']
val_acc = history.history['val_acc']
plt.plot(epochs, acc, color='red', label='train data')
plt.plot(epochs, val_acc, color='yellow', label='validation data')
plt.title('Accuracy')
plt.legend()
plt.show()
```



```
epochs = history.epoch
loss = history.history['loss']
val_loss = history.history['val_loss']
plt.plot(epochs, loss, color='red', label='train data')
plt.plot(epochs, val_loss, color='yellow', label='validation data')
plt.title('Loss')
plt.legend()
plt.show()
```



Saved successfully!

DoubledMNIST?

```
# For practise
```