Introduction

see V56 for the best result of LB632 -- Finally I beat the current best public kernel using Keras :) -- This probably be my last update on this kernel -- If you find this kernel helpful, please upvote

Version upto V60 have a silly bug of 'if <-- elif' so that model selection is wrong

This is my effort to do a `Keras` replication with comparable baseline to the great kernel of @mhiro2 https://www.kaggle.com/mhiro2/simple-2d-cnn-classifier-with-pytorch (https://www.kaggle.com/mhiro2/simple-2d-cnn-classifier-with-pytorch) (and further improved by @peining), which in turns use the excellent pre-processed data of @daisukelab https://www.kaggle.com/daisukelab/creating-fat2019-preprocessed-data (https://www.kaggle.com/daisukelab/creating-fat2019-preprocessed-data)) -- Note that to inference to the private data in stage-2, you have to preprocess data yourself.

One change I made in a Keras version, in addition to a simple conv net, we can also use a pre-defined architectures [trained from scratch] `MobileNetV2` , `InceptionV3` and `Xception` where you can choose in the kernel. Also, many ideas borrow from a nice kernel of @voglinio https://www.kaggle.com/voglinio/keras-2d-model-5-fold-log-specgram-curated-only (https://www.kaggle.com/voglinio/keras-2d-model-5-fold-log-specgram-curated-only) , I also borrow the SoftMax+BCE loss & TTA ideas from Giba's kernel (BTW, we all know Giba without having to mention his user :).

I apologize that my code is not at all clean; some of the `pytorch` code is still here albeit not used.

Major Updates

- V1 [CV680, LB574]
- V4 [CV66x, LB576]
- V5 [] Add image augmentation module
- V9 [CV679] Add lwlrap TF metric (credit @rio114 : https://www.kaggle.com/rio114/keras-cnn-with-lwlrap-evaluation (https://www.kaggle.com/rio114/keras-cnn-with-lwlrap-evaluation))
- V11 [] Employ list of augmentations mentioned in https://github.com/sainathadapa/kaggle-freesound-audio-tagging/blob/master/approaches_all.md (https://github.com/sainathadapa/kaggle-freesound-audio-tagging/blob/master/approaches_all.md)
- V16 [] Add BCEwithLogits (use only with ACTIVATION = 'linear')
- V17 add SimpleCNN similar to the pytorch baseline
- V22 add Curated-Only, Train-augment options
- V23 add CRNN model
- **V30 LB598 with shallow CNN in 400s, set iteration to 150**
- **V39 LB608 with CoarseDropout Augmentation**
- V40 Simple Snapshot (Checkpoint) Ensemble
- **V52 [CV811, LB616] MixUp+CoarseDropout : credit https://www.kaggle.com/mathormad/resnet50-v2-keras-focal-loss-mix-up (https://www.kaggle.com/mathormad/resnet50-v2-keras-focal-loss-mix-up)**
- **V56 [CV830, LB632] Change Architecture to get the best result**
- V61 fix silly bugs on model selection

In [1]:

```
import gc
import os
import pickle
import random
import time
from collections import Counter, defaultdict
from functools import partial
from pathlib import Path
from psutil import cpu_count
import matplotlib.pyplot as plt

import librosa
import numpy as np
import pandas as pd
from PIL import Image
from sklearn.model_selection import train_test_split
from imgaug import augmenters as iaa
#from skmultilearn.model_selection import iterative_train_test_split

import torch
import torch.nn as nn
import torch.nn.functional as F
from fastprogress import master_bar, progress_bar
from torch.optim import Adam
from torch.optim.lr_scheduler import CosineAnnealingLR
from torch.utils.data import Dataset, DataLoader
from torchvision.transforms import transforms
```

utils

In [2]:

```
NUM_CLASSES = 80
SIZE=128
checkpoint_file = ['model_best1.h5', 'model_best2.h5', 'model_best3.h5']
# See Version40 for 3 snapshots (or you can use only 1 which is normal run)
EPOCHS = [432, 0, 0] #150 for inception, 100 for xception
TTA = [19, 0, 0] #Number of test-time augmentation
BATCH_SIZE = 32

LR = 4e-4
PATIENCE = 10 #ReduceOnPlateau option
LR_FACTOR = 0.8 #ReduceOnPlateau option
CURATED_ONLY = True # use only curated data for training
TRAIN_AUGMENT = True # use augmentation for training data?
VALID_AUGMENT = False
MODEL = 'mobile' #'cnn8th' # choose among 'xception', 'inception', 'mobile', 'crnn', 'simple'
SEED = 520

USE_MIXUP = True
MIXUP_PROB = 0.275

# No K-Fold implementation yet
# NUM_K_FOLDS = 5 # how many folds (K) you gonna splits
# NUM_MODEL_RUN = 5 # how many models (<= K) you gonna train [e.g. set to 1 for a simple train/test split]

# if use BCEwithLogits loss, use Activation = 'linear' only
ACTIVATION = 'linear'
# ACTIVATION = 'softmax'
# ACTIVATION = 'sigmoid'

# LOSS = 'categorical_crossentropy'
# LOSS = 'binary_crossentropy'
LOSS = 'BCEwithLogits'
```

In [3]:

```
def seed_everything(seed):
    random.seed(seed)
    os.environ['PYTHONHASHSEED'] = str(seed)
    np.random.seed(seed)
    torch.manual_seed(seed)
    torch.cuda.manual_seed(seed)
    torch.backends.cudnn.deterministic = True

seed_everything(SEED)
```

