run_train_distracted_drivers-maxout8

August 4, 2016

The changes here are: - Orthogonal weight initialization - Decreasing learning rate by step size

In [1]:
```
from skimage import io, transform, exposure, color, util
import os, itertools, sys
from PIL import Image
%pylab inline
sys.setrecursionlimit(1000000)
```

```
Populating the interactive namespace from numpy and matplotlib
```

In [2]:
```
# data_dir = "/home/dylan/IdeaProjects/distracted_drivers/train/"
data_dir =  "/media/dylan/Science/Kaggle-Data/distracted_drivers/train/"
```

In [3]:
```
input_volume_shape = (128, 128)
```

In [4]:
```
def read_img_file_PIL(file_path, size=(32,32)):
    img = Image.open(file_path).convert('L')
    img.thumbnail(size, Image.NEAREST)
    data = np.array(img)
    shape = data.shape
    append_top = int(ceil(max(0, size[0] - shape[0])/2.0))
    append_bot = int(floor(max(0, size[0] - shape[0])/2.0))
    data = util.pad(data, ((append_top, append_bot),
                           (0,0)), mode='constant', constant_values=0)
    return data
```

In [5]:
```
def read_img_file(file_path, rescale=0.01):
    img = io.imread(file_path)
    img= color.rgb2gray(img)
    return transform.rescale(img, rescale)
```

In [6]:
```
def image_gen_from_dir(directory, batch_size, num_categories, size=input_volume_shape):
    result = {os.path.join(dp, f) : int(os.path.split(dp)[1]) for dp, dn, filenames in os.walk(
                for f in filenames if os.path.splitext(f)[1] == '.jpg'}
    # infinite loop
    while True:
        image_files = []
        labels = []
        # randomly choose batch size samples in result
        for category in range(num_categories):
            file_samples = np.random.choice([k for k, v in result.iteritems() if v == category]
                            size=batch_size, replace=False)
            for file_sample in file_samples:
                image_files.append(read_img_file_PIL(file_sample, size=size))
            labels.extend([v for v in itertools.repeat(category, batch_size)])
```

```
            # end category loop
            X = np.asarray(image_files, dtype=np.float32)
            # -1 to 1 range
            X = exposure.rescale_intensity(X, out_range=(-1,1))
            y = np.asarray(labels, dtype=np.int32)
            yield X, y
```

0.1 Another loader, augmentation time

We'll do 6 augmentations:

```
1.) Translation up to 10 pixels
2.) Rotation up to 15 degrees
3.) Zooming
4.) JPEG compression
5.) Sharpening
6.) Gamma correction
```

We won't do flips since the dataset only contains images from the passenger seat. Perhaps we can revisit this later.

In [7]:
```
from skimage.transform import rotate, warp, AffineTransform
from skimage import filters
from scipy import ndimage, misc
import StringIO
```

