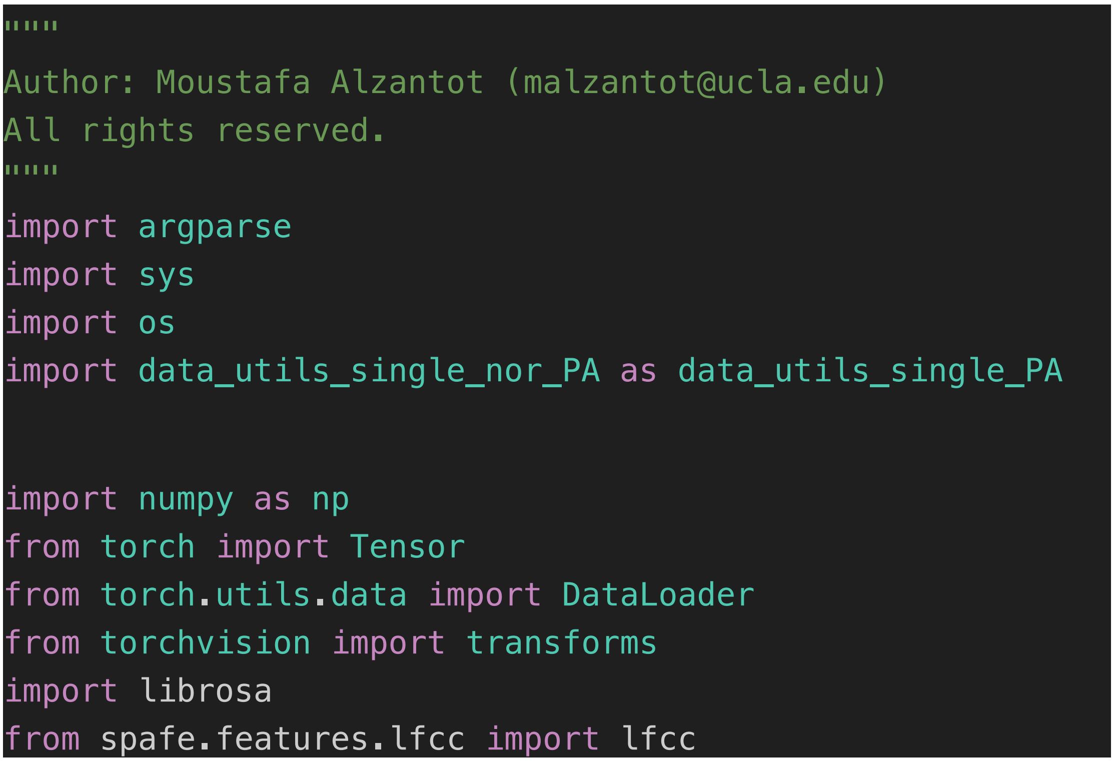

```
"""
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"""
import argparse
import sys
import os
import data_utils_single_nor_PA as data_utils_single_PA


import numpy as np
from torch import Tensor
from torch.utils.data import DataLoader
from torchvision import transforms
import librosa
from spafe.features.lfcc import lfcc
```
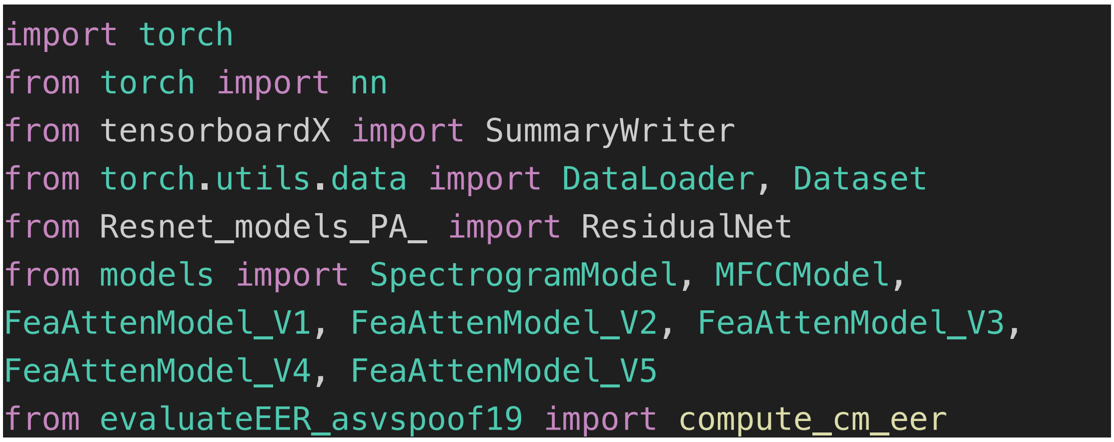
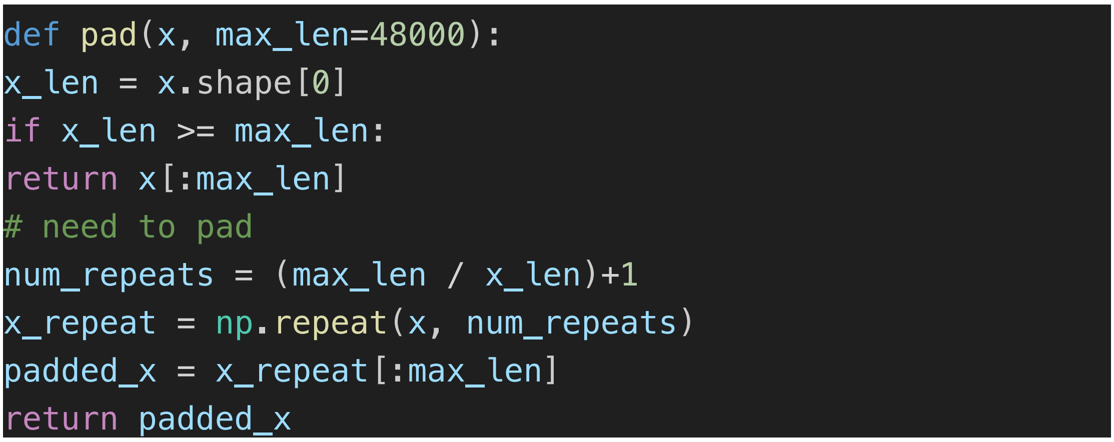
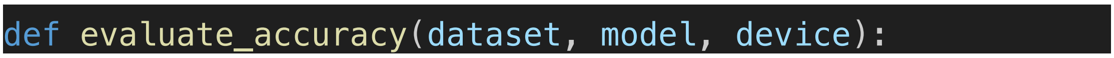



```
import torch
from torch import nn
from tensorboardX import SummaryWriter
from torch.utils.data import DataLoader, Dataset
from Resnet_models_PA_ import ResidualNet
from models import SpectrogramModel, MFCCModel,
FeaAttenModel_V1, FeaAttenModel_V2, FeaAttenModel_V3,
FeaAttenModel_V4, FeaAttenModel_V5
from evaluateEER_asvspoof19 import compute_cm_eer
```



```
def pad(x, max_len=48000):
x_len = x.shape[0]
if x_len >= max_len:
return x[:max_len]
# need to pad
num_repeats = (max_len / x_len)+1
x_repeat = np.repeat(x, num_repeats)
padded_x = x_repeat[:max_len]
return padded_x
```



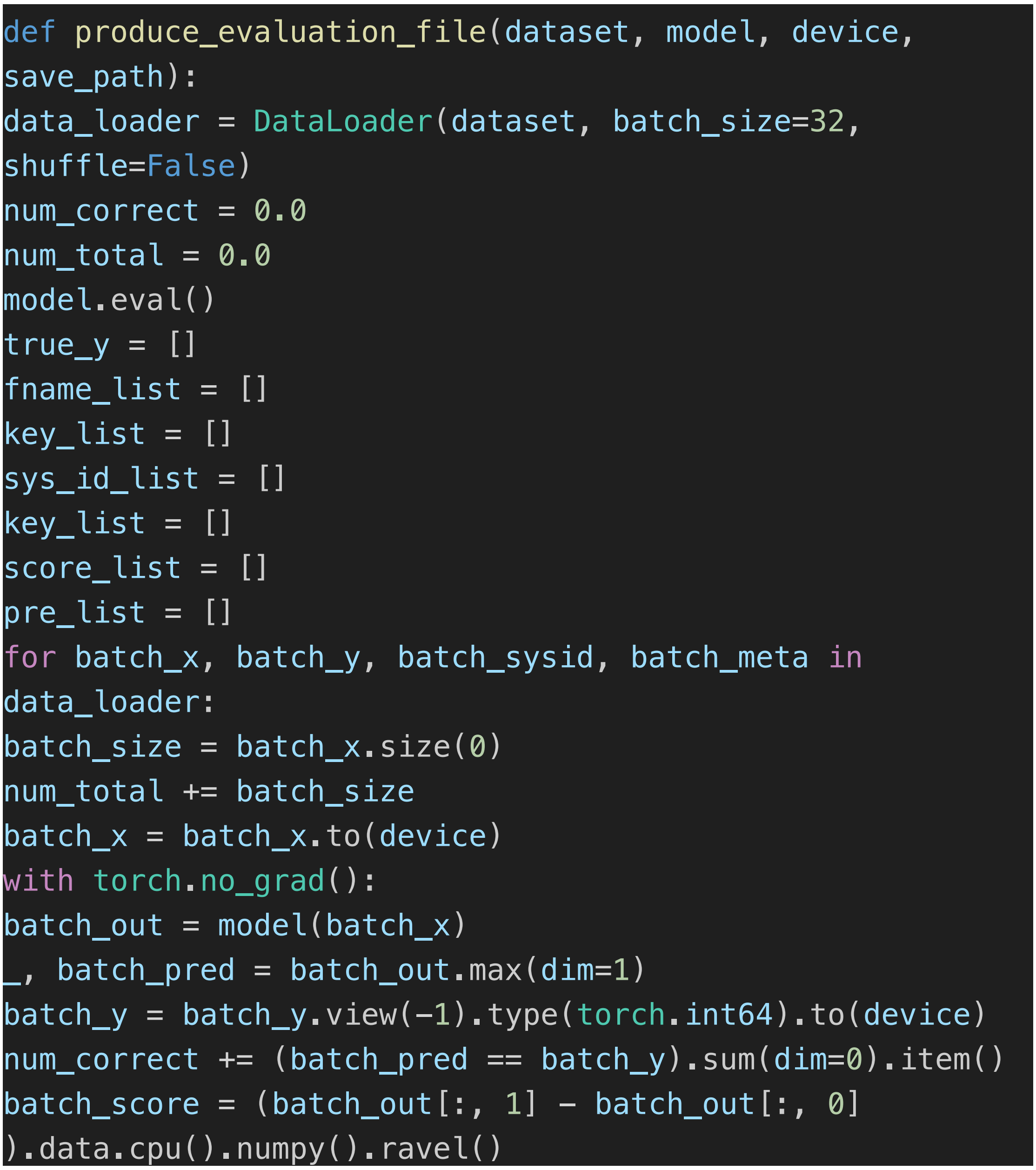
```
def evaluate_accuracy(dataset, model, device):
```

```
data_loader = DataLoader(dataset, batch_size=32,
shuffle=False)
num_correct = 0.0
num_total = 0.0
model.eval()
true_y = []
fname_list = []
key_list = []
sys_id_list = []
key_list = []
score_list = []
pre_list = []
```

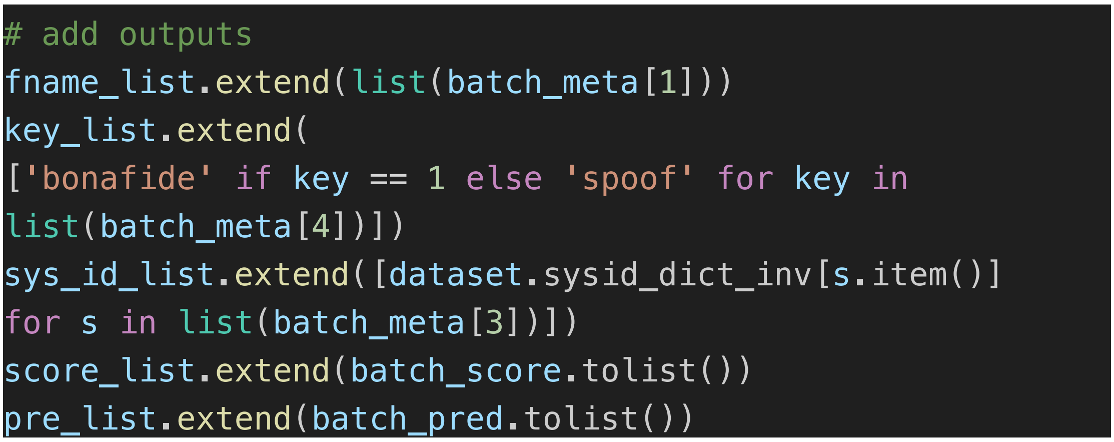
```
for batch_x, batch_y, batch_sysid, batch_meta in
data_loader:
batch_size = batch_x.size(0)
num_total += batch_size
batch_x = batch_x.to(device)
with torch.no_grad():
batch_out = model(batch_x)
_, batch_pred = batch_out.max(dim=1)