In [4]:

```
# from official code https://colab.research.google.com/drive/1AgPdhSp7ttY18O3fEoHOQKlt_3HJDLi8#scrollTo=cRCaCIb9oguU
def _one_sample_positive_class_precisions(scores, truth):
    """Calculate precisions for each true class for a single sample.

    Args:
      scores: np.array of (num_classes,) giving the individual classifier scores.
      truth: np.array of (num_classes,) bools indicating which classes are true.

    Returns:
      pos_class_indices: np.array of indices of the true classes for this sample.
      pos_class_precisions: np.array of precisions corresponding to each of those
        classes.
    """
    num_classes = scores.shape[0]
    pos_class_indices = np.flatnonzero(truth > 0)
    # Only calculate precisions if there are some true classes.
    if not len(pos_class_indices):
        return pos_class_indices, np.zeros(0)
    # Retrieval list of classes for this sample.
    retrieved_classes = np.argsort(scores)[::-1]
    # class_rankings[top_scoring_class_index] == 0 etc.
    class_rankings = np.zeros(num_classes, dtype=np.int)
    class_rankings[retrieved_classes] = range(num_classes)
    # Which of these is a true label?
    retrieved_class_true = np.zeros(num_classes, dtype=np.bool)
    retrieved_class_true[class_rankings[pos_class_indices]] = True
    # Num hits for every truncated retrieval list.
    retrieved_cumulative_hits = np.cumsum(retrieved_class_true)
    # Precision of retrieval list truncated at each hit, in order of pos_labels.
    precision_at_hits = (
            retrieved_cumulative_hits[class_rankings[pos_class_indices]] /
            (1 + class_rankings[pos_class_indices].astype(np.float)))
    return pos_class_indices, precision_at_hits


def calculate_per_class_lwlrap(truth, scores):
    """Calculate label-weighted label-ranking average precision.

    Arguments:
      truth: np.array of (num_samples, num_classes) giving boolean ground-truth
        of presence of that class in that sample.
      scores: np.array of (num_samples, num_classes) giving the classifier-under-
        test's real-valued score for each class for each sample.

    Returns:
      per_class_lwlrap: np.array of (num_classes,) giving the lwlrap for each
        class.
      weight_per_class: np.array of (num_classes,) giving the prior of each
        class within the truth labels.  Then the overall unbalanced lwlrap is
        simply np.sum(per_class_lwlrap * weight_per_class)
    """
    assert truth.shape == scores.shape
    num_samples, num_classes = scores.shape
    # Space to store a distinct precision value for each class on each sample.
    # Only the classes that are true for each sample will be filled in.
    precisions_for_samples_by_classes = np.zeros((num_samples, num_classes))
    for sample_num in range(num_samples):
```

In [5]:

```
import tensorflow as tf



# from https://www.kaggle.com/rio114/keras-cnn-with-lwlrap-evaluation/
def tf_one_sample_positive_class_precisions(y_true, y_pred) :
    num_samples, num_classes = y_pred.shape

    # find true labels
    pos_class_indices = tf.where(y_true > 0)

    # put rank on each element
    retrieved_classes = tf.nn.top_k(y_pred, k=num_classes).indices
    sample_range = tf.zeros(shape=tf.shape(tf.transpose(y_pred)), dtype=tf.i
nt32)
    sample_range = tf.add(sample_range, tf.range(tf.shape(y_pred)[0], delta=
1))
    sample_range = tf.transpose(sample_range)
    sample_range = tf.reshape(sample_range, (-1,num_classes*tf.shape(y_pre
d)[0]))
    retrieved_classes = tf.reshape(retrieved_classes, (-1,num_classes*tf.sha
pe(y_pred)[0]))
    retrieved_class_map = tf.concat((sample_range, retrieved_classes), axis=
0)
    retrieved_class_map = tf.transpose(retrieved_class_map)
    retrieved_class_map = tf.reshape(retrieved_class_map, (tf.shape(y_pre
d)[0], num_classes, 2))

    class_range = tf.zeros(shape=tf.shape(y_pred), dtype=tf.int32)
    class_range = tf.add(class_range, tf.range(num_classes, delta=1))

    class_rankings = tf.scatter_nd(retrieved_class_map,
                                      class_range,
                                      tf.shape(y_pred))

    #pick_up ranks
    num_correct_until_correct = tf.gather_nd(class_rankings, pos_class_indic
es)

    # add one for division for "presicion_at_hits"
    num_correct_until_correct_one = tf.add(num_correct_until_correct, 1)
    num_correct_until_correct_one = tf.cast(num_correct_until_correct_one, t
f.float32)

    # generate tensor [num_sample, predict_rank],
    # top-N predicted elements have flag, N is the number of positive for ea
ch sample.
    sample_label = pos_class_indices[:, 0]
    sample_label = tf.reshape(sample_label, (-1, 1))
    sample_label = tf.cast(sample_label, tf.int32)

    num_correct_until_correct = tf.reshape(num_correct_until_correct, (-1,
1))
    retrieved_class_true_position = tf.concat((sample_label,
                                           num_correct_until_correct), a
xis=1)
    retrieved_pos = tf.ones(shape=tf.shape(retrieved_class_true_positio
n)[0], dtype=tf.int32)
    retrieved_class_true = tf.scatter_nd(retrieved_class_true_position,
                                     retrieved_pos,
                                     tf.shape(y_pred))
    # cumulate predict_rank
    retrieved_cumulative_hits = tf.cumsum(retrieved_class_true, axis=1)

    # find positive position
    pos_ret_indices = tf.where(retrieved_class_true > 0)

    # find cumulative hits
```

In [6]:

```
from keras import backend as k
def BCEwithLogits(y_true, y_pred):
    return K.mean(K.binary_crossentropy(y_true, y_pred, from_logits=True), a
xis=-1)
```

```
Using TensorFlow backend.
```

dataset

In [7]:

```
dataset_dir = Path('../input/freesound-audio-tagging-2019')
preprocessed_dir = Path('../input/fat2019_prep_mels1')
```

In [8]:

```
csvs = {
    'train_curated': dataset_dir / 'train_curated.csv',
    #'train_noisy': dataset_dir / 'train_noisy.csv',
    'train_noisy': preprocessed_dir / 'trn_noisy_best50s.csv',
    'sample_submission': dataset_dir / 'sample_submission.csv',
}

dataset = {
    'train_curated': dataset_dir / 'train_curated',
    'train_noisy': dataset_dir / 'train_noisy',
    'test': dataset_dir / 'test',
}

mels = {
    'train_curated': preprocessed_dir / 'mels_train_curated.pkl',
    'train_noisy': preprocessed_dir / 'mels_trn_noisy_best50s.pkl',
    'test': preprocessed_dir / 'mels_test.pkl',  # NOTE: this data doesn't w
ork at 2nd stage
}
```

