Finetuning a pretrained network

We can take a network which was trained on the ImageNet dataset and adapt it to our own image classification problem. This can be a useful technique when training data is too limited to train a model from scratch.

Here we try to classify images as either pancakes or waffles.

In [ ]:

```
import numpy as np
import theano
import theano.tensor as T
import lasagne

%matplotlib inline
import matplotlib.pyplot as plt

import skimage.transform
import sklearn.cross_validation
import pickle
import os
```

In [2]:

```
# Seed for reproducibility
np.random.seed(42)
```

In [3]:

```
CLASSES = ['pancakes', 'waffles']
LABELS = {cls: i for i, cls in enumerate(CLASSES)}
```

Dataset

Images were downloaded from Google Image Search, and placed in the directories `./images/pancakes' and './images/waffles'.

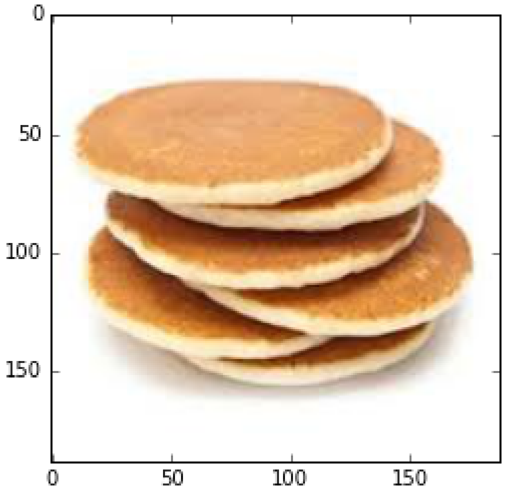
There are approximately 1300 images with a roughly even split.

In [8]:

```
# Read a few images and display
im = plt.imread('./images/pancakes/images?q=tbn:ANd9GcQ1Jtg2V7Me2uybx1rqxDMV58
Ow17JamorQ3GCrW5TUyT1tcr8EMg')
plt.imshow(im)
```

Out[8]:

```
<matplotlib.image.AxesImage at 0x7f86f04b0990>
```

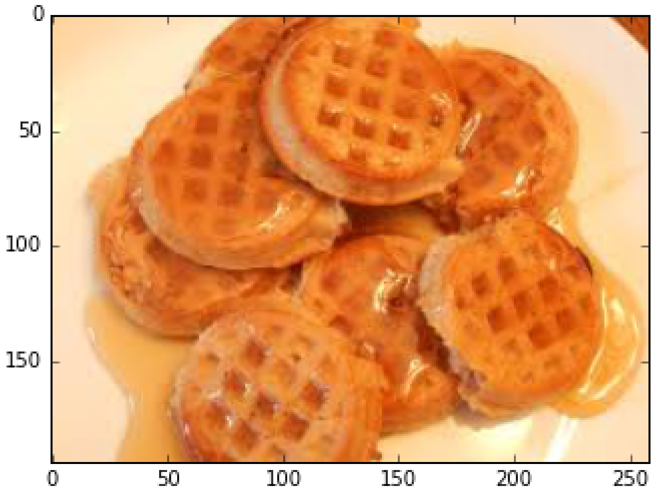


In [9]:

```
im = plt.imread('./images/waffles/images?q=tbn:ANd9GcQ-0-8U4TAw6fn4wDpj8V34Awb
hkpK9SNKwobolotFjNcgspX8wmA')
plt.imshow(im)
```