In [8]:
```
def random_translate(img):
    shift_random = AffineTransform(translation=(randint(-10, 10), randint(-10, 10)))
    min_value = 0 if min(img.ravel()) > 0 else min(img.ravel())
    return np.float32(warp(img, shift_random, mode='constant', cval=min_value))

def random_rotate(img):
    min_value = 0 if min(img.ravel()) > 0 else min(img.ravel())
    return np.float32(rotate(img, randint(-15, 15), mode='constant', cval=min_value))

def random_zoom(img):
    min_value = 0 if min(img.ravel()) > 0 else min(img.ravel())
    scale_random = AffineTransform(scale=(uniform(0.9, 1.1), uniform(0.9, 1.1)))
    return np.float32(warp(img, scale_random, mode='constant', cval=min_value))

def random_compress(img):
    max_v = np.ceil(img.max())
    min_v = np.floor(img.min())
    nd_im = exposure.rescale_intensity(img, out_range=(0, 1)).squeeze()
    nd_im = np.ndarray.astype(nd_im * 255, np.uint8)
    # nd_im = np.ndarray.astype(img * 255, np.uint8)
    im = Image.fromarray(nd_im)
    buf = StringIO.StringIO()
    im.save(buf, "JPEG", quality=np.random.randint(95, 99))
    buf.seek(0)
    im2 = Image.open(buf)
    x1 = exposure.rescale_intensity(np.ndarray.astype(np.array(im2), np.float32), out_range=(mi
    return x1
```

```
        def random_sharpening(img):
            blurred_f = ndimage.gaussian_filter(img, 0.5)
            filter_blurred_f = ndimage.gaussian_filter(blurred_f, 1)
            alpha = uniform(0.9, 1.2)
            img = blurred_f + alpha * (blurred_f - filter_blurred_f)
            return exposure.rescale_intensity(img, out_range=(-1 , 1))

        def random_gamma_correction(img):
            max_v = np.ceil(img.max())
            min_v = np.floor(img.min())
            img = exposure.rescale_intensity(img, out_range=(0,1))
            img = exposure.adjust_gamma(img, uniform(0.2, 0.8))
            return exposure.rescale_intensity(img, out_range=(-1, 1))
```

```
In [9]: def random_aug(img):
            choice = np.random.randint(0,6)
            # choose from 4 different augmentations!
            if choice == 0:
                return random_translate(img)
            elif choice == 1:
                return random_rotate(img)
            elif choice == 2:
                return random_zoom(img)
            elif choice == 3:
                return random_compress(img)
            elif choice == 4:
                return random_sharpening(img)
            else:
                return random_gamma_correction(img)
```

```
In [10]: def random_aug_batch(X, aug_algorithm):
             for i in range(X.shape[0]):
                 X[i] = aug_algorithm(X[i])
             return X
```

```
In [11]: def random_aug_gen(gen, aug_algorithm):
             for batchX, batchY in gen:
                 yield random_aug_batch(batchX, aug_algorithm), batchY
```

1 Process Generator with cached elements

```
In [12]: def threaded_generator(generator, num_cached=50):
             import Queue
             queue = Queue.Queue(maxsize=num_cached)
             sentinel = object()  # guaranteed unique reference

             # define producer (putting items into queue)
             def producer():
                 for item in generator:
                     queue.put(item)
                 queue.put(sentinel)

             # start producer (in a background thread)
             import threading
```

```
            thread = threading.Thread(target=producer)
            thread.daemon = True
            thread.start()

            # run as consumer (read items from queue, in current thread)
            item = queue.get()
            while item is not sentinel:
                yield item
                queue.task_done()
                item = queue.get()
```

In [13]:
```
from nolearn.lasagne import NeuralNet
from lasagne.layers import DenseLayer, ReshapeLayer, Upscale2DLayer, Conv2DLayer, InputLayer,
    MaxPool2DLayer, get_all_params, batch_norm, BatchNormLayer, FeaturePoolLayer
import numpy as np
from lasagne.nonlinearities import softmax, leaky_rectify, theano
from lasagne.updates import nesterov_momentum
from nolearn.lasagne import NeuralNet, BatchIterator, PrintLayerInfo, objective
from nolearn.lasagne import TrainSplit
from common import EarlyStopping, EndTrainingFromEarlyStopping
from lasagne.objectives import categorical_crossentropy, aggregate
import cPickle as pickle
from sklearn import metrics
import time, logging, logging.config, logging.handlers
from lasagne.init import Orthogonal
from notebook_functions import load_best_weights
```

```
Couldn't import dot_parser, loading of dot files will not be possible.

Using gpu device 0: GeForce GTX 960 (CNMeM is disabled, CuDNN 4004)
```