In [9]:

```
train_curated = pd.read_csv(csvs['train_curated'])
train_noisy = pd.read_csv(csvs['train_noisy'])
if CURATED_ONLY:
    train_df = train_curated
else:
    train_df = pd.concat([train_curated, train_noisy], sort=True, ignore_ind
ex=True)
train_df.head()
```

Out[9]:

	fname	labels
0	0006ae4e.wav	Bark
1	0019ef41.wav	Raindrop
2	001ec0ad.wav	Finger_snapping
3	0026c7cb.wav	Run
4	0026f116.wav	Finger_snapping

In [10]:

```
test_df = pd.read_csv(csvs['sample_submission'])
test_df.head()
```

Out[10]:

	fname	Accelerating_and_revving_and_vroom	Accordion	Acoustic_guitar	Applause	Bark	Bass_
0	000ccb97.wav	0	0	0	0	0	
1	0012633b.wav	0	0	0	0	0	
2	001ed5f1.wav	0	0	0	0	0	
3	00294be0.wav	0	0	0	0	0	
4	003fde7a.wav	0	0	0	0	0	

In [11]:

```
labels = test_df.columns[1:].tolist()
labels[:10]
```

Out[11]:

```
['Accelerating_and_revving_and_vroom',
 'Accordion',
 'Acoustic_guitar',
 'Applause',
 'Bark',
 'Bass_drum',
 'Bass_guitar',
 'Bathtub_(filling_or_washing)',
 'Bicycle_bell',
 'Burping_and_eructation']
```

In [12]:

```
num_classes = len(labels)
num_classes
```

Out[12]:

```
80
```

In [13]:

```
y_train = np.zeros((len(train_df), num_classes)).astype(int)
for i, row in enumerate(train_df['labels'].str.split(',')):
    for label in row:
        idx = labels.index(label)
        y_train[i, idx] = 1

y_train.shape
```

Out[13]:

```
(4970, 80)
```

In [14]:

```
with open(mels['train_curated'], 'rb') as curated, open(mels['train_noisy'],
'rb') as noisy:
    x_train = pickle.load(curated)
    if CURATED_ONLY == False:
        x_train.extend(pickle.load(noisy))

with open(mels['test'], 'rb') as test:
    x_test = pickle.load(test)

len(x_train), len(x_test)
```

Out[14]:

```
(4970, 1120)
```

In [15]:

```
for ii in range(5):
    print(x_train[ii].shape) #x_train is of shape (TRAIN_NUM,128,LEN,3) [4D
Tensor]
    print(x_test[ii].shape,'\n')  #x_test of shape (TEST_NUM,128,LEN,3) [4D
Tensor]
```

```
(128, 448, 3)
(128, 128, 3)

(128, 131, 3)
(128, 1021, 3)

(128, 128, 3)
(128, 300, 3)

(128, 1623, 3)
(128, 1146, 3)

(128, 128, 3)
(128, 1442, 3)
```

model

In [16]:

```
from keras.layers import *
from keras.models import Sequential, load_model, Model
from keras import metrics
from keras.optimizers import Adam
from keras import backend as K
import keras
from keras.models import Model
from keras.applications.inception_v3 import InceptionV3
from keras.applications.inception_v3 import preprocess_input as preprocess_inception
from keras.applications.mobilenet_v2 import MobileNetV2
from keras.applications.mobilenet_v2 import preprocess_input as preprocess_mobile
from keras.applications.xception import Xception
from keras.applications.xception import preprocess_input as preprocess_xception

from keras.utils import Sequence
from sklearn.utils import shuffle
def create_model_inception(n_out=NUM_CLASSES):

    base_model =InceptionV3(weights=None, include_top=False)

    x0 = base_model.output
    x1 = GlobalAveragePooling2D()(x0)
    x2 = GlobalMaxPooling2D()(x0)
    x = Concatenate()([x1,x2])

    x = BatchNormalization()(x)
    x = Dropout(0.5)(x)

    x = Dense(256, activation='relu')(x)
    x = BatchNormalization()(x)
    x = Dropout(0.5)(x)


    predictions = Dense(n_out, activation=ACTIVATION)(x)

    # this is the model we will train
    model = Model(inputs=base_model.input, outputs=predictions)
    return model
```

In [17]:

```
def create_model_xception(n_out=NUM_CLASSES):

    base_model = Xception(weights=None, include_top=False)

    x0 = base_model.output
    x1 = GlobalAveragePooling2D()(x0)
    x2 = GlobalMaxPooling2D()(x0)
    x = Concatenate()([x1,x2])

    x = BatchNormalization()(x)
    x = Dropout(0.5)(x)

    x = Dense(256, activation='relu')(x)
    x = BatchNormalization()(x)
    x = Dropout(0.5)(x)

#     x = Dense(128, activation='relu')(x)
#     x = BatchNormalization()(x)
#     x = Dropout(0.3)(x)

    predictions = Dense(n_out, activation=ACTIVATION)(x)

    # this is the model we will train
    model = Model(inputs=base_model.input, outputs=predictions)
    return model
```

In [18]:

```
def create_model_mobile(n_out=NUM_CLASSES):

    base_model =MobileNetV2(weights=None, include_top=False)

    x0 = base_model.output
    x1 = GlobalAveragePooling2D()(x0)
    x2 = GlobalMaxPooling2D()(x0)
    x = Concatenate()([x1,x2])

    x = BatchNormalization()(x)
    x = Dropout(0.5)(x)

    x = Dense(256, activation='relu')(x)
    x = BatchNormalization()(x)
    x = Dropout(0.5)(x)

#     x = Dense(128, activation='relu')(x)
#     x = BatchNormalization()(x)
#     x = Dropout(0.25)(x)


    predictions = Dense(n_out, activation=ACTIVATION)(x)

    # this is the model we will train
    model = Model(inputs=base_model.input, outputs=predictions)
    return model
```

In [19]:

```
def conv_simple_block(x, n_filters):

    x = Convolution2D(n_filters, (3,1), padding="same")(x)
    x = BatchNormalization()(x)
    x = Activation("relu")(x)

    x = Convolution2D(n_filters, (3,1), padding="same")(x)
    x = BatchNormalization()(x)
    x = Activation("relu")(x)
    x = AveragePooling2D()(x)

    return x

def create_model_simplecnn(n_out=NUM_CLASSES):

    inp = Input(shape=(128,128,3))
#     inp = Input(shape=(None,None,3))
    x = conv_simple_block(inp,64)
    x = conv_simple_block(x,128)
    x = conv_simple_block(x,256)
    x = conv_simple_block(x,128)

#     x1 = GlobalAveragePooling2D()(x)
#     x2 = GlobalMaxPooling2D()(x)
#     x = Add()([x1,x2])

    x = Flatten()(x)
    x = Dropout(0.2)(x)

    x = Dense(128, activation='linear')(x)
    x = PReLU()(x)
    x = BatchNormalization()(x)
    x = Dropout(0.2)(x)
    predictions = Dense(n_out, activation=ACTIVATION)(x)

    model = Model(inputs=inp, outputs=predictions)
    return model
```

In [20]:

```
def output_of_lambda(input_shape):
    return (input_shape[0], input_shape[2], input_shape[3])

def my_max(x):
    return K.max(x, axis=1, keepdims=False)

def crnn_simple_block(x, n_filters):

    x = Convolution2D(n_filters, (3,1), padding="same")(x)
    x = Activation("relu")(x)

    x = Convolution2D(n_filters, (3,1), padding="same")(x)
    x = Activation("relu")(x)
    x = MaxPooling2D()(x)
    x = Dropout(0.2)(x)

    return x

def create_model_crnn(n_out=NUM_CLASSES):

#     inp = Input(shape=(128,128,3))
    inp = Input(shape=(128,None,3))
    x = crnn_simple_block(inp,64)
    x = crnn_simple_block(x,128)
    x = crnn_simple_block(x,256)

    # eliminate the frequency dimension, x = (batch, time, channels)
    x = Lambda(my_max, output_shape=output_of_lambda)(x)

    x = Bidirectional(CuDNNGRU(128, return_sequences=True))(x)
#     x = Bidirectional(CuDNNLSTM(64, return_sequences=True))(x)
    x = GlobalMaxPooling1D()(x)
    x = Dense(128, activation='linear')(x)
    x = PReLU()(x)
    x = BatchNormalization()(x)
    x = Dropout(0.2)(x)
    predictions = Dense(n_out, activation=ACTIVATION)(x)

    model = Model(inputs=inp, outputs=predictions)
    return model
```

In [21]:

```
# from the 8th solution in 2018 competition
# https://github.com/sainathadapa/kaggle-freesound-audio-tagging
def create_model_cnn8th(n_out=NUM_CLASSES):
    regu=0
    inp = Input(shape=(128,128,3))

    x = Conv2D(48, 11,  strides=(1,1),kernel_initializer='he_uniform', activation='relu', padding='same',kernel_regularizer=regularizers.l2(regu))(inp)
    x = BatchNormalization()(x)
    x = Conv2D(48, 11,  strides=(2,3),kernel_initializer='he_uniform', activation='relu', padding='same',kernel_regularizer=regularizers.l2(regu))(x)
    x = MaxPooling2D(3, strides=(1,2))(x)
    x = BatchNormalization()(x)

    x = Conv2D(128, 5, strides=(1,1),kernel_initializer='he_uniform', activation='relu', padding='same',kernel_regularizer=regularizers.l2(regu))(x)
    x = BatchNormalization()(x)
    x = Conv2D(128, 5, strides=(2,3),kernel_initializer='he_uniform', activation='relu', padding='same',kernel_regularizer=regularizers.l2(regu))(x)
    x = MaxPooling2D(3, strides=2)(x)
    x = BatchNormalization()(x)

    x = Conv2D(192, 3, strides=1,kernel_initializer='he_uniform', activation='relu', padding='same')(x)
    x = BatchNormalization()(x)
    x = Conv2D(192, 3, strides=1,kernel_initializer='he_uniform', activation='relu', padding='same')(x)
    x = BatchNormalization()(x)
    x = Conv2D(128, 3, strides=1,kernel_initializer='he_uniform', activation='relu', padding='same',kernel_regularizer=regularizers.l2(regu))(x)
    x = MaxPooling2D(3, strides=(1,2))(x)
    x = BatchNormalization()(x)

    x = Flatten()(x)
    x = Dense(256, activation='relu')(x)
    x = Dropout(0.5)(x)
    x = Dense(256, activation='relu')(x)
    x = Dropout(0.5)(x)

    predictions = Dense(n_out, activation=ACTIVATION)(x)

    model = Model(inputs=inp, outputs=predictions)
    return model
```

In [22]:

```
K.clear_session()
'''Choose your model here'''
if MODEL == 'xception':
    preprocess_input = preprocess_xception
    model = create_model_xception(n_out=NUM_CLASSES)
elif MODEL == 'inception':
    preprocess_input = preprocess_inception
    model = create_model_inception(n_out=NUM_CLASSES)
elif MODEL == 'mobile':
    preprocess_input = preprocess_mobile
    model = create_model_mobile(n_out=NUM_CLASSES)
elif MODEL == 'crnn':
    preprocess_input = preprocess_mobile
    model = create_model_crnn(n_out=NUM_CLASSES)
elif MODEL == 'cnn8th':
    preprocess_input = preprocess_mobile
    model = create_model_cnn8th(n_out=NUM_CLASSES)
else:
    preprocess_input = preprocess_mobile
    model = create_model_simplecnn(n_out=NUM_CLASSES)

print(MODEL)
model.summary()
```

```
WARNING:tensorflow:From /opt/conda/lib/python3.6/site-packages/tensorflow/pyt
hon/framework/op_def_library.py:263: colocate_with (from tensorflow.python.fr
amework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
WARNING:tensorflow:From /opt/conda/lib/python3.6/site-packages/keras/backend/
tensorflow_backend.py:3445: calling dropout (from tensorflow.python.ops.nn_op
s) with keep_prob is deprecated and will be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - k
eep_prob`.
mobile
______________________________________________________________________________
____________________
Layer (type)                    Output Shape         Param #     Connected to
==============================================================================
====================
input_1 (InputLayer)            (None, None, None, 3 0
______________________________________________________________________________
____________________
Conv1_pad (ZeroPadding2D)       (None, None, None, 3 0           input_1
[0][0]
______________________________________________________________________________
____________________
Conv1 (Conv2D)                  (None, None, None, 3 864         Conv1_pad
[0][0]
______________________________________________________________________________
____________________
bn_Conv1 (BatchNormalization)   (None, None, None, 3 128         Conv1[0][0]
______________________________________________________________________________
____________________
Conv1_relu (ReLU)               (None, None, None, 3 0           bn_Conv1
[0][0]
______________________________________________________________________________
____________________
expanded_conv_depthwise (Depthw (None, None, None, 3 288         Conv1_relu
[0][0]
______________________________________________________________________________
____________________
expanded_conv_depthwise_BN (Bat (None, None, None, 3 128         expanded_con
v_depthwise[0][0]
______________________________________________________________________________
____________________
expanded_conv_depthwise_relu (R (None, None, None, 3 0           expanded_con
v_depthwise_BN[0][0]
______________________________________________________________________________
____________________
expanded_conv_project (Conv2D)  (None, None, None, 1 512         expanded_con
v_depthwise_relu[0][0
______________________________________________________________________________
____________________
expanded_conv_project_BN (Batch (None, None, None, 1 64          expanded_con
v_project[0][0]
______________________________________________________________________________
____________________
block_1_expand (Conv2D)         (None, None, None, 9 1536        expanded_con
v_project_BN[0][0]
______________________________________________________________________________
____________________
block_1_expand_BN (BatchNormali (None, None, None, 9 384         block_1_expa
nd[0][0]
______________________________________________________________________________
____________________
block_1_expand_relu (ReLU)      (None, None, None, 9 0           block_1_expa
nd_BN[0][0]
______________________________________________________________________________
____________________
block_1_pad (ZeroPadding2D)     (None, None, None, 9 0           block_1_expa
```

train

In [23]:

```
import numpy as np
xx = np.random.rand(1)
print(xx.shape,xx)

xx = np.random.rand(1,1)
print(xx.shape)
```

```
(1,) [0.70582626]
(1, 1)
```

In [24]:

In [24]:
```
# If you want, you can try more advanced augmentation like this
augment_img = iaa.Sequential([
#         iaa.ContrastNormalization((0.9, 1.1)),
#         iaa.Multiply((0.9, 1.1), per_channel=0.2),
        iaa.Fliplr(0.5),
#         iaa.GaussianBlur(sigma=(0, 0.1)),
#         iaa.Affine( # x-shift
#             translate_percent={"x": (-0.1, 0.1), "y": (-0.0, 0.0)},
#         ),
        iaa.CoarseDropout(0.12,size_percent=0.05) # see examples : https://g
ithub.com/aleju/imgaug
            ], random_order=True)



# Or you can choose this simplest augmentation (like pytorch version)
# augment_img = iaa.Fliplr(0.5)

# This is my ugly modification; sorry about that
class FATTrainDataset(Sequence):

    def mix_up(x, y):
        x = np.array(x, np.float32)
        lam = np.random.beta(1.0, 1.0)
        ori_index = np.arange(int(len(x)))
        index_array = np.arange(int(len(x)))
        np.random.shuffle(index_array)

        mixed_x = lam * x[ori_index] + (1 - lam) * x[index_array]
        mixed_y = lam * y[ori_index] + (1 - lam) * y[index_array]

        return mixed_x, mixed_y

    def getitem(image):
        # crop 2sec

        base_dim, time_dim, _ = image.shape
        crop = random.randint(0, time_dim - base_dim)
        image = image[:,crop:crop+base_dim,:]

        image = preprocess_input(image)

#         label = self.labels[idx]
        return image
    def create_generator(train_X, train_y, batch_size, shape, augument=Fals
e, shuffling=False, test_data=False, mixup=False, mixup_prob=0.3):
        assert shape[2] == 3
        while True:
            if shuffling:
                train_X,train_y = shuffle(train_X,train_y)

            for start in range(0, len(train_y), batch_size):
                end = min(start + batch_size, len(train_y))
                batch_images = []
                X_train_batch = train_X[start:end]
                if test_data == False:
                    batch_labels = train_y[start:end]

                for i in range(len(X_train_batch)):
                    image = FATTrainDataset.getitem(X_train_batch[i])
                    if augument:
                        image = FATTrainDataset.augment(image)
                    batch_images.append(image)

                if (mixup and test_data == False):
                    dice = np.random.rand(1)
                    if dice > mixup_prob:
                        batch_images, batch_labels =  FATTrainDataset.mix_up
```

In [25]:
```
from keras.callbacks import (ModelCheckpoint, LearningRateScheduler,
                             EarlyStopping, ReduceLROnPlateau,CSVLogger)

from sklearn.model_selection import train_test_split,KFold


reduceLROnPlat = ReduceLROnPlateau(monitor='val_tf_lwlrap', factor=LR_FACTO
R, patience=PATIENCE,
                                   verbose=1, mode='max', min_delta=0.0001,
cooldown=2, min_lr=1e-5 )

csv_logger = CSVLogger(filename='../working/training_log.csv',
                       separator=',',
                       append=True)

checkpoint = ModelCheckpoint(checkpoint_file[0], monitor='val_tf_lwlrap', ve
rbose=1,
                             save_best_only=True, mode='max', save_weights_o
nly = False)
callbacks_list = [checkpoint, csv_logger, reduceLROnPlat]
```

In [26]:
```
# split data into train, valid
x_trn, x_val, y_trn, y_val = train_test_split(x_train, y_train, test_size=0.
2, random_state=SEED)

# create train and valid datagens
train_generator = FATTrainDataset.create_generator(
    x_trn, y_trn, BATCH_SIZE, (SIZE,SIZE,3), augument=TRAIN_AUGMENT, shuffli
ng=True, mixup = USE_MIXUP, mixup_prob = MIXUP_PROB)
validation_generator = FATTrainDataset.create_generator(
    x_val, y_val, BATCH_SIZE, (SIZE,SIZE,3), augument=VALID_AUGMENT, shuffli
ng=False)
```

In [27]:
```
train_steps = np.ceil(float(len(x_trn)) / float(BATCH_SIZE))
val_steps = np.ceil(float(len(x_val)) / float(BATCH_SIZE))
train_steps = train_steps.astype(int)
val_steps = val_steps.astype(int)
print(train_steps, val_steps)
print(len(x_trn))
```

```
125 32
3976
```

In [28]:
```
print(LOSS)
if LOSS=='BCEwithLogits':
     model.compile(loss=BCEwithLogits,
            optimizer=Adam(lr=LR),
            metrics=[tf_lwlrap,'categorical_accuracy'])
else:
    model.compile(loss=LOSS,
            optimizer=Adam(lr=LR),
            metrics=[tf_lwlrap,'categorical_accuracy'])
```

```
BCEwithLogits
```

In [29]:
```
print(LR, PATIENCE, LR_FACTOR,BATCH_SIZE, TRAIN_AUGMENT, USE_MIXUP, MIXUP_PR
OB)
```

```
0.0004 10 0.8 32 True True 0.275
```

In [30]:

```
hist = model.fit_generator(
    train_generator,
    steps_per_epoch=train_steps,
    validation_data=validation_generator,
    validation_steps=val_steps,
    epochs=EPOCHS[0],
    verbose=1,
    callbacks=callbacks_list)
```

```
WARNING:tensorflow:From /opt/conda/lib/python3.6/site-packages/tensorflow/pyt
hon/ops/math_ops.py:3066: to_int32 (from tensorflow.python.ops.math_ops) is d
eprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
WARNING:tensorflow:From /opt/conda/lib/python3.6/site-packages/tensorflow/pyt
hon/ops/math_grad.py:102: div (from tensorflow.python.ops.math_ops) is deprec
ated and will be removed in a future version.
Instructions for updating:
Deprecated in favor of operator or tf.math.divide.
Epoch 1/432
125/125 [==============================] - 30s 238ms/step - loss: 0.8264 - tf
_lwlrap: 0.0999 - categorical_accuracy: 0.0133 - val_loss: 0.6638 - val_tf_lw
lrap: 0.0758 - val_categorical_accuracy: 0.0141

Epoch 00001: val_tf_lwlrap improved from -inf to 0.07578, saving model to mod
el_best1.h5
Epoch 2/432
125/125 [==============================] - 16s 129ms/step - loss: 0.6238 - tf
_lwlrap: 0.0978 - categorical_accuracy: 0.0090 - val_loss: 0.4021 - val_tf_lw
lrap: 0.0717 - val_categorical_accuracy: 0.0221

Epoch 00002: val_tf_lwlrap did not improve from 0.07578
Epoch 3/432
125/125 [==============================] - 16s 129ms/step - loss: 0.3651 - tf
_lwlrap: 0.0926 - categorical_accuracy: 0.0103 - val_loss: 0.1388 - val_tf_lw
lrap: 0.0615 - val_categorical_accuracy: 0.0080

Epoch 00003: val_tf_lwlrap did not improve from 0.07578
Epoch 4/432
125/125 [==============================] - 16s 130ms/step - loss: 0.1845 - tf
_lwlrap: 0.0982 - categorical_accuracy: 0.0148 - val_loss: 0.1091 - val_tf_lw
lrap: 0.0715 - val_categorical_accuracy: 0.0231

Epoch 00004: val_tf_lwlrap did not improve from 0.07578
Epoch 5/432
125/125 [==============================] - 16s 129ms/step - loss: 0.1222 - tf
_lwlrap: 0.0999 - categorical_accuracy: 0.0108 - val_loss: 0.1082 - val_tf_lw
lrap: 0.0747 - val_categorical_accuracy: 0.0191

Epoch 00005: val_tf_lwlrap did not improve from 0.07578
Epoch 6/432
125/125 [==============================] - 16s 129ms/step - loss: 0.0965 - tf
_lwlrap: 0.1110 - categorical_accuracy: 0.0168 - val_loss: 0.0800 - val_tf_lw
lrap: 0.0819 - val_categorical_accuracy: 0.0161

Epoch 00006: val_tf_lwlrap improved from 0.07578 to 0.08190, saving model to
model_best1.h5
Epoch 7/432
125/125 [==============================] - 16s 130ms/step - loss: 0.0881 - tf
_lwlrap: 0.1187 - categorical_accuracy: 0.0205 - val_loss: 0.0843 - val_tf_lw
lrap: 0.0866 - val_categorical_accuracy: 0.0191

Epoch 00007: val_tf_lwlrap improved from 0.08190 to 0.08659, saving model to
model_best1.h5
Epoch 8/432
125/125 [==============================] - 17s 134ms/step - loss: 0.0851 - tf
_lwlrap: 0.1251 - categorical_accuracy: 0.0213 - val_loss: 0.1017 - val_tf_lw
lrap: 0.0875 - val_categorical_accuracy: 0.0211

Epoch 00008: val_tf_lwlrap improved from 0.08659 to 0.08750, saving model to
model_best1.h5
Epoch 9/432
125/125 [==============================] - 16s 129ms/step - loss: 0.0835 - tf
_lwlrap: 0.1282 - categorical_accuracy: 0.0238 - val_loss: 0.0800 - val_tf_lw
lrap: 0.0975 - val_categorical_accuracy: 0.0211

Epoch 00009: val_tf_lwlrap improved from 0.08750 to 0.09754, saving model to
```

In [31]:
```
print(K.eval(model.optimizer.lr))
```

```
1e-05
```

In [32]:
```
# if LOSS=='BCEwithLogits':
#      model.compile(loss=BCEwithLogits,
#             optimizer=Adam(lr=3e-4),
#             metrics=[tf_lwlrap,'categorical_accuracy'])
# else:
#     model.compile(loss=LOSS,
#             optimizer=Adam(lr=3e-4),
#             metrics=[tf_lwlrap,'categorical_accuracy'])

# train_generator = FATTrainDataset.create_generator(
#     x_trn, y_trn, BATCH_SIZE, (SIZE,SIZE,3), augument=TRAIN_AUGMENT,
#     shuffling=True, mixup = False, mixup_prob=0.1)

# EPOCHS = [100, 66, 0]

# print(K.eval(model.optimizer.lr))
```

In [33]:
```
if EPOCHS[1] > 0:
    checkpoint = ModelCheckpoint(checkpoint_file[1], monitor='val_tf_lwlrap
', verbose=1,
                             save_best_only=True, mode='max', save_weights_o
nly = False)
    callbacks_list = [checkpoint, csv_logger, reduceLROnPlat]

    hist = model.fit_generator(
    train_generator,
    steps_per_epoch=train_steps,
    validation_data=validation_generator,
    validation_steps=val_steps,
    epochs=EPOCHS[1],
    verbose=1,
    callbacks=callbacks_list)
```

In [34]:
```
print(K.eval(model.optimizer.lr))
```

```
1e-05
```

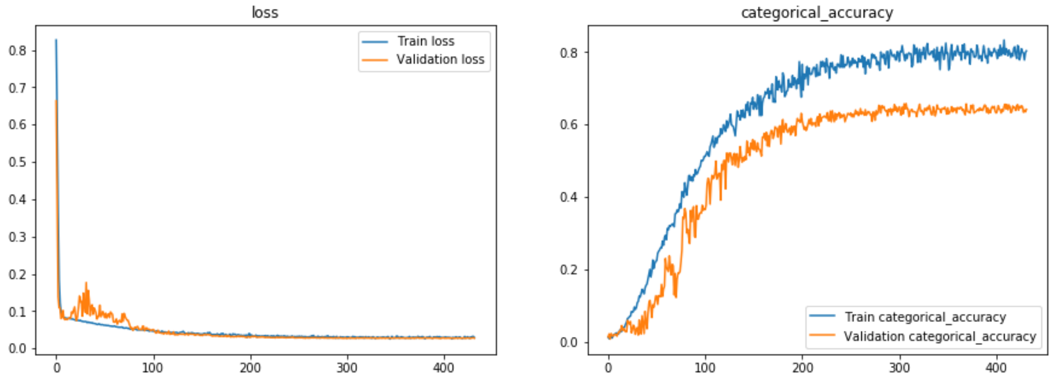
In [35]:
```
if EPOCHS[2] > 0:
    checkpoint = ModelCheckpoint(checkpoint_file[2], monitor='val_tf_lwlrap
', verbose=1,
                             save_best_only=True, mode='max', save_weights_o
nly = False)
    callbacks_list = [checkpoint, csv_logger, reduceLROnPlat]

    hist = model.fit_generator(
    train_generator,
    steps_per_epoch=train_steps,
    validation_data=validation_generator,
    validation_steps=val_steps,
    epochs=EPOCHS[2],
    verbose=1,
    callbacks=callbacks_list)
```

In [36]:
```
print(K.eval(model.optimizer.lr))
```

```
1e-05
```

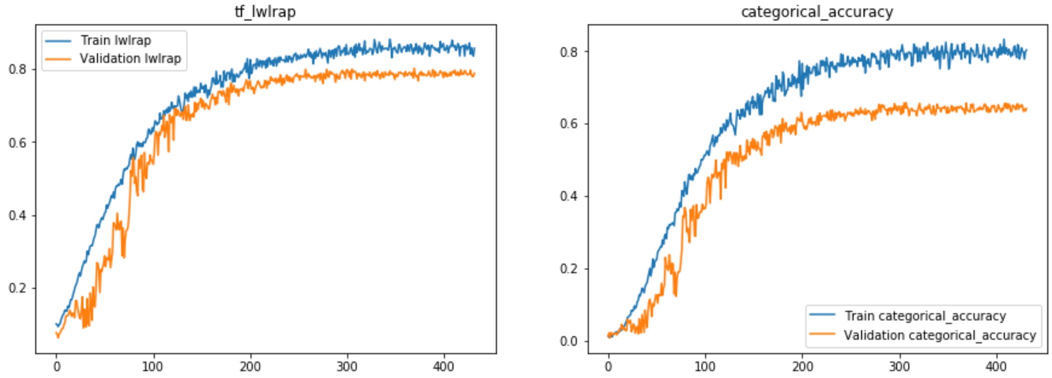
In [37]:
```
fig, ax = plt.subplots(1, 2, figsize=(15,5))
ax[0].set_title('loss')
ax[0].plot(hist.epoch, hist.history["loss"], label="Train loss")
ax[0].plot(hist.epoch, hist.history["val_loss"], label="Validation loss")
ax[1].set_title('categorical_accuracy')
ax[1].plot(hist.epoch, hist.history["categorical_accuracy"], label="Train ca
tegorical_accuracy")
ax[1].plot(hist.epoch, hist.history["val_categorical_accuracy"], label="Vali
dation categorical_accuracy")
ax[0].legend()
ax[1].legend()
```

Out[37]:
```
<matplotlib.legend.Legend at 0x7fd0e9d46898>
```



In [38]:
```
fig, ax = plt.subplots(1, 2, figsize=(15,5))
ax[0].set_title('tf_lwlrap')
ax[0].plot(hist.epoch, hist.history["tf_lwlrap"], label="Train lwlrap")
ax[0].plot(hist.epoch, hist.history["val_tf_lwlrap"], label="Validation lwlr
ap")
ax[1].set_title('categorical_accuracy')
ax[1].plot(hist.epoch, hist.history["categorical_accuracy"], label="Train ca
tegorical_accuracy")
ax[1].plot(hist.epoch, hist.history["val_categorical_accuracy"], label="Vali
dation categorical_accuracy")
ax[0].legend()
ax[1].legend()
```

Out[38]:
```
<matplotlib.legend.Legend at 0x7fd4b26e4e48>
```



In [39]:

Calculate Validation Score using TTA

Note that we have to initiate validation_generation everytime before doing a new prediction as `model.fit_generator` will mis-index examples at the end of epoch (and you will get random score)

In [39]:
```
model.load_weights(checkpoint_file[0])

validation_generator = FATTrainDataset.create_generator(
      x_val, y_val, BATCH_SIZE, (SIZE,SIZE,3), augument=False, shuffling=Fal
se)
pred_val_y = model.predict_generator(validation_generator,steps=val_steps,ve
rbose=1)

for kk in range(len(TTA)):

    for ii in range(TTA[kk]):
        validation_generator = FATTrainDataset.create_generator(
          x_val, y_val, BATCH_SIZE, (SIZE,SIZE,3), augument=False, shufflin
g=False)

        pred_val_y += model.predict_generator(validation_generator,steps=val
_steps,verbose=1)

    if kk+1 < len(TTA) and TTA[kk+1] > 0:
        model.load_weights(checkpoint_file[kk+1])

'''Since the score is based on ranking, we do not need to normalize the pred
iction'''
# pred_val_y = pred_val_y/10
```

```
32/32 [==============================] - 2s 52ms/step
32/32 [==============================] - 0s 15ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 0s 15ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 0s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 0s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
32/32 [==============================] - 1s 16ms/step
```

Out[39]:
```
'Since the score is based on ranking, we do not need to normalize the predict
ion'
```

In [40]:
```
train_generator = FATTrainDataset.create_generator(
    x_trn, y_trn, BATCH_SIZE, (SIZE,SIZE,3), augument=False, shuffling=Fals
e)
pred_train_y = model.predict_generator(train_generator,steps=train_steps,ver
bose=1)
```

```
125/125 [==============================] - 2s 15ms/step
```

In [41]:

```
import sklearn.metrics
def calculate_overall_lwlrap_sklearn(truth, scores):
    """Calculate the overall lwlrap using sklearn.metrics.lrap."""
    # sklearn doesn't correctly apply weighting to samples with no labels, s
o just skip them.
    sample_weight = np.sum(truth > 0, axis=1)
    nonzero_weight_sample_indices = np.flatnonzero(sample_weight > 0)
    overall_lwlrap = sklearn.metrics.label_ranking_average_precision_score(
      truth[nonzero_weight_sample_indices, :] > 0,
      scores[nonzero_weight_sample_indices, :],
      sample_weight=sample_weight[nonzero_weight_sample_indices])
    return overall_lwlrap
```

In [42]:

```
print(pred_val_y.shape, y_val.shape)
print(np.sum(pred_val_y), np.sum(y_val))
# for ii in range(len(y_val)):
#     print(np.sum(pred_val_y[ii]), np.sum(y_val[ii]))
```

```
(994, 80) (994, 80)
-11160808.0 1128
```

In [43]:

```
print("lwlrap from sklearn.metrics for training data =", calculate_overall_l
wlrap_sklearn(y_trn, pred_train_y))
print("val lwlrap from sklearn.metrics =", calculate_overall_lwlrap_sklearn
(y_val, pred_val_y/10))

score, weight = calculate_per_class_lwlrap(y_val, pred_val_y)
lwlrap = (score * weight).sum()
print('direct calculation of val lwlrap : %.4f' % (lwlrap))
```

```
lwlrap from sklearn.metrics for training data = 0.9937980679367769
val lwlrap from sklearn.metrics = 0.7947953814827754
direct calculation of val lwlrap : 0.7948
```

Simple Error Analysis

In [44]:

```
idx = np.sum(y_val,axis=1) > 1
print(y_val[idx, :].shape, y_val[idx==False, :].shape)

print("val lwlrap for multi-labels =", calculate_overall_lwlrap_sklearn(y_va
l[idx], pred_val_y[idx]))
print("val lwlrap for single-label =", calculate_overall_lwlrap_sklearn(y_va
l[idx==False], pred_val_y[idx==False]))
```

```
(125, 80) (869, 80)
val lwlrap for multi-labels = 0.7788500531195031
val lwlrap for single-label = 0.7995477865991014
```

Predict Test Data with TTA

In [45]:

In [45]:

```
test_steps = np.ceil(float(len(x_test)) / float(BATCH_SIZE)).astype(int)
```

In [46]:

```
model.load_weights(checkpoint_file[0])

test_generator = FATTrainDataset.create_generator(
    x_test, x_test, BATCH_SIZE, (SIZE,SIZE,3), augument=False, shuffling=False, test_data=True)
pred_test_y = model.predict_generator(test_generator,steps=test_steps,verbose=1)

for kk in range(len(TTA)):
    for ii in range(TTA[kk]):
        test_generator = FATTrainDataset.create_generator(
        x_test, x_test, BATCH_SIZE, (SIZE,SIZE,3), augument=False, shuffling=False, test_data=True)

        pred_test_y += model.predict_generator(test_generator,steps=test_steps,verbose=1)

    if kk+1 < len(TTA) and TTA[kk+1] > 0:
        model.load_weights(checkpoint_file[kk+1])
```

```
35/35 [==============================] - 1s 16ms/step
35/35 [==============================] - 1s 16ms/step
35/35 [==============================] - 1s 16ms/step
35/35 [==============================] - 1s 16ms/step
35/35 [==============================] - 1s 15ms/step
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35/35 [==============================] - 1s 16ms/step
35/35 [==============================] - 1s 16ms/step
35/35 [==============================] - 1s 16ms/step
35/35 [==============================] - 1s 16ms/step
35/35 [==============================] - 1s 16ms/step
35/35 [==============================] - 1s 15ms/step
```

In [47]:

```
 sort_idx = np.argsort(labels).astype(int)
```

In [48]:

```
print(sort_idx)
```

```
[ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71
 72 73 74 75 76 77 78 79]
```

In [49]:
```
sample_sub = pd.read_csv('../input/freesound-audio-tagging-2019/sample_submi
ssion.csv')
test_Y_sort = pred_test_y[:, sort_idx]
sample_sub.iloc[:, 1:] =  test_Y_sort
sample_sub.to_csv('submission.csv', index=False)

sample_sub.head()
```

Out[49]:

	fname	Accelerating_and_revving_and_vroom	Accordion	Acoustic_guitar	Applause	B
0	000ccb97.wav	-154.853333	-178.622345	-137.645279	-154.654419	-124.198
1	0012633b.wav	-62.905537	-155.926025	-138.813126	-119.286285	-128.623
2	001ed5f1.wav	-101.077438	-147.583435	-141.133286	-120.893265	-146.542
3	00294be0.wav	-173.398453	-147.612381	-148.860428	-205.831070	-120.307
4	003fde7a.wav	-167.963501	-154.409439	-134.879196	-167.252792	-130.279