Out[9]:

```
<matplotlib.image.AxesImage at 0x7f86ee71c150>
```



In [10]:

```python
# Model definition for VGG-16, 16-layer model from the paper:
# "Very Deep Convolutional Networks for Large-Scale Image Recognition"
# Original source: https://gist.github.com/ksimonyan/211839e770f7b538e2d8

# More pretrained models are available from
# https://github.com/Lasagne/Recipes/blob/master/modelzoo/
from lasagne.layers import InputLayer, DenseLayer, NonlinearityLayer
from lasagne.layers.dnn import Conv2DDNNLayer as ConvLayer
from lasagne.layers import Pool2DLayer as PoolLayer
from lasagne.nonlinearities import softmax
from lasagne.utils import floatX

def build_model():
    net = {}
    net['input'] = InputLayer((None, 3, 224, 224))
    net['conv1_1'] = ConvLayer(net['input'], 64, 3, pad=1)
    net['conv1_2'] = ConvLayer(net['conv1_1'], 64, 3, pad=1)
    net['pool1'] = PoolLayer(net['conv1_2'], 2)
    net['conv2_1'] = ConvLayer(net['pool1'], 128, 3, pad=1)
    net['conv2_2'] = ConvLayer(net['conv2_1'], 128, 3, pad=1)
    net['pool2'] = PoolLayer(net['conv2_2'], 2)
    net['conv3_1'] = ConvLayer(net['pool2'], 256, 3, pad=1)
    net['conv3_2'] = ConvLayer(net['conv3_1'], 256, 3, pad=1)
    net['conv3_3'] = ConvLayer(net['conv3_2'], 256, 3, pad=1)
    net['pool3'] = PoolLayer(net['conv3_3'], 2)
    net['conv4_1'] = ConvLayer(net['pool3'], 512, 3, pad=1)
    net['conv4_2'] = ConvLayer(net['conv4_1'], 512, 3, pad=1)
    net['conv4_3'] = ConvLayer(net['conv4_2'], 512, 3, pad=1)
    net['pool4'] = PoolLayer(net['conv4_3'], 2)
    net['conv5_1'] = ConvLayer(net['pool4'], 512, 3, pad=1)
    net['conv5_2'] = ConvLayer(net['conv5_1'], 512, 3, pad=1)
    net['conv5_3'] = ConvLayer(net['conv5_2'], 512, 3, pad=1)
    net['pool5'] = PoolLayer(net['conv5_3'], 2)
    net['fc6'] = DenseLayer(net['pool5'], num_units=4096)
    net['fc7'] = DenseLayer(net['fc6'], num_units=4096)
    net['fc8'] = DenseLayer(net['fc7'], num_units=1000, nonlinearity=None)
    net['prob'] = NonlinearityLayer(net['fc8'], softmax)

    return net
```

In [14]:

```python
# Load model weights and metadata
d = pickle.load(open('vgg16.pkl'))
```

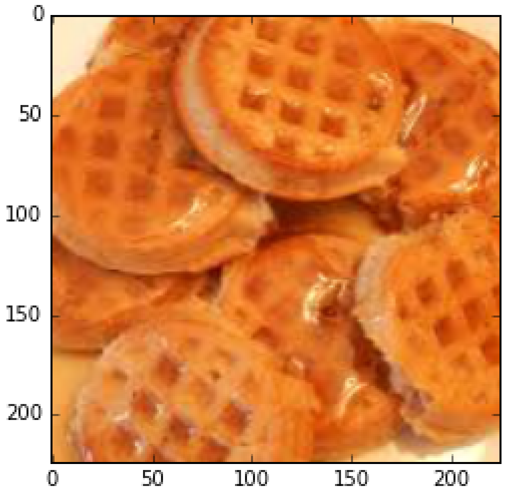
In [15]:

```python
# Build the network and fill with pretrained weights
net = build_model()
lasagne.layers.set_all_param_values(net['prob'], d['param values'])
```

In [16]:
```
# The network expects input in a particular format and size.
# We define a preprocessing function to load a file and apply the necessary transformations
IMAGE_MEAN = d['mean value'][:, np.newaxis, np.newaxis]

def prep_image(fn, ext='jpg'):
    im = plt.imread(fn, ext)

    # Resize so smallest dim = 256, preserving aspect ratio
    h, w, _ = im.shape
    if h < w:
        im = skimage.transform.resize(im, (256, w*256/h), preserve_range=True)
    else:
        im = skimage.transform.resize(im, (h*256/w, 256), preserve_range=True)

    # Central crop to 224x224
    h, w, _ = im.shape
    im = im[h//2-112:h//2+112, w//2-112:w//2+112]

    rawim = np.copy(im).astype('uint8')

    # Shuffle axes to c01
    im = np.swapaxes(np.swapaxes(im, 1, 2), 0, 1)

    # discard alpha channel if present
    im = im[:3]

    # Convert to BGR
    im = im[::-1, :, :]

    im = im - IMAGE_MEAN
    return rawim, floatX(im[np.newaxis])
```