batch_y = batch_y.view(-1).type(torch.int64).to(device)
num_correct += (batch_pred == batch_y).sum(dim=0).item()
batch_score = (batch_out[:, 1] - batch_out[:, 0]
).data.cpu().numpy().ravel()
```

```
# add outputs
fname_list.extend(list(batch_meta[1]))
key_list.extend(
['bonafide' if key == 1 else 'spoof' for key in
list(batch_meta[4])])
sys_id_list.extend([dataset.sysid_dict_inv[s.item()]
for s in list(batch_meta[3])])
score_list.extend(batch_score.tolist())
pre_list.extend(batch_pred.tolist())
```

```
eer = compute_cm_eer(key_list, score_list)
accuracy = 100 * (num_correct / num_total)
return eer, accuracy
```



```
def produce_evaluation_file(dataset, model, device,
save_path):
data_loader = DataLoader(dataset, batch_size=32,
shuffle=False)
num_correct = 0.0
num_total = 0.0
model.eval()
true_y = []
fname_list = []
key_list = []
sys_id_list = []
key_list = []
score_list = []
pre_list = []
for batch_x, batch_y, batch_sysid, batch_meta in
data_loader:
batch_size = batch_x.size(0)
num_total += batch_size
batch_x = batch_x.to(device)
with torch.no_grad():
batch_out = model(batch_x)
_, batch_pred = batch_out.max(dim=1)
batch_y = batch_y.view(-1).type(torch.int64).to(device)
num_correct += (batch_pred == batch_y).sum(dim=0).item()
batch_score = (batch_out[:, 1] - batch_out[:, 0]
).data.cpu().numpy().ravel()
```

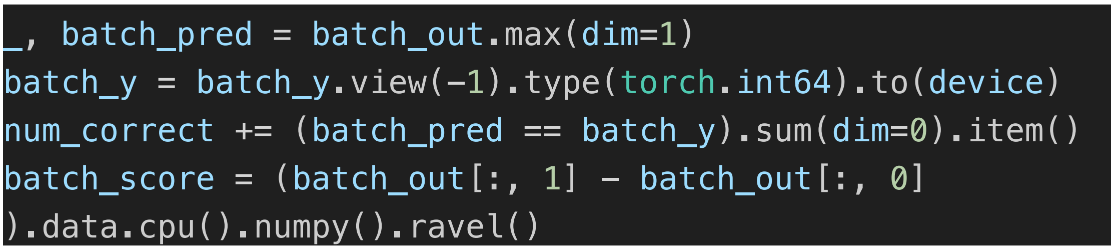


```
# add outputs
fname_list.extend(list(batch_meta[1]))
key_list.extend(
['bonafide' if key == 1 else 'spoof' for key in
list(batch_meta[4])])
sys_id_list.extend([dataset.sysid_dict_inv[s.item()]
for s in list(batch_meta[3])])
score_list.extend(batch_score.tolist())
pre_list.extend(batch_pred.tolist())
```

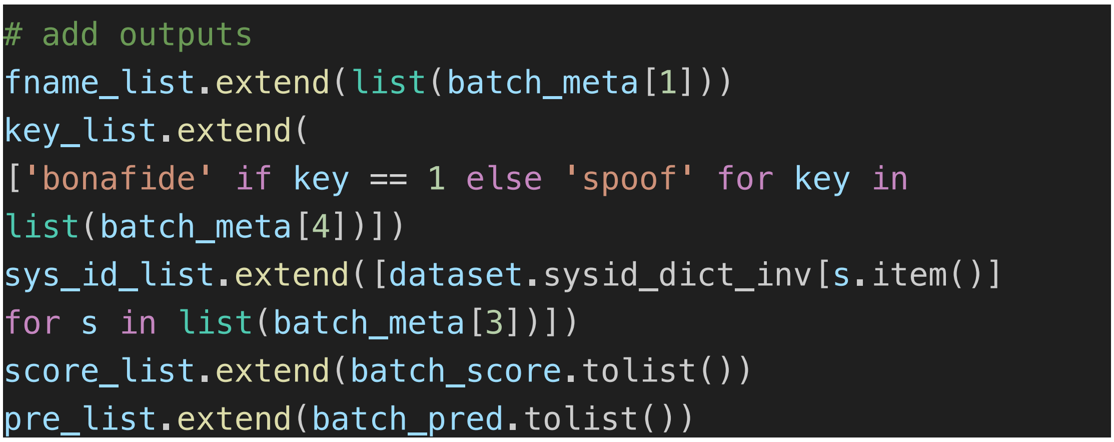
```
sys.stdout.write("\naccuracy: " + '\r \t {:.2f}'.format(
(num_correct / num_total) * 100))
```

```
with open(save_path, 'w') as fh:
for f, s, k, cm, p in zip(fname_list, sys_id_list, key_list,
score_list, pre_list):
if not dataset.is_eval:
fh.write('{} {} {} {} {}\n'.format(f, s, k, cm, p))
else:
fh.write('{} {} {} {} {}\n'.format(f, s, k, cm, p))
print('Result saved to {}'.format(save_path))
```

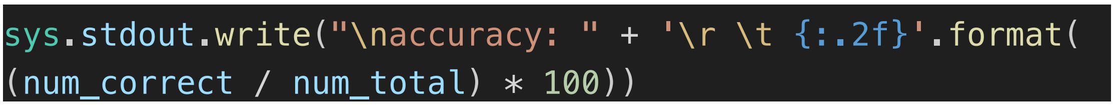
```
def produce_evaluation_file_eval(dataset, model, device,
save_path,mean, std):
data_loader = DataLoader(dataset, batch_size=32,
shuffle=False)
num_correct = 0.0
num_total = 0.0
model.eval()
true_y = []
fname_list = []
key_list = []
sys_id_list = []
key_list = []
score_list = []
pre_list = []
mean = mean.to(device)
std = std.to(device)
for batch_x, batch_y, batch_sysid, batch_meta in
data_loader:
batch_size = batch_x.size(0)
num_total += batch_size
batch_x = batch_x.to(device)
batch_x = (batch_x - mean) / std
batch_x = torch.where(torch.isnan(batch_x),
torch.full_like(batch_x, 0), batch_x)
with torch.no_grad():
batch_out = model(batch_x)
```



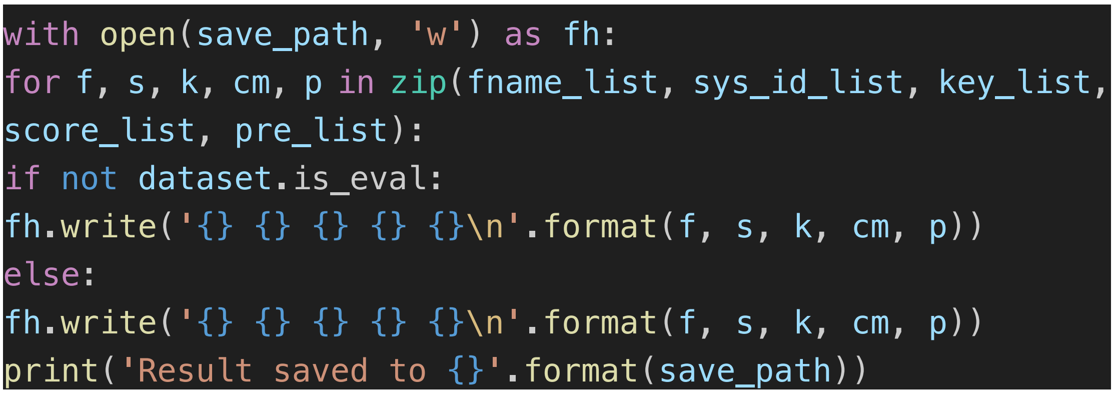
```
_, batch_pred = batch_out.max(dim=1)
batch_y = batch_y.view(-1).type(torch.int64).to(device)
num_correct += (batch_pred == batch_y).sum(dim=0).item()
batch_score = (batch_out[:, 1] - batch_out[:, 0]
).data.cpu().numpy().ravel()
```



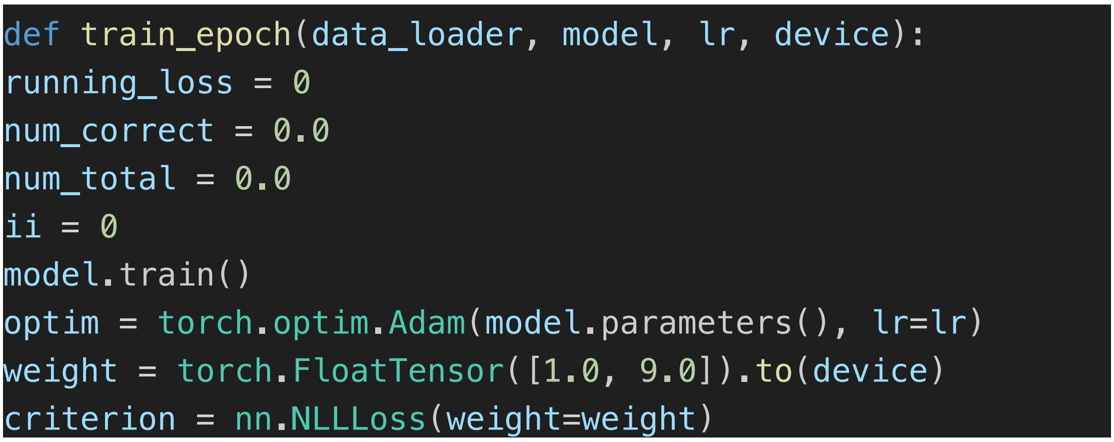
```
# add outputs
fname_list.extend(list(batch_meta[1]))
key_list.extend(
['bonafide' if key == 1 else 'spoof' for key in
list(batch_meta[4])])
sys_id_list.extend([dataset.sysid_dict_inv[s.item()]
for s in list(batch_meta[3])])
score_list.extend(batch_score.tolist())
pre_list.extend(batch_pred.tolist())
```



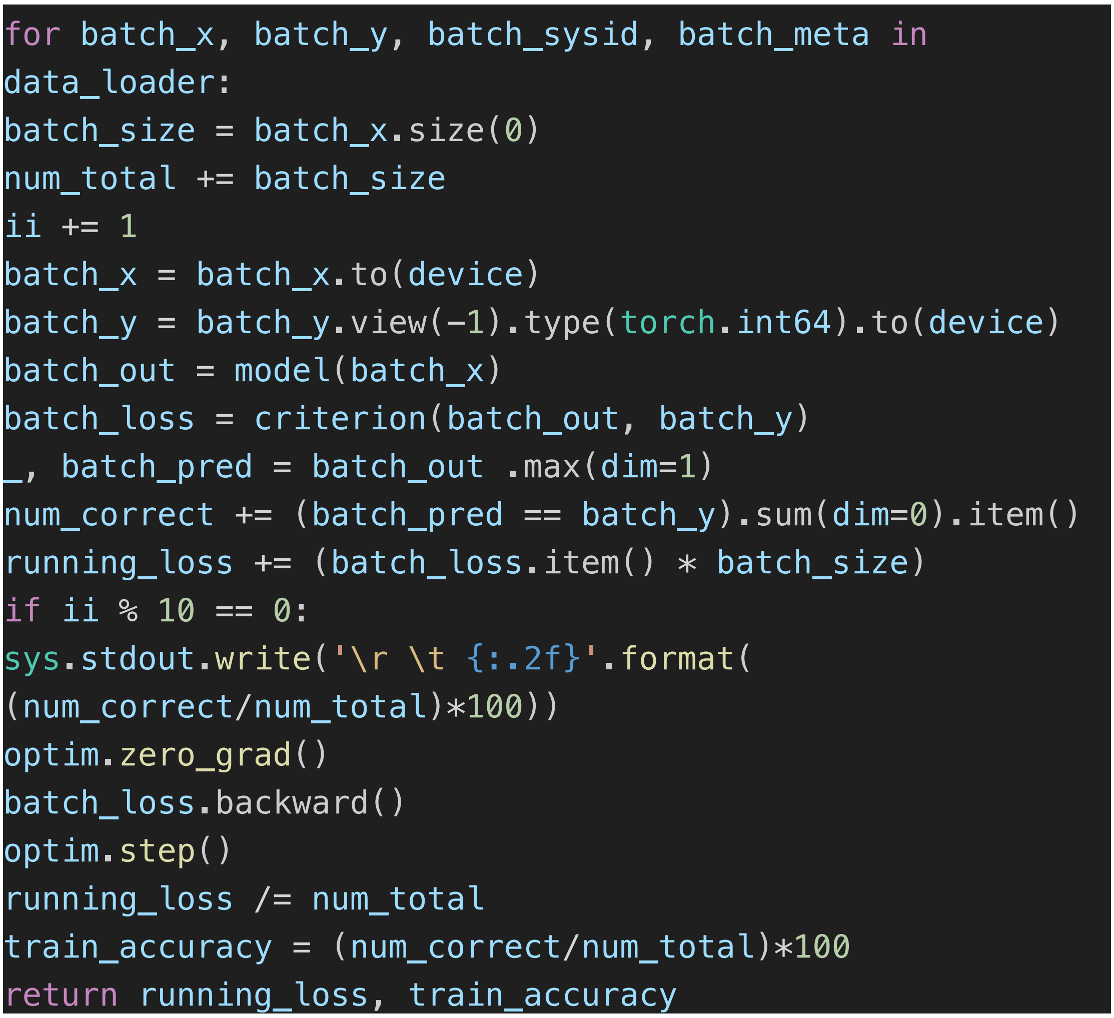
```
sys.stdout.write("\naccuracy: " + '\r \t {:.2f}'.format(
(num_correct / num_total) * 100))
```



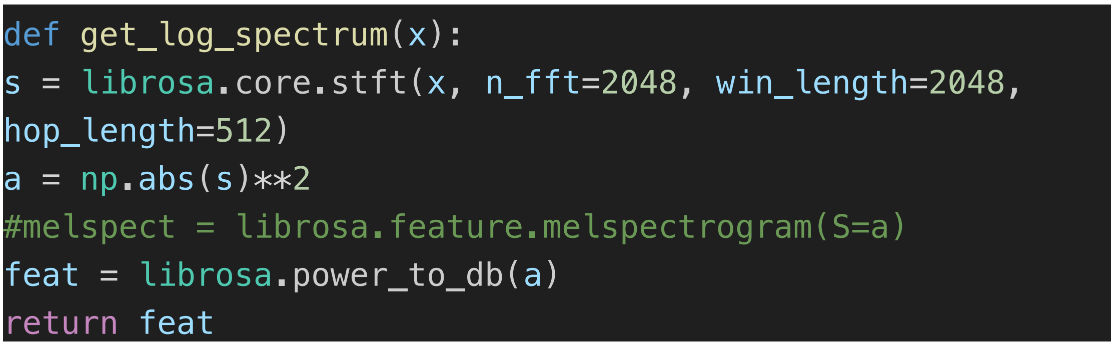
```
with open(save_path, 'w') as fh:
for f, s, k, cm, p in zip(fname_list, sys_id_list, key_list,
score_list, pre_list):
if not dataset.is_eval:
fh.write('{} {} {} {} {}\n'.format(f, s, k, cm, p))
else:
fh.write('{} {} {} {} {}\n'.format(f, s, k, cm, p))
print('Result saved to {}'.format(save_path))
```



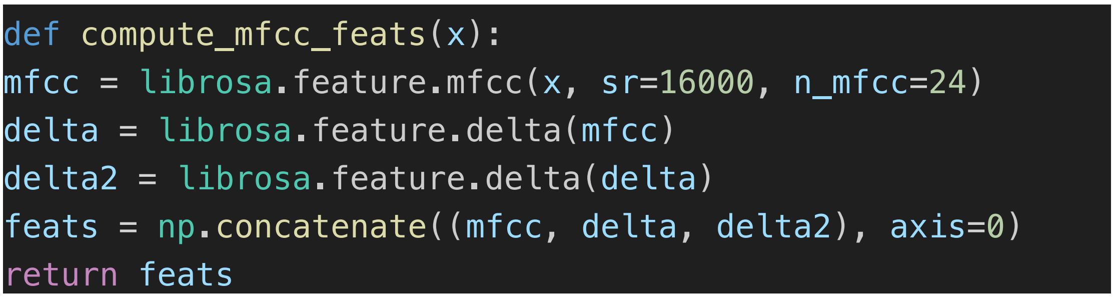
```
def train_epoch(data_loader, model, lr, device):
running_loss = 0
num_correct = 0.0
num_total = 0.0
ii = 0
model.train()
optim = torch.optim.Adam(model.parameters(), lr=lr)
weight = torch.FloatTensor([1.0, 9.0]).to(device)
criterion = nn.NLLLoss(weight=weight)
```



```
for batch_x, batch_y, batch_sysid, batch_meta in
data_loader:
batch_size = batch_x.size(0)
num_total += batch_size
ii += 1
batch_x = batch_x.to(device)
batch_y = batch_y.view(-1).type(torch.int64).to(device)
batch_out = model(batch_x)
batch_loss = criterion(batch_out, batch_y)
_, batch_pred = batch_out .max(dim=1)
num_correct += (batch_pred == batch_y).sum(dim=0).item()
running_loss += (batch_loss.item() * batch_size)
if ii % 10 == 0:
sys.stdout.write('\r \t {:.2f}'.format(
(num_correct/num_total)*100))
optim.zero_grad()
batch_loss.backward()
optim.step()
running_loss /= num_total
train_accuracy = (num_correct/num_total)*100
return running_loss, train_accuracy
```



```
def get_log_spectrum(x):
s = librosa.core.stft(x, n_fft=2048, win_length=2048,
hop_length=512)
a = np.abs(s)**2
#melspect = librosa.feature.melspectrogram(S=a)
feat = librosa.power_to_db(a)
return feat
```



```
def compute_mfcc_feats(x):
mfcc = librosa.feature.mfcc(x, sr=16000, n_mfcc=24)
delta = librosa.feature.delta(mfcc)
delta2 = librosa.feature.delta(delta)
feats = np.concatenate((mfcc, delta, delta2), axis=0)
return feats
```

```
def compute_lfcc_feats(x):
lfccs = lfcc(x, fs=16000, num_ceps=30)
delta = librosa.feature.delta(lfccs)
delta2 = librosa.feature.delta(delta)
feats = np.concatenate((lfccs, delta, delta2), axis=1)
feat = feats.T
return feat
```

```
def get_log_spectrum_original(x):
s = librosa.core.stft(x, n_fft=2048, win_length=2048,
hop_length=512)
a = np.abs(s)**2
#melspect = librosa.feature.melspectrogram(S=a)
feat = librosa.power_to_db(a)
return feat
```

```
def get_fea(feature):
if(feature == 'spect'):
feature_fn = get_log_spectrum
elif(feature == 'mfcc'):
feature_fn = compute_mfcc_feats
elif(feature == 'lfcc'):
feature_fn = compute_lfcc_feats
elif (feature == 'cqcc'):
feature_fn = None
```

```
return feature_fn
```

```
class MyDataset(Dataset):
def __init__(self, dataset1, dataset2, dataset3):
self.dataset1 = dataset1
self.dataset2 = dataset2
self.dataset3 = dataset3
```

```
def __getitem__(self, index):
x1 = self.dataset1[index]
x2 = self.dataset2[index]
x3 = self.dataset3[index]
return x1, x2, x3
```

```
def __len__(self):
return len(self.dataset1)
```

```
def get_sysid_dict_inv(self):
return self.dataset2.get_sysid_dict_inv()
```

```
if __name__ == '__main__':
parser = argparse.ArgumentParser('UCLANESL ASVSpoof2019
model')
# 模型路径
parser.add_argument('--model_path', type=str,
default="/home/hyl/project/asvspoof2019-master/PA/models/
model_physical_mfcc_150_32_0.0001__mfcc90*376_nor_48000pa
d_Resnet18/epoch_70.pth", help='Model checkpoint')
# 评估结果保存路径
parser.add_argument('--eval_output', type=str,
default="/home/hyl/project/asvspoof2019-master/PA/eval_ou
tput/original/mfcc90*376_nor/cm_LA_mfcc_epoch_70_eval_Res
net18.txt",
help='Path to save the evaluation result')
# 模型版本
parser.add_argument('--model_version', type=str,
default="V1", help='Path to save the evaluation result')
# 批处理大小
parser.add_argument('--batch_size', type=int, default=32)
# 迭代次数
parser.add_argument('--num_epochs', type=int, default=150)
# 学习率
parser.add_argument('--lr', type=float, default=0.0001)
# 模型注释
parser.add_argument('--comment', type=str,
default='_spect',
help='Comment to describe the saved mdoel')
# 训练集类型
parser.add_argument('--track', type=str,
default='physical')
# 指定特征类型
```

```
parser.add_argument('--features', type=str,
default='spect')
# 是否进行模型评估
parser.add_argument('--is_eval', action='store_true',
default= True)
# 是否进行模型训练
parser.add_argument('--is_train', action='store_true',
default= False)
parser.add_argument('--eval_part', type=int, default=0)
# 如果文件夹不存在，则创建文件夹
if not os.path.exists('models'):
os.mkdir('models')
# 解析参数
args = parser.parse_args()
# 指定训练集类型
track = args.track
assert args.features in ['mfcc', 'spect', 'cqcc', 'fuse_RGB',
'lfcc', 'imfcc','joint',
'fuse_RGB2','fuse_RGB_spect_cqcc_lfcc',
'fuse_RGB_mfcc_cqcc_lfcc'], 'Not supported feature'
model_tag = 'model_{}_{}_{}_{}_{}'.format(
track, args.features, args.num_epochs, args.batch_size,
args.lr)
if args.comment:
model_tag = model_tag + '_{}'.format(args.comment)+
'_{}'.format(args.model_version)
model_save_path = os.path.join('models', model_tag)
print("model_save_path: " + str(model_save_path))
assert track in ['logical', 'physical'], 'Invalid track
given'
is_logical = (track == 'logical')
if not os.path.exists(model_save_path):
os.mkdir(model_save_path)
```

```
if args.features == 'spect' or args.features == 'mfcc' or
args.features =='cqcc' or args.features =='lfcc':
print("使用单一特征：")
feature_fn = get_fea(args.features)
```

```
# model_cls = CQCCModel
if (args.model_version == 'V1'):
print("使用: FeaAttenModel_V1")
model_cls = FeaAttenModel_V1
elif (args.model_version == 'V2'):
print("使用: FeaAttenModel_V2")
model_cls = FeaAttenModel_V2
elif (args.model_version == 'V3'):
print("使用: FeaAttenModel_V3")
model_cls = FeaAttenModel_V3
elif (args.model_version == 'V4'):
print("使用: FeaAttenModel_V4")
model_cls = FeaAttenModel_V4
elif (args.model_version == 'V5'):
print("使用: FeaAttenModel_V5")
model_cls = FeaAttenModel_V5
elif (args.model_version == 'Resnet18'):
print("使用: ResidualNet18")
model_cls = ResidualNet
else:
print("使用: spect_Model")
model_cls = SpectrogramModel
```

```
transforms = transforms.Compose([
lambda x: pad(x),
lambda x: librosa.util.normalize(x),
lambda x: feature_fn(x),
lambda x: Tensor(x)
])
device = 'cuda:2' if torch.cuda.is_available() else 'cpu'
# 训练集
dev_set = data_utils_single_PA.ASVDataset(is_train=False,
is_logical=is_logical,
transform=transforms,
feature_name=args.features, is_eval=args.is_eval,
eval_part=args.eval_part)
dev_loader = DataLoader(dev_set, batch_size=args.batch_size,
shuffle=True)
```

```
model = model_cls().to(device)
print(args)
```

```
if args.model_path:
model.load_state_dict(torch.load(args.model_path))
print('Model loaded : {}'.format(args.model_path))
```

```
if args.is_eval:
assert args.eval_output is not None, 'You must provide an output path'
assert args.model_path is not None, 'You must provide model checkpoint'
```

```
if (args.features == 'spect' or args.features == 'cqcc' or args.features == 'lfcc' or args.features == 'mfcc'):
```

```
produce_evaluation_file(dev_set, model, device, args.eval_output)
```

```
sys.exit(0)
```

```
elif not args.is_train:
assert args.eval_output is not None, 'You must provide an output path'
assert args.model_path is not None, 'You must provide model checkpoint'
produce_evaluation_file(dev_set, model, device, args.eval_output)
```

```
sys.exit(0)
```

```
else:
```

```
train_set = data_utils_single_PA.ASVDataset(is_train=True, is_logical=is_logical, transform=transforms, feature_name=args.features)
```

```
train_loader = DataLoader(
train_set, batch_size=args.batch_size, shuffle=True)
```

```
result_save_path = os.path.join(model_save_path,
'accuracy_eer_dev.txt')
print(result_save_path)
f = open(result_save_path, "w")
f.write(model_save_path + "\n")
```

```
start_epoch = 0
```

```
num_epochs = args.num_epochs
writer = SummaryWriter('logs/{}'.format(model_tag))
for epoch in range(start_epoch, args.num_epochs):
running_loss, train_accuracy = train_epoch(
train_loader, model, args.lr, device)
valid_eer, valid_accuracy = evaluate_accuracy(dev_set,
model, device)
```

```
writer.add_scalar('train_accuracy', train_accuracy, epoch)
writer.add_scalar('valid_accuracy', valid_accuracy, epoch)
writer.add_scalar('loss', running_loss, epoch)
print('\n{} - {} - {:.2f} - {:.2f} - {:.2f}'.format(epoch,
running_loss, train_accuracy, valid_accuracy, valid_eer))
f.write("Epoch" + str(epoch) + " " + str(valid_eer) + " " +
str(valid_accuracy) + "\n")
torch.save(model.state_dict(), os.path.join(
model_save_path, 'epoch_{}.pth'.format(epoch)))
```