def batch_norm(s): return s

In [14]:
```
try:
    from lasagne.layers.dnn import Conv2DDNNLayer, MaxPool2DDNNLayer
    def conv_2_layer_stack(top, num_filters):
        conv1 = batch_norm(Conv2DDNNLayer(top, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv2 = batch_norm(Conv2DDNNLayer(conv1, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        return MaxPool2DDNNLayer(conv2, (2, 2), 2)

    def conv_3_layer_stack(top, num_filters):
        conv1 = batch_norm(Conv2DDNNLayer(top, num_filters, (3, 3),
                    stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv2 = batch_norm(Conv2DDNNLayer(conv1, num_filters, (3, 3),
                    stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv3 = batch_norm(Conv2DDNNLayer(conv2, num_filters, (3, 3),
                    stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        return MaxPool2DDNNLayer(conv3, (2, 2), 2)

    def conv_4_layer_stack(top, num_filters):
        conv1 = batch_norm(Conv2DDNNLayer(top, num_filters, (3, 3),
                    stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv2 = batch_norm(Conv2DDNNLayer(conv1, num_filters, (3, 3),
```

```
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv3 = batch_norm(Conv2DDNNLayer(conv2, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv4 = batch_norm(Conv2DDNNLayer(conv3, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        return MaxPool2DDNNLayer(conv4, (2, 2), 2)

    def conv_6_layer_stack(top, num_filters):
        conv1 = batch_norm(Conv2DDNNLayer(top, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv2 = batch_norm(Conv2DDNNLayer(conv1, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv3 = batch_norm(Conv2DDNNLayer(conv2, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv4 = batch_norm(Conv2DDNNLayer(conv3, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv5 = batch_norm(Conv2DDNNLayer(conv4, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        conv6 = batch_norm(Conv2DDNNLayer(conv5, num_filters, (3, 3),
                stride=1, pad=1, nonlinearity=leaky_rectify, W=Orthogonal()))
        return MaxPool2DLayer(conv6, (2, 2), 2)

except ImportError:
    def conv_2_layer_stack(top, num_filters):
        conv1 = batch_norm(Conv2DLayer(top, num_filters, (3, 3), stride=1, pad=1, nonlinearity=
        conv2 = batch_norm(Conv2DLayer(conv1, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        return MaxPool2DLayer(conv2, (2, 2), 2)

    def conv_3_layer_stack(top, num_filters):
        conv1 = batch_norm(Conv2DLayer(top, num_filters, (3, 3), stride=1, pad=1, nonlinearity=
        conv2 = batch_norm(Conv2DLayer(conv1, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        conv3 = batch_norm(Conv2DLayer(conv2, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        return MaxPool2DLayer(conv3, (2, 2), 2)

    def conv_4_layer_stack(top, num_filters):
        conv1 = batch_norm(Conv2DLayer(top, num_filters, (3, 3), stride=1, pad=1, nonlinearity=
        conv2 = batch_norm(Conv2DLayer(conv1, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        conv3 = batch_norm(Conv2DLayer(conv2, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        conv4 = batch_norm(Conv2DLayer(conv3, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        return MaxPool2DLayer(conv4, (2, 2), 2)

    def conv_6_layer_stack(top, num_filters):
        conv1 = batch_norm(Conv2DLayer(top, num_filters, (3, 3), stride=1, pad=1, nonlinearity=
        conv2 = batch_norm(Conv2DLayer(conv1, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        conv3 = batch_norm(Conv2DLayer(conv2, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        conv4 = batch_norm(Conv2DLayer(conv3, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        conv5 = batch_norm(Conv2DLayer(conv4, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        conv6 = batch_norm(Conv2DLayer(conv5, num_filters, (3, 3), stride=1, pad=1, nonlinearit
        return MaxPool2DLayer(conv6, (2, 2), 2)
```

In [15]:
```
k = 8
input_layer = InputLayer((None, 1, input_volume_shape[0], input_volume_shape[1]))
conv_stack_1 = conv_2_layer_stack(input_layer, 32)
dropout1 = DropoutLayer(conv_stack_1, p=0.1)
```

```
conv_stack_2 = conv_2_layer_stack(dropout1, 64)
dropout2 = DropoutLayer(conv_stack_2, p=0.2)

conv_stack_3 = conv_2_layer_stack(dropout2, 128)
dropout3 = DropoutLayer(conv_stack_3, p=0.3)

conv_stack_4 = conv_2_layer_stack(dropout3, 256)
dropout4 = DropoutLayer(conv_stack_4, p=0.4)

conv_stack_5 = conv_2_layer_stack(dropout4, 512)
dropout17 = DropoutLayer(conv_stack_5, p=0.5)

dense18 = DenseLayer(dropout17, 2048, nonlinearity=None)
norm1 = BatchNormLayer(dense18)
maxout1 = FeaturePoolLayer(norm1, k)
dropout19 = DropoutLayer(maxout1, p=0.5)

dense20 = DenseLayer(dropout19, 2048, nonlinearity=None)
norm2 = BatchNormLayer(dense20)
maxout2 = FeaturePoolLayer(norm2, k)

softmax21 = DenseLayer(maxout2, 10, nonlinearity=softmax)
```

1.1 Quality of Life Functions

```
In [16]: if not os.path.exists("logs"):
             os.mkdir("logs")
         logging.config.fileConfig("logging-training.conf")

         def regularization_objective(layers, lambda1=0., lambda2=0., *args, **kwargs):
             # default loss
             losses = objective(layers, *args, **kwargs)
             # get layer weights except for the biases
             weights = get_all_params(layers[-1], regularizable=True)
             regularization_term = 0.0
             # sum of abs weights for L1 regularization
             if lambda1 != 0.0:
                 sum_abs_weights = sum([abs(w).sum() for w in weights])
                 regularization_term += (lambda1 * sum_abs_weights)
             # sum of squares (sum(theta^2))
             if lambda2 != 0.0:
                 sum_squared_weights = (1 / 2.0) * sum([(w ** 2).sum() for w in weights])
                 regularization_term += (lambda2 * sum_squared_weights)
             # add weights to regular loss
             losses += regularization_term
             return losses

         def eval_regularization(net):
             if net.objective_lambda1 == 0 and net.objective_lambda2 == 0:
                 return 0
             # check the loss if the regularization term is not overpowering the loss
             weights = get_all_params(net.layers_[-1], regularizable=True)
             # sum of abs weights for L1 regularization
```

```
    sum_abs_weights = sum([abs(w).sum() for w in weights])
    # sum of squares (sum(theta^2))
    sum_squared_weights = (1 / 2.0) * sum([(w ** 2).sum() for w in weights])
    # add weights to regular loss
    regularization_term = (net.objective_lambda1 * sum_abs_weights) \
                          + (net.objective_lambda2 * sum_squared_weights)
    return regularization_term


def print_regularization_term(net):
    if net.objective_lambda1 > 0.0 or net.objective_lambda2 > 0.0:
        regularization_term = eval_regularization(net)
        print "Regularization term: {}".format(regularization_term.eval())

def validation_set_loss(_net, _X, _y):
    """We need this to track the validation loss"""
    _yb = _net.predict_proba(_X)
    _y_pred = np.argmax(_yb, axis=1)
    _acc = metrics.accuracy_score(_y, _y_pred)
    loss = aggregate(categorical_crossentropy(_yb, _y))
    loss += eval_regularization(_net)
    return loss, _acc


def store_model(model_file_name, net):
    directory_name = os.path.dirname(model_file_name)
    model_file_name = os.path.basename(model_file_name)
    if not os.path.exists(directory_name):
        os.makedirs(directory_name)
    # write model
    output_model_file_name = os.path.join(directory_name, model_file_name)
    start_write_time = time.time()
    if os.path.isfile(output_model_file_name):
        os.remove(output_model_file_name)
    with open(output_model_file_name, 'wb') as experiment_model:
        pickle.dump(net, experiment_model)
    total_write_time = time.time() - start_write_time
    m, s = divmod(total_write_time, 60)
    h, m = divmod(m, 60)
    logging.log(logging.INFO, "Duration of saving to disk: %0d:%02d:%02d", h, m, s)

def write_validation_loss_and_store_best(validation_file_name, best_weights_file_name,
                                         net, X_val, y_val, best_vloss, best_acc):
    # write validation loss
    start_validate_time = time.time()
    vLoss, vAcc = validation_set_loss(net, X_val, y_val)
    loss = vLoss.eval()
    current_epoch = net.train_history_[-1]['epoch']
    with open(validation_file_name, 'a') as validation_file:
        validation_file.write("{}, {}, {}\n".format(current_epoch, loss, vAcc))

    total_validate_time = time.time() - start_validate_time
    m, s = divmod(total_validate_time, 60)
    h, m = divmod(m, 60)
```

```
            logging.log(logging.INFO, "Duration of validation: %0d:%02d:%02d", h, m, s)

            # store best weights here
            if loss < best_vloss:
                start_bw_time = time.time()
                best_vloss = loss
                best_acc = vAcc
                with open(best_weights_file_name, 'wb') as best_model_file:
                    pickle.dump(net.get_all_params_values(), best_model_file, -1)

            return best_vloss, best_acc


        class AdjustVariableWithStepSize(object):
            """This class adjusts any variable during training
            """

            def __init__(self, name, start=0.03, steps=3, after_epochs=2000):
                self.name = name
                self.start = start
                self.steps=steps
                self.after_epochs=after_epochs
                self.ls = []

            def __call__(self, nn, train_history):
                if not self.ls:
                    for i in range(self.steps):
                        self.ls.extend(np.repeat(self.start/(np.power(10,i)), self.after_epochs))

                try:
                    epoch = train_history[-1]['epoch']
                    new_value = np.float32(self.ls[epoch - 1])
                    getattr(nn, self.name).set_value(new_value)
                except IndexError:
                    pass
```