In [17]:
```
# Test preprocesing and show the cropped input
rawim, im = prep_image('./images/waffles/images?q=tbn:ANd9GcQ-0-8U4TAw6fn4wDpj8V34AwbhkpK9SNKwobolotFjNcgspX8wmA')
plt.imshow(rawim)
```

Out[17]:
```
<matplotlib.image.AxesImage at 0x7f86ee5e3090>
```



In [18]:

```
# Load and preprocess the entire dataset into numpy arrays
X = []
y = []

for cls in CLASSES:
    for fn in os.listdir('./images/{}'.format(cls)):
        _, im = prep_image('./images/{}/{}'.format(cls, fn))
        X.append(im)
        y.append(LABELS[cls])

X = np.concatenate(X)
y = np.array(y).astype('int32')
```

In [19]:

```
# Split into train, validation and test sets
train_ix, test_ix = sklearn.cross_validation.train_test_split(range(len(y)))
train_ix, val_ix = sklearn.cross_validation.train_test_split(range(len(train_i
x)))

X_tr = X[train_ix]
y_tr = y[train_ix]

X_val = X[val_ix]
y_val = y[val_ix]

X_te = X[test_ix]
y_te = y[test_ix]
```

In [20]:

```
# We'll connect our output classifier to the last fully connected layer of the
 network
output_layer = DenseLayer(net['fc7'], num_units=len(CLASSES), nonlinearity=sof
tmax)
```

In [21]:

```
# Define loss function and metrics, and get an updates dictionary
X_sym = T.tensor4()
y_sym = T.ivector()

prediction = lasagne.layers.get_output(output_layer, X_sym)
loss = lasagne.objectives.categorical_crossentropy(prediction, y_sym)
loss = loss.mean()

acc = T.mean(T.eq(T.argmax(prediction, axis=1), y_sym),
                      dtype=theano.config.floatX)

params = lasagne.layers.get_all_params(output_layer, trainable=True)
updates = lasagne.updates.nesterov_momentum(
        loss, params, learning_rate=0.0001, momentum=0.9)
```

In [22]:

```
# Compile functions for training, validation and prediction
train_fn = theano.function([X_sym, y_sym], loss, updates=updates)
val_fn = theano.function([X_sym, y_sym], [loss, acc])
pred_fn = theano.function([X_sym], prediction)
```

In [23]:

```
# generator splitting an iterable into chunks of maximum length N
def batches(iterable, N):
    chunk = []
    for item in iterable:
        chunk.append(item)
        if len(chunk) == N:
            yield chunk
            chunk = []
    if chunk:
        yield chunk
```

In [24]:

```
# We need a fairly small batch size to fit a large network like this in GPU me
mory
BATCH_SIZE = 16
```

In [25]:

```
def train_batch():
    ix = range(len(y_tr))
    np.random.shuffle(ix)
    ix = ix[:BATCH_SIZE]
    return train_fn(X_tr[ix], y_tr[ix])

def val_batch():
    ix = range(len(y_val))
    np.random.shuffle(ix)
    ix = ix[:BATCH_SIZE]
    return val_fn(X_val[ix], y_val[ix])
```

In [26]:

```
for epoch in range(5):
    for batch in range(25):
        loss = train_batch()

    ix = range(len(y_val))
    np.random.shuffle(ix)

    loss_tot = 0.
    acc_tot = 0.
    for chunk in batches(ix, BATCH_SIZE):
        loss, acc = val_fn(X_val[chunk], y_val[chunk])
        loss_tot += loss * len(chunk)
        acc_tot += acc * len(chunk)

    loss_tot /= len(ix)
    acc_tot /= len(ix)
    print(epoch, loss_tot, acc_tot * 100)
```

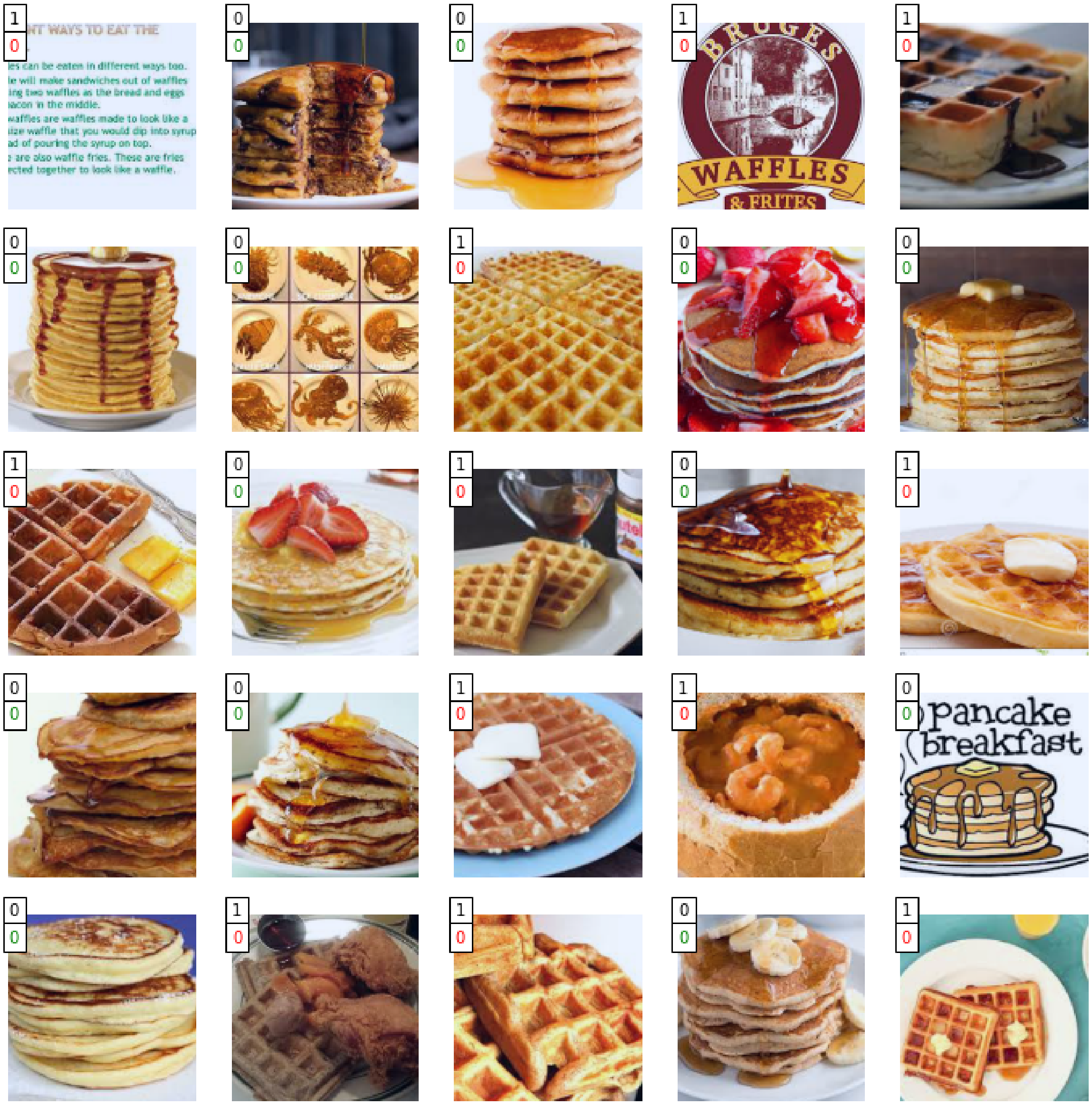
```
(0, 0.24825756545141925, 89.370078787090264)
(1, 0.17160476673775771, 93.700787260776437)
(2, nan, 54.330708661417326)
(3, nan, 54.330708614484536)
(4, nan, 54.330708661417326)
```

In [27]:

```
def deprocess(im):
    im = im[::-1, :, :]
    im = np.swapaxes(np.swapaxes(im, 0, 1), 1, 2)
    im = (im - im.min())
    im = im / im.max()
    return im
```

In [28]:

```
# Plot some results from the validation set
p_y = pred_fn(X_val[:25]).argmax(-1)

plt.figure(figsize=(12, 12))
for i in range(0, 25):
    plt.subplot(5, 5, i+1)
    plt.imshow(deprocess(X_val[i]))
    true = y_val[i]
    pred = p_y[i]
    color = 'green' if true == pred else 'red'
    plt.text(0, 0, true, color='black', bbox=dict(facecolor='white', alpha=1))
    plt.text(0, 32, pred, color=color, bbox=dict(facecolor='white', alpha=1))

    plt.axis('off')
```



In [ ]: