

ML/DL for Everyone Season2

with  TensorFlow

Lab 11-4 CNN with MNIST Dataset using Model Ensemble



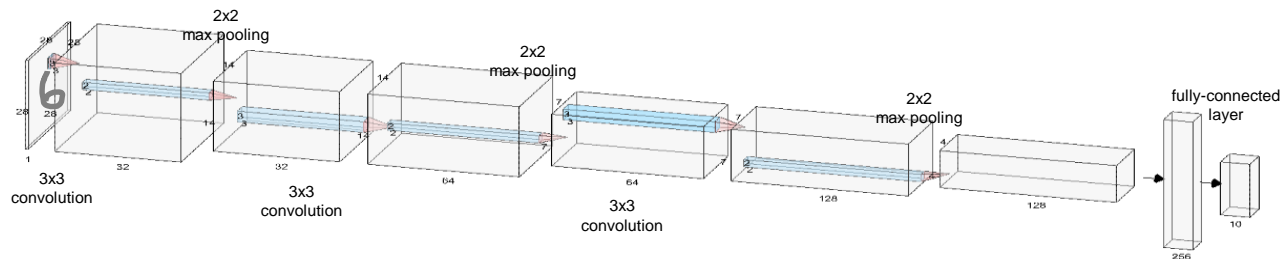
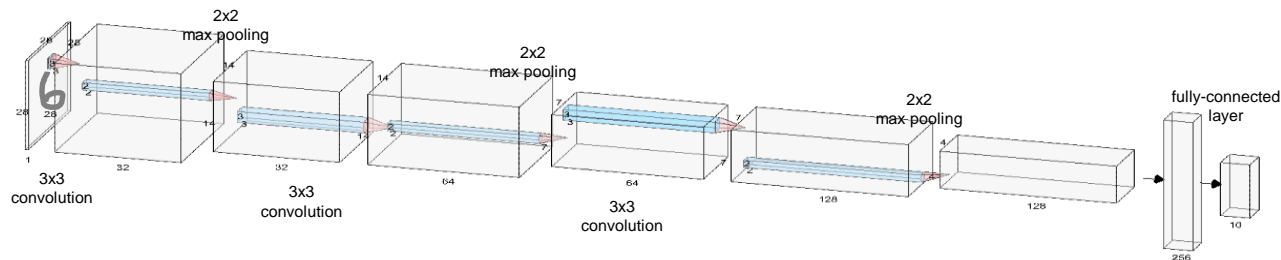
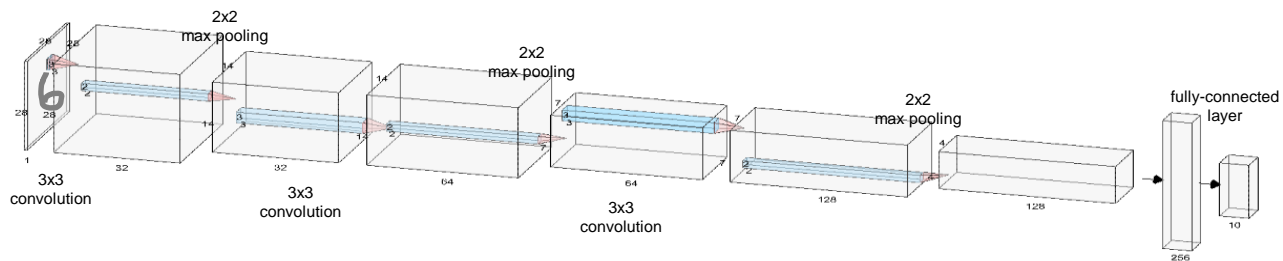
Code: <https://github.com/deeplearningzerotoall/TensorFlow>
Slides: <http://bit.ly/2LQMKVv>
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NN Implementation Flow in TensorFlow

1. Set hyper parameters – learning rate, training epochs, batch size, etc.
2. Make a data pipelining – use `tf.data`
3. Build a neural network model – use `tf.keras`
4. Define a loss function – cross entropy
5. Calculate a gradient – use `tf.GradientTape`
6. Select an optimizer – Adam optimizer
7. Define a metric for model's performance – accuracy
8. (optional) Make a checkpoint for saving
9. Train and Validate a neural network model

CNN Model Ensemble with MNIST Data



0. Import Libraries

```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.utils import to_categorical
import numpy as np
import matplotlib.pyplot as plt
import os
```

1. Set Hyper Parameters

```
learning_rate = 0.001  
training_epochs = 15  
batch_size = 100
```

```
cur_dir = os.getcwd()  
ckpt_dir_name = 'checkpoints'  
model_dir_name = 'minst_cnn_ensemble'
```

```
checkpoint_dir = os.path.join(cur_dir, ckpt_dir_name, model_dir_name)  
os.makedirs(checkpoint_dir, exist_ok=True)
```

```
checkpoint_prefix = os.path.join(checkpoint_dir, model_dir_name)
```

2. Make a Data Pipelining

```
mnist = keras.datasets.mnist
```

```
(train_images, train_labels), (test_images, test_labels) = mnist.load_data()
```

```
train_images = train_images.astype(np.float32) / 255.
```

```
test_images = test_images.astype(np.float32) / 255.
```

```
train_images = np.expand_dims(train_images, axis=-1)
```

```
test_images = np.expand_dims(test_images, axis=-1)
```

```
train_labels = to_categorical(train_labels, 10)
```

```
test_labels = to_categorical(test_labels, 10)
```

```
train_dataset = tf.data.Dataset.from_tensor_slices((train_images,
                                                    train_labels)).shuffle(buffer_size=100000).batch(batch_size)
```

[illegible]

3. Build a Neural Network Model

– Model Subclassing

```
class MNISTModel(tf.keras.Model):
```

```
    def __init__(self):
```

```
        super(MNISTModel, self).__init__()
```

```
        self.conv1 = keras.layers.Conv2D(filters=32, kernel_size=3, padding='SAME',  
                                           activation=tf.nn.relu)
```

```
        self.pool1 = keras.layers.MaxPool2D(padding='SAME')
```

```
        self.conv2 = keras.layers.Conv2D(filters=64, kernel_size=3, padding='SAME',  
                                           activation=tf.nn.relu)
```

```
        self.pool2 = keras.layers.MaxPool2D(padding='SAME')
```

```
        self.conv3 = keras.layers.Conv2D(filters=128, kernel_size=3, padding='SAME',  
                                           activation=tf.nn.relu)
```

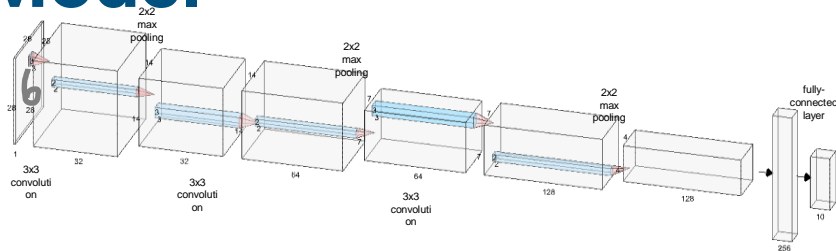
```
        self.pool3 = keras.layers.MaxPool2D(padding='SAME')
```

```
        self.pool3_flat = keras.layers.Flatten()
```

```
        self.dense4 = keras.layers.Dense(units=256, activation=tf.nn.relu)
```

```
        self.drop4 = keras.layers.Dropout(rate=0.4)
```

```
        self.dense5 = keras.layers.Dense(units=10)
```

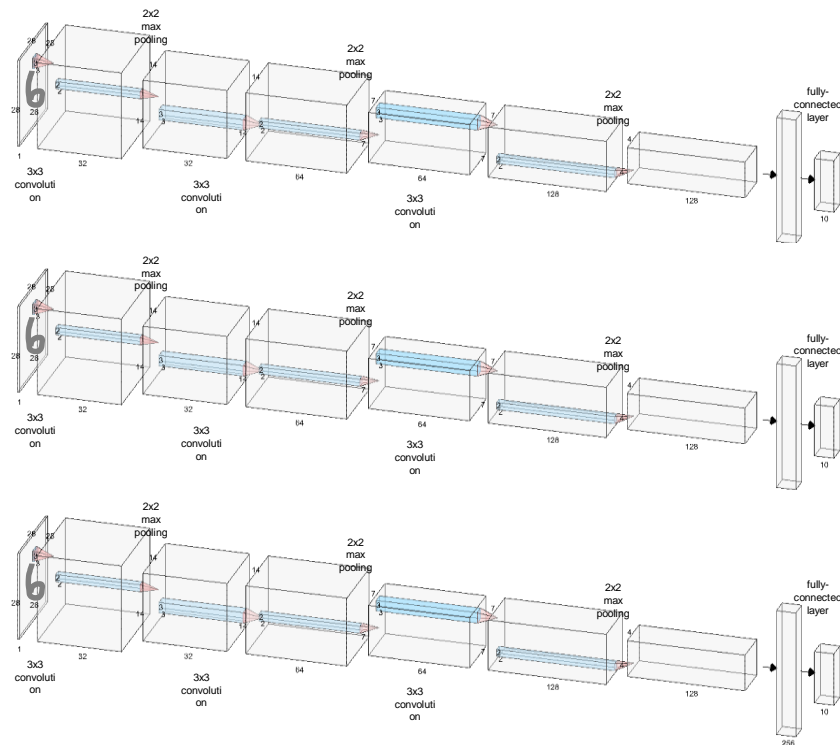


3. Build a Neural Network Model

– Model Subclassing

```
def call(self, inputs, training=False):  
    net = self.conv1(inputs)  
    net = self.pool1(net)  
    net = self.conv2(net)  
    net = self.pool2(net)  
    net = self.conv3(net)  
    net = self.pool3(net)  
    net = self.pool3_flat(net)  
    net = self.dense4(net)  
    net = self.drop4(net)  
    net = self.dense5(net)  
    return net
```

```
models = []  
num_models = 3  
for m in range(num_models):  
    models.append(MNISTModel())
```



4. Define a Loss Function

5. Calculate a Gradient

```
def loss_fn(model, images, labels):  
    logits = model(images, training=True)  
    loss = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits_v2(  
        logits=logits, labels=labels))  
    return loss
```

```
def grad(model, images, labels):  
    with tf.GradientTape() as tape:  
        loss = loss_fn(model, images, labels)  
    return tape.gradient(loss, model.variables)
```

6. Select an Optimizer

7. Define a Metric for Model's Performance

8. Make a Checkpoint for Saving

```
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
```

```
def evaluate(models, images, labels):  
    predictions = tf.zeros_like(labels)  
    for model in models:  
        logits = model(images, training=False)  
        predictions += logits  
    correct_prediction = tf.equal(tf.argmax(predictions, 1),  
                                tf.argmax(labels, 1))  
    accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))  
    return accuracy
```

```
checkpoints = []  
for m in range(num_models):  
    checkpoints.append(tf.train.Checkpoint(cnn=models[m]))
```

9. Train and Validate a Neural Network Model

```
for epoch in range(training_epochs):
    avg_loss = 0.; avg_train_acc = 0.; avg_test_acc = 0.
    train_step = 0; test_step = 0

    for images, labels in train_dataset:
        for model in models:
            grads = grad(model, images, labels)
            optimizer.apply_gradients(zip(grads, model.variables))
            loss = loss_fn(model, images, labels)
            avg_loss += loss / num_models
        acc = evaluate(models, images, labels)
        avg_train_acc += acc
        train_step += 1
    avg_loss = avg_loss / train_step
    avg_train_acc = avg_train_acc / train_step
```

9. Train and Validate a Neural Network Model

```
for images, labels in test_dataset:
    acc = evaluate(models, images, labels)
    avg_test_acc += acc
    test_step += 1
avg_test_acc = avg_test_acc / test_step

print('Epoch:', '{}'.format(epoch + 1), 'loss =', '{:.8f}'.format(avg_loss),
      'train accuracy = ', '{:.4f}'.format(avg_train_acc),
      'test accuracy = ', '{:.4f}'.format(avg_test_acc))

for idx, checkpoint in enumerate(checkpoints):
    checkpoint.save(file_prefix=checkpoint_prefix+'-{}'.format(idx))
```

Accuracy : 99.47%

What's Next?

- Best CNN with MNIST Dataset