1.2 CNN

```
In [17]: lambda1 = 0.0
         lambda2 = 5e-3

         net = NeuralNet(
             layers=softmax21,
             max_epochs=1,
             update=nesterov_momentum,
             update_learning_rate=theano.shared(np.float32(0.001)),
             update_momentum = 0.99,
             # update=adam,
             on_epoch_finished=[
                 EarlyStopping(patience=1000),
                 AdjustVariableWithStepSize('update_learning_rate', start=0.001, steps=2, after_epochs=8
             ],
             on_training_finished=[
                 EndTrainingFromEarlyStopping()
```

```
            ],
            objective=regularization_objective,
            objective_lambda2=lambda2,
            objective_lambda1=lambda1,
            batch_iterator_train=BatchIterator(batch_size=100),
            train_split=TrainSplit(
                eval_size=0.25),
            # train_split=TrainSplit(eval_size=0.0),
            verbose=3,
        )
```

In [18]:
```
p = PrintLayerInfo()
net.initialize()
# p(net)
```

1.2.1 load cnn instead

In [19]:
```
dir_name = 'net.vgg.large.l2.5e3.orthog-norm-maxout8'
validation_file_name = "{}/vloss-{}.txt".format(dir_name, dir_name)
model_file_name = "{}/{}.pickle".format(dir_name, dir_name)
best_weights_file_name = "{}/bw-{}.weights".format(dir_name, dir_name)
if os.path.exists(dir_name):
    print "Model exists. Loading {}.".format(dir_name)
    with open(model_file_name, 'rb') as reader:
        net = pickle.load(reader)
else:
    print "Training model from the beginning {}".format(dir_name)
```

```
Model exists. Loading net.vgg.large.l2.5e3.orthog-norm-maxout8.
```

