

Assignment 1B - Question 2

Person Re-Identification

In [1]:

```
import pandas
import numpy as np
import matplotlib.pyplot as plt
import statsmodels.api as sm
import scipy.stats as stats
from scipy.io import loadmat

import tensorflow as tf

from tensorflow import keras
from tensorflow.keras import layers
from tensorboard import notebook
from tensorflow.keras.preprocessing.image import Iterator

from sklearn import decomposition
from sklearn import discriminant_analysis
from sklearn import datasets
from sklearn.manifold import TSNE
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import plot_confusion_matrix
import matplotlib.pyplot as plt

import cv2
import os
import glob
import random
```

```
INFO:tensorflow:Enabling eager execution
INFO:tensorflow:Enabling v2 tensorshape
INFO:tensorflow:Enabling resource variables
INFO:tensorflow:Enabling tensor equality
INFO:tensorflow:Enabling control flow v2
```

Load data

Uses opencv's cv2.imread function on all files in a directory to load into a numpy array

In [2]:

```

train = []
gnd = []
files = glob.glob('Data/Q2/Q2/Q2/Training/*.jpg')
for myfile in files:
    image = cv2.imread(myfile, 0)
    gnd.append(myfile[23:27])
    train.append(image)

train = np.array(train)
gnd = np.array(gnd)

print('Training shape: ', train.shape)
print('Training gnd: ', gnd[1:10])

```

Training shape: (5933, 128, 64)
 Training gnd: ['0001' '0001' '0001' '0001' '0001' '0001' '0001' '0001' '0001']

In [3]:

```

test_gal = []
test_gal_gnd = []
files = glob.glob('Data/Q2/Q2/Q2/Testing/Gallery/*.jpg')
for myfile in files:
    image = cv2.imread(myfile, 0)
    test_gal_gnd.append(myfile[30:34])
    test_gal.append(image)

test_gal = np.array(test_gal)

print('Training shape: ', test_gal.shape)
print('Training gnd: ', test_gal_gnd[1:10])

```

Training shape: (301, 128, 64)
 Training gnd: ['1201', '1202', '1203', '1204', '1205', '1206', '1207', '1208', '1209']

In [4]:

```

test_pro = []
test_pro_gnd = []
files = glob.glob('Data/Q2/Q2/Q2/Testing/Probe/*.jpg')
for myfile in files:
    image = cv2.imread(myfile, 0)
    test_pro_gnd.append(myfile[28:32])
    test_pro.append(image)

test_pro = np.array(test_pro)

print('Training shape: ', test_pro.shape)
print('Training gnd: ', test_pro_gnd[1:10])

```

Training shape: (301, 128, 64)
 Training gnd: ['1201', '1202', '1203', '1204', '1205', '1206', '1207', '1208', '1209']

In [5]:

```
train_fea = np.reshape(train.transpose(), (64, 128, 1, len(train)))
fig = plt.figure(figsize=[20, 8])
for i in range(40):
    ax = fig.add_subplot(4, 10, i + 1)
    ax.imshow(train_fea[:, :, 0, i].transpose(), cmap=plt.get_cmap('gray'))
    ax.set_axis_off()
```



In [6]:

```
testfea_img = np.reshape(test_gal.transpose(), (64, 128, 1, len(test_gal)))
fig = plt.figure(figsize=[20, 8])
for i in range(40):
    ax = fig.add_subplot(4, 10, i + 1)
    ax.imshow(testfea_img[:, :, 0, i].transpose(), cmap=plt.get_cmap('gray'))
    ax.set_axis_off()
```



In [7]:

```
print(test_gal.shape)
```

(301, 128, 64)

In [8]:

```
test_pro_img = np.reshape(test_pro.transpose(), (64, 128, 1, len(test_pro)))
fig = plt.figure(figsize=[20, 8])
for i in range(40):
    ax = fig.add_subplot(4, 10, i + 1)
    ax.imshow(test_pro_img[:, :, 0, i].transpose(), cmap=plt.get_cmap('gray'))
    ax.set_axis_off()
```



PCA

Code taken from Week 6 Example 5 Eigenfaces

In [9]:

```
train_fea = train
train_gnd = gnd
test_fea = test_gal
test_gnd = test_gal_gnd
print(np.shape(train_fea))
print(np.shape(test_fea))
```

```
(5933, 128, 64)
(301, 128, 64)
```

In [10]:

```
meanperson = np.reshape(np.mean(train_fea, axis=0), (-1, 1));
print(meanperson.shape)
fig = plt.figure(figsize=[5, 5])
ax = fig.add_subplot(1, 1, 1)
meanperson_im = np.reshape(meanperson, (128, 64))
ax.imshow(meanperson_im.transpose(), cmap=plt.get_cmap('gray'))
ax.set_axis_off()
ax.set_title('A Very Average Person');
```

(8192, 1)

A Very Average Person



In [11]:

```
nsamples, nx, ny = train_fea.shape
d2_train_dataset = train_fea.reshape((nsamples,nx*ny))

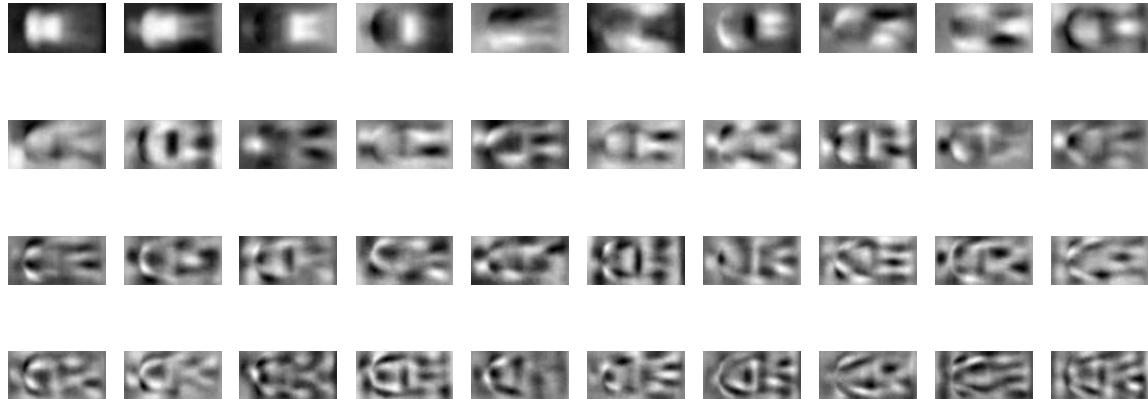
nsamples, nx, ny = test_fea.shape
d2_test_dataset = test_fea.reshape((nsamples,nx*ny))

nsamples, nx, ny = test_pro.shape
d2_probe_dataset = test_pro.reshape((nsamples,nx*ny))

pca = decomposition.PCA()
pca.fit(d2_train_dataset)
transformed = pca.transform(d2_train_dataset)
transformed_test = pca.transform(d2_test_dataset)
transformed_probe = pca.transform(d2_probe_dataset)
```

In [12]:

```
fig = plt.figure(figsize=[20, 8])
for i in range(40):
    ax = fig.add_subplot(4, 10, i + 1)
    pc = np.reshape(pca.components_[i,:], (128, 64))
    ax.imshow(pc.transpose(), cmap=plt.get_cmap('gray'))
    ax.set_axis_off()
```

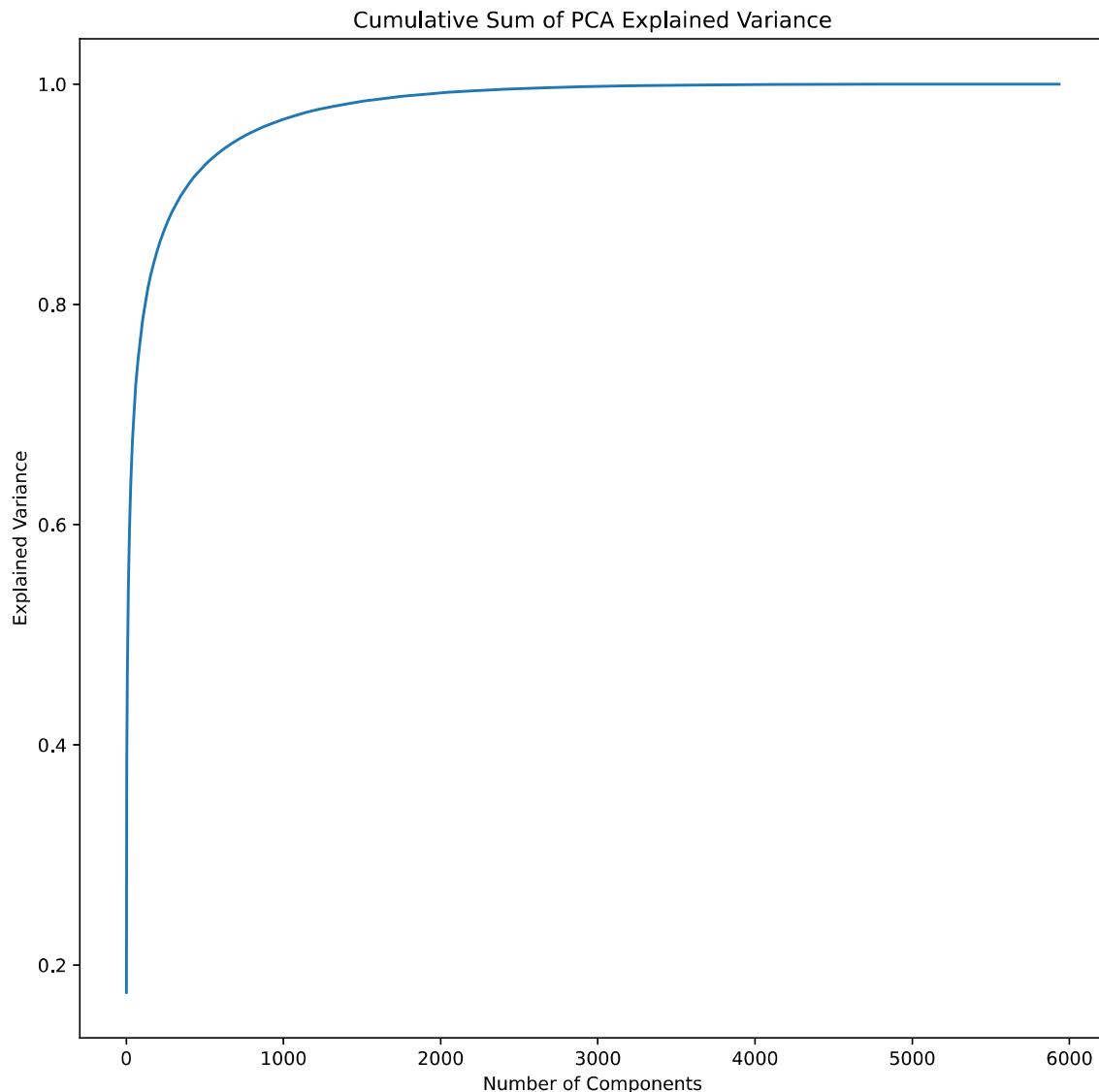


In [13]:

```
cumulative_sum = np.cumsum(pca.explained_variance_ratio_, axis=0)
fig = plt.figure(figsize=[10, 10])
ax = fig.add_subplot(1, 1, 1)
ax.plot(cumulative_sum)
ax.set_title('Cumulative Sum of PCA Explained Variance')
ax.set_ylabel('Explained Variance')
ax.set_xlabel('Number of Components')
```

Out[13]:

Text(0.5, 0, 'Number of Components')



In [14]:

```
top90 = np.where(cumulative_sum > 0.90)[0][0]
print('90% in ' + '%d' % (top90+1) + ' components')
top95 = np.where(cumulative_sum > 0.95)[0][0]
print('95% in ' + '%d' % (top95+1) + ' components')
top99 = np.where(cumulative_sum > 0.99)[0][0]
print('99% in ' + '%d' % (top99+1) + ' components')
```

90% in 355 components
 95% in 715 components
 99% in 1832 components

In [15]:

```
print(train_fea.shape)
```

(5933, 128, 64)

In [16]:

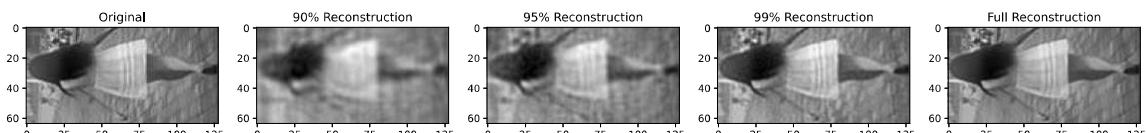
```
fig = plt.figure(figsize=[20, 5])
ax = fig.add_subplot(1, 5, 1)
ax.imshow(np.reshape(d2_train_dataset[0,:] - pca.mean_, (128, 64)).transpose(), cmap=plt.get_cmap('gray'))
ax.set_title('Original');

ax = fig.add_subplot(1, 5, 2)
ax.imshow(np.reshape(pca.components_[0:top90,:].transpose().dot(np.reshape(transformed[0,0:top90], (-1, 1))), (128, 64)).transpose(), cmap=plt.get_cmap('gray'))
ax.set_title('90% Reconstruction');

ax = fig.add_subplot(1, 5, 3)
ax.imshow(np.reshape(pca.components_[0:top95,:].transpose().dot(np.reshape(transformed[0,0:top95], (-1, 1))), (128, 64)).transpose(), cmap=plt.get_cmap('gray'))
ax.set_title('95% Reconstruction');

ax = fig.add_subplot(1, 5, 4)
ax.imshow(np.reshape(pca.components_[0:top99,:].transpose().dot(np.reshape(transformed[0,0:top99], (-1, 1))), (128, 64)).transpose(), cmap=plt.get_cmap('gray'))
ax.set_title('99% Reconstruction');

ax = fig.add_subplot(1, 5, 5)
ax.imshow(np.reshape(pca.components_[:, :].transpose().dot(np.reshape(transformed[0,:], (-1, 1))), (128, 64)).transpose(), cmap=plt.get_cmap('gray'))
ax.set_title('Full Reconstruction');
```



In [17]:

```
transformed_train_90 = transformed[:, 0:top90]

transformed_test = pca.transform(d2_test_dataset)
transformed_test_90 = transformed_test[:, 0:top90]

transformed_probe = pca.transform(d2_probe_dataset)
transformed_probe_90 = transformed_probe[:, 0:top90]

distance = np.sqrt(np.sum((transformed_train_90 - transformed_test_90[0,:])**2, axis=1))

index_min = np.argmin(distance)

print(train_gnd[index_min])
print(test_gnd[0])
```

0231
1200

CMC for PCA - 90

In [18]:

```
vector = np.vectorize(np.int)
```

```
ID_1 = vector(np.array(test_gnd))
ID_2 = vector(np.array(test_pro_gnd))
Feat_1 = transformed_test_90
Feat_2 = transformed_probe_90
print(Feat_1)
print(Feat_2)
```

```
[[ -8.49220617e+02  1.83749737e+02 -6.54313054e+02 ... -4.58680802e+01
   -1.09986638e+02 -7.86400808e+01]
 [-3.64926407e+02 -1.03960456e+03  1.04404176e+01 ... -3.31126700e+01
   7.65057545e-01 -5.08426061e+01]
 [ 1.88868883e+03  2.64765370e+03  1.05595416e+02 ...  2.46982324e+01
  -5.00788847e+01  8.52737718e+01]
 ...
 [-1.70274140e+03 -1.14014197e+03 -9.44224282e+02 ...  1.27089824e+02
  -9.76317538e+00 -2.13296224e+01]
 [-5.11923554e+02  6.92347505e+02 -7.08931015e+02 ... -3.66523329e+01
  -9.46441361e+01  7.22179543e+01]
 [ 8.68886202e+02 -4.64037805e+02  2.11727342e+03 ... -7.33490915e+00
  -2.98766253e+01 -1.13083337e+02]]
 [[ -1.01270063e+03  1.55429417e+02 -6.78405830e+02 ...  9.97964129e+01
   2.40295361e+01 -4.31671586e-01]
 [-2.78922823e+03  2.67592527e+03  1.25071424e+03 ...  7.20875117e+01
  -6.13149251e+01 -2.35690161e+01]
 [ 3.16695051e+03  5.79911683e+02 -8.05360941e+02 ... -4.89490968e+01
  5.54554675e+01 -1.22451800e+02]
 ...
 [ 5.79157766e+02 -1.24738571e+03 -1.50131049e+03 ... -1.73412096e+02
  1.48557748e+02  4.14689706e+01]
 [ 2.73372195e+03  2.29472244e+02 -1.27164897e+03 ...  1.61053500e+01
  8.37480288e+00 -6.51915946e+01]
 [-9.61418338e+02  2.55551297e+02  9.86341587e+02 ...  3.59300290e+01
  -1.09596689e+02  2.23187980e+01]]
```

In [19]:

```
# storage for ranked histogram
ranked_histogram = np.zeros(len(test_gnd))

# Loop over all IDs in the probe set
for i in range(len(ID_2)):
    # get the true ID of this sample
    true_ID = ID_2[i]
    print('Searching for ID %d' % (true_ID))

    # get the distance between the current probe and the whole gallery, L1 distance here. Note that L1
    # may not always be the best choice, so consider your distance metric given your problem
    dist = np.sqrt(np.sum(((Feat_2[:] - Feat_1[i])**2), axis=1)) #This one needs to change - Too Large?
    print('Distance between source feature and all target features:')
    print(dist)

    # get the sorted order of the distances
    a = np.argsort(dist)
    # apply the order to the gallery IDs, such that the first ID in the list is the closest, the second
    # ID is the second closest, and so on
    ranked = ID_1[a]
    print('Ranked IDs for query:')
    print(a)

    # find the location of the True Match in the ranked list
    ranked_result = np.where(ranked == true_ID)[0][0]
    print(ranked_result)

    # store the ranking result in the histogram
    ranked_histogram[ranked_result] += 1
    print('')

print(ranked_histogram)
```

009952 6114.93845201
 6266.9726034 6878.03048626 5789.24522253 8712.48237164 6210.23814123
 6220.2664637 6507.41174164 4770.2778351 7267.97085443 5522.22533897
 5702.19139662 4889.42695119 6642.17449823 4936.06796975 5300.63874506
 5355.49511911 6589.41344298 5854.43812857 5427.66251618 5585.26508857
 8177.25032289 5415.62065228 6188.04224032 6601.65500431 5707.74718017
 6093.11256623 4651.43321237 6561.3571771 6558.41829815 8420.91705063
 6107.52400439 6972.88941827 6471.6148855 5657.88268721 5213.11514206
 6343.68468744 7265.22050182 6662.37638822 5660.13185779 4827.90542267
 6472.73494776 4909.46663359 6441.98589465 6016.63402064 4930.98465906
 4953.82593793 5747.98961603 5826.82492682 5615.4109062 5246.64424561
 5487.32739373]

Ranked IDs for query:

[116 105 171 19 147 3 73 199 245 117 238 276 128 187 180 120 235 161
 119 129 257 151 30 241 91 289 12 82 236 261 95 158 291 176 294 263
 79 295 153 38 208 227 149 111 45 34 48 122 17 103 178 72 181 31
 28 198 209 131 88 168 102 284 154 60 299 127 27 225 148 93 240 205
 264 86 172 196 215 200 243 11 92 265 4 74 101 195 98 242 206 271
 268 53 66 54 300 56 191 183 50 110 0 184 259 140 118 231 222 192
 232 36 269 207 170 298 90 146 70 26 283 288 41 224 87 229 260 274
 237 71 40 137 296 14 218 252 177 175 85 297 150 211 39 55 267 5
 234 59 142 65 230 210 115 2 155 49 8 61 124 293 29 201 52 109
 44 275 159 280 249 23 247 58 68 57 16 63 213 272 254 255 24 21
 141 162 250 104 64 25 239 285 80 194 13 193 75 248 97 106 37 292
 246 160 43 282 290 125 133 203 202 20 256 219 157 156 78 278 277 134
 130 46 266 273 185 32 262 287 221 226 233 144 165 10 166 18 67 204
 152 51 217 197 6 251 35 107 212 223 121 214 281 83 182 84 138 108
 77 96 7 164 190 112 167 33 173 216 286 258 220 179 132 62 169 81
 123 89 22 145 100 9 113 188 163 126 1 174 189 94 99 15 186 143
 228 76 139 135 47 114 270 244 42 136 69 279 253]

137

Searching for ID 1498

Distance between source feature and all target features:

[4769.11920122 6383.03225568 7542.55162014 5461.59939271 4758.93015124
 4525.23800913 5429.73644537 6510.98174194 4878.44176079 5259.67694557
 5522.36831873 7195.01645956 7221.75318468 5505.74935224 5141.7682297
 6212.44689428 5760.98491324 4830.17434072 4449.34857922 6129.68067495
 4554.68470074 4752.6519907 5252.52144723 6137.64790497 4919.25614282
 4737.05308449 6648.96476012 5441.64869411 6912.1853546 5845.60275122
 4998.75634617 6128.17915525 6173.76290707 7098.36144415 5594.474193
 5978.71616344 6439.51317675 7659.76932264 5571.13842284 6173.66602713
 5005.26512689 5090.7520303 6892.41181706 5321.44129064 4756.96836201
 4871.76853047 5280.06595128 7329.54328752 4403.06911347 4367.92722797
 4915.81966796 6341.47163142 5353.26084252 4609.30605631 6156.42346433
 6300.30687496 7022.86511363 4671.86719175 8117.02861366 4967.20962681
 6098.33514561 4883.65994633 5231.3058021 4435.04478967 4429.63659408
 5918.8881855 5002.85382662 7666.12638023 5218.08508425 6175.26821861
 4615.96688006 4888.39406826 5709.67640702 5410.80759363 6289.44542563
 6775.9108819 6714.00213646 6002.6958951 4371.33467376 5873.1655486
 7826.90824666 4982.82743491 5251.93467675 6020.97100476 6105.68249339
 6825.75044207 4276.87460343 4382.8669824 6501.0416463 8249.92558241
 4768.58457039 4806.87799223 4847.93815516 4823.14532494 6727.65173982
 4332.94898755 5233.67214818 4786.48593489 5943.58938505 7465.03070636
 6120.99819815 4953.3938561 5269.03053616 5454.63492838 6254.96249167
 5906.4790874 3856.3973388 4686.79211542 4890.74766188 4719.92691786
 6062.12875865 7126.74511215 5966.66758378 5878.54783306 9283.97403929
 7263.61860526 5639.94121107 5495.46202476 5046.01155724 6169.39199707
 7488.08698069 5032.87917646 4368.95942544 6524.6742911 4392.69767207
 5140.64132749 6359.82402363 6014.03606129 6357.08006148 5003.7024815
 6053.6861966 5388.331544 6391.0800076 5260.81015074 7031.19759127

7127.71491923 5867.01956998 6934.43847931 5858.87506503 7438.84907527
 5456.42774007 7246.58355343 4983.83852535 6066.37115359 5713.55784367
 9101.5295083 4495.48468754 5758.55260959 5591.87870131 6737.53493052
 5413.72074548 5963.10972729 5326.16150445 6533.17351584 7261.53747831
 5556.32716403 5968.39640461 6364.09748926 5109.59815883 7510.1963714
 7179.74485527 6525.6015072 5122.26197022 8352.34964643 6920.08289239
 7057.54888164 7373.00226489 5721.45966164 5417.36439416 4832.95386956
 5987.01543958 5484.78622812 7279.39314785 5383.59718935 6483.09860764
 4368.83059221 5462.60703452 5201.8454082 5715.50339692 5747.31795136
 4709.96307102 5683.87494544 5075.40090045 6462.30075999 6253.58098806
 5778.67849951 7821.0445502 5670.48202318 5071.78751246 6666.5307645
 7449.39996534 5250.7076178 5799.37758295 4389.5619478 5434.39962631
 4484.42631591 5259.35368695 6363.19749801 7731.49785904 5730.55076307
 5230.37903837 5518.08891908 5881.92180249 4298.15530109 6218.64804572
 5922.85104972 4919.33988228 4990.70755094 5548.11732313 4771.24938666
 4491.71591924 5647.73284118 5199.76105948 6213.79172612 4925.57270313
 4682.02947152 5627.41712592 4501.75918007 4703.60955814 5398.47561943
 6527.26204644 4912.16199978 6567.22332344 4345.5005912 5601.00556195
 4922.55357284 6033.71318841 5131.65260149 5748.06282082 4414.1506663
 5574.81531146 4656.11615632 8026.14915795 5040.59493778 5712.84352546
 5006.17903968 5765.23575127 5142.81954002 5477.65416907 4668.59803571
 4500.4027123 5072.87927679 6150.39593792 4203.15977983 7470.40016155
 5897.60720012 4938.79921156 3805.44080935 3826.96957468 4642.66738834
 7338.03840216 5789.62132692 4788.78839039 6753.3230159 6922.06803059
 4158.13125729 4878.0251065 4762.45884721 6772.43195684 6077.43528197
 5141.54885976 8139.80659042 5712.91321875 5033.61723766 4468.47849419
 5846.96798831 5562.91410316 5634.46049593 4409.2431651 6006.64908334
 6512.96608824 4340.7631233 5154.18623138 6312.84480328 5149.60689762
 6468.75776234 4218.28554511 5602.47709996 4467.45891035 6577.90719931
 7293.34464693 4891.87314128 4940.30487648 6841.79222534 6778.2882922
 5396.44244158 5393.96528526 4768.29473962 5013.1917369 5072.597718
 7542.52247045 7113.34178441 4581.50912756 4917.91791274 4499.1872816
 6485.69469804 5514.01829803 7565.67912552 4714.17243089 6703.06216482
 4991.678484]

Ranked IDs for query:

[247 248 106 255 243 276 86 203 95 271 223 49 175 122 78 87 193 124
 48 268 229 64 63 18 278 264 195 210 146 294 240 217 5 20 292 53
 70 249 231 239 57 215 107 218 180 298 109 25 21 44 4 257 287 90
 0 209 97 252 91 93 17 169 92 45 256 8 61 71 108 281 221 50
 293 24 206 225 214 246 282 101 59 81 142 207 300 30 66 129 40 235
 288 121 263 233 118 188 289 241 182 41 158 162 227 125 260 14 237 274
 272 212 177 68 200 62 96 191 82 22 196 9 133 102 46 43 152 52
 173 131 286 285 219 73 150 168 6 194 27 103 140 3 176 238 171 117
 13 296 201 10 208 155 266 38 230 148 34 224 277 216 267 116 211 187
 181 72 234 262 144 178 167 199 179 228 147 16 236 185 251 192 29 265
 138 136 79 113 202 245 105 65 205 98 151 112 156 35 170 77 269 127
 83 226 130 110 143 259 60 84 100 31 19 23 242 54 119 39 32 69
 15 213 204 184 104 74 55 273 51 128 126 197 157 1 132 36 183 275
 174 295 88 7 270 123 161 220 153 222 279 26 189 299 76 94 149 253
 258 75 284 85 283 42 28 164 254 137 56 134 165 33 291 111 135 160
 11 12 141 154 115 172 280 47 250 166 139 190 99 244 120 159 290 2
 297 37 67 198 186 80 232 58 261 89 163 145 114]

45

Searching for ID 1499

Distance between source feature and all target features:

[4108.16410418 5911.15536052 6588.95472756 4437.79964932 4398.19558477
 5015.29888309 5308.17057637 5255.31578711 4737.16792309 5348.18643421
 5347.82543269 6171.97273503 6046.01142056 5127.62456974 5446.16244525
 6133.20463708 5185.87303461 4474.10434416 5289.20318488 5602.47832398
 4787.51852049 4904.73861536 5003.84250975 6905.70401047 4953.26371972

5201.64796192 5006.75952073 5401.6738461 6534.32186368 5377.96389735
 4656.89465022 4911.22297281 5387.55546948 5376.77784553 4393.11111696
 4945.36689831 5279.19981884 6848.70598795 4947.75595743 4666.48650384
 4021.8138791 4969.98675473 6203.63468554 6086.30226017 5066.21195315
 5114.80623664 5460.57199638 6319.1300203 4550.53070132 5729.1629992
 5330.20809774 6519.52291546 5560.45327176 5522.47965752 5911.5063926
 5006.09356479 6676.42266763 5280.04374488 7571.14184489 6074.96135603
 5882.36516399 5344.55200912 5082.44913844 5779.33354448 5377.31400593
 6452.81178969 4408.42073427 6461.49512891 5766.2180786 5752.23509379
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 5409.30201902 6065.22720692 5508.4873737 4801.12286217 5388.77779546
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 5021.31843058 4192.66962287 4768.56001918 5600.13467913 6686.28367628
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 5503.78090658 5724.88040927 5043.74985135 5288.65058725 6242.53156306
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 4761.87118952 5439.41699828 6018.96767336 5577.50674328 4236.99994485
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 4179.17319139 5761.78051622 5162.48008602 6194.09350456 6162.33654347
 7384.74974366 5083.04054941 4962.94202932 5170.20121132 6558.3513186
 5287.51005231 5538.36394109 5927.89044333 5514.96748061 6808.09038217
 4920.18026323 5454.56842393 5774.7372006 4992.52495217 5804.84483528
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 6766.15814166 5769.05137498 5349.54890603 5015.89023111 5329.49586061
 5312.9717157 5096.14118614 6034.79276374 4955.40878744 6031.04628326
 5492.38103831 4421.44022406 5107.50627882 5308.97443418 5910.11741887
 4490.880087 4751.28927681 6060.41163971 5181.78798607 5765.06955709
 5021.9742683 8425.92130724 5403.01161569 5479.90628634 5356.77515953
 6073.80868505 4891.98039523 5134.07762324 4561.69552702 4792.94954996
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 4135.10477759 5110.80292932 4917.96014791 4882.43108745 5377.73284515
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 4893.01776077 5757.52807015 6223.09129595 5372.08055486 5738.93318274
 4511.00369704 5545.18253646 5299.00632493 4828.46999099 5594.70833879
 5628.51491104 4481.41385631 4695.66442343 5111.31275204 5662.20981021
 5142.62708777 4929.56300494 4924.67525652 5425.9043373 4490.38058173
 5565.79437174 4555.63610284 7273.92205684 5897.26382429 5402.35588249
 3952.39603324 5352.7809687 4854.18477353 5088.20841951 5018.60151664
 4958.55178938 5168.91519434 5815.43771182 4356.17362785 6200.88211458
 4730.73232114 5438.10708055 5529.3289125 5289.14454882 5367.66370411
 7320.99982638 5891.75528143 5494.08688647 6492.94660778 6115.15559164
 4518.53611612 4770.24636129 4521.2455312 5561.81564759 5431.33872366
 5851.12653529 6960.98211221 5708.982936 5380.34043209 5232.52509684
 5553.91613062 4703.2298637 6183.36975967 3722.33823568 5073.2336761
 6222.25295203 4804.84889788 5381.66585157 5814.77261616 4685.42502306
 5734.16519708 4267.73810762 4669.51127884 5042.61769553 5917.82635572
 5610.18033802 5327.94493298 6000.29771556 6207.95407515 7221.05709761
 4795.01117647 5310.19461473 4802.41731467 5719.12116891 4702.55710568
 6033.26856609 5774.57867243 5588.76234613 4952.93336998 5165.81266269
 6288.3679527 5861.79640957 5900.20144359 5154.35812719 5964.82743412
 4566.86094325]

Ranked IDs for query:

[268 235 40 0 200 95 140 86 129 276 243 207 34 97 4 66 176 195
 3 122 106 91 17 221 229 180 215 255 257 48 231 193 300 124 30 39
 277 274 222 289 266 245 8 181 125 87 256 117 73 20 194 285 78 287
 271 92 116 218 237 96 70 203 191 210 209 21 31 202 155 227 226 35]

38	293	24	173	240	147	41	205	81	158	131	22	55	26	5	168	239	85
185	206	74	278	102	44	269	62	146	238	171	177	138	199	201	223	45	93
13	192	225	298	142	294	105	90	241	148	107	183	16	121	25	109	264	7
72	36	57	112	150	103	248	18	217	6	178	286	170	281	169	50	61	10
9	167	164	236	189	249	213	33	64	204	29	263	272	32	79	82	27	234
187	161	75	228	259	246	126	119	14	156	46	134	188	208	175	252	100	77
153	53	247	151	216	108	265	52	258	230	71	128	292	219	88	19	280	220
224	137	197	132	262	288	101	49	113	275	214	69	162	211	141	184	68	166
291	157	63	84	136	159	118	273	242	196	98	260	296	94	60	110	251	233
297	179	1	54	279	152	139	299	282	127	174	290	172	12	182	76	190	59
43	83	133	254	15	111	144	11	267	198	143	244	42	283	270	212	104	115
295	80	47	120	123	65	67	253	51	28	160	149	130	2	163	56	89	99
165	154	37	23	261	284	135	232	250	145	58	114	186]					

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Searching for ID 1500

Distance between source feature and all target features:

[4983.21840189	6065.64286489	6180.20255619	3948.77364065	4641.25489815
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6279.60678962	5984.11325915	4883.08756573	5120.07594596	5289.95123869
6383.93079907	5478.75713817	5273.44787706	6108.94836956	4559.35778475
6169.37181362	5261.25536175	6432.83783848	5905.93417918	5451.04454653
6084.75882089	5702.47644029	5379.43573346	5115.32912	5769.94879121
4457.76030458	4202.12499442	6282.89025037	6773.80331112	4008.61001221
6310.60625955	5649.42203408	6151.95806354	4598.55286983	5502.80863489
4442.98163368	4904.65398985	7775.64325771	5852.8939449	5168.66363438
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6009.76703065	5441.7998477	5064.84609109	5680.24027161	5319.39334376
4633.14249138	4910.89593698	6332.86806389	5282.74979802	5466.15511961
4763.507063	5539.99650035	7418.19151969	4860.29164468	7322.75590779
4924.03120784	4824.87591289	4479.66921427	5571.77387232	5749.61855646
6296.88486799	6413.00326464	7343.52047498	5319.47146437	4807.48771885
6338.14493297	6564.91294956	3960.15067061	5928.12909253	6403.11027927
5660.23761753	5107.62323411	5160.73205975	4213.79884263	6737.50791232
5014.95907641	4367.57764845	4676.84452031	4703.17606235	6864.87015104
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6422.92198767	4996.91435326	3693.01962046	4389.77595003	4543.51530314
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5376.67712531	5205.4233334	5901.45043052	6659.1026677	6814.9442576
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5494.34204754	4914.81376937	4748.84283566	4773.30040593	5603.45495822
6401.00230939	5451.99071817	5704.6065425	7185.27366489	6288.87144988
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5023.34829801	4714.44723927	6239.43504815	6250.85446843	6286.37307638
5056.18816269	4356.10082061	5621.76599639	5672.5256352	5791.52785721
4213.0987223	5703.25065577	5357.41693641	4881.17771203	4512.53733343
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5423.90074521	5540.9397105	5676.78693348	5955.34729139	4230.37851067
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5101.85537553	5757.52583707	5654.7845469	4583.66954504	4293.71203129

```

5578.75828661 5850.82560484 5535.71764188 6294.02205561 4044.56344236
4736.43770061 5745.33549531 3844.47908882 6538.15212 4473.60738574
4675.16335944 4872.06345788 6122.07249763 5783.98170595 5903.0093815
4228.83290766 5595.38019378 5476.54749097 4228.8909983 6162.34213118
4560.36990361 4619.46342232 5824.91558791 4098.65469662 7708.22292545
4050.21019562 5828.98335951 5167.9784617 5868.41727007 5353.87522765
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4975.23269817 6903.6058645 5503.88834342 4495.49498639 5241.79106341
6539.30530883 6241.82881018 5886.10591284 5375.91763261 4912.44262002
5193.31916097 4944.34001533 6586.64702927 5852.36501183 6507.78569065
4191.12405296]

```

Ranked IDs for query:

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[102 259 227 3 117 82 148 34 129 224 245 168 208 263 243 300 31 180
 88 235 238 199 276 105 219 209 176 91 151 103 131 53 264 40 30 48
229 72 288 184 104 19 240 206 274 272 218 38 241 60 4 128 267 230
 92 257 93 171 120 225 157 65 158 119 50 79 191 71 95 205 252 116
185 68 187 231 147 183 12 41 118 61 294 156 70 45 273 296 149 210
285 0 153 101 133 146 90 170 250 175 5 122 57 269 52 215 154 86
 28 194 13 268 124 260 8 150 87 247 211 44 203 130 295 51 141 111
200 283 207 109 289 21 17 106 63 14 193 97 59 78 125 249 182 293
110 27 271 195 284 56 24 161 64 237 16 213 155 39 287 49 140 277
222 66 196 107 54 73 220 236 261 159 152 177 108 36 217 85 282 178
197 165 58 167 26 256 181 162 255 265 251 226 74 134 216 192 29 233
179 142 242 246 127 221 298 43 248 292 112 234 23 83 198 11 201 55
138 214 1 96 25 144 18 232 9 98 266 37 281 239 20 2 212 123
262 172 280 291 173 10 32 137 174 164 223 75 35 121 62 80 6 254
275 202 15 160 84 76 100 22 188 46 169 99 299 228 290 190 81 297
115 135 113 258 132 278 89 33 143 7 114 270 94 286 47 204 145 189
136 163 126 69 77 166 139 253 67 279 244 42 186]
```

15

```
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 1. 1. 1. 0. 4. 1. 1. 1. 3. 2. 2. 2. 0. 2. 0. 2. 2. 2.
 0. 1. 1. 1. 0. 1. 1. 2. 5. 1. 0. 0. 2. 1. 0. 1. 3. 0.
 1. 4. 2. 1. 0. 1. 2. 1. 1. 1. 1. 1. 1. 2. 1. 0. 0. 2. 2.
 1. 2. 0. 1. 1. 2. 0. 1. 1. 1. 2. 2. 3. 1. 0. 0. 0. 0. 4.
 2. 1. 1. 1. 0. 1. 0. 0. 0. 0. 0. 3. 1. 1. 0. 0. 0. 0. 0. 2.
 0. 1. 1. 0. 0. 2. 0. 1. 0. 1. 0. 2. 1. 0. 0. 1. 0. 1. 1.
 2. 1. 0. 2. 0. 0. 0. 0. 1. 0. 0. 0. 1. 0. 1. 0. 0. 0. 2. 3.
 1. 0. 0. 2. 1. 0. 0. 2. 1. 1. 1. 0. 0. 1. 1. 1. 0. 1. 0. 1.
 1. 0. 0. 0. 1. 0. 0. 1. 0. 0. 1. 1. 2. 0. 1. 0. 1. 0. 1. 2.
 0. 0. 0. 0. 1. 3. 0. 2. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1. 0.
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 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
```

In [20]:

```
print(Feat_1.shape)
```

(301, 354)

In [21]:

```
print(Feat_2.shape)
```

(301, 354)

In [22]:

```
cmc = np.zeros(301)
for i in range(301):
    cmc[i] = np.sum(ranked_histogram[::(i + 1)])
```

```
print(cmc)
```

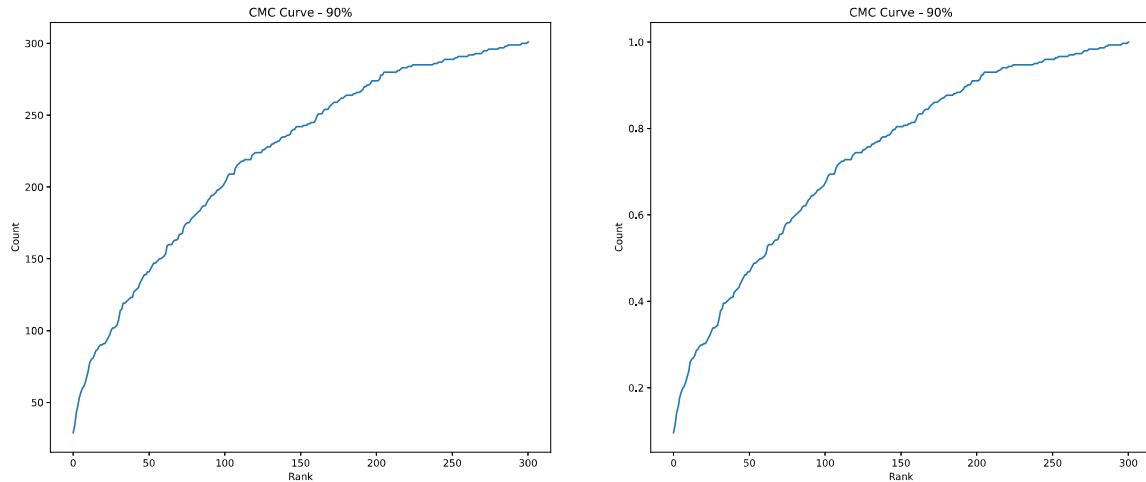
```
[ 29.  34.  43.  47.  53.  57.  60.  61.  64.  68.  72.  78.  80.  81.
  83.  86.  87.  89.  90.  90.  91.  91.  93.  95.  97.  100.  102.  102.
  103.  104.  108.  114.  115.  119.  119.  120.  121.  122.  123.  123.  127.  128.
  129.  130.  133.  135.  137.  139.  139.  141.  141.  143.  145.  147.  147.  148.
  149.  150.  150.  151.  152.  154.  159.  160.  160.  160.  162.  163.  163.  164.
  167.  167.  168.  172.  174.  175.  175.  176.  178.  179.  180.  181.  182.  183.
  184.  186.  187.  187.  189.  191.  192.  194.  194.  195.  196.  198.  198.  199.
  200.  201.  203.  205.  208.  209.  209.  209.  209.  213.  215.  216.  217.  218.
  218.  219.  219.  219.  219.  222.  223.  224.  224.  224.  224.  224.  226.
  226.  227.  228.  228.  228.  230.  230.  231.  231.  232.  232.  234.  235.  235.
  235.  236.  236.  237.  239.  240.  240.  242.  242.  242.  242.  242.  243.  243.
  243.  244.  244.  245.  245.  245.  247.  250.  251.  251.  251.  253.  254.  254.
  254.  256.  257.  258.  259.  259.  259.  260.  261.  262.  262.  263.  264.  264.
  264.  264.  265.  265.  266.  266.  266.  267.  268.  270.  270.  271.  271.
  272.  274.  274.  274.  274.  274.  275.  275.  278.  278.  280.  280.  280.  280.
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  290.  290.  291.  291.  291.  291.  291.  291.  291.  292.  292.  292.  292.  293.
  293.  293.  293.  293.  294.  295.  295.  295.  296.  296.  296.  296.  296.
  296.  297.  297.  297.  297.  298.  298.  299.  299.  299.  299.  299.  299.
  299.  299.  300.  300.  300.  300.  301.]
```

In [23]:

```
fig = plt.figure(figsize=[20, 8])
ax = fig.add_subplot(1, 2, 1)
ax.plot(cmc)
ax.set_xlabel('Rank')
ax.set_ylabel('Count')
ax.set_title('CMC Curve - 90%')
ax = fig.add_subplot(1, 2, 2)
ax.plot(cmc/len(test_gnd))
ax.set_xlabel('Rank')
ax.set_ylabel('Count')
ax.set_title('CMC Curve - 90%')
```

Out[23]:

Text(0.5, 1.0, 'CMC Curve - 90%')



CMC for PCA-95

In [24]:

```
transformed_test = pca.transform(d2_test_dataset)
transformed_test_95 = transformed_test[:, 0:top95]

transformed_probe = pca.transform(d2_probe_dataset)
transformed_probe_95 = transformed_probe[:, 0:top95]
```

In [25]:

```
# storage for ranked histogram
ranked_histogram = np.zeros(len(test_gnd))

# Loop over all IDs in the probe set
for i in range(len(ID_2)):
    # get the true ID of this sample
    true_ID = ID_2[i]
    print('Searching for ID %d' % (true_ID))

    # get the distance between the current probe and the whole gallery, L1 distance here. Note that L1
    # may not always be the best choice, so consider your distance metric given your problem
    dist = np.sqrt(np.sum(((Feat_2[:] - Feat_1[i])**2), axis=1)) #This one needs to change - Too Large?
    print('Distance between source feature and all target features:')
    print(dist)

    # get the sorted order of the distances
    a = np.argsort(dist)
    # apply the order to the gallery IDs, such that the first ID in the list is the closest, the second
    # ID is the second closest, and so on
    ranked = ID_1[a]
    print('Ranked IDs for query:')
    print(a)

    # find the location of the True Match in the ranked list
    ranked_result = np.where(ranked == true_ID)[0][0]
    print(ranked_result)

    # store the ranking result in the histogram
    ranked_histogram[ranked_result] += 1
    print('')

print(ranked_histogram)
```

009952 6114.93845201
 6266.9726034 6878.03048626 5789.24522253 8712.48237164 6210.23814123
 6220.2664637 6507.41174164 4770.2778351 7267.97085443 5522.22533897
 5702.19139662 4889.42695119 6642.17449823 4936.06796975 5300.63874506
 5355.49511911 6589.41344298 5854.43812857 5427.66251618 5585.26508857
 8177.25032289 5415.62065228 6188.04224032 6601.65500431 5707.74718017
 6093.11256623 4651.43321237 6561.3571771 6558.41829815 8420.91705063
 6107.52400439 6972.88941827 6471.6148855 5657.88268721 5213.11514206
 6343.68468744 7265.22050182 6662.37638822 5660.13185779 4827.90542267
 6472.73494776 4909.46663359 6441.98589465 6016.63402064 4930.98465906
 4953.82593793 5747.98961603 5826.82492682 5615.4109062 5246.64424561
 5487.32739373]

Ranked IDs for query:

[116 105 171 19 147 3 73 199 245 117 238 276 128 187 180 120 235 161
 119 129 257 151 30 241 91 289 12 82 236 261 95 158 291 176 294 263
 79 295 153 38 208 227 149 111 45 34 48 122 17 103 178 72 181 31
 28 198 209 131 88 168 102 284 154 60 299 127 27 225 148 93 240 205
 264 86 172 196 215 200 243 11 92 265 4 74 101 195 98 242 206 271
 268 53 66 54 300 56 191 183 50 110 0 184 259 140 118 231 222 192
 232 36 269 207 170 298 90 146 70 26 283 288 41 224 87 229 260 274
 237 71 40 137 296 14 218 252 177 175 85 297 150 211 39 55 267 5
 234 59 142 65 230 210 115 2 155 49 8 61 124 293 29 201 52 109
 44 275 159 280 249 23 247 58 68 57 16 63 213 272 254 255 24 21
 141 162 250 104 64 25 239 285 80 194 13 193 75 248 97 106 37 292
 246 160 43 282 290 125 133 203 202 20 256 219 157 156 78 278 277 134
 130 46 266 273 185 32 262 287 221 226 233 144 165 10 166 18 67 204
 152 51 217 197 6 251 35 107 212 223 121 214 281 83 182 84 138 108
 77 96 7 164 190 112 167 33 173 216 286 258 220 179 132 62 169 81
 123 89 22 145 100 9 113 188 163 126 1 174 189 94 99 15 186 143
 228 76 139 135 47 114 270 244 42 136 69 279 253]

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Searching for ID 1498

Distance between source feature and all target features:

[4769.11920122 6383.03225568 7542.55162014 5461.59939271 4758.93015124
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Ranked IDs for query:

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 293 24 206 225 214 246 282 101 59 81 142 207 300 30 66 129 40 235
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 138 136 79 113 202 245 105 65 205 98 151 112 156 35 170 77 269 127
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 15 213 204 184 104 74 55 273 51 128 126 197 157 1 132 36 183 275
 174 295 88 7 270 123 161 220 153 222 279 26 189 299 76 94 149 253
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45

Searching for ID 1499

Distance between source feature and all target features:

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Ranked IDs for query:

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224	137	197	132	262	288	101	49	113	275	214	69	162	211	141	184	68	166
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241

Searching for ID 1500

Distance between source feature and all target features:

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Ranked IDs for query:

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15

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 1. 0. 1. 0. 0. 0. 0. 0. 0. 1. 0. 0. 0. 0. 1. 0. 0. 0. 0. 0.
 1. 1. 0. 0. 0. 1. 0. 0. 0. 0. 0. 0. 1. 0. 0. 0. 0. 0. 0. 1.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]

In [26]:

```
cmc = np.zeros(301)
for i in range(301):
    cmc[i] = np.sum(ranked_histogram[::(i + 1)])
```

```
print(cmc)
```

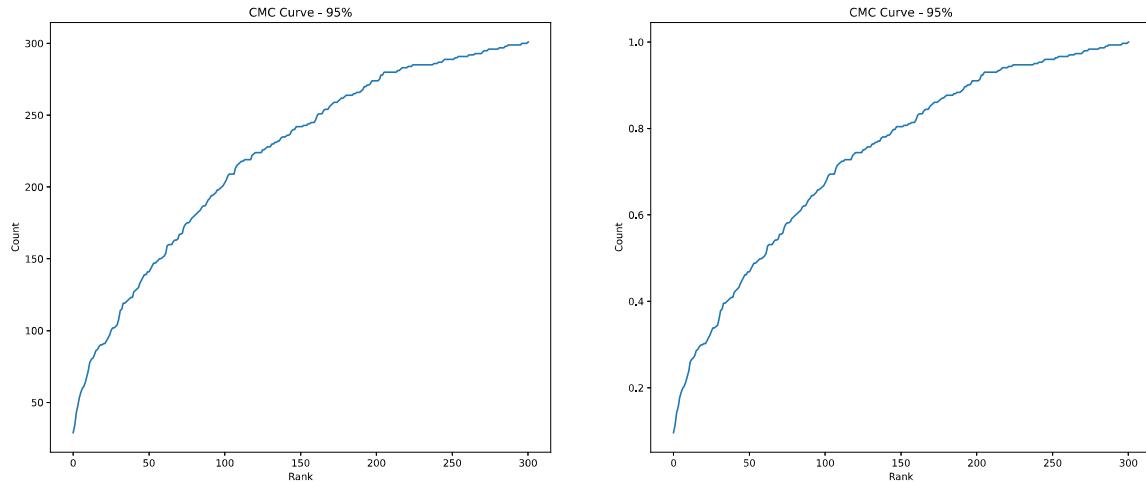
```
[ 29.  34.  43.  47.  53.  57.  60.  61.  64.  68.  72.  78.  80.  81.
  83.  86.  87.  89.  90.  90.  91.  91.  93.  95.  97.  100.  102.  102.
  103.  104.  108.  114.  115.  119.  119.  120.  121.  122.  123.  123.  127.  128.
  129.  130.  133.  135.  137.  139.  139.  141.  141.  143.  145.  147.  147.  148.
  149.  150.  150.  151.  152.  154.  159.  160.  160.  160.  162.  163.  163.  164.
  167.  167.  168.  172.  174.  175.  175.  176.  178.  179.  180.  181.  182.  183.
  184.  186.  187.  187.  189.  191.  192.  194.  194.  195.  196.  198.  198.  199.
  200.  201.  203.  205.  208.  209.  209.  209.  213.  215.  216.  217.  218.
  218.  219.  219.  219.  219.  222.  223.  224.  224.  224.  224.  224.  226.
  226.  227.  228.  228.  228.  230.  230.  231.  231.  232.  232.  234.  235.  235.
  235.  236.  236.  237.  239.  240.  240.  242.  242.  242.  242.  243.  243.
  243.  244.  244.  245.  245.  245.  247.  250.  251.  251.  251.  253.  254.  254.
  254.  256.  257.  258.  259.  259.  259.  260.  261.  262.  262.  263.  264.  264.
  264.  264.  265.  265.  266.  266.  266.  267.  268.  270.  270.  271.  271.
  272.  274.  274.  274.  274.  275.  275.  278.  278.  280.  280.  280.  280.  280.
  280.  280.  280.  281.  281.  282.  283.  283.  283.  283.  284.  284.  284.
  285.  285.  285.  285.  285.  285.  285.  285.  285.  285.  285.  285.  285.
  286.  286.  286.  287.  287.  287.  288.  289.  289.  289.  289.  289.  289.
  290.  290.  291.  291.  291.  291.  291.  291.  292.  292.  292.  292.  293.
  293.  293.  293.  294.  295.  295.  295.  296.  296.  296.  296.  296.  296.
  296.  297.  297.  297.  297.  298.  298.  299.  299.  299.  299.  299.  299.
  299.  299.  300.  300.  300.  300.  301.]
```

In [27]:

```
fig = plt.figure(figsize=[20, 8])
ax = fig.add_subplot(1, 2, 1)
ax.plot(cmc)
ax.set_xlabel('Rank')
ax.set_ylabel('Count')
ax.set_title('CMC Curve - 95%')
ax = fig.add_subplot(1, 2, 2)
ax.plot(cmc/len(test_gnd))
ax.set_xlabel('Rank')
ax.set_ylabel('Count')
ax.set_title('CMC Curve - 95%')
```

Out[27]:

Text(0.5, 1.0, 'CMC Curve - 95%')



CMC for PCA - 99

In [28]:

```
transformed_test = pca.transform(d2_test_dataset)
transformed_test_99 = transformed_test[:, 0:top99]

transformed_probe = pca.transform(d2_probe_dataset)
transformed_probe_99 = transformed_probe[:, 0:top99]
```

In [29]:

```
# storage for ranked histogram
ranked_histogram = np.zeros(len(test_gnd))

# Loop over all IDs in the probe set
for i in range(len(ID_2)):
    # get the true ID of this sample
    true_ID = ID_2[i]
    print('Searching for ID %d' % (true_ID))

    # get the distance between the current probe and the whole gallery, L1 distance here. Note that L1
    # may not always be the best choice, so consider your distance metric given your problem
    dist = np.sqrt(np.sum(((Feat_2[:] - Feat_1[i])**2), axis=1)) #This one needs to change - Too Large?
    print('Distance between source feature and all target features:')
    print(dist)

    # get the sorted order of the distances
    a = np.argsort(dist)
    # apply the order to the gallery IDs, such that the first ID in the list is the closest, the second
    # ID is the second closest, and so on
    ranked = ID_1[a]
    print('Ranked IDs for query:')
    print(a)

    # find the location of the True Match in the ranked list
    ranked_result = np.where(ranked == true_ID)[0][0]
    print(ranked_result)

    # store the ranking result in the histogram
    ranked_histogram[ranked_result] += 1
    print('')

print(ranked_histogram)
```

009952 6114.93845201
 6266.9726034 6878.03048626 5789.24522253 8712.48237164 6210.23814123
 6220.2664637 6507.41174164 4770.2778351 7267.97085443 5522.22533897
 5702.19139662 4889.42695119 6642.17449823 4936.06796975 5300.63874506
 5355.49511911 6589.41344298 5854.43812857 5427.66251618 5585.26508857
 8177.25032289 5415.62065228 6188.04224032 6601.65500431 5707.74718017
 6093.11256623 4651.43321237 6561.3571771 6558.41829815 8420.91705063
 6107.52400439 6972.88941827 6471.6148855 5657.88268721 5213.11514206
 6343.68468744 7265.22050182 6662.37638822 5660.13185779 4827.90542267
 6472.73494776 4909.46663359 6441.98589465 6016.63402064 4930.98465906
 4953.82593793 5747.98961603 5826.82492682 5615.4109062 5246.64424561
 5487.32739373]

Ranked IDs for query:

[116 105 171 19 147 3 73 199 245 117 238 276 128 187 180 120 235 161
 119 129 257 151 30 241 91 289 12 82 236 261 95 158 291 176 294 263
 79 295 153 38 208 227 149 111 45 34 48 122 17 103 178 72 181 31
 28 198 209 131 88 168 102 284 154 60 299 127 27 225 148 93 240 205
 264 86 172 196 215 200 243 11 92 265 4 74 101 195 98 242 206 271
 268 53 66 54 300 56 191 183 50 110 0 184 259 140 118 231 222 192
 232 36 269 207 170 298 90 146 70 26 283 288 41 224 87 229 260 274
 237 71 40 137 296 14 218 252 177 175 85 297 150 211 39 55 267 5
 234 59 142 65 230 210 115 2 155 49 8 61 124 293 29 201 52 109
 44 275 159 280 249 23 247 58 68 57 16 63 213 272 254 255 24 21
 141 162 250 104 64 25 239 285 80 194 13 193 75 248 97 106 37 292
 246 160 43 282 290 125 133 203 202 20 256 219 157 156 78 278 277 134
 130 46 266 273 185 32 262 287 221 226 233 144 165 10 166 18 67 204
 152 51 217 197 6 251 35 107 212 223 121 214 281 83 182 84 138 108
 77 96 7 164 190 112 167 33 173 216 286 258 220 179 132 62 169 81
 123 89 22 145 100 9 113 188 163 126 1 174 189 94 99 15 186 143
 228 76 139 135 47 114 270 244 42 136 69 279 253]

137

Searching for ID 1498

Distance between source feature and all target features:

[4769.11920122 6383.03225568 7542.55162014 5461.59939271 4758.93015124
 4525.23800913 5429.73644537 6510.98174194 4878.44176079 5259.67694557
 5522.36831873 7195.01645956 7221.75318468 5505.74935224 5141.7682297
 6212.44689428 5760.98491324 4830.17434072 4449.34857922 6129.68067495
 4554.68470074 4752.6519907 5252.52144723 6137.64790497 4919.25614282
 4737.05308449 6648.96476012 5441.64869411 6912.1853546 5845.60275122
 4998.75634617 6128.17915525 6173.76290707 7098.36144415 5594.474193
 5978.71616344 6439.51317675 7659.76932264 5571.13842284 6173.66602713
 5005.26512689 5090.7520303 6892.41181706 5321.44129064 4756.96836201
 4871.76853047 5280.06595128 7329.54328752 4403.06911347 4367.92722797
 4915.81966796 6341.47163142 5353.26084252 4609.30605631 6156.42346433
 6300.30687496 7022.86511363 4671.86719175 8117.02861366 4967.20962681
 6098.33514561 4883.65994633 5231.3058021 4435.04478967 4429.63659408
 5918.8881855 5002.85382662 7666.12638023 5218.08508425 6175.26821861
 4615.96688006 4888.39406826 5709.67640702 5410.80759363 6289.44542563
 6775.9108819 6714.00213646 6002.6958951 4371.33467376 5873.1655486
 7826.90824666 4982.82743491 5251.93467675 6020.97100476 6105.68249339
 6825.75044207 4276.87460343 4382.8669824 6501.0416463 8249.92558241
 4768.58457039 4806.87799223 4847.93815516 4823.14532494 6727.65173982
 4332.94898755 5233.67214818 4786.48593489 5943.58938505 7465.03070636
 6120.99819815 4953.3938561 5269.03053616 5454.63492838 6254.96249167
 5906.4790874 3856.3973388 4686.79211542 4890.74766188 4719.92691786
 6062.12875865 7126.74511215 5966.66758378 5878.54783306 9283.97403929
 7263.61860526 5639.94121107 5495.46202476 5046.01155724 6169.39199707
 7488.08698069 5032.87917646 4368.95942544 6524.6742911 4392.69767207
 5140.64132749 6359.82402363 6014.03606129 6357.08006148 5003.7024815
 6053.6861966 5388.331544 6391.0800076 5260.81015074 7031.19759127

7127.71491923 5867.01956998 6934.43847931 5858.87506503 7438.84907527
 5456.42774007 7246.58355343 4983.83852535 6066.37115359 5713.55784367
 9101.5295083 4495.48468754 5758.55260959 5591.87870131 6737.53493052
 5413.72074548 5963.10972729 5326.16150445 6533.17351584 7261.53747831
 5556.32716403 5968.39640461 6364.09748926 5109.59815883 7510.1963714
 7179.74485527 6525.6015072 5122.26197022 8352.34964643 6920.08289239
 7057.54888164 7373.00226489 5721.45966164 5417.36439416 4832.95386956
 5987.01543958 5484.78622812 7279.39314785 5383.59718935 6483.09860764
 4368.83059221 5462.60703452 5201.8454082 5715.50339692 5747.31795136
 4709.96307102 5683.87494544 5075.40090045 6462.30075999 6253.58098806
 5778.67849951 7821.0445502 5670.48202318 5071.78751246 6666.5307645
 7449.39996534 5250.7076178 5799.37758295 4389.5619478 5434.39962631
 4484.42631591 5259.35368695 6363.19749801 7731.49785904 5730.55076307
 5230.37903837 5518.08891908 5881.92180249 4298.15530109 6218.64804572
 5922.85104972 4919.33988228 4990.70755094 5548.11732313 4771.24938666
 4491.71591924 5647.73284118 5199.76105948 6213.79172612 4925.57270313
 4682.02947152 5627.41712592 4501.75918007 4703.60955814 5398.47561943
 6527.26204644 4912.16199978 6567.22332344 4345.5005912 5601.00556195
 4922.55357284 6033.71318841 5131.65260149 5748.06282082 4414.1506663
 5574.81531146 4656.11615632 8026.14915795 5040.59493778 5712.84352546
 5006.17903968 5765.23575127 5142.81954002 5477.65416907 4668.59803571
 4500.4027123 5072.87927679 6150.39593792 4203.15977983 7470.40016155
 5897.60720012 4938.79921156 3805.44080935 3826.96957468 4642.66738834
 7338.03840216 5789.62132692 4788.78839039 6753.3230159 6922.06803059
 4158.13125729 4878.0251065 4762.45884721 6772.43195684 6077.43528197
 5141.54885976 8139.80659042 5712.91321875 5033.61723766 4468.47849419
 5846.96798831 5562.91410316 5634.46049593 4409.2431651 6006.64908334
 6512.96608824 4340.7631233 5154.18623138 6312.84480328 5149.60689762
 6468.75776234 4218.28554511 5602.47709996 4467.45891035 6577.90719931
 7293.34464693 4891.87314128 4940.30487648 6841.79222534 6778.2882922
 5396.44244158 5393.96528526 4768.29473962 5013.1917369 5072.597718
 7542.52247045 7113.34178441 4581.50912756 4917.91791274 4499.1872816
 6485.69469804 5514.01829803 7565.67912552 4714.17243089 6703.06216482
 4991.678484]

Ranked IDs for query:

[247 248 106 255 243 276 86 203 95 271 223 49 175 122 78 87 193 124
 48 268 229 64 63 18 278 264 195 210 146 294 240 217 5 20 292 53
 70 249 231 239 57 215 107 218 180 298 109 25 21 44 4 257 287 90
 0 209 97 252 91 93 17 169 92 45 256 8 61 71 108 281 221 50
 293 24 206 225 214 246 282 101 59 81 142 207 300 30 66 129 40 235
 288 121 263 233 118 188 289 241 182 41 158 162 227 125 260 14 237 274
 272 212 177 68 200 62 96 191 82 22 196 9 133 102 46 43 152 52
 173 131 286 285 219 73 150 168 6 194 27 103 140 3 176 238 171 117
 13 296 201 10 208 155 266 38 230 148 34 224 277 216 267 116 211 187
 181 72 234 262 144 178 167 199 179 228 147 16 236 185 251 192 29 265
 138 136 79 113 202 245 105 65 205 98 151 112 156 35 170 77 269 127
 83 226 130 110 143 259 60 84 100 31 19 23 242 54 119 39 32 69
 15 213 204 184 104 74 55 273 51 128 126 197 157 1 132 36 183 275
 174 295 88 7 270 123 161 220 153 222 279 26 189 299 76 94 149 253
 258 75 284 85 283 42 28 164 254 137 56 134 165 33 291 111 135 160
 11 12 141 154 115 172 280 47 250 166 139 190 99 244 120 159 290 2
 297 37 67 198 186 80 232 58 261 89 163 145 114]

45

Searching for ID 1499

Distance between source feature and all target features:

[4108.16410418 5911.15536052 6588.95472756 4437.79964932 4398.19558477
 5015.29888309 5308.17057637 5255.31578711 4737.16792309 5348.18643421
 5347.82543269 6171.97273503 6046.01142056 5127.62456974 5446.16244525
 6133.20463708 5185.87303461 4474.10434416 5289.20318488 5602.47832398
 4787.51852049 4904.73861536 5003.84250975 6905.70401047 4953.26371972

5201.64796192 5006.75952073 5401.6738461 6534.32186368 5377.96389735
 4656.89465022 4911.22297281 5387.55546948 5376.77784553 4393.11111696
 4945.36689831 5279.19981884 6848.70598795 4947.75595743 4666.48650384
 4021.8138791 4969.98675473 6203.63468554 6086.30226017 5066.21195315
 5114.80623664 5460.57199638 6319.1300203 4550.53070132 5729.1629992
 5330.20809774 6519.52291546 5560.45327176 5522.47965752 5911.5063926
 5006.09356479 6676.42266763 5280.04374488 7571.14184489 6074.96135603
 5882.36516399 5344.55200912 5082.44913844 5779.33354448 5377.31400593
 6452.81178969 4408.42073427 6461.49512891 5766.2180786 5752.23509379
 4879.60917357 5568.81063984 5269.70167952 4782.33395435 5033.73069091
 5409.30201902 6065.22720692 5508.4873737 4801.12286217 5388.77779546
 6297.56890944 4988.65732989 5395.77129941 6099.89759815 5789.33234301
 5021.31843058 4192.66962287 4768.56001918 5600.13467913 6686.28367628
 5166.85489858 4468.11630436 4806.25139447 5119.69195425 5875.8718801
 4170.14718009 4869.7481447 4397.04119605 5846.18267134 6720.97973217
 5503.78090658 5724.88040927 5043.74985135 5288.65058725 6242.53156306
 5166.78940035 4455.62933986 5172.11763295 5545.46444113 5222.36601704
 5888.09159376 6154.19843623 5287.4022151 5730.31391426 7676.44208045
 6249.45722264 4810.23692748 4773.29098995 5812.80530925 5444.13930433
 6330.09189467 5194.50289133 4440.07661143 6371.33517462 4637.96754429
 4761.87118952 5439.41699828 6018.96767336 5577.50674328 4236.99994485
 6576.51147158 5000.14093976 5706.58876672 6110.63031148 5476.0958187
 7263.0833007 5791.93963792 5674.84887734 5108.09715347 5957.60778458
 4179.17319139 5761.78051622 5162.48008602 6194.09350456 6162.33654347
 7384.74974366 5083.04054941 4962.94202932 5170.20121132 6558.3513186
 5287.51005231 5538.36394109 5927.89044333 5514.96748061 6808.09038217
 4920.18026323 5454.56842393 5774.7372006 4992.52495217 5804.84483528
 6556.39007378 5405.70007164 5756.64086486 6600.92644031 5352.08666973
 6766.15814166 5769.05137498 5349.54890603 5015.89023111 5329.49586061
 5312.9717157 5096.14118614 6034.79276374 4955.40878744 6031.04628326
 5492.38103831 4421.44022406 5107.50627882 5308.97443418 5910.11741887
 4490.880087 4751.28927681 6060.41163971 5181.78798607 5765.06955709
 5021.9742683 8425.92130724 5403.01161569 5479.90628634 5356.77515953
 6073.80868505 4891.98039523 5134.07762324 4561.69552702 4792.94954996
 4436.59379023 5841.49153429 5682.51559107 6192.57415533 5109.2100271
 4135.10477759 5110.80292932 4917.96014791 4882.43108745 5377.73284515
 4972.3748959 5030.01475144 4371.76677221 5491.9925511 4895.18382976
 4893.01776077 5757.52807015 6223.09129595 5372.08055486 5738.93318274
 4511.00369704 5545.18253646 5299.00632493 4828.46999099 5594.70833879
 5628.51491104 4481.41385631 4695.66442343 5111.31275204 5662.20981021
 5142.62708777 4929.56300494 4924.67525652 5425.9043373 4490.38058173
 5565.79437174 4555.63610284 7273.92205684 5897.26382429 5402.35588249
 3952.39603324 5352.7809687 4854.18477353 5088.20841951 5018.60151664
 4958.55178938 5168.91519434 5815.43771182 4356.17362785 6200.88211458
 4730.73232114 5438.10708055 5529.3289125 5289.14454882 5367.66370411
 7320.99982638 5891.75528143 5494.08688647 6492.94660778 6115.15559164
 4518.53611612 4770.24636129 4521.2455312 5561.81564759 5431.33872366
 5851.12653529 6960.98211221 5708.982936 5380.34043209 5232.52509684
 5553.91613062 4703.2298637 6183.36975967 3722.33823568 5073.2336761
 6222.25295203 4804.84889788 5381.66585157 5814.77261616 4685.42502306
 5734.16519708 4267.73810762 4669.51127884 5042.61769553 5917.82635572
 5610.18033802 5327.94493298 6000.29771556 6207.95407515 7221.05709761
 4795.01117647 5310.19461473 4802.41731467 5719.12116891 4702.55710568
 6033.26856609 5774.57867243 5588.76234613 4952.93336998 5165.81266269
 6288.3679527 5861.79640957 5900.20144359 5154.35812719 5964.82743412
 4566.86094325]

Ranked IDs for query:

[268 235 40 0 200 95 140 86 129 276 243 207 34 97 4 66 176 195
 3 122 106 91 17 221 229 180 215 255 257 48 231 193 300 124 30 39
 277 274 222 289 266 245 8 181 125 87 256 117 73 20 194 285 78 287
 271 92 116 218 237 96 70 203 191 210 209 21 31 202 155 227 226 35]

| | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|
| 38 | 293 | 24 | 173 | 240 | 147 | 41 | 205 | 81 | 158 | 131 | 22 | 55 | 26 | 5 | 168 | 239 | 85 |
| 185 | 206 | 74 | 278 | 102 | 44 | 269 | 62 | 146 | 238 | 171 | 177 | 138 | 199 | 201 | 223 | 45 | 93 |
| 13 | 192 | 225 | 298 | 142 | 294 | 105 | 90 | 241 | 148 | 107 | 183 | 16 | 121 | 25 | 109 | 264 | 7 |
| 72 | 36 | 57 | 112 | 150 | 103 | 248 | 18 | 217 | 6 | 178 | 286 | 170 | 281 | 169 | 50 | 61 | 10 |
| 9 | 167 | 164 | 236 | 189 | 249 | 213 | 33 | 64 | 204 | 29 | 263 | 272 | 32 | 79 | 82 | 27 | 234 |
| 187 | 161 | 75 | 228 | 259 | 246 | 126 | 119 | 14 | 156 | 46 | 134 | 188 | 208 | 175 | 252 | 100 | 77 |
| 153 | 53 | 247 | 151 | 216 | 108 | 265 | 52 | 258 | 230 | 71 | 128 | 292 | 219 | 88 | 19 | 280 | 220 |
| 224 | 137 | 197 | 132 | 262 | 288 | 101 | 49 | 113 | 275 | 214 | 69 | 162 | 211 | 141 | 184 | 68 | 166 |
| 291 | 157 | 63 | 84 | 136 | 159 | 118 | 273 | 242 | 196 | 98 | 260 | 296 | 94 | 60 | 110 | 251 | 233 |
| 297 | 179 | 1 | 54 | 279 | 152 | 139 | 299 | 282 | 127 | 174 | 290 | 172 | 12 | 182 | 76 | 190 | 59 |
| 43 | 83 | 133 | 254 | 15 | 111 | 144 | 11 | 267 | 198 | 143 | 244 | 42 | 283 | 270 | 212 | 104 | 115 |
| 295 | 80 | 47 | 120 | 123 | 65 | 67 | 253 | 51 | 28 | 160 | 149 | 130 | 2 | 163 | 56 | 89 | 99 |
| 165 | 154 | 37 | 23 | 261 | 284 | 135 | 232 | 250 | 145 | 58 | 114 | 186] | | | | | |

241

Searching for ID 1500

Distance between source feature and all target features:

| | | | | |
|----------------|---------------|---------------|---------------|---------------|
| [4983.21840189 | 6065.64286489 | 6180.20255619 | 3948.77364065 | 4641.25489815 |
| 5063.00246578 | 6344.70300796 | 6797.53749228 | 5151.0335208 | 6123.54155244 |
| 6279.60678962 | 5984.11325915 | 4883.08756573 | 5120.07594596 | 5289.95123869 |
| 6383.93079907 | 5478.75713817 | 5273.44787706 | 6108.94836956 | 4559.35778475 |
| 6169.37181362 | 5261.25536175 | 6432.83783848 | 5905.93417918 | 5451.04454653 |
| 6084.75882089 | 5702.47644029 | 5379.43573346 | 5115.32912 | 5769.94879121 |
| 4457.76030458 | 4202.12499442 | 6282.89025037 | 6773.80331112 | 4008.61001221 |
| 6310.60625955 | 5649.42203408 | 6151.95806354 | 4598.55286983 | 5502.80863489 |
| 4442.98163368 | 4904.65398985 | 7775.64325771 | 5852.8939449 | 5168.66363438 |
| 4932.77503512 | 6460.7554949 | 6919.72857121 | 4464.91106808 | 5505.45407356 |
| 4792.04231809 | 5197.30477439 | 5085.46732205 | 4408.60942303 | 5561.48629127 |
| 6009.76703065 | 5441.7998477 | 5064.84609109 | 5680.24027161 | 5319.39334376 |
| 4633.14249138 | 4910.89593698 | 6332.86806389 | 5282.74979802 | 5466.15511961 |
| 4763.507063 | 5539.99650035 | 7418.19151969 | 4860.29164468 | 7322.75590779 |
| 4924.03120784 | 4824.87591289 | 4479.66921427 | 5571.77387232 | 5749.61855646 |
| 6296.88486799 | 6413.00326464 | 7343.52047498 | 5319.47146437 | 4807.48771885 |
| 6338.14493297 | 6564.91294956 | 3960.15067061 | 5928.12909253 | 6403.11027927 |
| 5660.23761753 | 5107.62323411 | 5160.73205975 | 4213.79884263 | 6737.50791232 |
| 5014.95907641 | 4367.57764845 | 4676.84452031 | 4703.17606235 | 6864.87015104 |
| 4829.70513097 | 6073.9667105 | 5312.93669716 | 6135.89903883 | 6487.92084892 |
| 6422.92198767 | 4996.91435326 | 3693.01962046 | 4389.77595003 | 4543.51530314 |
| 4269.31210518 | 5281.11296053 | 5551.71514062 | 5645.20016002 | 5216.18304106 |
| 5376.67712531 | 5205.4233334 | 5901.45043052 | 6659.1026677 | 6814.9442576 |
| 6608.43297767 | 4857.49285549 | 3954.07838886 | 4909.01344974 | 4775.9113004 |
| 4735.66794036 | 6320.97700282 | 5063.22741926 | 6185.43243536 | 5135.06608221 |
| 5345.05047953 | 7238.81320228 | 5836.82169788 | 4641.3225395 | 4013.66558839 |
| 5176.4281785 | 4397.6365464 | 6669.58466148 | 5002.62310734 | 5751.49382652 |
| 6610.42687401 | 7177.11305742 | 6283.90714284 | 6032.88632298 | 7402.51040828 |
| 5506.43545041 | 5203.64464745 | 5792.12346495 | 6782.94620182 | 6095.09922783 |
| 7075.53485266 | 5007.23811036 | 4875.26142904 | 4004.9274539 | 4947.64563511 |
| 5157.13072233 | 4375.56465798 | 5620.61328565 | 4988.39964801 | 5103.5395028 |
| 5494.34204754 | 4914.81376937 | 4748.84283566 | 4773.30040593 | 5603.45495822 |
| 6401.00230939 | 5451.99071817 | 5704.6065425 | 7185.27366489 | 6288.87144988 |
| 5677.10223039 | 7383.81998631 | 5686.50736072 | 4051.80808967 | 6468.5226368 |
| 5023.34829801 | 4714.44723927 | 6239.43504815 | 6250.85446843 | 6286.37307638 |
| 5056.18816269 | 4356.10082061 | 5621.76599639 | 5672.5256352 | 5791.52785721 |
| 4213.0987223 | 5703.25065577 | 5357.41693641 | 4881.17771203 | 4512.53733343 |
| 4859.59140246 | 7831.49163669 | 4871.74320706 | 6433.34817397 | 7114.4685455 |
| 6544.93747574 | 4821.03509265 | 5768.87864134 | 5302.72793431 | 5116.74106846 |
| 5423.90074521 | 5540.9397105 | 5676.78693348 | 5955.34729139 | 4230.37851067 |
| 5209.76501258 | 5992.48812971 | 6382.54305048 | 5175.96508771 | 7010.82079373 |
| 4841.33256866 | 4561.29010942 | 5216.155227 | 4054.02477657 | 4298.90878269 |
| 4949.57827115 | 5168.51238554 | 6181.0240047 | 5482.49253199 | 6054.783188 |
| 5101.85537553 | 5757.52583707 | 5654.7845469 | 4583.66954504 | 4293.71203129 |

5578.75828661 5850.82560484 5535.71764188 6294.02205561 4044.56344236
 4736.43770061 5745.33549531 3844.47908882 6538.15212 4473.60738574
 4675.16335944 4872.06345788 6122.07249763 5783.98170595 5903.0093815
 4228.83290766 5595.38019378 5476.54749097 4228.8909983 6162.34213118
 4560.36990361 4619.46342232 5824.91558791 4098.65469662 7708.22292545
 4050.21019562 5828.98335951 5167.9784617 5868.41727007 5353.87522765
 5030.94032321 5744.59572863 4844.82050782 7416.38676131 6357.86521246
 5714.71283651 5702.8016211 4688.04010517 6660.57166577 3732.98315374
 5141.8782879 5601.06399802 6199.91574262 4088.71266782 4427.89780879
 5730.77715688 6148.17111163 4644.83505308 5133.48817932 5071.01653245
 6836.38528015 5416.07228908 4579.50318992 4941.82567193 4573.19811181
 6361.057206 4258.95450172 5514.32885354 6678.85051413 7458.76662998
 6241.1711345 6153.97992918 5672.01461986 5214.75103834 5425.1154187
 4975.23269817 6903.6058645 5503.88834342 4495.49498639 5241.79106341
 6539.30530883 6241.82881018 5886.10591284 5375.91763261 4912.44262002
 5193.31916097 4944.34001533 6586.64702927 5852.36501183 6507.78569065
 4191.12405296]

Ranked IDs for query:

[102 259 227 3 117 82 148 34 129 224 245 168 208 263 243 300 31 180
 88 235 238 199 276 105 219 209 176 91 151 103 131 53 264 40 30 48
 229 72 288 184 104 19 240 206 274 272 218 38 241 60 4 128 267 230
 92 257 93 171 120 225 157 65 158 119 50 79 191 71 95 205 252 116
 185 68 187 231 147 183 12 41 118 61 294 156 70 45 273 296 149 210
 285 0 153 101 133 146 90 170 250 175 5 122 57 269 52 215 154 86
 28 194 13 268 124 260 8 150 87 247 211 44 203 130 295 51 141 111
 200 283 207 109 289 21 17 106 63 14 193 97 59 78 125 249 182 293
 110 27 271 195 284 56 24 161 64 237 16 213 155 39 287 49 140 277
 222 66 196 107 54 73 220 236 261 159 152 177 108 36 217 85 282 178
 197 165 58 167 26 256 181 162 255 265 251 226 74 134 216 192 29 233
 179 142 242 246 127 221 298 43 248 292 112 234 23 83 198 11 201 55
 138 214 1 96 25 144 18 232 9 98 266 37 281 239 20 2 212 123
 262 172 280 291 173 10 32 137 174 164 223 75 35 121 62 80 6 254
 275 202 15 160 84 76 100 22 188 46 169 99 299 228 290 190 81 297
 115 135 113 258 132 278 89 33 143 7 114 270 94 286 47 204 145 189
 136 163 126 69 77 166 139 253 67 279 244 42 186]

15

[29. 5. 9. 4. 6. 4. 3. 1. 3. 4. 4. 6. 2. 1. 2. 3. 1. 2.
 1. 0. 1. 0. 2. 2. 2. 3. 2. 0. 1. 1. 4. 6. 1. 4. 0. 1.
 1. 1. 1. 0. 4. 1. 1. 1. 3. 2. 2. 2. 0. 2. 0. 2. 2. 2.
 0. 1. 1. 1. 0. 1. 1. 2. 5. 1. 0. 0. 2. 1. 0. 1. 3. 0.
 1. 4. 2. 1. 0. 1. 2. 1. 1. 1. 1. 1. 1. 2. 1. 0. 0. 2. 2.
 1. 2. 0. 1. 1. 2. 0. 1. 1. 1. 2. 2. 3. 1. 0. 0. 0. 0. 4.
 2. 1. 1. 1. 0. 1. 0. 0. 0. 0. 0. 3. 1. 1. 0. 0. 0. 0. 0. 2.
 0. 1. 1. 0. 0. 2. 0. 1. 0. 1. 0. 2. 1. 0. 0. 1. 0. 1. 0. 1.
 2. 1. 0. 2. 0. 0. 0. 0. 1. 0. 0. 0. 1. 0. 1. 0. 0. 0. 2. 3.
 1. 0. 0. 2. 1. 0. 0. 2. 1. 1. 1. 0. 0. 1. 1. 1. 0. 1. 0. 1.
 1. 0. 0. 0. 1. 0. 0. 1. 0. 0. 1. 1. 2. 0. 1. 0. 1. 0. 1. 2.
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 0. 0. 0. 0. 0. 0. 0. 0. 0. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1.]

In [30]:

```
cmc = np.zeros(301)
for i in range(301):
    cmc[i] = np.sum(ranked_histogram[::(i + 1)])
```

```
print(cmc)
```

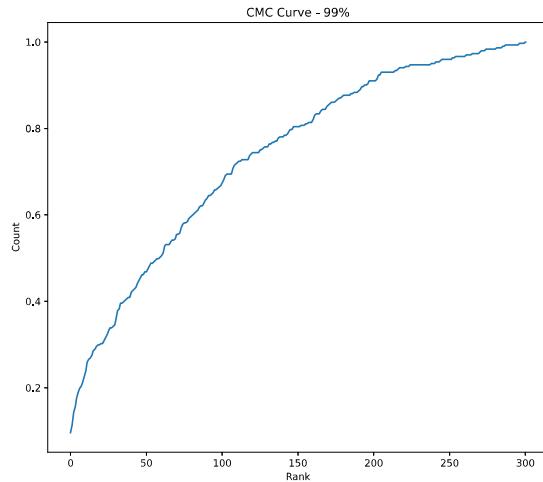
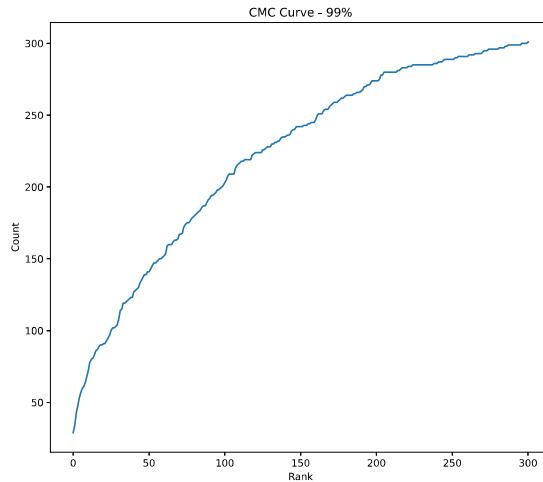
```
[ 29.  34.  43.  47.  53.  57.  60.  61.  64.  68.  72.  78.  80.  81.
  83.  86.  87.  89.  90.  90.  91.  91.  93.  95.  97.  100.  102.  102.
  103.  104.  108.  114.  115.  119.  119.  120.  121.  122.  123.  123.  127.  128.
  129.  130.  133.  135.  137.  139.  139.  141.  141.  143.  145.  147.  147.  148.
  149.  150.  150.  151.  152.  154.  159.  160.  160.  160.  162.  163.  163.  164.
  167.  167.  168.  172.  174.  175.  175.  176.  178.  179.  180.  181.  182.  183.
  184.  186.  187.  187.  189.  191.  192.  194.  194.  195.  196.  198.  198.  199.
  200.  201.  203.  205.  208.  209.  209.  209.  213.  215.  216.  217.  218.
  218.  219.  219.  219.  219.  222.  223.  224.  224.  224.  224.  224.  226.
  226.  227.  228.  228.  228.  230.  230.  231.  231.  232.  232.  234.  235.  235.
  235.  236.  236.  237.  239.  240.  240.  242.  242.  242.  242.  243.  243.
  243.  244.  244.  245.  245.  245.  247.  250.  251.  251.  251.  253.  254.  254.
  254.  256.  257.  258.  259.  259.  259.  260.  261.  262.  262.  263.  264.  264.
  264.  264.  265.  265.  266.  266.  266.  267.  268.  270.  270.  271.  271.
  272.  274.  274.  274.  274.  275.  275.  278.  278.  280.  280.  280.  280.  280.
  280.  280.  280.  281.  281.  282.  283.  283.  283.  283.  284.  284.  284.
  285.  285.  285.  285.  285.  285.  285.  285.  285.  285.  285.  285.  285.
  286.  286.  286.  287.  287.  287.  288.  289.  289.  289.  289.  289.  289.
  290.  290.  291.  291.  291.  291.  291.  291.  292.  292.  292.  292.  293.
  293.  293.  293.  294.  295.  295.  295.  296.  296.  296.  296.  296.  296.
  296.  297.  297.  297.  297.  298.  298.  299.  299.  299.  299.  299.  299.
  299.  299.  300.  300.  300.  300.  301.]
```

In [31]:

```
fig = plt.figure(figsize=[20, 8])
ax = fig.add_subplot(1, 2, 1)
ax.plot(cmc)
ax.set_xlabel('Rank')
ax.set_ylabel('Count')
ax.set_title('CMC Curve - 99%')
ax = fig.add_subplot(1, 2, 2)
ax.plot(cmc/len(test_gnd))
ax.set_xlabel('Rank')
ax.set_ylabel('Count')
ax.set_title('CMC Curve - 99%)')
```

Out[31]:

Text(0.5, 1.0, 'CMC Curve - 99%)')



Deep Learning Model - Siamese

Week 7 example 1

In [32]:

```
def GetSiameseData(imgs, labels, batch_size):  
  
    image_a = np.zeros((batch_size, np.shape(imgs)[1], np.shape(imgs)[2], np.shape(imgs)[3]));  
    image_b = np.zeros((batch_size, np.shape(imgs)[1], np.shape(imgs)[2], np.shape(imgs)[3]));  
    label = np.zeros(batch_size);  
  
    for i in range(batch_size):  
  
        if (i % 2 == 0):  
            idx1 = random.randint(0, len(imgs) - 1)  
            idx2 = random.randint(0, len(imgs) - 1)  
            l = 1  
            while (labels[idx1] != labels[idx2]):  
                idx2 = random.randint(0, len(imgs) - 1)  
  
        else:  
            idx1 = random.randint(0, len(imgs) - 1)  
            idx2 = random.randint(0, len(imgs) - 1)  
            l = 0  
            while (labels[idx1] == labels[idx2]):  
                idx2 = random.randint(0, len(imgs) - 1)  
  
    image_a[i, :, :, :] = imgs[idx1,:,:,:]  
    image_b[i, :, :, :] = imgs[idx2,:,:,:]  
    label[i] = l  
  
    return [image_a, image_b], label  
  
def PairGenerator(imgs, labels, batch_size):  
    while True:  
        [image_a, image_b], label = GetSiameseData(imgs, labels, batch_size)  
        yield [image_a, image_b], label
```

In [33]:

```
def conv_block(inputs, filters, spatial_dropout = 0.0, max_pool = True):  
    x = layers.Conv2D(filters=filters, kernel_size=(3,3), padding='same', activation='relu')(inputs)  
    x = layers.Conv2D(filters=filters, kernel_size=(3,3), padding='same', activation=None)(x)  
    x = layers.BatchNormalization()(x)  
    x = layers.Activation('relu')(x)  
    if (spatial_dropout > 0.0):  
        x = layers.SpatialDropout2D(spatial_dropout)(x)  
    if (max_pool == True):  
        x = layers.MaxPool2D(pool_size=(2, 2))(x)  
  
    return x  
  
def fc_block(inputs, size, dropout):  
    x = layers.Dense(size, activation=None)(inputs)  
    x = layers.BatchNormalization()(x)  
    x = layers.Activation('relu')(x)  
    if (dropout > 0.0):  
        x = layers.Dropout(dropout)(x)  
  
    return x  
  
def vgg_net(inputs, filters, fc, spatial_dropout = 0.0, dropout = 0.0):  
    x = inputs  
    for idx,i in enumerate(filters):  
        x = conv_block(x, i, spatial_dropout, not (idx==len(filters) - 1))  
  
    x = layers.Flatten()(x)  
  
    for i in fc:  
        x = fc_block(x, i, dropout)  
  
    return x
```

In [34]:

```
embedding_size = 32
dummy_input = keras.Input((128, 64, 1))
base_network = vgg_net(dummy_input, [8, 16, 32], [256], 0.2, 0)
embedding_layer = layers.Dense(embedding_size, activation=None)(base_network)
base_network = keras.Model(dummy_input, embedding_layer, name='SiameseBranch')
base_network.summary()
```

Model: "SiameseBranch"

| Layer (type) | Output Shape | Param # |
|------------------------------|--------------------|---------|
| <hr/> | | |
| input_1 (InputLayer) | [None, 128, 64, 1] | 0 |
| conv2d (Conv2D) | (None, 128, 64, 8) | 80 |
| conv2d_1 (Conv2D) | (None, 128, 64, 8) | 584 |
| batch_normalization (BatchNo | (None, 128, 64, 8) | 32 |
| activation (Activation) | (None, 128, 64, 8) | 0 |
| spatial_dropout2d (SpatialDr | (None, 128, 64, 8) | 0 |
| max_pooling2d (MaxPooling2D) | (None, 64, 32, 8) | 0 |
| conv2d_2 (Conv2D) | (None, 64, 32, 16) | 1168 |
| conv2d_3 (Conv2D) | (None, 64, 32, 16) | 2320 |
| batch_normalization_1 (Batch | (None, 64, 32, 16) | 64 |
| activation_1 (Activation) | (None, 64, 32, 16) | 0 |
| spatial_dropout2d_1 (Spatial | (None, 64, 32, 16) | 0 |
| max_pooling2d_1 (MaxPooling2 | (None, 32, 16, 16) | 0 |
| conv2d_4 (Conv2D) | (None, 32, 16, 32) | 4640 |
| conv2d_5 (Conv2D) | (None, 32, 16, 32) | 9248 |
| batch_normalization_2 (Batch | (None, 32, 16, 32) | 128 |
| activation_2 (Activation) | (None, 32, 16, 32) | 0 |
| spatial_dropout2d_2 (Spatial | (None, 32, 16, 32) | 0 |
| flatten (Flatten) | (None, 16384) | 0 |
| dense (Dense) | (None, 256) | 4194560 |
| batch_normalization_3 (Batch | (None, 256) | 1024 |
| activation_3 (Activation) | (None, 256) | 0 |
| dense_1 (Dense) | (None, 32) | 8224 |
| <hr/> | | |
| Total params: 4,222,072 | | |
| Trainable params: 4,221,448 | | |
| Non-trainable params: 624 | | |

In [35]:

```
input_a = keras.Input((128, 64, 1), name='InputA')
input_b = keras.Input((128, 64, 1), name='InputB')

embedding_a = base_network(input_a)
embedding_b = base_network(input_b)
```

In [36]:

```
combined = layers.concatenate([embedding_a, embedding_b])
combined = layers.Dense(128, activation='relu')(combined)
output = layers.Dense(1, activation='sigmoid')(combined)

siamese_network = keras.Model([input_a, input_b], output, name='SiameseNetwork')
siamese_network.summary()
```

Model: "SiameseNetwork"

| Layer (type)
ed to | Output Shape | Param # | Connect |
|---|------------------------|---------|--------------------|
| InputA (InputLayer) | [(None, 128, 64, 1)] 0 | | |
| InputB (InputLayer) | [(None, 128, 64, 1)] 0 | | |
| SiameseBranch (Functional)
[0][0] | (None, 32) | 4222072 | InputA
InputB |
| concatenate (Concatenate)
Branch[0][0] | (None, 64) | 0 | Siamese
Siamese |
| Branch[1][0] | | | |
| dense_2 (Dense)
dense[0][0] | (None, 128) | 8320 | concat |
| dense_3 (Dense)
[0][0] | (None, 1) | 129 | dense_2 |
| Total params: 4,230,521 | | | |
| Trainable params: 4,229,897 | | | |
| Non-trainable params: 624 | | | |

In [37]:

```
siamese_network.compile(loss='binary_crossentropy', optimizer=keras.optimizers.RMSprop(), metrics=['accuracy'])
```

In [38]:

```
test_fea = np.reshape(test_gal.transpose(), (301, 128, 64, 1))
test_pro_fea = np.reshape(test_pro.transpose(), (301, 128, 64, 1))
train_fea = np.reshape(train_fea.transpose(), (5933, 128, 64, 1))
```

In [39]:

```
print(test_fea.shape)
```

```
(301, 128, 64, 1)
```

In [40]:

```
print(test_pro_fea.shape)
```

```
(301, 128, 64, 1)
```

In [41]:

```
print(train_fea.shape)
```

```
(5933, 128, 64, 1)
```

In [42]:

```
batch_size = 32
training_gen = PairGenerator(train_fea, gnd, batch_size)

siamese_test_x, siamese_test_y = GetSiameseData(test_fea, test_gnd, 5933)
siamese_network.fit(training_gen, steps_per_epoch = 256 // batch_size, epochs=100, validation_data = (siamese_test_x, siamese_test_y))
```

Epoch 1/100
8/8 [=====] - 28s 3s/step - loss: 0.7875 - accuracy: 0.4804 - val_loss: 10.4787 - val_accuracy: 0.5001
Epoch 2/100
8/8 [=====] - 24s 3s/step - loss: 0.7723 - accuracy: 0.5037 - val_loss: 1.8938 - val_accuracy: 0.5001
Epoch 3/100
8/8 [=====] - 25s 3s/step - loss: 0.7476 - accuracy: 0.4976 - val_loss: 0.9554 - val_accuracy: 0.5001
Epoch 4/100
8/8 [=====] - 25s 3s/step - loss: 0.7347 - accuracy: 0.5000 - val_loss: 0.9820 - val_accuracy: 0.5011
Epoch 5/100
8/8 [=====] - 24s 3s/step - loss: 0.7257 - accuracy: 0.5710 - val_loss: 1.0308 - val_accuracy: 0.5001
Epoch 6/100
8/8 [=====] - 24s 3s/step - loss: 0.7041 - accuracy: 0.5785 - val_loss: 0.8523 - val_accuracy: 0.5001
Epoch 7/100
8/8 [=====] - 23s 3s/step - loss: 0.6826 - accuracy: 0.5509 - val_loss: 0.6873 - val_accuracy: 0.5077
Epoch 8/100
8/8 [=====] - 24s 3s/step - loss: 0.7053 - accuracy: 0.5675 - val_loss: 0.8533 - val_accuracy: 0.5009
Epoch 9/100
8/8 [=====] - 25s 4s/step - loss: 0.6812 - accuracy: 0.5822 - val_loss: 1.7557 - val_accuracy: 0.5001
Epoch 10/100
8/8 [=====] - 25s 3s/step - loss: 0.7176 - accuracy: 0.4875 - val_loss: 0.8647 - val_accuracy: 0.5024
Epoch 11/100
8/8 [=====] - 23s 3s/step - loss: 0.6796 - accuracy: 0.5398 - val_loss: 0.7114 - val_accuracy: 0.5781
Epoch 12/100
8/8 [=====] - 22s 3s/step - loss: 0.7295 - accuracy: 0.5466 - val_loss: 0.6660 - val_accuracy: 0.6794
Epoch 13/100
8/8 [=====] - 22s 3s/step - loss: 0.7191 - accuracy: 0.5546 - val_loss: 0.6233 - val_accuracy: 0.6867
Epoch 14/100
8/8 [=====] - 22s 3s/step - loss: 0.7036 - accuracy: 0.5311 - val_loss: 0.6818 - val_accuracy: 0.5077
Epoch 15/100
8/8 [=====] - 22s 3s/step - loss: 0.6601 - accuracy: 0.5885 - val_loss: 0.6687 - val_accuracy: 0.6000
Epoch 16/100
8/8 [=====] - 23s 3s/step - loss: 0.6508 - accuracy: 0.6124 - val_loss: 0.6137 - val_accuracy: 0.7420
Epoch 17/100
8/8 [=====] - 24s 3s/step - loss: 0.7215 - accuracy: 0.5823 - val_loss: 0.6625 - val_accuracy: 0.6349
Epoch 18/100
8/8 [=====] - 23s 3s/step - loss: 0.7004 - accuracy: 0.5178 - val_loss: 0.6372 - val_accuracy: 0.6460
Epoch 19/100
8/8 [=====] - 22s 3s/step - loss: 0.6760 - accuracy: 0.5388 - val_loss: 0.6637 - val_accuracy: 0.6434
Epoch 20/100
8/8 [=====] - 22s 3s/step - loss: 0.7109 - accuracy: 0.5755 - val_loss: 0.6379 - val_accuracy: 0.6973
Epoch 21/100

```
8/8 [=====] - 22s 3s/step - loss: 0.6405 - accuracy: 0.6217 - val_loss: 0.5682 - val_accuracy: 0.7472
Epoch 22/100
8/8 [=====] - 23s 3s/step - loss: 0.7476 - accuracy: 0.5370 - val_loss: 0.6855 - val_accuracy: 0.5485
Epoch 23/100
8/8 [=====] - 23s 3s/step - loss: 0.6919 - accuracy: 0.5714 - val_loss: 0.7264 - val_accuracy: 0.4900
Epoch 24/100
8/8 [=====] - 22s 3s/step - loss: 0.6316 - accuracy: 0.6621 - val_loss: 0.7544 - val_accuracy: 0.5078
Epoch 25/100
8/8 [=====] - 22s 3s/step - loss: 0.6313 - accuracy: 0.6370 - val_loss: 0.7373 - val_accuracy: 0.4974
Epoch 26/100
8/8 [=====] - 22s 3s/step - loss: 0.6514 - accuracy: 0.6188 - val_loss: 0.7456 - val_accuracy: 0.5100
Epoch 27/100
8/8 [=====] - 22s 3s/step - loss: 0.6146 - accuracy: 0.6412 - val_loss: 0.7283 - val_accuracy: 0.5129
Epoch 28/100
8/8 [=====] - 22s 3s/step - loss: 0.6122 - accuracy: 0.6630 - val_loss: 0.7421 - val_accuracy: 0.5001
Epoch 29/100
8/8 [=====] - 22s 3s/step - loss: 0.5903 - accuracy: 0.6727 - val_loss: 0.6970 - val_accuracy: 0.5016
Epoch 30/100
8/8 [=====] - 23s 3s/step - loss: 0.6426 - accuracy: 0.6016 - val_loss: 0.7030 - val_accuracy: 0.5001
Epoch 31/100
8/8 [=====] - 22s 3s/step - loss: 0.6495 - accuracy: 0.5932 - val_loss: 0.7039 - val_accuracy: 0.5304
Epoch 32/100
8/8 [=====] - 22s 3s/step - loss: 0.6238 - accuracy: 0.6205 - val_loss: 0.6958 - val_accuracy: 0.5001
Epoch 33/100
8/8 [=====] - 22s 3s/step - loss: 0.6751 - accuracy: 0.6404 - val_loss: 0.6935 - val_accuracy: 0.4986
Epoch 34/100
8/8 [=====] - 22s 3s/step - loss: 0.6251 - accuracy: 0.6211 - val_loss: 0.7495 - val_accuracy: 0.5001
Epoch 35/100
8/8 [=====] - 22s 3s/step - loss: 0.6741 - accuracy: 0.5965 - val_loss: 0.6941 - val_accuracy: 0.5001
Epoch 36/100
8/8 [=====] - 23s 3s/step - loss: 0.6598 - accuracy: 0.6306 - val_loss: 0.6929 - val_accuracy: 0.5774
Epoch 37/100
8/8 [=====] - 23s 3s/step - loss: 0.6338 - accuracy: 0.5831 - val_loss: 0.6906 - val_accuracy: 0.4252
Epoch 38/100
8/8 [=====] - 23s 3s/step - loss: 0.6707 - accuracy: 0.6345 - val_loss: 0.7052 - val_accuracy: 0.5001
Epoch 39/100
8/8 [=====] - 24s 3s/step - loss: 0.6832 - accuracy: 0.5257 - val_loss: 0.6951 - val_accuracy: 0.5001
Epoch 40/100
8/8 [=====] - 24s 3s/step - loss: 0.6413 - accuracy: 0.6362 - val_loss: 0.7630 - val_accuracy: 0.4999
Epoch 41/100
8/8 [=====] - 24s 3s/step - loss: 0.6885 - accuracy:
```

```
cy: 0.5658 - val_loss: 0.7247 - val_accuracy: 0.5129
Epoch 42/100
8/8 [=====] - 25s 4s/step - loss: 0.6259 - accuracy: 0.6269 - val_loss: 0.6888 - val_accuracy: 0.5314
Epoch 43/100
8/8 [=====] - 28s 4s/step - loss: 0.6276 - accuracy: 0.6612 - val_loss: 0.8319 - val_accuracy: 0.5001
Epoch 44/100
8/8 [=====] - 25s 3s/step - loss: 0.6367 - accuracy: 0.6614 - val_loss: 0.7498 - val_accuracy: 0.5001
Epoch 45/100
8/8 [=====] - 26s 4s/step - loss: 0.6338 - accuracy: 0.6592 - val_loss: 0.7956 - val_accuracy: 0.5001
Epoch 46/100
8/8 [=====] - 26s 4s/step - loss: 0.5883 - accuracy: 0.6732 - val_loss: 0.7760 - val_accuracy: 0.5001
Epoch 47/100
8/8 [=====] - 27s 4s/step - loss: 0.6356 - accuracy: 0.6269 - val_loss: 0.7018 - val_accuracy: 0.5026
Epoch 48/100
8/8 [=====] - 25s 4s/step - loss: 0.6681 - accuracy: 0.5654 - val_loss: 0.6953 - val_accuracy: 0.5336
Epoch 49/100
8/8 [=====] - 26s 4s/step - loss: 0.6671 - accuracy: 0.6001 - val_loss: 0.7409 - val_accuracy: 0.5001
Epoch 50/100
8/8 [=====] - 24s 3s/step - loss: 0.5909 - accuracy: 0.7400 - val_loss: 0.7599 - val_accuracy: 0.5001
Epoch 51/100
8/8 [=====] - 24s 3s/step - loss: 0.6538 - accuracy: 0.6243 - val_loss: 0.6650 - val_accuracy: 0.6074
Epoch 52/100
8/8 [=====] - 26s 4s/step - loss: 0.6454 - accuracy: 0.5987 - val_loss: 0.6717 - val_accuracy: 0.5879
Epoch 53/100
8/8 [=====] - 25s 4s/step - loss: 0.6464 - accuracy: 0.6306 - val_loss: 0.6788 - val_accuracy: 0.5427
Epoch 54/100
8/8 [=====] - 25s 4s/step - loss: 0.6410 - accuracy: 0.6237 - val_loss: 0.6767 - val_accuracy: 0.5500
Epoch 55/100
8/8 [=====] - 23s 3s/step - loss: 0.6579 - accuracy: 0.6096 - val_loss: 0.6997 - val_accuracy: 0.5350
Epoch 56/100
8/8 [=====] - 22s 3s/step - loss: 0.6511 - accuracy: 0.5909 - val_loss: 0.6976 - val_accuracy: 0.5186
Epoch 57/100
8/8 [=====] - 25s 3s/step - loss: 0.6572 - accuracy: 0.5883 - val_loss: 0.7618 - val_accuracy: 0.5001
Epoch 58/100
8/8 [=====] - 24s 3s/step - loss: 0.6411 - accuracy: 0.6597 - val_loss: 0.6993 - val_accuracy: 0.5001
Epoch 59/100
8/8 [=====] - 23s 3s/step - loss: 0.6632 - accuracy: 0.6328 - val_loss: 0.7161 - val_accuracy: 0.5001
Epoch 60/100
8/8 [=====] - 22s 3s/step - loss: 0.6638 - accuracy: 0.5993 - val_loss: 0.6915 - val_accuracy: 0.5142
Epoch 61/100
8/8 [=====] - 22s 3s/step - loss: 0.6204 - accuracy: 0.6848 - val_loss: 0.7049 - val_accuracy: 0.5011
```

Epoch 62/100
8/8 [=====] - 22s 3s/step - loss: 0.6182 - accuracy: 0.6644 - val_loss: 0.7410 - val_accuracy: 0.5001
Epoch 63/100
8/8 [=====] - 22s 3s/step - loss: 0.6530 - accuracy: 0.6240 - val_loss: 0.6968 - val_accuracy: 0.5609
Epoch 64/100
8/8 [=====] - 25s 4s/step - loss: 0.6259 - accuracy: 0.6643 - val_loss: 0.6857 - val_accuracy: 0.5362
Epoch 65/100
8/8 [=====] - 25s 3s/step - loss: 0.6420 - accuracy: 0.6672 - val_loss: 0.7402 - val_accuracy: 0.5001
Epoch 66/100
8/8 [=====] - 25s 4s/step - loss: 0.6507 - accuracy: 0.6153 - val_loss: 0.7113 - val_accuracy: 0.5004
Epoch 67/100
8/8 [=====] - 26s 4s/step - loss: 0.6737 - accuracy: 0.5862 - val_loss: 0.7020 - val_accuracy: 0.5024
Epoch 68/100
8/8 [=====] - 24s 3s/step - loss: 0.6590 - accuracy: 0.5640 - val_loss: 0.6967 - val_accuracy: 0.5094
Epoch 69/100
8/8 [=====] - 24s 3s/step - loss: 0.6317 - accuracy: 0.6400 - val_loss: 0.7076 - val_accuracy: 0.5055
Epoch 70/100
8/8 [=====] - 23s 3s/step - loss: 0.6539 - accuracy: 0.5933 - val_loss: 0.7521 - val_accuracy: 0.5001
Epoch 71/100
8/8 [=====] - 24s 3s/step - loss: 0.6042 - accuracy: 0.6562 - val_loss: 0.7492 - val_accuracy: 0.5001
Epoch 72/100
8/8 [=====] - 25s 3s/step - loss: 0.6398 - accuracy: 0.6473 - val_loss: 0.7138 - val_accuracy: 0.5001
Epoch 73/100
8/8 [=====] - 25s 3s/step - loss: 0.6673 - accuracy: 0.6339 - val_loss: 0.6872 - val_accuracy: 0.5139
Epoch 74/100
8/8 [=====] - 24s 3s/step - loss: 0.6156 - accuracy: 0.6523 - val_loss: 0.7286 - val_accuracy: 0.5001
Epoch 75/100
8/8 [=====] - 24s 3s/step - loss: 0.6611 - accuracy: 0.6278 - val_loss: 0.6946 - val_accuracy: 0.5147
Epoch 76/100
8/8 [=====] - 24s 3s/step - loss: 0.6238 - accuracy: 0.6851 - val_loss: 0.6897 - val_accuracy: 0.5373
Epoch 77/100
8/8 [=====] - 24s 3s/step - loss: 0.6202 - accuracy: 0.6708 - val_loss: 0.7294 - val_accuracy: 0.5019
Epoch 78/100
8/8 [=====] - 24s 3s/step - loss: 0.6386 - accuracy: 0.6070 - val_loss: 0.7281 - val_accuracy: 0.5048
Epoch 79/100
8/8 [=====] - 24s 3s/step - loss: 0.6511 - accuracy: 0.6465 - val_loss: 0.6996 - val_accuracy: 0.5014
Epoch 80/100
8/8 [=====] - 23s 3s/step - loss: 0.6371 - accuracy: 0.6493 - val_loss: 0.7321 - val_accuracy: 0.5001
Epoch 81/100
8/8 [=====] - 24s 3s/step - loss: 0.6413 - accuracy: 0.6147 - val_loss: 0.6777 - val_accuracy: 0.5110
Epoch 82/100

```
8/8 [=====] - 24s 3s/step - loss: 0.6177 - accuracy: 0.6317 - val_loss: 0.7218 - val_accuracy: 0.5001
Epoch 83/100
8/8 [=====] - 24s 3s/step - loss: 0.6084 - accuracy: 0.6803 - val_loss: 0.7547 - val_accuracy: 0.5001
Epoch 84/100
8/8 [=====] - 24s 3s/step - loss: 0.6316 - accuracy: 0.6269 - val_loss: 0.6820 - val_accuracy: 0.5513
Epoch 85/100
8/8 [=====] - 24s 3s/step - loss: 0.6292 - accuracy: 0.6427 - val_loss: 0.7667 - val_accuracy: 0.5001
Epoch 86/100
8/8 [=====] - 24s 3s/step - loss: 0.5858 - accuracy: 0.6751 - val_loss: 0.7014 - val_accuracy: 0.5035
Epoch 87/100
8/8 [=====] - 24s 3s/step - loss: 0.6551 - accuracy: 0.6117 - val_loss: 0.6873 - val_accuracy: 0.5345
Epoch 88/100
8/8 [=====] - 23s 3s/step - loss: 0.5833 - accuracy: 0.6474 - val_loss: 0.7590 - val_accuracy: 0.5001
Epoch 89/100
8/8 [=====] - 24s 3s/step - loss: 0.6543 - accuracy: 0.6171 - val_loss: 0.7232 - val_accuracy: 0.5006
Epoch 90/100
8/8 [=====] - 24s 3s/step - loss: 0.6092 - accuracy: 0.6568 - val_loss: 0.8197 - val_accuracy: 0.5001
Epoch 91/100
8/8 [=====] - 24s 3s/step - loss: 0.6609 - accuracy: 0.6099 - val_loss: 0.6991 - val_accuracy: 0.5036
Epoch 92/100
8/8 [=====] - 24s 3s/step - loss: 0.6250 - accuracy: 0.6646 - val_loss: 0.7367 - val_accuracy: 0.5004
Epoch 93/100
8/8 [=====] - 24s 3s/step - loss: 0.6300 - accuracy: 0.6229 - val_loss: 0.7089 - val_accuracy: 0.5458
Epoch 94/100
8/8 [=====] - 24s 3s/step - loss: 0.6381 - accuracy: 0.6497 - val_loss: 0.6773 - val_accuracy: 0.5626
Epoch 95/100
8/8 [=====] - 24s 3s/step - loss: 0.6322 - accuracy: 0.6455 - val_loss: 0.7090 - val_accuracy: 0.5326
Epoch 96/100
8/8 [=====] - 25s 4s/step - loss: 0.6311 - accuracy: 0.6260 - val_loss: 0.6744 - val_accuracy: 0.5840
Epoch 97/100
8/8 [=====] - 26s 4s/step - loss: 0.6104 - accuracy: 0.6881 - val_loss: 0.7293 - val_accuracy: 0.5233
Epoch 98/100
8/8 [=====] - 27s 4s/step - loss: 0.6583 - accuracy: 0.6302 - val_loss: 0.6909 - val_accuracy: 0.5788
Epoch 99/100
8/8 [=====] - 25s 3s/step - loss: 0.6313 - accuracy: 0.5985 - val_loss: 0.7182 - val_accuracy: 0.5029
Epoch 100/100
8/8 [=====] - 25s 4s/step - loss: 0.5951 - accuracy: 0.6626 - val_loss: 0.6781 - val_accuracy: 0.5581
```

Out[42]:

```
<tensorflow.python.keras.callbacks.History at 0x172c8467be0>
```

In [43]:

```
gal_x, gal_y = GetSiameseData(test_fea, test_gnd, 301)
gal_predict = siamese_network.predict(gal_x)

pro_x, pro_y = GetSiameseData(test_pro_fea, test_pro_gnd, 301)
pro_predict = siamese_network.predict(pro_x)
```

CMC for DNN

In [44]:

```
vector = np.vectorize(np.int)

ID_1 = vector(np.array(test_gnd))
ID_2 = vector(np.array(test_pro_gnd))
Feat_1 = gal_predict
Feat_2 = pro_predict
print(Feat_1)
print(Feat_2)
```

```
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```

In [45]:

```
# storage for ranked histogram
ranked_histogram = np.zeros(len(test_gnd))

# Loop over all IDs in the probe set
for i in range(len(ID_2)):
    # get the true ID of this sample
    true_ID = ID_2[i]
    print('Searching for ID %d' % (true_ID))

    # get the distance between the current probe and the whole gallery, L1 distance here. Note that L1
    # may not always be the best choice, so consider your distance metric given your problem
    dist = np.sqrt(np.sum(((Feat_2[:] - Feat_1[i])**2), axis=1)) #This one needs to change - Too Large?
    print('Distance between source feature and all target features:')
    print(dist)

    # get the sorted order of the distances
    a = np.argsort(dist)
    # apply the order to the gallery IDs, such that the first ID in the list is the closest, the second
    # ID is the second closest, and so on
    ranked = ID_1[a]
    print('Ranked IDs for query:')
    print(a)

    # find the location of the True Match in the ranked list
    ranked_result = np.where(ranked == true_ID)[0][0]
    print(ranked_result)

    # store the ranking result in the histogram
    ranked_histogram[ranked_result] += 1
    print('')

print(ranked_histogram)
```

71163487e-02
 2.14194059e-02 6.28912449e-03 2.25645900e-02 1.36694312e-02
 3.38870287e-03 1.27164721e-02 4.43518162e-04 8.88496041e-02
 4.19467092e-02 3.83845568e-02 1.22823119e-02 1.56219006e-02
 1.36548281e-03 4.44877148e-03 5.01194000e-02 9.25738811e-02
 1.41707063e-02 4.56765294e-02 1.54252052e-02 2.18755603e-02
 2.22819448e-02 5.36539555e-02 6.24643564e-02 9.61171389e-02
 2.88474560e-03 6.97732568e-02 1.31863356e-03 1.50358498e-01
 5.53482771e-03 1.59776241e-01 3.46218944e-02 1.29825234e-01
 3.67615819e-02 3.30417156e-02 1.94246769e-02 9.63215828e-02
 2.34612823e-02 2.58168578e-02 1.06851459e-02 1.42481327e-02
 6.17901087e-02 8.10112357e-02 3.12977433e-02 1.02622628e-01
 3.91916037e-02 3.84138227e-02 3.15281749e-02 1.79123282e-02
 2.03127861e-02 1.78327560e-02 3.96412015e-02 1.65957808e-02
 4.65095043e-03 5.11898398e-02 1.02806091e-02 4.90880013e-02
 2.93691754e-02 9.01876092e-02 3.38330865e-02 2.41125226e-02
 1.00845098e-02 4.54658866e-02 5.23598194e-02 5.14885187e-02
 2.44855881e-03 3.12798619e-02 1.63000226e-02 4.26210761e-02
 1.66105032e-02 2.88438201e-02 7.67007470e-02 5.16922474e-02
 1.00845098e-02 1.36937201e-01 6.41797781e-02 2.21490860e-03
 1.62221193e-02 1.06042385e-01 4.67903614e-02 2.53009200e-02
 4.76479530e-04 9.01550055e-03 2.41665840e-02 1.53839380e-01
 2.76224613e-02]

Ranked IDs for query:

[161 222 296 115 70 106 18 128 130 134 168 242 228 154 126 180 37 85
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 90 14 100 213 276 288 194 5 270 200 146 254 40 153 8 22 13 226
 95 221 176 189 210 29 119 219 232 255 144 148 185 80 48 10 234 109
 227 178 23 86 292 282 121 196 267 284 36 56 147 27 129 197 265 263
 49 250 33 264 83 160 216 9 127 235 236 204 218 193 19 50 252 195
 182 275 298 98 107 171 42 54 295 253 111 20 152 74 0 84 44 212
 97 300 91 209 170 285 72 96 272 179 2 108 7 150 138 281 258 28
 262 124 192 181 191 66 159 249 274 110 75 208 246 92 46 157 162 141
 99 155 24 248 188 132 215 211 225 261 118 123 34 52 140 260 32 12
 266 26 60 122 62 64 68 224 283 45 103 277 233 25 294 35 65 4
 87 201 271 71 39 230 269 279 166 287 113 76 278 202 67 15 237 114
 55 145 120 199 207 6 136 143 142 151 256 238 82 290 94 78 21 149
 241 139 89 286 59 117 183 257 77 131 163 43 51 101 223 112 63 273
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 93 73 11 247 289 243 299 53 245 165 3 135 173]

50

Searching for ID 1498

Distance between source feature and all target features:

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 4.12201881e-03 1.39355063e-02 7.49135017e-03 1.21954501e-01
 3.18512917e-02 4.24766541e-03 1.78706646e-03 4.55586910e-02
 3.88681889e-03 4.76837158e-06 8.75878334e-03 1.48668885e-02
 1.86417699e-02 5.78948259e-02 4.12201881e-03 7.97706842e-03
 2.89248228e-02 3.85656357e-02 3.24239731e-02 9.50002670e-03
 2.36536860e-02 5.49370050e-03 1.04260445e-03 1.41441822e-03
 3.14016938e-02 1.18165016e-02 3.11008692e-02 3.92314196e-02
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 1.36294961e-02 1.50078535e-03 1.47746801e-02 5.87952137e-03
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 1.56713724e-02 1.80269480e-02 2.89523602e-03 6.45822287e-03
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 1.98325515e-02]

Ranked IDs for query:

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 29 119 219  37 180 126 154 232 228 255 168 128 144 106 148 296 222 185
 10  48  80 234 161 109 227 178  23  86 115 292  70 282 121  18 196 267
284 130 134  36  56 147 242  27  85 169 129 197 167 291 265 263 164 280
 49 250  33 264  83 160 216   9 127 235 236 204 218 193  19  50 252 195
182 275 298  98 107 171  42  54 295 253 111  20 152  74   0  84  44 212
 97 300  91 209 170 285  72  96 272 179   2 108  7 150 138 281 258  28
262 124 192 181 191  66 159 249 274 110  75 208 246  92  46 157 162 141
 99 155  24 248 188 132 215 211 225 261 118 123  34  52 140 260  32 12
266  26  60 122  62  64  68 224 283  45 103 277 233  25 294  35  65   4
 87 201 271  71  39 230 269 279 166 287 113  76 278 202  67  15 237 114
 55 145 120 199 207   6 136 143 142 151 256 238  82 290  94  78  21 149
241 139  89 286  59 117 183 257  77 131 163  43  51 101 223 112  63 273
231 205 177 104 239 251  79  81 133 259  69 293  41  61  47  57   1 175
 93  73  11 247 289 243 299  53 245 165   3 135 173]
```

128

Searching for ID 1499

Distance between source feature and all target features:

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 0.07364962 0.1006451  0.11966339 0.1098499  0.11629406 0.00183091
 0.09193411 0.11953774 0.12199834 0.07822672 0.12767223 0.12378064
 0.13254419 0.10891852 0.10514364 0.06589058 0.11966339 0.11580834
 0.09486058 0.08521977 0.09136143 0.11428538 0.10013172 0.11829171
 0.1227428 0.12237099 0.09238371 0.1119689 0.09268454 0.08455399
 0.11479476 0.1298028 0.12321153 0.08158258 0.12079802 0.02506188
 0.10631254 0.04889342 0.10469487 0.08894399 0.09673098 0.02214012
 0.11629406 0.11310062 0.1082525 0.04517749 0.0924705 0.02693182
 0.10631254 0.07651582 0.11479476 0.01817217 0.12398258 0.05275658
 0.09019175 0.02357593 0.09012362 0.04180762 0.08967212 0.08361605
 0.09879121 0.07900706 0.08962861 0.02775499 0.1322684 0.08215567
 0.1025584 0.00295261 0.10505989 0.0975987 0.07951465 0.04908767
 0.06631544 0.03447875 0.11629406 0.0320842 0.06739554 0.11073479
 0.10472384 0.13335499 0.11575618 0.08318105 0.12575248 0.05523643
 0.1221424 0.10394022 0.09695342 0.00651285 0.0663155 0.11902031
 0.10254827 0.10403863 0.10723165 0.09499827 0.12199834 0.04297337
 0.12453243 0.08675888 0.03809384 0.12913802 0.13066939 0.10710827
 0.10097918 0.11602721 0.0976356 0.10519508 0.04184398 0.07958379
 0.07741937 0.13215652 0.126358 0.05190316 0.09309229 0.1181452
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 0.12993303 0.10973021 0.13049468 0.11394688 0.13268879 0.04900429
 0.09481373 0.02954963 0.13272277 0.08475503 0.07335672 0.1280705
 0.1003451 0.05956903 0.0924705 0.09532896 0.07138517 0.07229164
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 0.09535679 0.04893455 0.13400301 0.03042784 0.07990029 0.13376
 0.1303328 0.13357332 0.10358682 0.10632101 0.1221424 0.08717099
 0.12759522 0.00855866 0.11860827 0.03825548 0.11594507 0.10217813
 0.12981513 0.09979191 0.10794386 0.05168822 0.12261686 0.11636069
 0.12453267 0.12480393 0.09481373 0.11854073 0.1269243 0.09938136
 0.09985098 0.10899791 0.12149081 0.10803595 0.11499014 0.11387089
 0.12589869 0.07435957 0.12099025 0.08299932 0.0792155 0.12458548
 0.10901073 0.03845271 0.12339053 0.07368734 0.09753612 0.10385111
 0.11851445 0.09333691 0.10469487 0.12180337 0.12298408 0.09445897
 0.11015591 0.12528619 0.10901073 0.11790588 0.12818661 0.11885884
 0.1311318 0.04272571 0.08962861 0.09319076 0.119293 0.11595342
 0.13020983 0.12712654 0.08145592 0.03900144 0.11740461 0.08589879
 0.11615011 0.10969976 0.10929337 0.07792136 0.06911096 0.03545818
```

```

0.12869057 0.06180206 0.13289395 0.01878318 0.12604049 0.02820092
0.09695342 0.00175008 0.09481373 0.0985336 0.11215064 0.03525373
0.10811403 0.10575846 0.12089017 0.11732718 0.06978521 0.05056408
0.10027757 0.02895269 0.09238371 0.09316149 0.10004714 0.11366299
0.11126253 0.11374256 0.09193411 0.11497954 0.12692437 0.08038548
0.12129471 0.08248731 0.10220614 0.04138771 0.09774223 0.10746279
0.12149081 0.08610943 0.0792155 0.0800868 0.13402387 0.10029545
0.11527529 0.08895424 0.11496481 0.1027315 0.05487457 0.07988307
0.12149081 0.00536188 0.06739554 0.13379022 0.1153532 0.02553293
0.08478495 0.1062744 0.13109884 0.12255982 0.10740873 0.02226406
0.10395285]

```

Ranked IDs for query:

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[247 11 73 289 93 175 1 57 243 47 299 61 41 293 53 69 245 259
133 165 81 79 251 239 104 177 205 231 273 63 112 223 101 51 43 163
131 77 257 3 183 117 59 286 89 139 241 149 21 78 94 82 290 238
256 151 142 143 136 6 207 199 120 145 55 114 237 15 67 202 278 76
113 287 166 279 269 230 39 71 271 201 87 4 65 35 135 294 25 233
277 103 173 45 283 68 224 64 62 122 60 26 12 266 32 260 52 140
34 123 118 261 225 211 215 248 188 132 24 155 99 141 162 157 46 246
92 208 75 110 274 249 159 66 191 181 124 192 262 28 258 281 138 150
7 108 2 179 272 96 72 285 170 209 91 300 97 212 44 84 0 152
74 20 111 253 295 42 54 171 107 98 298 275 182 195 252 50 19 193
204 218 236 235 127 9 216 160 83 264 33 250 49 263 265 197 129 27
147 36 56 284 267 196 121 282 292 86 23 178 227 109 234 10 48 80
185 148 144 255 232 219 119 29 210 189 176 221 95 226 13 8 22 153
40 254 200 146 270 5 276 194 288 213 14 100 90 172 158 31 297 184
30 214 38 206 17 58 102 186 203 187 217 88 198 244 116 190 268 229
174 16 137 156 220 240 125 105 37 180 126 154 228 168 128 106 296 222
161 115 70 18 130 134 242 85 169 167 291 164 280]
```

10

Searching for ID 1500

Distance between source feature and all target features:

```

[5.25534153e-03 1.01589978e-01 8.58938694e-03 1.60830408e-01
2.70343423e-02 1.12127066e-02 3.65828872e-02 9.58740711e-03
9.43088531e-03 3.82602215e-04 6.06155396e-03 1.08401597e-01
1.82983875e-02 9.30523872e-03 1.17658377e-02 3.20057869e-02
1.74397230e-02 1.35481358e-02 2.23116875e-02 1.31398439e-03
5.08886576e-03 4.43419218e-02 9.43088531e-03 5.57583570e-03
1.53719187e-02 2.50127316e-02 1.88710690e-02 4.05287743e-03
1.01007819e-02 8.05920362e-03 1.25102997e-02 1.21384859e-02
1.78487897e-02 1.73640251e-03 1.75479650e-02 2.56785154e-02
4.56225872e-03 1.95702910e-02 1.29790306e-02 2.86499262e-02
1.05655193e-02 8.51706266e-02 3.91995907e-03 6.13390803e-02
5.53762913e-03 2.12885141e-02 1.35015249e-02 8.80923867e-02
6.06155396e-03 2.86811590e-03 1.98000669e-03 6.50550127e-02
1.77620053e-02 1.37164325e-01 3.91995907e-03 3.37166786e-02
4.56225872e-03 9.20603275e-02 1.37500763e-02 5.74759245e-02
2.00407505e-02 8.66565704e-02 2.01088786e-02 6.84248805e-02
2.05603838e-02 2.66164541e-02 1.14412904e-02 3.12254429e-02
2.06038952e-02 8.24775100e-02 2.20358968e-02 2.80768275e-02
7.67409801e-03 1.07279897e-01 5.17261028e-03 1.26338005e-02
3.07178497e-02 6.11448288e-02 4.39170599e-02 7.57537484e-02
6.06155396e-03 7.81483054e-02 4.28369641e-02 5.02288342e-04
5.50866127e-03 2.31224895e-02 5.52368164e-03 2.70514488e-02
1.55199766e-02 5.49960732e-02 1.19099021e-02 6.29228354e-03
1.32790804e-02 1.03719652e-01 4.39170003e-02 8.78781080e-03
7.68423080e-03 6.19387627e-03 3.00085545e-03 1.52342319e-02
1.17658377e-02 6.72591329e-02 1.42999291e-02 2.34736204e-02
7.21386671e-02 1.89055204e-02 2.04368830e-02 3.12423706e-03
9.25332308e-03 5.79470396e-03 1.25969052e-02 5.03742695e-03

```

6.83885217e-02 3.06487083e-02 3.28131318e-02 2.19240189e-02
 1.61255002e-02 5.83293438e-02 1.71402097e-02 7.91269541e-03
 3.44324112e-02 5.00619411e-03 2.01088786e-02 1.71717405e-02
 1.03815198e-02 1.86098814e-02 1.97005272e-02 5.02288342e-04
 2.02621818e-02 3.71438265e-03 2.24562883e-02 6.12282157e-02
 1.54187679e-02 8.06828737e-02 2.24902630e-02 1.94987535e-01
 3.68757844e-02 1.78380013e-02 9.88739729e-03 5.06634712e-02
 1.77620053e-02 1.49035454e-02 3.88473272e-02 3.79408598e-02
 6.71005249e-03 3.41709852e-02 1.07577443e-02 4.55117226e-03
 6.51592016e-03 4.58611250e-02 9.67866182e-03 3.98195982e-02
 5.17261028e-03 9.50628519e-03 1.97665691e-02 1.52695775e-02
 1.79541111e-02 1.44820213e-02 1.19836926e-02 1.15106702e-02
 2.49147415e-05 2.12681293e-02 1.48757100e-02 6.12979531e-02
 2.37705112e-02 1.40660346e-01 3.03322077e-02 2.35275030e-02
 2.01002955e-02 2.33408213e-02 6.64567947e-03 3.91149521e-03
 1.19099021e-02 1.97403491e-01 1.73627138e-02 1.01673841e-01
 8.37576389e-03 7.19770193e-02 5.71256876e-03 8.05437565e-03
 1.95826292e-02 1.04405880e-02 2.28863955e-03 5.85442781e-02
 1.23843551e-02 6.12819195e-03 1.43001676e-02 1.45714283e-02
 1.54187679e-02 8.30823183e-03 1.66918039e-02 1.08511448e-02
 1.03815198e-02 1.23459101e-03 1.12583041e-02 2.19655037e-03
 4.75764275e-03 3.63838673e-03 1.56661868e-02 3.58729362e-02
 1.07577443e-02 2.72331834e-02 3.10170054e-02 1.43529773e-02
 1.22177601e-03 7.17797875e-02 1.31580234e-02 3.65451574e-02
 1.26963854e-02 6.38139248e-03 8.28194618e-03 1.68955922e-02
 5.53762913e-03 1.15708709e-02 1.27515793e-02 1.57735348e-02
 7.65919685e-05 1.50536895e-02 1.22177601e-03 7.67338276e-03
 1.79541111e-02 8.62634182e-03 2.08992958e-02 6.75067902e-02
 2.06038952e-02 1.70417428e-02 9.06050205e-03 5.72091341e-03
 1.99773312e-02 1.68940425e-02 2.87765861e-02 7.12310672e-02
 7.17210770e-03 2.43337154e-02 5.91760874e-03 5.32746315e-04
 9.39130783e-04 3.23111415e-02 4.11215425e-02 7.47743249e-02
 1.84580684e-02 4.84304428e-02 2.26614475e-02 1.29015684e-01
 1.58079863e-02 1.38433427e-01 1.32790804e-02 1.08482420e-01
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 4.04472947e-02 5.96684217e-02 9.95492935e-03 8.12798142e-02
 1.78487897e-02 1.70710087e-02 1.01853609e-02 3.43048573e-03
 1.03002787e-03 3.51005793e-03 1.82983875e-02 4.74703312e-03
 1.66918635e-02 2.98470259e-02 1.10622048e-02 2.77451873e-02
 8.02636147e-03 6.88447952e-02 1.24902725e-02 2.76970863e-03
 1.12583041e-02 2.41230726e-02 3.10170054e-02 3.01457047e-02
 2.37913728e-02 9.93704796e-03 5.04279137e-03 2.12782621e-02
 4.73231077e-03 7.50100613e-03 5.53579330e-02 3.03494334e-02
 1.12583041e-02 1.15594387e-01 4.28369641e-02 2.35577226e-02
 5.12069464e-03 8.46995711e-02 2.54475474e-02 3.95810604e-03
 2.08663344e-02 1.23273134e-02 2.82377005e-03 1.32496566e-01
 6.27964735e-03]

Ranked IDs for query:

| | | | | | | | | | | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| [160 | 216 | 9 | 127 | 83 | 235 | 236 | 264 | 204 | 218 | 193 | 19 | 33 | 250 | 50 | 252 | 195 | 182 |
| 275 | 298 | 49 | 98 | 107 | 263 | 265 | 197 | 129 | 171 | 54 | 42 | 295 | 27 | 253 | 147 | 36 | 56 |
| 284 | 267 | 196 | 121 | 111 | 282 | 20 | 292 | 74 | 152 | 0 | 84 | 86 | 212 | 44 | 23 | 178 | 227 |
| 109 | 234 | 48 | 80 | 10 | 185 | 97 | 300 | 91 | 209 | 148 | 170 | 144 | 255 | 232 | 285 | 219 | 72 |
| 96 | 119 | 272 | 179 | 29 | 210 | 189 | 176 | 2 | 221 | 95 | 226 | 108 | 13 | 22 | 8 | 153 | 7 |
| 150 | 138 | 281 | 258 | 28 | 262 | 124 | 192 | 181 | 40 | 254 | 146 | 200 | 191 | 270 | 5 | 288 | 276 |
| 194 | 66 | 159 | 213 | 249 | 100 | 14 | 90 | 172 | 158 | 31 | 297 | 184 | 274 | 30 | 110 | 75 | 208 |
| 214 | 38 | 206 | 246 | 92 | 46 | 17 | 58 | 102 | 186 | 203 | 157 | 187 | 162 | 141 | 217 | 99 | 155 |
| 24 | 248 | 132 | 188 | 88 | 198 | 215 | 244 | 116 | 190 | 268 | 229 | 211 | 225 | 261 | 118 | 123 | 174 |
| 16 | 34 | 52 | 140 | 137 | 32 | 260 | 220 | 156 | 12 | 266 | 240 | 125 | 26 | 105 | 37 | 180 | 126 |
| 154 | 228 | 60 | 168 | 62 | 122 | 128 | 106 | 64 | 68 | 224 | 296 | 222 | 161 | 283 | 45 | 115 | 70 |
| 18 | 130 | 134 | 242 | 85 | 169 | 103 | 167 | 291 | 164 | 280 | 277 | 233 | 25 | 294 | 35 | 65 | 4 |

```

87 201 271 71 39 230 269 279 166 287 113 76 202 278 67 15 237 114
55 145 120 199 207 6 136 143 142 151 256 238 290 82 94 78 21 149
241 139 89 286 59 117 183 257 77 131 163 43 51 101 223 112 63 273
231 205 177 104 239 251 79 81 133 259 69 293 41 61 47 57 1 175
93 73 11 247 289 243 299 53 245 165 3 135 173]

```

61

```
[1. 0. 0. 2. 2. 1. 1. 2. 0. 2. 0. 1. 5. 1. 1. 2. 2. 2. 2. 0. 2. 1. 2.
0. 1. 2. 0. 4. 2. 1. 0. 0. 0. 4. 4. 2. 0. 0. 1. 0. 0. 0. 1. 1. 0. 2. 0.
1. 1. 1. 1. 2. 2. 1. 0. 1. 2. 1. 2. 0. 1. 1. 0. 2. 1. 1. 2. 0. 2. 3. 1.
0. 1. 1. 1. 4. 2. 1. 0. 2. 0. 2. 0. 2. 1. 0. 0. 0. 0. 1. 1. 0. 1. 0. 2.
1. 0. 2. 3. 0. 2. 1. 1. 0. 2. 2. 0. 1. 0. 0. 1. 3. 0. 1. 1. 0. 2. 0. 0.
2. 3. 0. 0. 1. 1. 0. 0. 1. 1. 2. 2. 1. 0. 1. 0. 2. 0. 1. 2. 3. 0. 0. 2.
1. 1. 2. 0. 3. 1. 0. 0. 2. 1. 1. 2. 2. 0. 2. 1. 1. 0. 1. 0. 0. 1. 1.
0. 1. 1. 2. 2. 0. 2. 0. 2. 4. 2. 0. 2. 1. 2. 2. 0. 3. 0. 2. 1. 0. 1. 1.
2. 1. 0. 2. 1. 0. 0. 2. 2. 0. 0. 1. 1. 1. 0. 1. 0. 2. 0. 0. 0. 2. 1.
0. 1. 2. 2. 0. 1. 0. 0. 2. 0. 1. 0. 2. 1. 1. 0. 1. 1. 0. 1. 1. 2. 1.
0. 3. 1. 0. 1. 0. 0. 1. 2. 1. 2. 0. 0. 1. 0. 2. 2. 1. 1. 1. 1. 1. 0.
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1. 0. 1. 0. 0. 0. 0. 1. 1. 1. 2. 1. 1.]
```

In [46]:

```

cmc = np.zeros(301)
for i in range(301):
    cmc[i] = np.sum(ranked_histogram[: (i + 1)])

print(cmc)

```

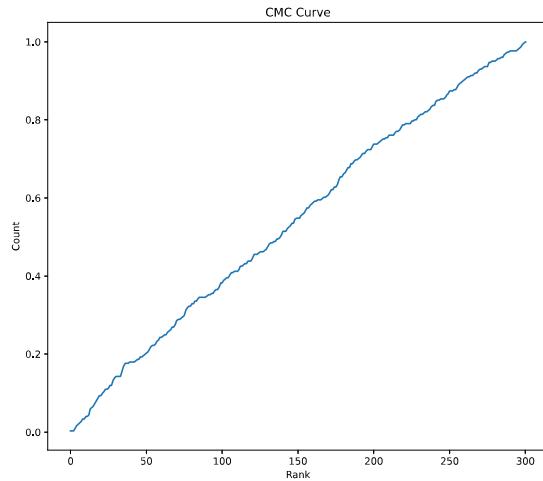
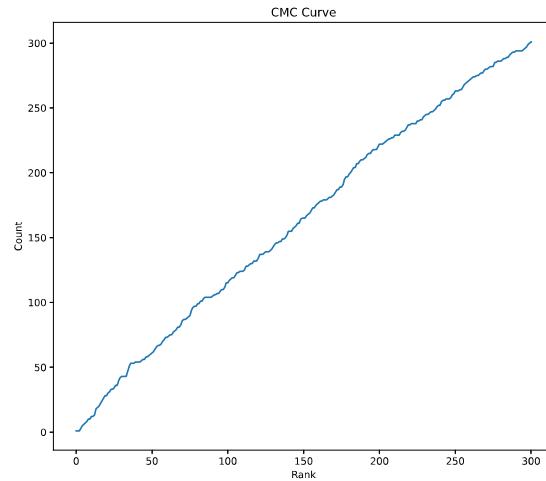
```
[ 1.   1.   1.   3.   5.   6.   7.   8.   10.  10.  12.  12.  13.  18.
19.  20.  22.  24.  26.  28.  28.  30.  31.  33.  33.  34.  36.  36.
40.  42.  43.  43.  43.  43.  47.  51.  53.  53.  53.  54.  54.  54.
54.  55.  56.  56.  58.  58.  59.  60.  61.  62.  64.  66.  67.  67.
68.  70.  71.  73.  73.  74.  75.  75.  77.  78.  79.  81.  81.  83.
86.  87.  87.  88.  89.  90.  94.  96.  97.  97.  99.  99.  101.  101.
103. 104. 104. 104. 104. 105. 106. 106. 107. 107. 107. 109. 110. 110.
112. 115. 115. 117. 118. 119. 119. 121. 123. 123. 124. 124. 124. 125.
128. 128. 129. 130. 130. 132. 132. 132. 134. 137. 137. 137. 138. 139.
139. 139. 140. 141. 143. 145. 146. 146. 147. 147. 147. 149. 149. 149. 150.
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181. 182. 183. 185. 187. 187. 189. 189. 191. 195. 197. 197. 199. 200.
202. 204. 204. 207. 207. 209. 210. 210. 211. 212. 214. 215. 215. 217.
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229. 229. 229. 229. 231. 232. 232. 233. 235. 237. 237. 238. 238. 238.
238. 240. 240. 241. 241. 243. 244. 245. 245. 246. 247. 247. 248. 249.
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263. 264. 264. 266. 268. 269. 270. 271. 272. 273. 274. 274. 275. 275.
276. 277. 277. 279. 280. 280. 281. 282. 282. 282. 285. 285. 286. 286.
286. 287. 288. 288. 289. 289. 291. 292. 293. 293. 294. 294. 294. 294.
294. 295. 296. 297. 299. 300. 301.]
```

In [47]:

```
fig = plt.figure(figsize=[20, 8])
ax = fig.add_subplot(1, 2, 1)
ax.plot(cmc)
ax.set_xlabel('Rank')
ax.set_ylabel('Count')
ax.set_title('CMC Curve')
ax = fig.add_subplot(1, 2, 2)
ax.plot(cmc/len(test_gnd))
ax.set_xlabel('Rank')
ax.set_ylabel('Count')
ax.set_title('CMC Curve')
```

Out[47]:

Text(0.5, 1.0, 'CMC Curve')



In []: