Convolutional Neural Networks

In this notebook, we train an MLP to classify images from the CIFAR-10 database.

1. Load CIFAR-10 Database

In [1]:

```
import keras
from keras.datasets import cifar10

# load the pre-shuffled train and test data
(x_train, y_train), (x_test, y_test) = cifar10.load_data()
```

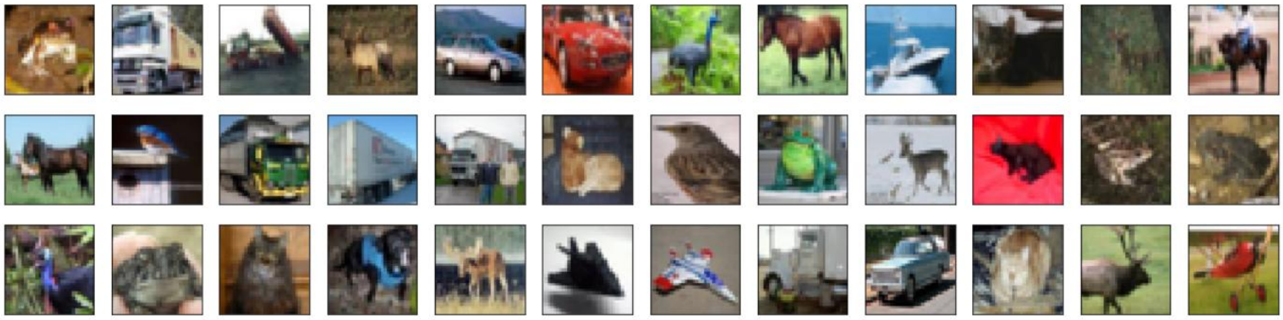
```
Using TensorFlow backend.
Downloading data from http://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
Untaring file...
```

2. Visualize the First 24 Training Images

In [2]:

```
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline

fig = plt.figure(figsize=(20,5))
for i in range(36):
    ax = fig.add_subplot(3, 12, i + 1, xticks=[], yticks=[])
    ax.imshow(np.squeeze(x_train[i]))
```



3. Rescale the Images by Dividing Every Pixel in Every Image by 255

In [3]:

```
# rescale [0,255] --> [0,1]
x_train = x_train.astype('float32')/255
x_test = x_test.astype('float32')/255
```

4. Break Dataset into Training, Testing, and Validation Sets

In [4]:

```
from keras.utils import np_utils

# one-hot encode the labels
num_classes = len(np.unique(y_train))
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)
```

```
# break training set into training and validation sets
(x_train, x_valid) = x_train[5000:], x_train[:5000]
(y_train, y_valid) = y_train[5000:], y_train[:5000]

# print shape of training set
print('x_train shape:', x_train.shape)

# print number of training, validation, and test images
print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')
print(x_valid.shape[0], 'validation samples')
```

```
x_train shape: (45000, 32, 32, 3)
45000 train samples
10000 test samples
5000 validation samples
```

5. Define the Model Architecture

In [5]:

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

# define the model
model = Sequential()
model.add(Flatten(input_shape = x_train.shape[1:]))
model.add(Dense(1000, activation='relu'))
model.add(Dropout(0.2))
model.add(Dense(512, activation='relu'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))

model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
flatten_1 (Flatten)          (None, 3072)              0
_________________________________________________________________
dense_1 (Dense)              (None, 1000)              3073000
_________________________________________________________________
dropout_1 (Dropout)          (None, 1000)              0
_________________________________________________________________
dense_2 (Dense)              (None, 512)               512512
_________________________________________________________________
dropout_2 (Dropout)          (None, 512)               0
_________________________________________________________________
dense_3 (Dense)              (None, 10)                5130
=================================================================
Total params: 3,590,642.0
Trainable params: 3,590,642.0
Non-trainable params: 0.0
_________________________________________________________________
```

6. Compile the Model

In [6]:

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

7. Train the Model

In [7]:

```
from keras.callbacks import ModelCheckpoint

# train the model
checkpointer = ModelCheckpoint(filepath='MLP.weights.best.hdf5', verbose=1,
                               save_best_only=True)
hist = model.fit(x_train, y_train, batch_size=32, epochs=20,
          validation_data=(x_valid, y_valid), callbacks=[checkpointer],
          verbose=2, shuffle=True)
```

```
Train on 45000 samples, validate on 5000 samples
Epoch 1/20
Epoch 00000: val_loss improved from inf to 1.91876, saving model to
MLP.weights.best.hdf5
52s - loss: 3.2886 - acc: 0.2462 - val_loss: 1.9188 - val_acc: 0.3000
Epoch 2/20
Epoch 00001: val_loss did not improve
54s - loss: 1.8626 - acc: 0.3242 - val_loss: 1.9204 - val_acc: 0.3082
……
Epoch 00019: val_loss improved from 1.70597 to 1.70173, saving model to
MLP.weights.best.hdf5
52s - loss: 1.7857 - acc: 0.3670 - val_loss: 1.7017 - val_acc: 0.3926
```

Out[7]:

```
<keras.callbacks.History at 0x10935a4a8>
```

8. Load the Model with the Best Classification Accuracy on the Validation Set

In [8]:

```
# load the weights that yielded the best validation accuracy
model.load_weights('MLP.weights.best.hdf5')
```

9. Calculate Classification Accuracy on Test Set

In [9]:

```
# evaluate and print test accuracy
score = model.evaluate(x_test, y_test, verbose=0)
print('\n', 'Test accuracy:', score[1])
```

```
 Test accuracy: 0.4
```