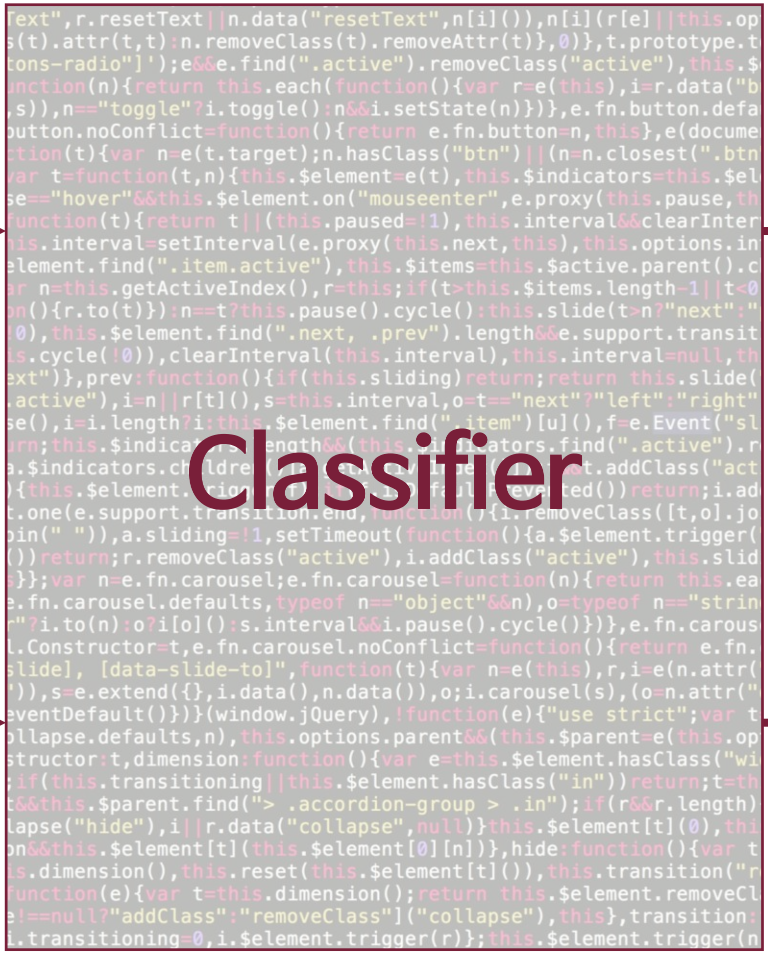
서강대학교
SOGANG UNIVERSITY

Convolutional Neural Network

Systems Programming
Department of Computer Science and Engineering
Sogang University

Image Classification

1 Image classification



Cat

Dog

https://www.pexels.com/photo/calico-cat-1359300/
https://www.pexels.com/photo/adorable-animal-baby-beautiful-245037/
https://www.pexels.com/photo/full-frame-shot-of-abstract-pattern-249798/