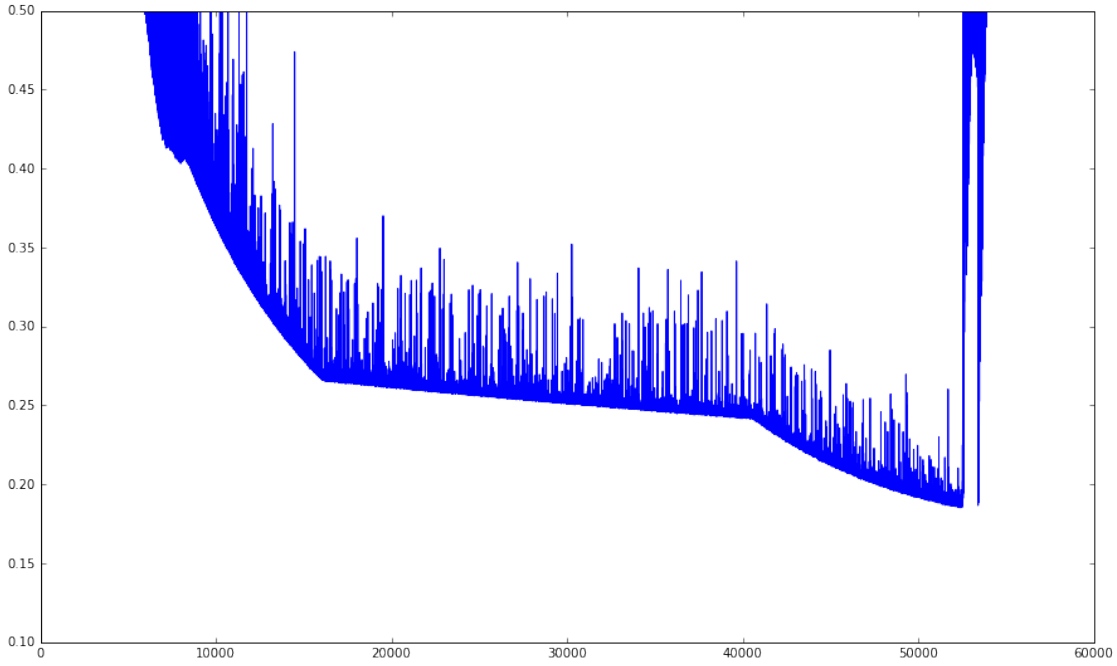
In [20]:
```
load_best_weights(best_weights_file_name, net)
```

```
Loaded parameters to layer 'conv2ddnn1' (shape 32x1x3x3).
Loaded parameters to layer 'batchnorm2' (shape 32).
Loaded parameters to layer 'batchnorm2' (shape 32).
Loaded parameters to layer 'batchnorm2' (shape 32).
Loaded parameters to layer 'batchnorm2' (shape 32).
Loaded parameters to layer 'conv2ddnn4' (shape 32x32x3x3).
Loaded parameters to layer 'batchnorm5' (shape 32).
Loaded parameters to layer 'batchnorm5' (shape 32).
Loaded parameters to layer 'batchnorm5' (shape 32).
Loaded parameters to layer 'batchnorm5' (shape 32).
Loaded parameters to layer 'conv2ddnn9' (shape 64x32x3x3).
Loaded parameters to layer 'batchnorm10' (shape 64).
Loaded parameters to layer 'batchnorm10' (shape 64).
Loaded parameters to layer 'batchnorm10' (shape 64).
Loaded parameters to layer 'batchnorm10' (shape 64).
Loaded parameters to layer 'conv2ddnn12' (shape 64x64x3x3).
Loaded parameters to layer 'batchnorm13' (shape 64).
Loaded parameters to layer 'batchnorm13' (shape 64).
Loaded parameters to layer 'batchnorm13' (shape 64).
Loaded parameters to layer 'batchnorm13' (shape 64).
Loaded parameters to layer 'conv2ddnn17' (shape 128x64x3x3).
Loaded parameters to layer 'batchnorm18' (shape 128).
Loaded parameters to layer 'batchnorm18' (shape 128).
```

```
Loaded parameters to layer 'batchnorm18' (shape 128).
Loaded parameters to layer 'batchnorm18' (shape 128).
Loaded parameters to layer 'conv2ddnn20' (shape 128x128x3x3).
Loaded parameters to layer 'batchnorm21' (shape 128).
Loaded parameters to layer 'batchnorm21' (shape 128).
Loaded parameters to layer 'batchnorm21' (shape 128).
Loaded parameters to layer 'batchnorm21' (shape 128).
Loaded parameters to layer 'conv2ddnn25' (shape 256x128x3x3).
Loaded parameters to layer 'batchnorm26' (shape 256).
Loaded parameters to layer 'batchnorm26' (shape 256).
Loaded parameters to layer 'batchnorm26' (shape 256).
Loaded parameters to layer 'batchnorm26' (shape 256).
Loaded parameters to layer 'conv2ddnn28' (shape 256x256x3x3).
Loaded parameters to layer 'batchnorm29' (shape 256).
Loaded parameters to layer 'batchnorm29' (shape 256).
Loaded parameters to layer 'batchnorm29' (shape 256).
Loaded parameters to layer 'batchnorm29' (shape 256).
Loaded parameters to layer 'conv2ddnn33' (shape 512x256x3x3).
Loaded parameters to layer 'batchnorm34' (shape 512).
Loaded parameters to layer 'batchnorm34' (shape 512).
Loaded parameters to layer 'batchnorm34' (shape 512).
Loaded parameters to layer 'batchnorm34' (shape 512).
Loaded parameters to layer 'conv2ddnn36' (shape 512x512x3x3).
Loaded parameters to layer 'batchnorm37' (shape 512).
Loaded parameters to layer 'batchnorm37' (shape 512).
Loaded parameters to layer 'batchnorm37' (shape 512).
Loaded parameters to layer 'batchnorm37' (shape 512).
Loaded parameters to layer 'dense41' (shape 8192x2048).
Loaded parameters to layer 'dense41' (shape 2048).
Loaded parameters to layer 'batchnorm42' (shape 2048).
Loaded parameters to layer 'batchnorm42' (shape 2048).
Loaded parameters to layer 'batchnorm42' (shape 2048).
Loaded parameters to layer 'batchnorm42' (shape 2048).
Loaded parameters to layer 'dense45' (shape 256x2048).
Loaded parameters to layer 'dense45' (shape 2048).
Loaded parameters to layer 'batchnorm46' (shape 2048).
Loaded parameters to layer 'batchnorm46' (shape 2048).
Loaded parameters to layer 'batchnorm46' (shape 2048).
Loaded parameters to layer 'batchnorm46' (shape 2048).
Loaded parameters to layer 'dense48' (shape 256x10).
Loaded parameters to layer 'dense48' (shape 10).
```

```
In [21]: from nolearn.lasagne.visualize import plot_loss
         plt.figure( figsize=(15,9))
         plt.ylim([0.1,0.5])
         plt.plot([v['valid_loss'] for v in net.train_history_])
```

```
Out[21]: [<matplotlib.lines.Line2D at 0x7f8fcd494b10>]
```




```
In [22]: net.on_epoch_finished
```

```
Out[22]: [<nolearn.lasagne.handlers.PrintLog instance at 0x7f8fcabb9248>]
```

```
In [23]: net.update_learning_rate = 0.00001
         # net.on_epoch_finished.pop(0)
```

