CIFAR-10

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Introduction

CIFAR-10 classification is a common benchmark problem in machine learning. The problem is to classify RGB 32x32 pixel images across 10 categories:

airplane, automobile, bird, cat, deer, dog, frog, horse, ship, truck.

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.

Refer to CIFAR-10 webpage (https://www.cs.toronto.edu/~kriz/cifar.html) for more details.

1. Load data

The CIFAR-10 data-set is about 163 MB and will be downloaded automatically if it is not located in the given path. It might take a few minutes to download. Just wait.

In [1]:
```
import cifar10
cifar10.maybe_download_and_extract()
```

```
Data has apparently already been downloaded and unpacked.
```

Load the class-names.

In [2]:
```
class_names = cifar10.load_class_names()
print(class_names)
```

```
Loading data: data/CIFAR-10/cifar-10-batches-py/batches.meta
['airplane', 'automobile', 'bird', 'cat', 'deer', 'dog', 'frog', 'horse', 'ship', 'truck']
```

Load the training-set. This returns the images, the class-numbers as integers, and the class-numbers as One-Hot arrays called labels.

In [3]:
```
images_train, cls_train, labels_train = cifar10.load_training_data()
```

```
Loading data: data/CIFAR-10/cifar-10-batches-py/data_batch_1
Loading data: data/CIFAR-10/cifar-10-batches-py/data_batch_2
Loading data: data/CIFAR-10/cifar-10-batches-py/data_batch_3
Loading data: data/CIFAR-10/cifar-10-batches-py/data_batch_4
Loading data: data/CIFAR-10/cifar-10-batches-py/data_batch_5
```

In [4]:
```
print(images_train.shape)
print(cls_train.shape)
print(labels_train.shape)
```

```
(50000, 32, 32, 3)
(50000,)
(50000, 10)
```

Load the test-set.

In [5]:
```
images_test, cls_test, labels_test = cifar10.load_test_data()
```

```
Loading data: data/CIFAR-10/cifar-10-batches-py/test_batch
```

In [6]:
```
print(images_test.shape)
print(cls_test.shape)
print(labels_test.shape)
```

```
(10000, 32, 32, 3)
(10000,)
(10000, 10)
```

The CIFAR-10 data-set has now been loaded and consists of 60,000 images and associated labels (i.e. classifications of the images). The data-set is split into 2 mutually exclusive sub-sets, the training-set and the test-set.

In [7]:
```
print("Size of:")
print("- Training-set:\t\t{}".format(len(images_train)))
print("- Test-set:\t\t{}".format(len(images_test)))
```

```
Size of:
- Training-set:		50000
- Test-set:		10000
```

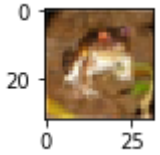
Data Dimensions

In [8]:
```
from cifar10 import img_size, num_channels, num_classes
print(img_size)
print(num_channels) # RGB
print(num_classes)
```

```
32
3
10
```

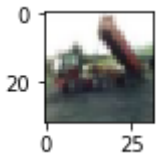
Plot a few images to see.

In [9]:
```
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline

for i in range(10):
    img = images_train[i]
    label = labels_train[i]

    plt.figure(figsize=(1,1))
    plt.imshow(img)
    plt.show()
    cls = np.argmax(label)
    cls_name = class_names[cls]
    print(cls_name)
```

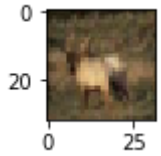



```
frog
```

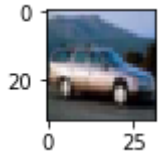

```
truck
```



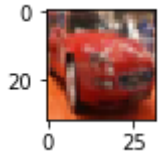

```
truck
```



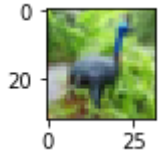

```
deer
```



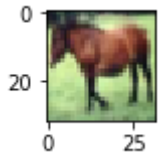

```
automobile
```



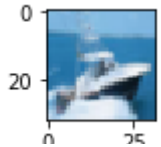

```
automobile
```



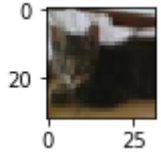

```
bird
```




```
horse
```




```
ship
```




```
cat
```

2. Train a two-layer neural network on CIFAR-10

Build the compuation graph.

In [10]:

```
import tensorflow as tf

# 1. Create the model (build the compuation graph)
## Hyperparameters
batch_size = 512
n_input = 32*32*3 # image is 32x32x3
n_hidden = 256
n_classes = 10
learning_rate = 0.1


## Model input
x = tf.placeholder(tf.float32, [None, n_input])

## Hidden layer
W1 = tf.Variable(tf.random_normal([n_input, n_hidden], stddev=0.1))
b1 = tf.Variable(tf.zeros([n_hidden]))
h1 = tf.matmul(x, W1) + b1
h1 = tf.nn.relu(h1)

## Output layer
W_out = tf.Variable(tf.random_normal([n_hidden, n_classes], stddev=0.1))
b_out = tf.Variable(tf.zeros([n_classes]))
y_pred = tf.matmul(h1, W_out) + b_out

#W1 = tf.Variable(tf.random_normal([n_input, n_classes], stddev=0.1))
#b1 = tf.Variable(tf.zeros([n_classes]))
#y_pred = tf.matmul(x, W1) + b1


## Define loss and optimizer
y_gt = tf.placeholder(tf.float32, [None, n_classes])
loss = tf.reduce_mean(
    tf.nn.softmax_cross_entropy_with_logits_v2(
        logits=y_pred, labels=y_gt, name='loss'))

## Train (update model parameters)
#optimizer = tf.train.GradientDescentOptimizer(learning_rate)
#optimizer = tf.train.MomentumOptimizer(learning_rate, 0.9)
optimizer = tf.train.AdamOptimizer()
train_step = optimizer.minimize(loss)
```

```
42
43 ## Compute Accuracy
44 correct_prediction = tf.equal(tf.argmax(y_pred, 1), tf.argmax(y_gt, 1))
45 accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
46
47
```

Helper-function to get a random training-batch

There are 50,000 images in the training-set. It takes a long time to calculate the gradient of the model using all these images. We therefore only use a small batch of images in each iteration of the optimizer.

If your computer crashes or becomes very slow because you run out of RAM, then you may lower the batch size, but you may then need to perform more optimization iterations.

In [11]:
```
1  def random_batch(images_train, labels_train, batch_size):
2      # Number of images in the training-set.
3      num_images = len(images_train)
4
5      # Create a random index.
6      idx = np.random.choice(num_images,
7                             size=batch_size,
8                             replace=False)
9
10     # Use the random index to select random images and labels.
11     x_batch = images_train[idx]
12     y_batch = labels_train[idx]
13
14     return x_batch, y_batch
```

Train

In [12]:

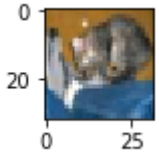
```
## Initialize
sess = tf.InteractiveSession()
tf.global_variables_initializer().run()

max_iter = 2000

images_train = images_train.reshape([50000, -1])
images_test = images_test.reshape([10000, -1])

for iter in range(max_iter):
    batch_x, batch_y = random_batch(images_train, labels_train, batch_size)
    sess.run(train_step, feed_dict = {x: batch_x, y_gt: batch_y})
    if iter % 100 == 0:
        train_loss = sess.run(loss, feed_dict = {x: batch_x, y_gt: batch_y})
        train_accuracy = sess.run(accuracy, feed_dict = {x: batch_x, y_gt: batch_y})

        test_x = images_test
        test_y = labels_test
        test_accuracy = sess.run(accuracy, {x: test_x, y_gt: test_y})

        print("iter step %d, loss %f, training accuracy %f, test accuracy %f" %
              (iter, train_loss, train_accuracy, test_accuracy))
```

```
iter step 0, loss 4.940394, training accuracy 0.113281, test accuracy 0.107200
iter step 100, loss 1.943059, training accuracy 0.300781, test accuracy 0.330900
iter step 200, loss 1.722278, training accuracy 0.392578, test accuracy 0.366500
iter step 300, loss 1.686835, training accuracy 0.394531, test accuracy 0.403800
iter step 400, loss 1.655210, training accuracy 0.406250, test accuracy 0.418900
iter step 500, loss 1.592474, training accuracy 0.464844, test accuracy 0.433200
iter step 600, loss 1.598998, training accuracy 0.457031, test accuracy 0.437200
iter step 700, loss 1.591863, training accuracy 0.460938, test accuracy 0.446700
iter step 800, loss 1.452449, training accuracy 0.503906, test accuracy 0.456400
iter step 900, loss 1.494060, training accuracy 0.460938, test accuracy 0.447000
iter step 1000, loss 1.403091, training accuracy 0.505859, test accuracy 0.456200
iter step 1100, loss 1.402290, training accuracy 0.511719, test accuracy 0.455400
iter step 1200, loss 1.455233, training accuracy 0.509766, test accuracy 0.470000
iter step 1300, loss 1.439537, training accuracy 0.480469, test accuracy 0.460300
iter step 1400, loss 1.393633, training accuracy 0.513672, test accuracy 0.479100
iter step 1500, loss 1.413353, training accuracy 0.500000, test accuracy 0.482500
iter step 1600, loss 1.335781, training accuracy 0.529297, test accuracy 0.488900
iter step 1700, loss 1.368905, training accuracy 0.515625, test accuracy 0.485400
```

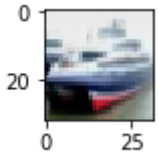
```
iter step 1800, loss 1.344125, training accuracy 0.541016, test accuracy 0.488700
iter step 1900, loss 1.272206, training accuracy 0.548828, test accuracy 0.490900
```

Use some examples to test your model

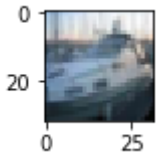
In [13]:
```
images_train = images_train.reshape([50000, 32, 32, 3])
images_test = images_test.reshape([10000, 32, 32, 3])
for i in range(10):
    img = images_test[i]
    label = labels_test[i]

    plt.figure(figsize=(1,1))
    plt.imshow(img)
    plt.show()
    cls = np.argmax(label)
    cls_name = class_names[cls]
    print("Ground Truth: %s" % cls_name)

    pred_label = sess.run(y_pred, feed_dict = {x: img.reshape([1, -1])})
    pred_cls = np.argmax(pred_label)
    pred_cls_name = class_names[pred_cls]
    print("Model prediction: %s" % pred_cls_name)
```



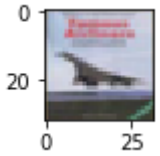

```
Ground Truth: cat
Model prediction: cat
```



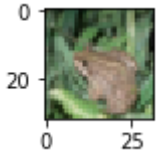

```
Ground Truth: ship
Model prediction: truck
```



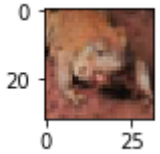
```
Ground Truth: ship
Model prediction: ship
```




```
Ground Truth: airplane
Model prediction: ship
```

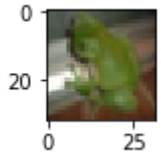



```
Ground Truth: frog
Model prediction: deer
```

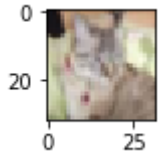



```
Ground Truth: frog
Model prediction: frog
```

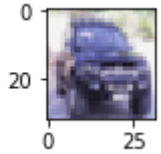

```
Ground Truth: automobile
Model prediction: cat
```




```
Ground Truth: frog
Model prediction: frog
```




```
Ground Truth: cat
Model prediction: bird
```




```
Ground Truth: automobile
Model prediction: automobile
```