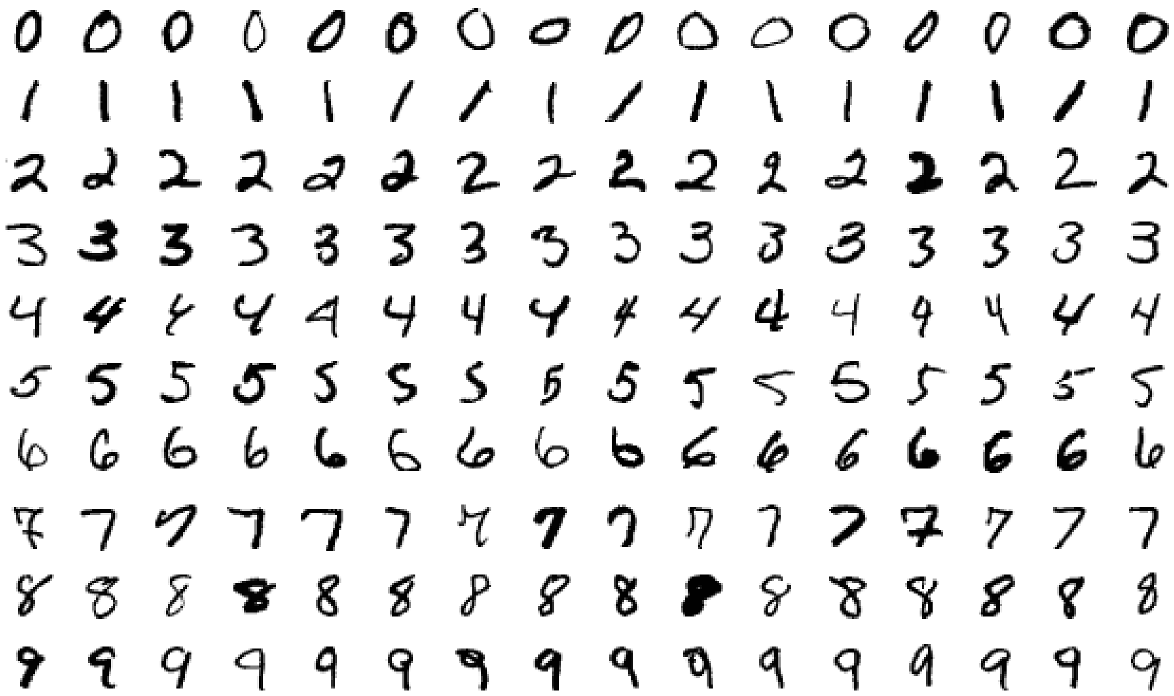
MNIST Classification

Use “04.MNIST.ipynb”

http://yann.lecun.com/exdb/mnist/

1 MNIST

The MNIST database of handwritten digits, available from this page, has a training set of 60,000 examples, and a test set of 10,000 examples. It is a subset of a larger set available from NIST. The digits have been size-normalized and centered in a fixed-size image.



2 Import modules and tuning parameters

```
[ ]  import keras
     from keras.datasets import mnist
     from keras.models import Sequential
     from keras.layers import Dense, Dropout, Flatten, Activation
     from keras.layers import Conv2D, MaxPooling2D
     from keras import backend as K
     from keras.utils.vis_utils import model_to_dot
     from IPython.display import SVG
     %matplotlib inline
     import matplotlib.pyplot as plt
     from sklearn.metrics import confusion_matrix
     import pandas as pd
     import seaborn as sns
```

```
[ ]  epochs = 10
     learning_rate=0.01
```

```
[ ]  batch_size = 128
     num_classes = 10
```

```
[ ]  def plot_images(x, y_true, y_pred=None, size=(5, 5)):
         assert len(x) == len(y_true) == size[0] * size[1]

         fig, axes = plt.subplots(size[0], size[1])
         fig.subplots_adjust(hspace=0.5, wspace=0.1)

         for i, ax in enumerate(axes.flat):
             if x[i].shape[-1] == 1:
               ax.imshow(x[i].reshape(x[i].shape[0], x[i].shape[1]))
             else:
               ax.imshow(x[i])

             if y_pred is None:
                 xlabel = "True: {0}".format(y_true[i].argmax())
             else:
                 xlabel = "True: {0}, Pred: {1}".format(y_true[i].argmax(),
                                                        y_pred[i].argmax())

             ax.set_xlabel(xlabel)

             ax.set_xticks([])
             ax.set_yticks([])

         plt.show()
```

3 Loading and reshaping the data

```
[ ]  (x_train, y_train), (x_test, y_test) = mnist.load_data()
```

```
[ ]  if len(x_train.shape) < 4:
       x_train = x_train.reshape(x_train.shape[0], x_train.shape[1], x_train.shape[2], 1)
       x_test = x_test.reshape(x_test.shape[0], x_train.shape[1], x_train.shape[2], 1)
```

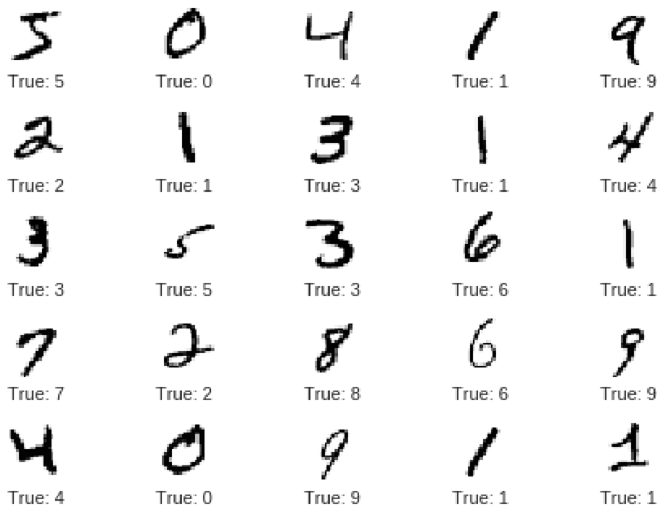
```
[ ]  x_train = x_train.astype('float32')
     x_test = x_test.astype('float32')
     x_train /= 255
     x_test /= 255
     print('x_train shape:', x_train.shape)
     print(x_train.shape[0], 'train samples')
     print(x_test.shape[0], 'test samples')
```

```
[ ]  y_train = keras.utils.to_categorical(y_train, num_classes)
     y_test = keras.utils.to_categorical(y_test, num_classes)
```

```
[ ]  plot_images(x_train[:25], y_train[:25])
```

```
x_train shape: (60000, 28, 28, 1)
60000 train samples
10000 test samples
```

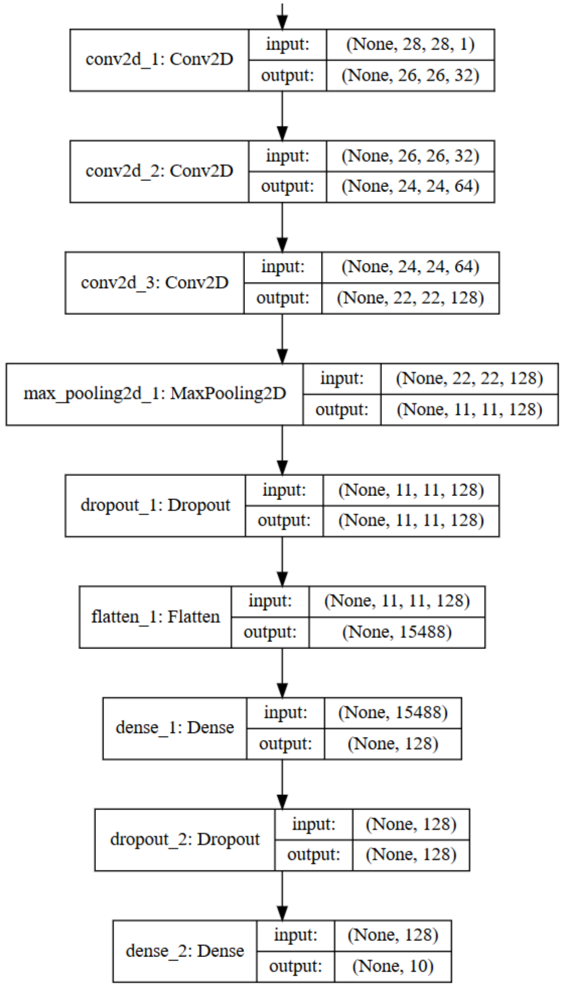
```
Download                                                /mnist.npz
11493376,                                               /step
```



4 Creating the model

```
[ ]  model = Sequential()
```

```
[ ]  model.add(Conv2D(32, kernel_size=(3, 3), activation='relu',
                      input_shape=x_train.shape[1:]))
     model.add(Conv2D(64, (3, 3), activation='relu'))
     model.add(Conv2D(128, (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(num_classes, activation='softmax'))
```



4 Creating the model

```
keras.layers.Conv2D(filter, kernel_size, strides, padding, activation, ······)
```

2D convolution layer.
Arguments: filters, kernel_size, strides, padding, activation and so on.

```
model.add(Conv2D(64, (3, 3), activation='relu'))
```

```
keras.layers.MaxPooling2D(pool_size, strides, padding, ······)
```

Max pooling operation for spatial data.
Arguments: pool_size, strides, padding and so on.

```
model.add(MaxPooling2D((2, 2))
```

```
keras.layers.Dropout(rate, ······)
```

Applies Dropout to the input.

```
keras.layers.Flatten(······)
```

Flattens the input.

5 Compiling and training the model

```
[ ]  optimizer = keras.optimizers.SGD(lr=learning_rate)
```

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

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

```
Train on 60000 samples, validate on 10000 samples
Epoch 1/10
60000/60000 [==============================] - 21s 346us/step - loss: 1.0488 - acc: 0.6583 - val_loss: 0.2787 - val_acc: 0.9176
Epoch 2/10
60000/60000 [==============================] - 16s 260us/step - loss: 0.3841 - acc: 0.8827 - val_loss: 0.1955 - val_acc: 0.9439
Epoch 3/10
60000/60000 [==============================] - 16s 260us/step - loss: 0.3117 - acc: 0.9061 - val_loss: 0.1772 - val_acc: 0.9465
Epoch 4/10
60000/60000 [==============================] - 16s 259us/step - loss: 0.2573 - acc: 0.9223 - val_loss: 0.1290 - val_acc: 0.9620
Epoch 5/10
60000/60000 [==============================] - 15s 256us/step - loss: 0.2223 - acc: 0.9344 - val_loss: 0.1118 - val_acc: 0.9664
Epoch 6/10
60000/60000 [==============================] - 15s 256us/step - loss: 0.1886 - acc: 0.9439 - val_loss: 0.0942 - val_acc: 0.9711
Epoch 7/10
60000/60000 [==============================] - 15s 257us/step - loss: 0.1658 - acc: 0.9505 - val_loss: 0.0806 - val_acc: 0.9753
Epoch 8/10
60000/60000 [==============================] - 15s 255us/step - loss: 0.1440 - acc: 0.9571 - val_loss: 0.0695 - val_acc: 0.9784
Epoch 9/10
60000/60000 [==============================] - 15s 254us/step - loss: 0.1307 - acc: 0.9616 - val_loss: 0.0662 - val_acc: 0.9785
Epoch 10/10
60000/60000 [==============================] - 15s 254us/step - loss: 0.1195 - acc: 0.9648 - val_loss: 0.0593 - val_acc: 0.9802
```

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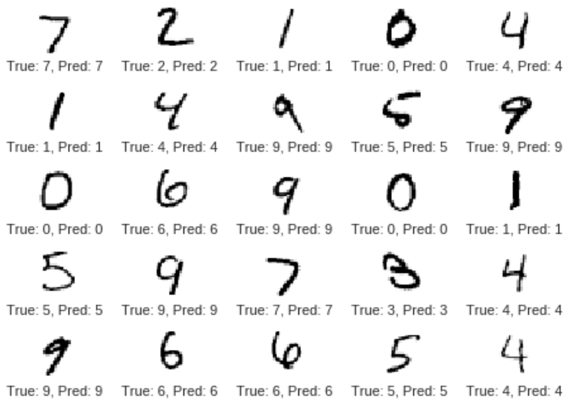
6 Evaluating and prediction the model

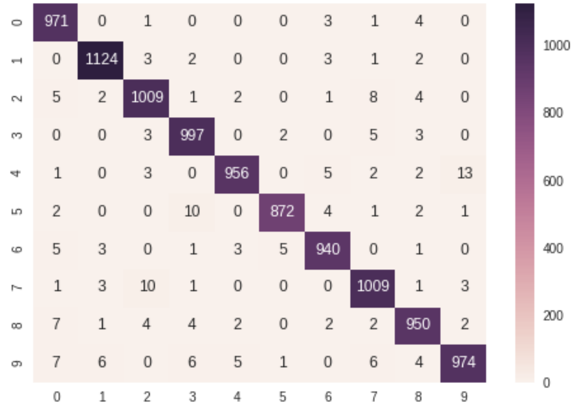
```
[ ]  score = model.evaluate(x_test, y_test, verbose=0)
     print('Test loss:', score[0])
     print('Test accuracy:', score[1])
```

```
[ ]  y_pred = model.predict(x_test)
```

```
[ ]  plot_images(x=x_test[:25], y_true=y_test[:25], y_pred=y_pred[:25])
```

```
[ ]  y_result = confusion_matrix(y_test.argmax(axis=1), y_pred.argmax(axis=1))
     sns.heatmap(pd.DataFrame(y_result, range(10), range(10)), annot=True, fmt='g')
```





CIFAR-10 Classification

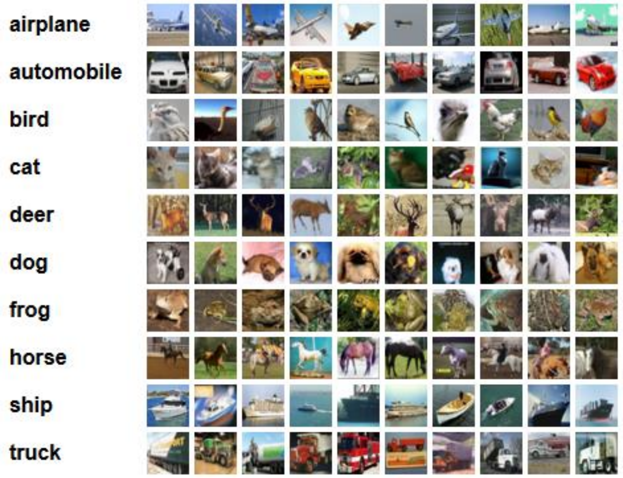
Use “05.CIFAR10.ipynb”

https://www.cs.toronto.edu/~kriz/cifar.html

1 CIFAR-10

The CIFAR-10 dataset consists of 60000 32x32 colour images in 10 classes, with 6000 images per class. There are 50000 training images and 10000 test images.

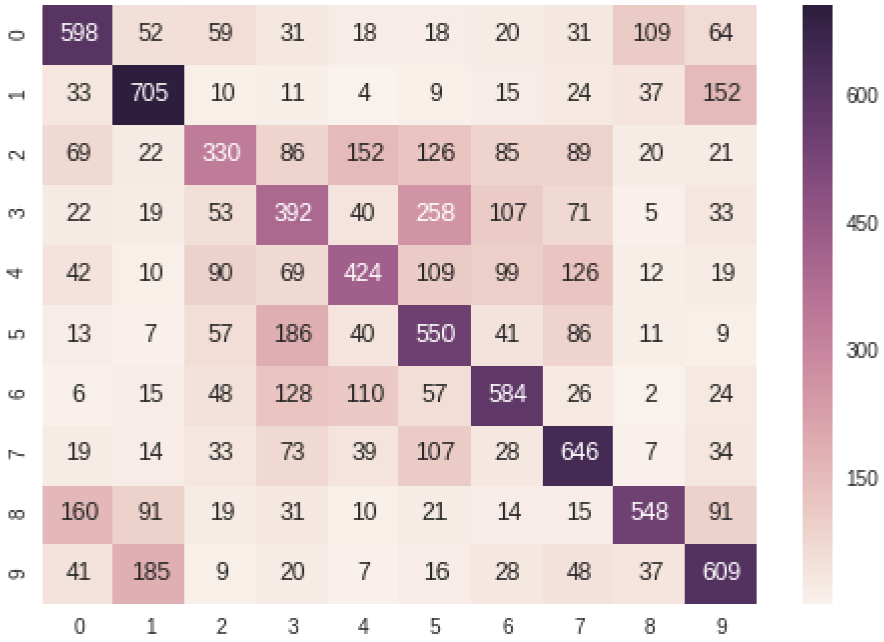
Here are the classes in the dataset, as well as 10 random images from each:



The classes are completely mutually exclusive. There is no overlap between automobiles and trucks. "Automobile" includes sedans, SUVs, things of that sort. "Truck" includes only big trucks. Neither includes pickup trucks.

2 Result of basic code

```
Test loss: 1.3167947158813476
Test accuracy: 0.5386
```



3 How to get higher accuracy

You can try the following:

- **Stack more layers.** (A key way to achieve higher accuracy!)
  - Core Layers: https://keras.io/layers/core/
  - Convolution Layers: https://keras.io/layers/convolutional/
  - Pooling Layers: https://keras.io/layers/pooling/
- Increase the epoch. (Do not run too many epochs.)
- Adjust the learning rate. (Between 0 to 1.)
- Use other optimizer. (https://keras.io/optimizers/)
- Change different activation function. (https://keras.io/activations/)

There are many other ways. Try to find it!

If you want to know more, go to: https://keras.io/examples/cifar10_cnn/