2 just this time.

net.on_epoch_finished.pop(1) print net.on_epoch_finished net.update_learning_rate=0.001

2.1 Define validation set

```
In [ ]: val_dir =  "/media/dylan/Science/Kaggle-Data/distracted_drivers/val/"
        X_val, y_val = image_gen_from_dir(val_dir, 40, 10, size=input_volume_shape).next()
        X_val = X_val.reshape(-1, 1, input_volume_shape[0], input_volume_shape[1])
```

```
In [ ]: image_gen = image_gen_from_dir(data_dir, 10, 10, size=input_volume_shape)
        gen = random_aug_gen(image_gen, random_aug)
        threaded_gen = threaded_generator(gen, num_cached=100)

        ops_every = 500
        best_acc = 0.0
        best_vloss = np.inf

        start_time = time.time()
        try:
            for step, (inputs, targets) in enumerate(threaded_gen):
                shape = inputs.shape
                net.fit(inputs.reshape(shape[0],1, shape[1], shape[2]), targets)
```

```
                if (step + 1) % ops_every == 0:
                    print_regularization_term(net)
                    store_model(model_file_name, net)
                    # center validation
                    best_vloss, best_acc = write_validation_loss_and_store_best(
                        validation_file_name, best_weights_file_name, net, X_val, y_val, best_vloss, bes

        except StopIteration:
            # terminate if already early stopping
            with open(model_file_name, 'wb') as writer:
                pickle.dump(net, writer)
            total_time = time.time() - start_time
            print("Training successful by early stopping. Elapsed: {}".format(total_time))
```

```
53903       0.54187       0.56071      0.96640      0.96667  1.04s
  53904       0.54011       0.67385      0.80153      0.96667  1.02s
  53905       0.57318       0.49750      1.15213      1.00000  1.01s
  53906       0.55604       0.49808      1.11635      1.00000  1.02s
  53907       0.53049       0.54025      0.98195      1.00000  1.03s
  53908       0.53793       0.49684      1.08270      1.00000  1.04s
  53909       0.58136       0.53941      1.07777      0.96667  1.03s
  53910       0.52917       0.50147      1.05524      1.00000  1.03s
  53911       0.54986       0.49550      1.10971      1.00000  1.03s
  53912       0.60367       0.52409      1.15183      0.96667  1.04s
  53913       0.56180       0.51511      1.09063      1.00000  1.02s
  53914       0.55625       0.49974      1.11308      1.00000  1.05s
  53915       0.54149       0.56290      0.96196      0.96667  1.03s
  53916       0.53287       0.49828      1.06942      1.00000  1.03s
  53917       0.51200       0.50430      1.01527      1.00000  1.03s
  53918       0.51252       0.77564      0.66077      0.93333  1.02s
  53919       0.53798       0.60664      0.88681      0.93333  1.03s
```

2.2 Visualizations

In [ ]:
```
from notebook_functions import plot_validation_loss
```

In [ ]:
```
plot_validation_loss(net, validation_file_name, ylim=[0, 0.5])
```

In [ ]: