TopN model + mask generation:

Purpose:

1. validate that baseline non-linear model has very good topN accuracy

2. create masking algorithm for distinguishing specificly top 2 classes

a. one mask for each pair - O(nClasses^2) masks

b. one mask for each class - nClasses masks

In [1]:
```
%load_ext autoreload
%autoreload 2
```

In [2]:
```
import sklearn
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.decomposition import PCA
import time
import sys
import math
import numpy as np
import random
import joblib
from scipy import stats
from tqdm import tqdm_notebook
import matplotlib.pyplot as plt
import copy

import Config
from Config import *
import Dataloader as DL
import HD_basis as HDB
import HD_encoder as HDE
import HD_classifier as HDC
```

In [3]:
```
# train data. with retrain
def train(hdc, traindata, trainlabels, testdata, testlabels, param = Config.conf
    train_accs = []
    test_accs = []
    for _ in tqdm_notebook(range(param["epochs"]), desc='epochs'):
        train_accs.append(hdc.fit(traindata, trainlabels, param))
        test_accs.append(hdc.test(testdata, testlabels, param["kernel"]))
        if len(train_accs) % 5 == 1:
            print("Train: %f \t \t Test: %f"%(train_accs[-1], test_accs[-1]))
        if train_accs[-1] == 1:
            print("Train: %f \t \t Test: %f"%(train_accs[-1], test_accs[-1]))
            break
    return np.asarray(train_accs), np.asarray(test_accs)
```

In [4]:
```
# train data. with retrain
def train_masks(hdc, traindata, trainlabels, testdata, testlabels, param = Confi
    train_accs = []
    test_accs = []

    for _ in range(5):
        train_accs.append(hdc.fit(traindata, trainlabels, param))
        test_accs.append(hdc.test(testdata, testlabels, param["kernel"]))
        if len(train_accs) % 5 == 1:
            print("Train: %f \t \t Test: %f"%(train_accs[-1], test_accs[-1]))
        if train_accs[-1] == 1:
            print("Train: %f \t \t Test: %f"%(train_accs[-1], test_accs[-1]))
            break


    print("Train memasks")
    for _ in tqdm_notebook(range(param["epochs"]), desc='epochs'):
        train_accs.append(hdc.fit_mask(traindata, trainlabels, param))
        test_accs.append(hdc.test(testdata, testlabels, param["kernel"]))
        if len(train_accs) % 5 == 1:
            print("Train: %f \t \t Test: %f"%(train_accs[-1], test_accs[-1]))
        if train_accs[-1] == 1:
            print("Train: %f \t \t Test: %f"%(train_accs[-1], test_accs[-1]))
            break
    return np.asarray(train_accs), np.asarray(test_accs)
```

In [5]:
```
def show_plots(fst_scs, snd_scs, pairs = None):

    new_fst = []
    new_snd = []

    if pairs is not None:
        for sc in fst_scs:
            if (sc[3], sc[4]) in pairs or (int(sc[4]), int(sc[3])) in pairs:
                new_fst.append(sc)
        for sc in snd_scs:
            if (sc[3], sc[4]) in pairs or (int(sc[4]), int(sc[3])) in pairs:
                new_snd.append(sc)
        fst_scs = np.asarray(new_fst)
        snd_scs = np.asarray(new_snd)

    rg = [min(np.min(fst_scs[:,:2]), np.min(snd_scs[:,:2])),
          max(np.max(fst_scs[:,:2]), np.max(snd_scs[:,:2]))]

    # Scatter plots
    plt.figure(figsize = (10, 10))
    plt.plot(rg, rg, ls = "--")
    plt.scatter(fst_scs[:,0], fst_scs[:,1], label = "fst", color = "g", alpha = (
    plt.legend()
    plt.show()

    plt.figure(figsize = (10, 10))
    plt.plot(rg, rg, ls = "--")
    plt.scatter(snd_scs[:,0], snd_scs[:,1], label = "snd", color = "r", alpha = (
    plt.legend()
    plt.show()

    plt.figure(figsize = (10, 10))
    plt.plot(rg, rg, ls = "--")
    plt.scatter(fst_scs[:,0], fst_scs[:,1], label = "fst", color = "g", alpha = (
    plt.scatter(snd_scs[:,0], snd_scs[:,1], label = "snd", color = "r", alpha = (
    plt.legend()
    plt.show()

    # ratio dist
    fst_rt = fst_scs[:,0]/fst_scs[:,1]
    snd_rt = snd_scs[:,0]/snd_scs[:,1]

    # Exclude but record outliers
    sd = np.std(np.append(fst_rt, snd_rt))
    mn = np.mean(np.append(fst_rt, snd_rt))
    z = 2
    print(sd, mn)
    fst_rt_ol = fst_rt[np.abs(fst_rt - mn) > 2 * z * sd]
    fst_rt_cl = fst_rt[np.abs(fst_rt - mn) <= 2 * z * sd]
    snd_rt_ol = snd_rt[np.abs(snd_rt - mn) > 2 * z * sd]
    snd_rt_cl = snd_rt[np.abs(snd_rt - mn) <= 2 * z * sd]

    plt.figure(figsize = (50, 20))
    plt.hist(fst_rt_cl, bins = 200, label = "fst", color = "r", alpha = 0.5)
    plt.hist(snd_rt_cl, bins = 200, label = "snd", color = "g", alpha = 0.5)
    plt.legend(prop={"size":80})
```

```
    # diff dist
    fst_sc = fst_scs[:,0]-fst_scs[:,1]
    snd_sc = snd_scs[:,0]-snd_scs[:,1]
    plt.figure(figsize = (50, 20))
    plt.hist(fst_sc, bins = 200, label = "fst", color = "r", alpha = 0.5)
    plt.hist(snd_sc, bins = 200, label = "snd", color = "g", alpha = 0.5)
    plt.legend(prop={"size":80})
```

In [6]:
```
dl = DL.Dataloader()
nFeatures, nClasses, traindata, trainlabels, testdata, testlabels = dl.getParam(
```

```
Loading dataset UCIHAR from UCIHAR
Loading train data... train data of shape (6213, 561) loaded
Loading test data...  test  data of shape (1554, 561) loaded
Data Loaded. Num of features = 561 Num of Classes = 12
```

In [7]:
```
#Data shuffling
shuf_train = np.random.permutation(len(traindata))
traindata = traindata[shuf_train]
trainlabels = trainlabels[shuf_train]

shuf_test = np.random.permutation(len(testdata))
testdata = testdata[shuf_test]
testlabels = testlabels[shuf_test]
```

In [8]:
```
traindata = traindata[:10000]
testdata = testdata[:5000]
```

In [9]:
```
param = Config.config
param["nFeatures"] = nFeatures
param["nClasses"] = nClasses
print(param)
```

```
{'data_location': '../dataset/', 'directory': 'UCIHAR', 'dataset': 'UCIHAR',
'D': 2000, 'vector': 'Gaussian', 'mu': 0, 'sigma': 1, 'binarize': 0, 'lr': 1,
'sparse': 0, 's': 0.1, 'binaryModel': 0, 'checkpoints': False, 'kernel': <Kerne
l_T.COS: 1>, 'width': None, 'height': None, 'nLayers': 5, 'uniform_dim': 1, 'un
iform_ker': 1, 'dArr': None, 'k': 3, 'kArr': None, 'one_shot': 0, 'data_percent
ages': [1.0, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5], 'train_percent': 1, 'dropout':
0, 'drop_percentages': [0, 0.1, 0.2, 0.5], 'dropout_rate': 0, 'update_type': <U
pdate_T.FULL: 1>, 'iter_per_trial': 3, 'iter_per_encoding': 5, 'epochs': 80, 'n
Features': 561, 'nClasses': 12}
```

Sample code to train a model

In [15]:
```
################## VANILLA #################
hdb = HDB.HD_basis(Config.Generator_T.Vanilla, param)
basis = hdb.getBasis()
bid = hdb.getParam()["id"]
# Update param with bid
param = hdb.getParam()
print(bid)
```

```
Generating vanilla HD basis of shape...
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

```
9238

(200, 561)
Encoding time: 0.02689337730407715
```

In [16]:
```
# Retrieve info upto basis generator, given correct bid
#bid = 6679
#basis, param = HDB.loadBasis("base_%d.pkl"%bid)
```

In [17]:
```
hde = HDE.HD_encoder(basis)

trainencoded = hde.encodeData(traindata)
#HDE.saveEncoded(trainencoded, trainlabels, bid, "train")

testencoded = hde.encodeData(testdata)
#HDE.saveEncoded(testencoded, testlabels, bid, "test")
```

```
Encoding data of shape (6213, 561)
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

```
Time spent: 0 sec
Encoding data of shape (1554, 561)
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

```
Time spent: 0 sec
```

In [18]:
```
# Retrieve info upto encoder, given correct bid
#bid = 6679
#basis, param = HDB.loadBasis("base_%d.pkl"%bid)
#trainencoded, trainlabels = HDE.loadEncoded("encoded_%d_train.pkl"%bid)
#testencoded, testlabels = HDE.loadEncoded("encoded_%d_test.pkl"%bid)
```

In [19]:
```
hdc = HDC.HD_classifier(param["D"], param["nClasses"], bid)
train_acc, test_acc = train(hdc, trainencoded, trainlabels, testencoded, testlabe
```

```
c:\program files (x86)\microsoft visual studio\shared\python37_64\lib\site-pack
ages\ipykernel_launcher.py:5: TqdmDeprecationWarning: This function will be rem
oved in tqdm==5.0.0
Please use `tqdm.notebook.tqdm` instead of `tqdm.tqdm_notebook`
  """
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

```
Fitting with configuration: [('one_shot', 0), ('dropout', 0), ('lr', 1), ('kern
el', <Kernel_T.COS: 1>)]

Train: 0.721552                 Test: 0.428571
Train: 0.878320                 Test: 0.822394
Train: 0.908418                 Test: 0.922780
Train: 0.920650                 Test: 0.945946
Train: 0.935458                 Test: 0.938867
Train: 0.940286                 Test: 0.920849
Train: 0.950427                 Test: 0.923423
Train: 0.954772                 Test: 0.940798
Train: 0.951392                 Test: 0.948520
Train: 0.956704                 Test: 0.953668
Train: 0.959440                 Test: 0.951737
Train: 0.961532                 Test: 0.922136
Train: 0.961532                 Test: 0.941441
Train: 0.961532                 Test: 0.958172
Train: 0.958796                 Test: 0.957529
Train: 0.968453                 Test: 0.957529
```

Top n accuracy

In [10]:
```
def topn_suit(traindata, trainlabels, testdata, testlabels, param):
    hdb = HDB.HD_basis(Config.Generator_T.Vanilla, param)
    basis = hdb.getBasis()
    bid = hdb.getParam()["id"]
    param = hdb.getParam()

    hde = HDE.HD_encoder(basis)
    trainencoded = hde.encodeData(traindata)
    testencoded = hde.encodeData(testdata)

    hdc = HDC.HD_classifier(param["D"], param["nClasses"], bid)
    train_acc, test_acc = train(hdc, trainencoded, trainlabels, testencoded, tes
    accs = []
    cmps = []
    for k in range(5):
        accs.append(hdc.test_topn(testencoded, testlabels, k+1))
        cmps.append(hdc.predict_topn(testencoded, k+1))
        print("Top %d accuracy: "%(k+1), accs[-1])
    return accs, cmps
```

In [ ]:
```
Ds = [200, 500, 1000]
accs_D = dict()
cmps_D = dict()
for D in Ds:
    param["D"] = D
    accs_D[D], cmps_D[D] = topn_suit(traindata, trainlabels, testdata, testlabels
param["D"] = Config.config["D"]
```

```
Generating vanilla HD basis of shape...
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

```
(200, 561)
Encoding time: 0.031884193420410156
Encoding data of shape (6213, 561)
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

```
Time spent: 0 sec
Encoding data of shape (1554, 561)
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

```
Time spent: 0 sec
c:\program files (x86)\microsoft visual studio\shared\python37_64\lib\site-pack
ages\ipykernel_launcher.py:5: TqdmDeprecationWarning: This function will be rem
oved in tqdm==5.0.0
Please use `tqdm.notebook.tqdm` instead of `tqdm.tqdm_notebook`
  """
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

```
Train: 0.721713                 Test: 0.809524

Fitting with configuration: [('one_shot', 0), ('dropout', 0), ('lr', 1), ('kern
el', <Kernel_T.DOT: 0>)]

Train: 0.891196                 Test: 0.879022
Train: 0.914695                 Test: 0.936937
Train: 0.919202                 Test: 0.933076
```

In [ ]:
```
for D in accs_D.keys():
    print(D)
    for i in range(len(accs_D[D])):
        print("Top %d Accuracy:"%(i+1), accs_D[D][i])
```

Mask generation: 2d masks

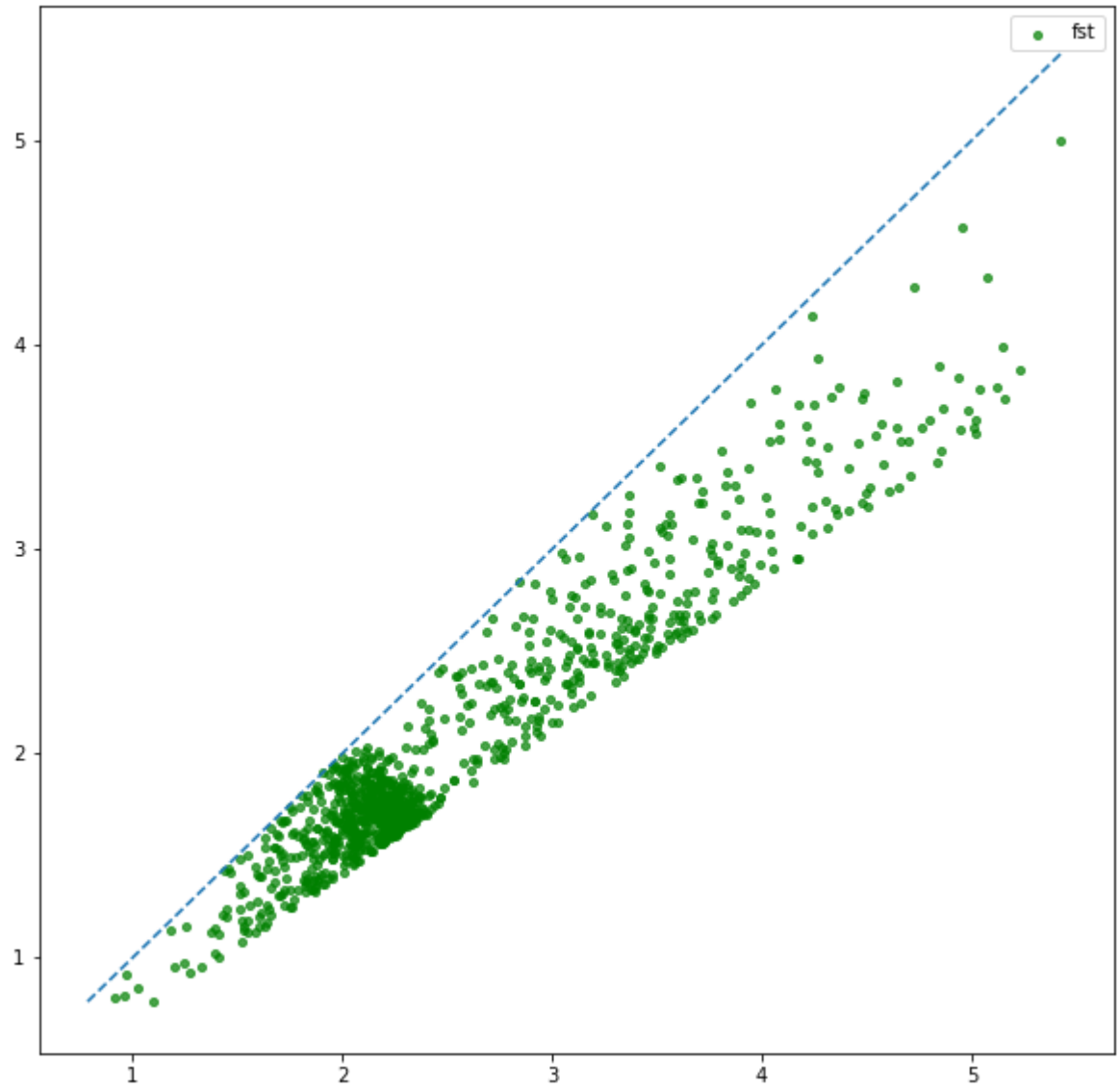
In [10]:
```
hdb = HDB.HD_basis(Config.Generator_T.Vanilla, param)
basis = hdb.getBasis()
bid = hdb.getParam()["id"]
param = hdb.getParam()

hde = HDE.HD_encoder(basis)
trainencoded = hde.encodeData(traindata)
testencoded = hde.encodeData(testdata)

hdc = HDC.HD_classifier(param["D"], param["nClasses"], bid)
#train_acc, test_acc = train_masks(hdc, trainencoded, trainlabels, testencoded, t
train_acc, test_acc = train(hdc, trainencoded, trainlabels, testencoded, testlabe
hdc.normalizeClasses()
acc_1 = hdc.test(testencoded, testlabels, param["kernel"])
acc_2 = hdc.test_topn(testencoded, testlabels, 2)
print("Normalized top1 and top 2 test accuracy:", acc_1, acc_2)
```

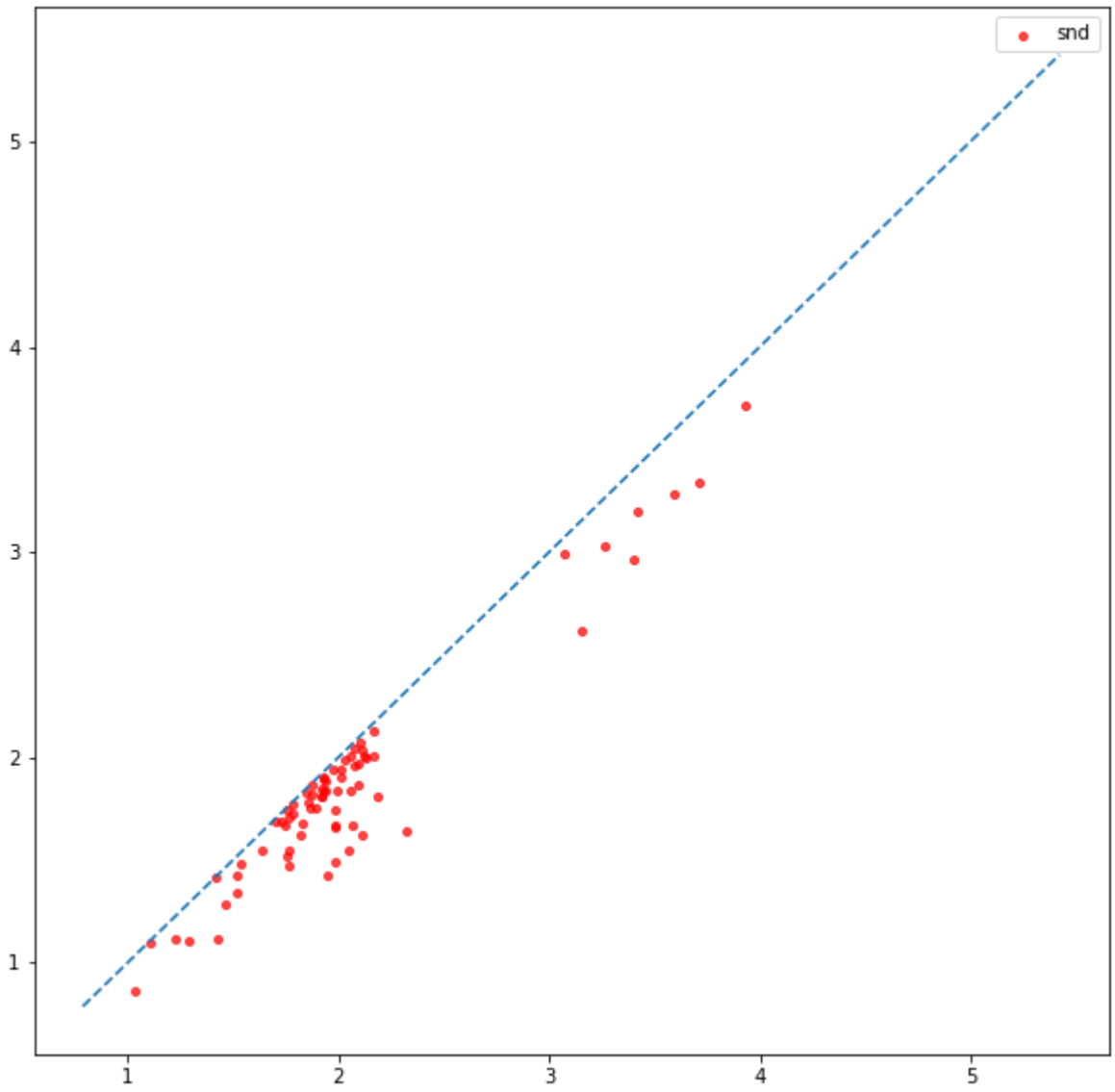
```
Generating vanilla HD basis of shape...

vectors: 100%                                   2000/2000 [00:59<00:00, 33.38it/s]



(2000, 561)
Encoding time: 0.08580851554870605
Encoding data of shape (6213, 561)

samples encoded: 100%                           6213/6213 [00:59<00:00, 104.40it/s]



Time spent: 2 sec
Encoding data of shape (1554, 561)

samples encoded: 100%                           1554/1554 [00:56<00:00, 27.30it/s]



Time spent: 0 sec
c:\program files (x86)\microsoft visual studio\shared\python37_64\lib\site-pack
ages\ipykernel_launcher.py:5: TqdmDeprecationWarning: This function will be rem
oved in tqdm==5.0.0
Please use `tqdm.notebook.tqdm` instead of `tqdm.tqdm_notebook`
  """

epochs: 100%                                    80/80 [00:56<00:00, 1.42it/s]

Fitting with configuration: [('one_shot', 0), ('dropout', 0), ('lr', 1), ('kern
el', <Kernel_T.COS: 1>)]

Train: 0.723000                 Test: 0.815959
Train: 0.909384                 Test: 0.929858
Train: 0.937228                 Test: 0.882239
Train: 0.947047                 Test: 0.926641
Train: 0.953807                 Test: 0.935006
Train: 0.960084                 Test: 0.964607
```

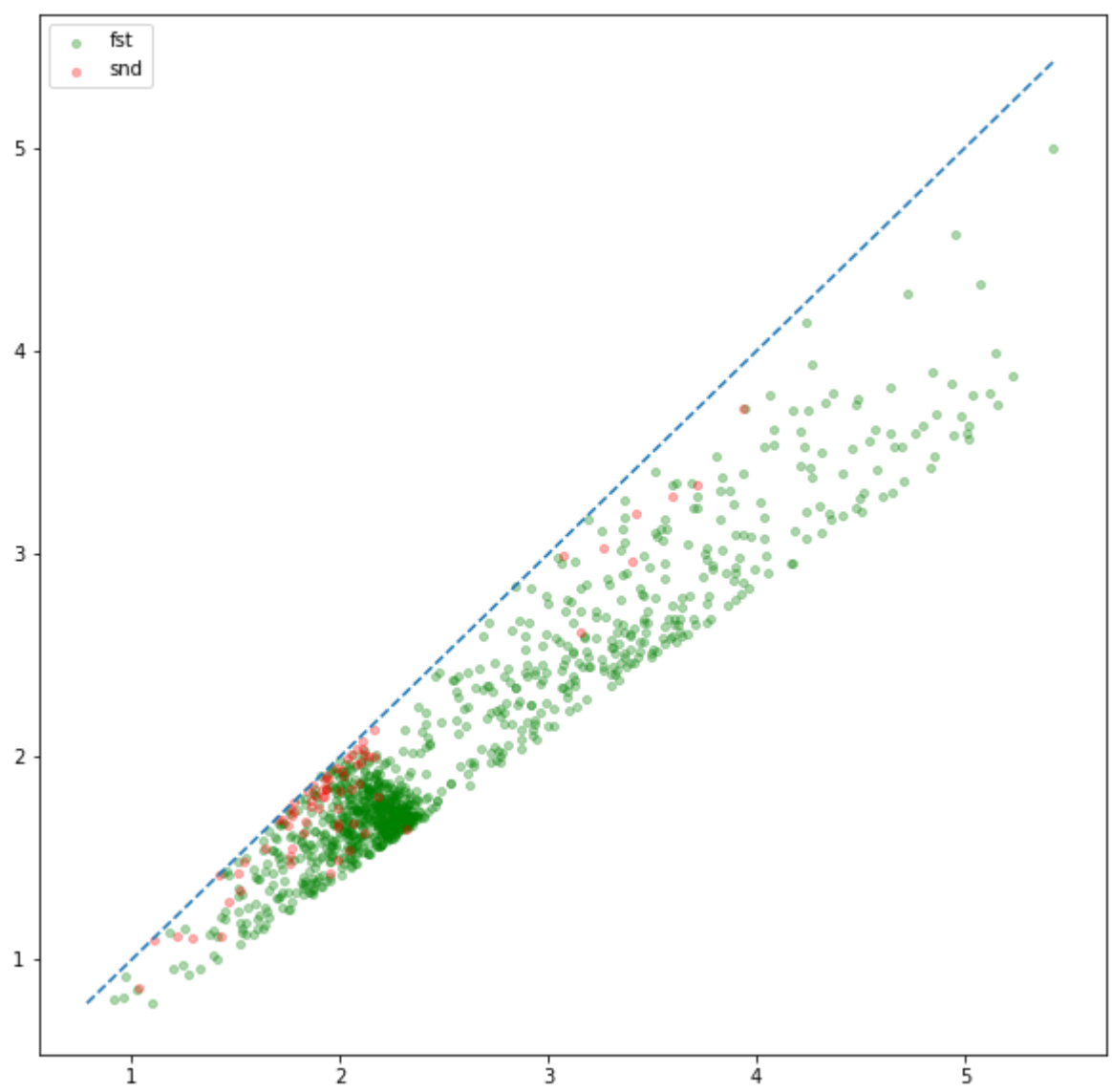
```
Train: 0.961049                Test: 0.952381
Train: 0.966200                Test: 0.954955
Train: 0.967166                Test: 0.931789
Train: 0.969580                Test: 0.964607
Train: 0.969741                Test: 0.944659
Train: 0.972316                Test: 0.965894
Train: 0.980203                Test: 0.968468
Train: 0.979720                Test: 0.939511
Train: 0.973765                Test: 0.926641
Train: 0.971511                Test: 0.963964

Normalized top1 and top 2 test accuracy: 0.9678249678249679 0.9974259974259975
```

In [11]:
```
fst_scs, snd_scs = hdc.analyze(trainencoded, trainlabels)
print("Len of fst, snd: ",len(fst_scs), len(snd_scs))

new_fst = []
beta = np.max(snd_scs[:,0]/snd_scs[:,1])
for sc in fst_scs:
    if sc[0]/sc[1] <= beta:
        new_fst.append(sc)
fst_scs = np.asarray(new_fst)

print("Len of fst after cropping: ",len(fst_scs))

show_plots(fst_scs, snd_scs)
```

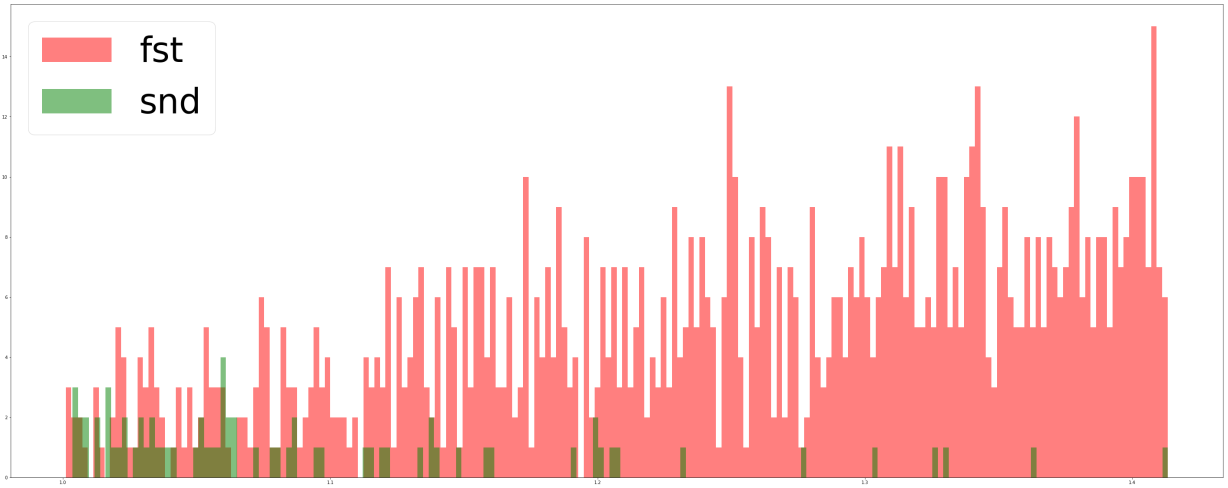
```
Len of fst, snd:  6141 72
Len of fst after cropping:  989
```

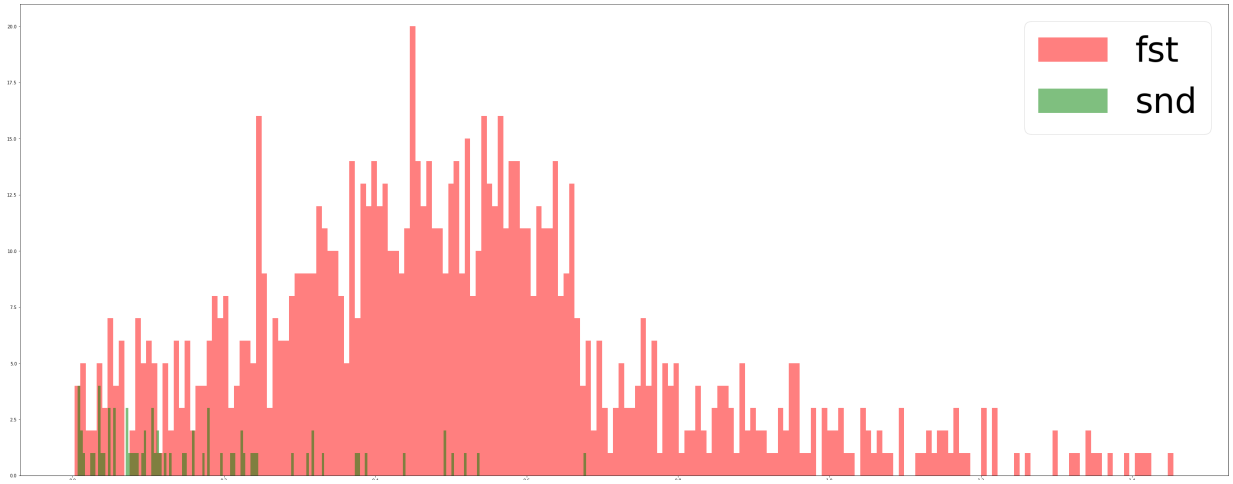



snd
1
2
3
4
5
1
2
3
4
5




```
0.11608539178423631 1.2422547430694069
```





In [ ]:

```
```

In [12]:

```
dominance = 1.2
hdc.make_mask(trainencoded, trainlabels, dominance)
```

In [13]:

```
fst_scs, snd_scs = hdc.analyze(trainencoded, trainlabels, dominance)
print("Len of fst, snd: ",len(fst_scs), len(snd_scs))
#show_plots(fst_scs, snd_scs)
```

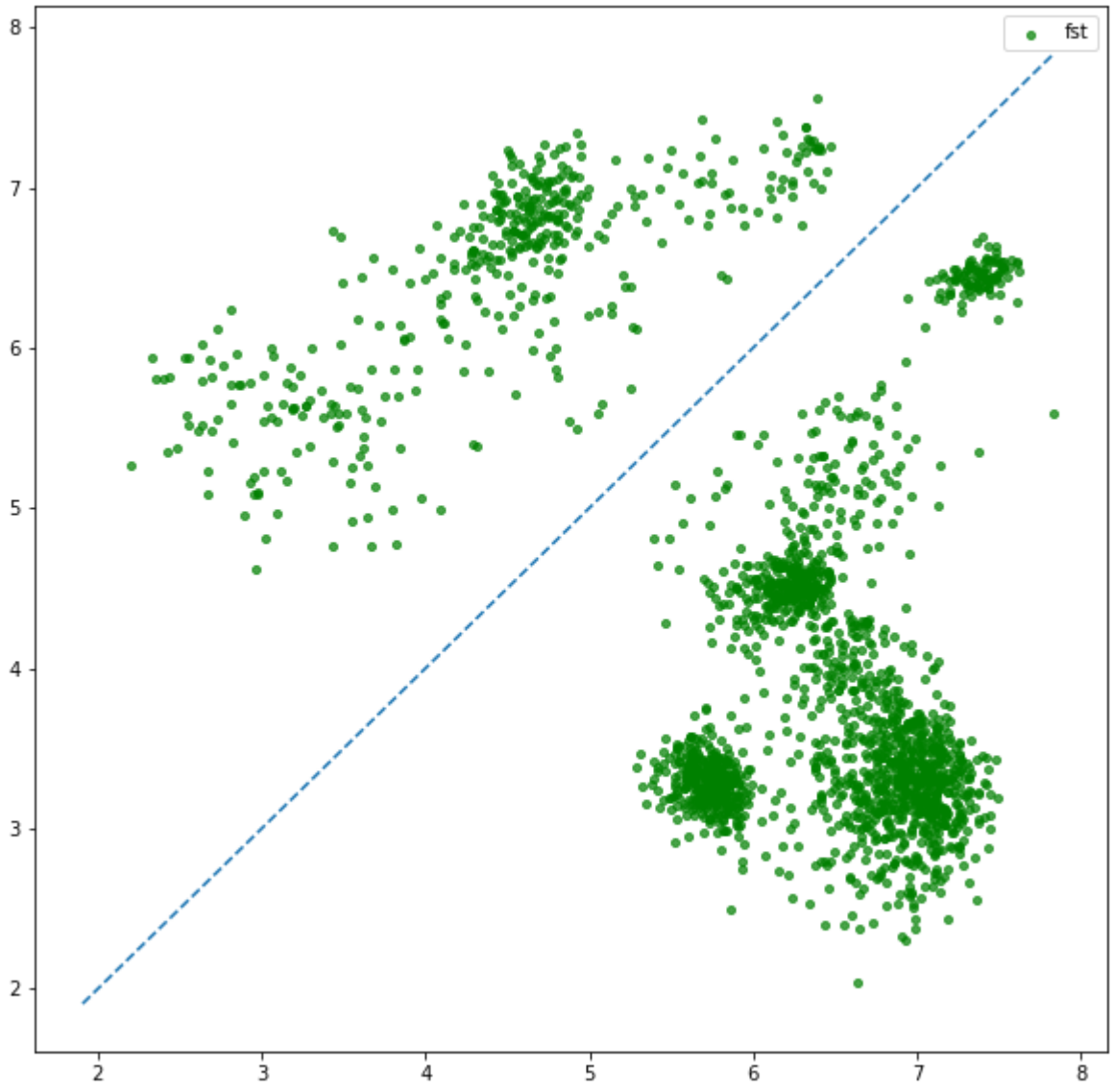
```
Len of fst, snd:  2128 1481
```

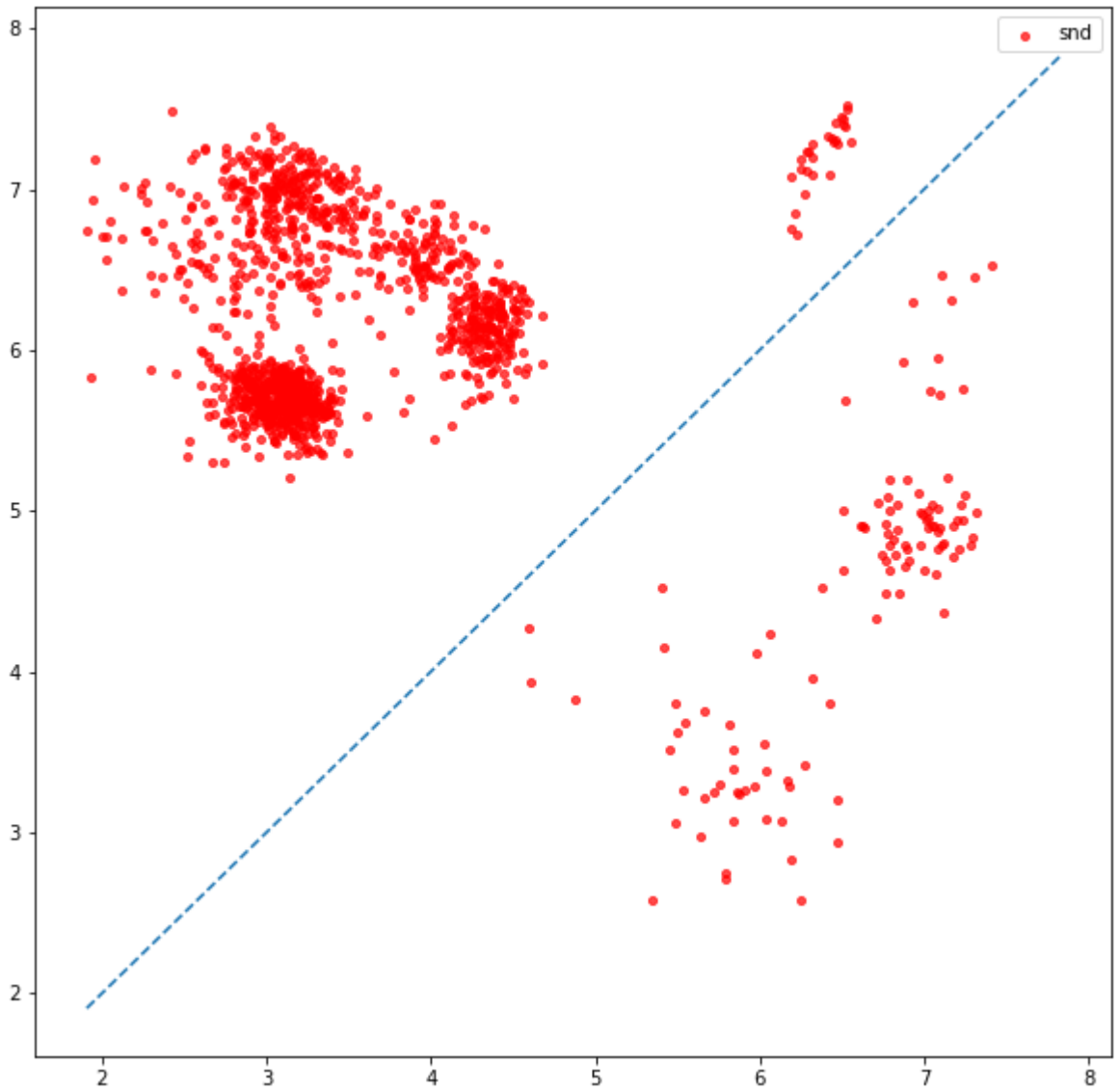
In [14]:

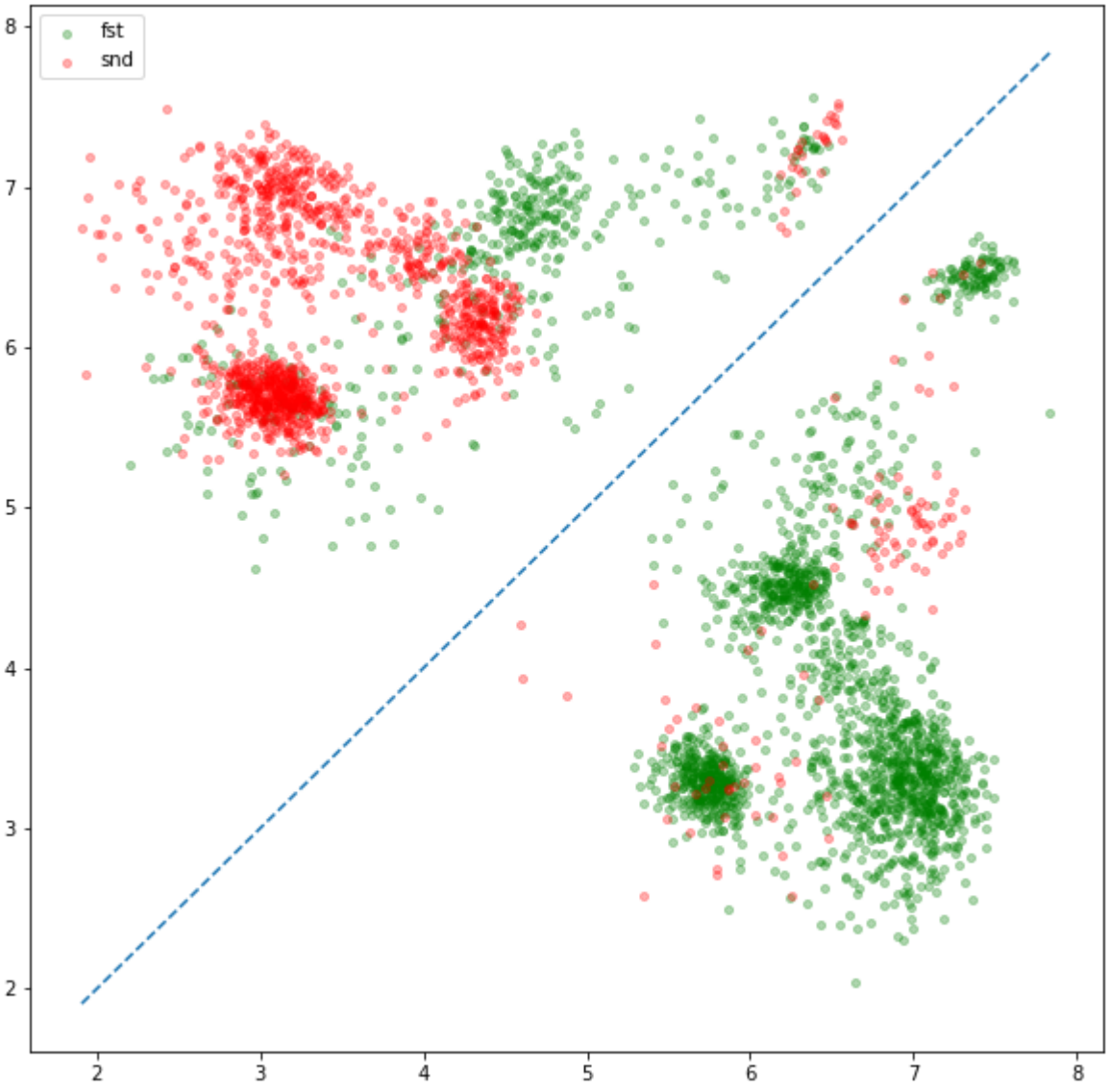
```
percent = 0.5
hdc.prep_mask(percent)
```

In [15]:
```
mask_t = "b" # b for binary, o for original
mask_d = 2
threshold = 0.3
hdc.set_decider(trainencoded, trainlabels, threshold, dominance, mask_t, mask_d)
fst_scs, snd_scs = hdc.analyze_topn(trainencoded, trainlabels, dominance, mask_t
print("Length fss, snd: ", len(fst_scs), len(snd_scs))
show_plots(fst_scs, snd_scs)
```

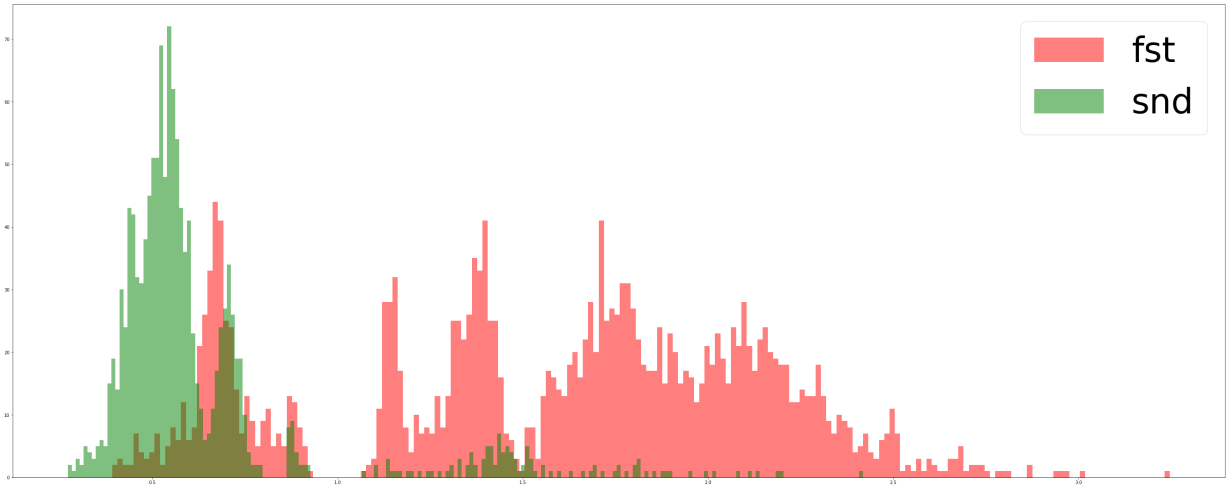
```
C:\HDComputing\TopnHD\HD_classifier.py:572: RuntimeWarning: invalid value encou
ntered in true_divide
  rate = net_mat/mat

Analyzing score with mask type b 2
Length fss, snd:  2128 1294
```




snd
8
7
6
5
4
3
2
2
3
4
5
6
7
8


fst
snd
8
7
6
5
4
3
2
2
3
4
5
6
7
8

```
0.6605766225366176 1.2151557893662173
```



In [22]:
```
def evaluate(func, data, labels, threshold, dominance, mask_t, mask_d):
    correct, c_1, c_2, c_r, w_1, w_2, w_3, count, mat, net_mat = func(data, labe
    print("Accuracy: ", correct/count)
    print("Original: ", c_1/count)
    print("Correct: ",correct)
    print("First is Correct: ", c_1)
    print("Wrong second is selected: ", w_1)
    print("Second is Correct: ", c_2)
    print("Correct Second is selected: ", c_r)
    print("Wrong first is selected: ", w_2)
    print("Out of top 2: ", w_3)
    print("Net increase in correct cases and accuracy: ", c_r-w_1, (c_r-w_1)/cou
    print("Potential increase in correct cases and accuracy: ", c_2, c_2/count)
    print("Total cases:", count)
    print("Confusion Matrix:\n", mat)
    print("Net correct Matrix:\n", net_mat)
```

In [23]:
```
def try_hp(curr_config, data, labels):

    global dominances, percents, thresholds

    mask_t = "b" # b for binary, o for original
    mask_d = 2
    i, j, k = curr_config
    print(i, j, k)
    (dominance, percent, threshold) = dominances[i], percents[j], thresholds[k]

    hdc.make_mask(data, labels, dominance)
    hdc.prep_mask(percent)
    hdc.set_decider(data, labels, threshold, dominance, mask_t, mask_d)

    print("############################ TEST MASK REVEAL ########################
    evaluate(hdc.test_mask, data, labels, threshold, dominance, mask_t, mask_d)

    print("############################ TEST DECIDER REVEAL ######################
    evaluate(hdc.test_decider, data, labels, threshold, dominance, mask_t, mask_
```

In [24]:
```
dominances = [1.1, 1.3, 1.5, 1.7]
percents = [0.2, 0.5, 0.8]
thresholds = [0.2, 0.3, 0.5]

def hp_tuning(hdc, data, labels):

    global dominances, percents, thresholds

    best_mk_acc = 0
    best_mk_config = (0, 0, 0)

    best_dc_acc = 0
    best_dc_config = (0, 0, 0)

    mask_t = "b" # b for binary, o for original
    mask_d = 2

    og_acc = 0
    op_acc = 0
    mk_accs = np.zeros((len(dominances), len(percents), len(thresholds)))
    dc_accs = np.zeros((len(dominances), len(percents), len(thresholds)))

    for i, dominance in enumerate(dominances):
        hdc.make_mask(data, labels, dominance)
        for j, percent in enumerate(percents):
            hdc.prep_mask(percent)

            for k, threshold in enumerate(thresholds):
                hdc.set_decider(data, labels, threshold, dominance, mask_t, mask_

                #fst_scs, snd_scs = hdc.analyze_topn(data, labels, dominance, mas
                #print("Length fss, snd: ", len(fst_scs), len(snd_scs))
                #show_plots(fst_scs, snd_scs)

                correct, c_1, c_2, c_r, w_1, w_2, w_3, count, mat, net_mat = \
                    hdc.test_mask(data, labels, threshold, dominance, mask_t, mas
                og_acc =  c_1/count
                op_acc =  (c_1 + c_2)/count
                mk_accs[i,j,k] = correct/count
                correct, c_1, c_2, c_r, w_1, w_2, w_3, count, mat, net_mat = \
                    hdc.test_decider(data, labels, threshold, dominance, mask_t,
                dc_accs[i,j,k] = correct/count

                # BEST MASK
                if mk_accs[i,j,k] > best_mk_acc:
                    best_mk_acc = mk_accs[i,j,k]
                    best_mk_config = (i,j,k)

                # BEST DECIDER
                if dc_accs[i,j,k] > best_dc_acc:
                    best_dc_acc = dc_accs[i,j,k]
                    best_dc_config = (i,j,k)

    print("Original Accuracy:", og_acc)
    print("Optimal mask at", best_mk_config, " with train accuracy", best_mk_acc
    print("Optimal decider at", best_dc_config, " with train accuracy", best_dc_a
```

```
    print("Ideal Accuracy:", op_acc)

    return og_acc, op_acc, mk_accs, dc_accs, best_mk_config, best_dc_config
```

In [15]:
```
og_acc, op_acc, mk_accs, dc_accs, best_mk_config, best_dc_config = hp_tuning(hdc
```

```
Original Accuracy: 0.9884113954611299
Optimal mask at (0, 1, 0)  with train accuracy 0.9795589892161597
Optimal decider at (0, 1, 0)  with train accuracy 0.9903428295509416
Ideal Accuracy: 0.9998390471591824
```

In [16]:
```
print("Original accu:", og_acc)
print("Optimal mask at", best_mk_config, " with train accuracy", np.max(mk_accs)
print("Optimal decider at", best_dc_config, " with train accuracy", np.max(dc_ac
print("Ideal/Top 2 accu:", op_acc)
print("Mask Accs:\n", mk_accs)
print("Decider Accs:\n", dc_accs)
```

```
Original accu: 0.9884113954611299
Optimal mask at (0, 1, 0)  with train accuracy 0.9795589892161597
Optimal decider at (0, 1, 0)  with train accuracy 0.9903428295509416
Ideal/Top 2 accu: 0.9998390471591824
Mask Accs:
 [[[0.97939804 0.97939804 0.97939804]
  [0.97955899 0.97955899 0.97955899]
  [0.97955899 0.97955899 0.97955899]]

 [[0.94189602 0.94189602 0.94189602]
  [0.94205698 0.94205698 0.94205698]
  [0.94205698 0.94205698 0.94205698]]

 [[0.88186061 0.88186061 0.88186061]
  [0.88266538 0.88266538 0.88266538]
  [0.88266538 0.88266538 0.88266538]]

 [[0.81088041 0.81088041 0.81088041]
  [0.81200708 0.81200708 0.81200708]
  [0.81200708 0.81200708 0.81200708]]]
Decider Accs:
 [[[0.99018188 0.99018188 0.99018188]
  [0.99034283 0.99034283 0.99034283]
  [0.99034283 0.99034283 0.99034283]]

 [[0.9884114  0.9884114  0.9884114 ]
  [0.98857235 0.98857235 0.98857235]
  [0.98857235 0.98857235 0.98857235]]

 [[0.98808949 0.98808949 0.98808949]
  [0.9884114  0.9884114  0.9884114 ]
  [0.9884114  0.9884114  0.9884114 ]]

 [[0.98792854 0.98792854 0.98792854]
  [0.9884114  0.9884114  0.9884114 ]
  [0.9884114  0.9884114  0.9884114 ]]]
```

In [25]:
```
try_hp(best_mk_config, testencoded, testlabels)
```

```
0 1 0
############################ TEST MASK REVEAL ################################
Accuracy:  0.9601029601029601
Original:  0.9678249678249679
Correct:  1492
First is Correct:  1504
Wrong second is selected:  20
Second is Correct:  46
Correct Second is selected:  8
Wrong first is selected:  38
Out of top 2:  4
Net increase in correct cases and accuracy:  -12 -0.007722007722007722
Potential increase in correct cases and accuracy:  46 0.029601029601029602
Total cases: 1554
Confusion Matrix:
 [[ 0.  3.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 3.  0.  9.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 1.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0. 16.  2.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0. 18.  0.  0.  1.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  1.  0.  0.]
 [ 0.  0.  0.  0.  0.  1.  0.  0.  0.  0.  1.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  1.]
 [ 0.  0.  0.  0.  0.  0.  0.  1.  1.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  3.  0.  0.]]
Net correct Matrix:
 [[  0.  -3.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [ -3.   0.   7.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [ -1.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   2.   2.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0. -10.   0.   0.  -1.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   1.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.  -1.   0.   0.]
 [  0.   0.   0.   0.   0.  -1.   0.   0.   0.   0.  -1.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.  -1.]
 [  0.   0.   0.   0.   0.   0.   0.  -1.  -1.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   3.   0.   0.]]
############################ TEST DECIDER REVEAL ################################
#
Accuracy:  0.9736164736164736
Original:  0.9678249678249679
Correct:  1513
First is Correct:  1504
Wrong second is selected:  9
Second is Correct:  46
Correct Second is selected:  18
Wrong first is selected:  28
Out of top 2:  4
Net increase in correct cases and accuracy:  9 0.005791505791505791
Potential increase in correct cases and accuracy:  46 0.029601029601029602
Total cases: 1554
Confusion Matrix:
```

```
 [[ 0.  3.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 3.  0.  9.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 1.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0. 16.  2.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0. 18.  0.  0.  1.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  1.  0.  0.]
 [ 0.  0.  0.  0.  0.  1.  0.  0.  0.  0.  1.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  1.]
 [ 0.  0.  0.  0.  0.  0.  0.  1.  1.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  3.  0.  0.]]
Net correct Matrix:
 [[ 0.  3.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 3.  0.  7.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 1.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0. -2.  2.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0. 10.  0.  0.  1.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  1.  0.  0.]
 [ 0.  0.  0.  0.  0.  1.  0.  0.  0.  0.  1.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  1.]
 [ 0.  0.  0.  0.  0.  0.  0. -1.  1.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  3.  0.  0.]]
```

In [26]:
```
try_hp(best_dc_config, testencoded, testlabels)
```

```
0 1 0
############################ TEST MASK REVEAL ################################
Accuracy:  0.9601029601029601
Original:  0.9678249678249679
Correct:  1492
First is Correct:  1504
Wrong second is selected:  20
Second is Correct:  46
Correct Second is selected:  8
Wrong first is selected:  38
Out of top 2:  4
Net increase in correct cases and accuracy:  -12 -0.007722007722007722
Potential increase in correct cases and accuracy:  46 0.029601029601029602
Total cases: 1554
Confusion Matrix:
 [[ 0.  3.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 3.  0.  9.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 1.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0. 16.  2.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0. 18.  0.  0.  1.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  1.  0.  0.]
 [ 0.  0.  0.  0.  0.  1.  0.  0.  0.  0.  1.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  1.]
 [ 0.  0.  0.  0.  0.  0.  0.  1.  1.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  3.  0.  0.]]
Net correct Matrix:
 [[  0.  -3.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [ -3.   0.   7.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [ -1.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   2.   2.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0. -10.   0.   0.  -1.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   1.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.  -1.   0.   0.]
 [  0.   0.   0.   0.   0.  -1.   0.   0.   0.   0.  -1.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.  -1.]
 [  0.   0.   0.   0.   0.   0.   0.  -1.  -1.   0.   0.   0.]
 [  0.   0.   0.   0.   0.   0.   0.   0.   0.   3.   0.   0.]]
############################ TEST DECIDER REVEAL ################################
#
Accuracy:  0.9736164736164736
Original:  0.9678249678249679
Correct:  1513
First is Correct:  1504
Wrong second is selected:  9
Second is Correct:  46
Correct Second is selected:  18
Wrong first is selected:  28
Out of top 2:  4
Net increase in correct cases and accuracy:  9 0.005791505791505791
Potential increase in correct cases and accuracy:  46 0.029601029601029602
Total cases: 1554
Confusion Matrix:
```

```
 [[ 0.  3.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 3.  0.  9.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 1.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0. 16.  2.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0. 18.  0.  0.  1.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  1.  0.  0.]
 [ 0.  0.  0.  0.  0.  1.  0.  0.  0.  0.  1.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  1.]
 [ 0.  0.  0.  0.  0.  0.  0.  1.  1.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  3.  0.  0.]]
Net correct Matrix:
 [[ 0.  3.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 3.  0.  7.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 1.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0. -2.  2.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0. 10.  0.  0.  1.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  1.  0.  0.]
 [ 0.  0.  0.  0.  0.  1.  0.  0.  0.  0.  1.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  1.]
 [ 0.  0.  0.  0.  0.  0.  0. -1.  1.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.  0.  0.  0.  0.  3.  0.  0.]]
```

In [ ]:

In [ ]:

In [ ]:

Scratch Paper

In [1]:
```
# Select two classes to separate
cl1 = 3
cl2 = 4

ncl1 = 0
cl1_sum = np.zeros(hdc.D)
for sc in fst_scs:
    if sc[3] == cl1 and sc[4] == cl2:
        cl1_sum += trainencoded[int(sc[2])]
        ncl1 += 1
for sc in snd_scs:
    if sc[3] == cl2 and sc[4] == cl1:
        cl1_sum += trainencoded[int(sc[2])]
        ncl1 += 1
ncl2 = 0
cl2_sum = np.zeros(hdc.D)
for sc in fst_scs:
    if sc[3] == cl2 and sc[4] == cl1:
        cl2_sum += trainencoded[int(sc[2])]
        ncl2 += 1
for sc in snd_scs:
    if sc[3] == cl1 and sc[4] == cl2:
        cl2_sum += trainencoded[int(sc[2])]
        ncl2 += 1
print("Component-wise sum of data points, sum1 sum2")
#print(cl1_sum)
#print(cl2_sum)

#print("Component-wise ratio sum1:sum2")
#print(cl1_sum/cl2_sum)
cl1_nm = sklearn.preprocessing.normalize(np.asarray([cl1_sum]), norm='l2')[0]
cl2_nm = sklearn.preprocessing.normalize(np.asarray([cl2_sum]), norm='l2')[0]
print("Component-wise normalized ratio normed(sum1):normed(sum2)")
print(cl1_nm/cl2_nm)
#print("Component-wise normalized diff normed(sum1) - normed(sum2)")
#print(cl1_nm - cl2_nm)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-1-69ba974ec519> in <module>
      4
      5 ncl1 = 0
----> 6 cl1_sum = np.zeros(hdc.D)
      7 for sc in fst_scs:
      8     if sc[3] == cl1 and sc[4] == cl2:

NameError: name 'np' is not defined
```

In [ ]:
```
og_mask1 = copy.deepcopy(hdc.mask2d[cl1][cl2])
og_mask2 = copy.deepcopy(hdc.mask2d[cl2][cl1])
hdc.mask2d[cl1][cl2] = mask
hdc.mask2d[cl2][cl1] = -mask
```

In [ ]:
```
hdc.mask2d[cl1][cl2] = og_mask1
hdc.mask2d[cl2][cl1] = og_mask2
```

In [ ]:
```
```

In [ ]:
```
np.set_printoptions(linewidth=85, suppress = True)
fst_mat = np.zeros((hdc.nClasses, hdc.nClasses))
for sc in fst_scs:
    fst_mat[int(sc[3]), int(sc[4])] += 1

snd_mat = np.zeros((hdc.nClasses, hdc.nClasses))
for sc in snd_scs:
    snd_mat[int(sc[3]), int(sc[4])] += 1
print("fst confusion matrix: top 2 choices (row, col) whose answer is first choi
print(fst_mat)
print("snd confusion matrix: top 2 choices (row, col) whose answer is second cho
print(snd_mat)
```

In [ ]:
```
```

In [ ]:
```
fst_r, snd_r = hdc.analyze(testencoded, testlabels)

print(len(fst_r), len(snd_r))
#beta = max(snd_r)
#fst_r = fst_r[fst_r <= beta]
print(len(fst_r))

fst_mr, snd_mr, fst_scs, snd_scs = hdc.analyze_topn(testencoded, testlabels, dom

print(len(fst_mr), len(snd_mr))
print(len(fst_scs), len(snd_scs))
#print(fst_mr)
#print(snd_mr)
#print(fst_scs)
#print(snd_scs)


plt.figure(figsize = (100, 20))
plt.hist(np.append(fst_mr,snd_mr), bins = 1000, label = "fst")
plt.hist(snd_mr, bins = 1000, label = "snd")
plt.legend()

plt.figure(figsize = (100, 20))
plt.hist(np.append(fst_scs,snd_scs), bins = 1000, label = "fst")
plt.hist(snd_scs, bins = 1000, label = "snd")
plt.legend()
```

In [ ]:
```
```

In [21]:
```
np.set_printoptions(threshold=sys.maxsize)
```

In [ ]:
```
```