HRI Lab #7, SP2024 525.786: Human Robotics Interaction

Introduction:

In this lab we will explore interfacing various types of motion tracking tools. These tools, in combination with the bioinstrumentation inputs you've used previously, can be used for natural and intuitive Human Robotic Interaction. The tools that we'll be using include the following devices:

```
- Inertial measurement Unit (3-axis, 6 Degrees of Freedom) on the Myo
- Kinect (20 Degrees of Freedom, Whole Body)
```

Setup the MiniVIE environment

```
thisPath = cd;
cd('C:\GitHub\MiniVIE');
MiniVIE.configurePath;
```

```
[MiniVIE.m] Configured MiniVIE path at: C:\GitHub\minivie
```

```
cd(thisPath);
```

Part 1: Inertial Measurement Unit on the Myo

Operating Principle: the Myo armband contains an Angular rate sensor, accelerometer, and magnetometer to resolve orientation. These sensors can be used to track motion of the arm in addition to the EMG signals

Before running the code below, be sure to start MyoUdp.exe in the MiniVIE/+Inputs folder

It might be more straightforward to run this in the Command Window (select, then hit F9)

```
% Setup the Myo Armband in matlab
hMyo = Inputs.MyoUdp.getInstance();
```

```
[MyoUdp] Calling constructor
```

```
hMyo.initialize()
```

```
[UserConfig.m] Calling constructor with config file
[UserConfig.m] No file  found
[UserConfig.m] No file  found
[UserConfig.m] No file  found

Loaded pnet Version  2.0.5  2003-09-16 Copyright (C) Peter Rydesäter, Sweden, et al. , 1998 - 2003
[PnetClass] Opened pnet socket #0 at local port: 10001; Default destination: port 45001 @ 127.0.0.1
[PnetClass] Opened pnet socket #1 at local port: 10002; Default destination: port 45001 @ 127.0.0.1
[MyoUdp] UDP Data Stream 1-8 NOT Detected
[MyoUdp] UDP Data Stream 9-16 NOT Detected
ans = 0
```

```
pause(1)

% Ensure data is streaming
myoData = hMyo.getData();
```

```
if isempty(hMyo.Orientation)
    error('Setup Failed.  MyoUdp Running?');
end

% Setup figure to show orientation
figure(1);
clf
daspect([1 1 1])
view(-170,15)

% Plot reference triad
PlotUtils.triad(eye(4),0.5)
```

```
ans = 10.0001
```

```
% Plot 'moving' triad
myoTriadHandle = PlotUtils.triad(eye(4),2);
StartStopForm([])
while StartStopForm()
    drawnow
    hMyo.getData();  % update stream receive
    Rxyz = hMyo.getEulerAngles; % Get roll pitch yaw
    disp(Rxyz)
    Rmat = LinAlg.makeRotationMtx(Rxyz); % create rotation matrix
    transMat = [Rmat [0; 0; 0]; 0 0 0 1];
    set(myoTriadHandle,'Matrix', transMat);
end
```

```
Warning: The JavaFrame figure property will be removed in a future release. For more information see UI
Alternatives for MATLAB Apps on mathworks.com.
  107.1941
   29.6672
 -141.7360

  109.9814
   29.7594
 -138.5009

   98.0325
   27.8338
 -158.6261

   91.4443
   22.8809
 -169.8104

   88.9113
   15.3903
 -178.7497

   89.6040
   10.0827
  178.7190

   91.4627
   13.3717
```

```
 179.3947

  92.0965
  17.9291
-179.7544

 100.7285
  33.4029
-173.6254

 106.3653
  39.7244
-168.4645

 129.0708
  51.6412
-146.8447

 153.7129
  52.2092
-122.8290

 161.0280
  50.1785
-115.9312

 170.0095
  44.9722
-108.1550

 176.4553
  39.5069
-104.0953

 178.1866
  37.9074
-103.6358

 178.1871
  34.4927
-107.1834

 177.9701
  29.8391
-112.1006

 177.7071
  28.1429
-114.2828

 177.0480
  24.9835
-119.4062

 178.6591
  23.9259
-121.4187

 179.6831
  24.2582
-121.5677

-178.3320
  25.4084
```

-121.0565

-177.2728
  26.0696
-120.3463

-174.9465
  27.9696
-118.1073

-174.1929
  29.6918
-117.3047

-171.1163
  34.5985
-115.7503

-170.2851
  36.6824
-114.3062

-172.1148
  36.2173
-113.5047

-170.1974
  32.3359
-110.5578

-168.5060
  29.7072
-108.5941

-166.3405
  28.6002
-107.3794

-163.9574
  25.6177
-106.5480

-162.2480
  24.2501
-104.7559

-159.4429
  21.4584
-100.9070

-159.1489
  19.4763
-100.7650

-160.7164
  18.5960
-106.7665

-160.7112
  18.1882
-107.5893

-159.3988
  16.3976

```
-111.0098

-156.1409
  14.6492
-111.1353

-151.9186
   8.0726
-105.5318

-151.5082
   7.4117
-104.8517

-150.8483
   5.8557
-101.9113

-151.3668
   5.9600
 -99.8623

-151.5524
   5.8165
 -98.5803

-152.0410
   5.8427
 -98.3686

-152.1056
   5.6273
 -98.2651

-150.8585
   4.0509
 -96.7550

-149.9361
   3.5357
 -95.8680

-149.3173
   3.5066
 -94.3805

-148.3141
   3.2673
 -92.8686

-149.6427
   6.8277
 -94.9660

-155.3811
  17.9163
 -98.5604

-151.0476
  27.1787
 -98.9489

-150.3469
  30.4721
```

-103.1837

-154.3445
  26.5272
-109.7494

-156.2504
  22.9854
-109.3142

-154.3631
  19.6675
-104.6181

-153.8913
  19.3086
-104.0264

-153.8159
  19.0040
-103.5902

-154.1977
  18.1638
-103.4984

-154.5036
  18.4189
-104.4168

-154.1292
  18.1173
-102.6628

-154.4991
  17.8389
-102.2474

-152.7280
  17.9526
-100.5577

-153.7264
  17.8883
-100.6100

-153.0853
  17.8506
 -99.9087

-153.9828
  17.1278
 -99.5688

-152.3619
  16.8163
 -99.1079

-152.3619
  16.8163
 -99.1079

-153.6115
  16.5144

```
-100.2358

-153.0627
  16.4467
 -99.7172

-153.3562
  15.1786
 -99.6525

-151.9539
  14.1707
 -99.4405

-151.3614
  14.2954
 -99.2089

-150.0531
  14.8171
 -98.0758

-149.4665
  13.7497
 -97.1827

-149.9745
  12.8822
 -97.4101

-149.6960
  12.7431
 -97.2029

-149.5364
  13.4387
 -96.9980

-149.6456
  13.2968
 -96.6734

-149.7378
  12.9338
 -96.8254

-150.2394
  14.0659
 -97.7405

-150.8357
  14.8539
 -98.4228

-151.5522
  18.5119
 -99.4985

-153.1775
  36.3035
 -98.3765

-147.5627
  65.1111
```

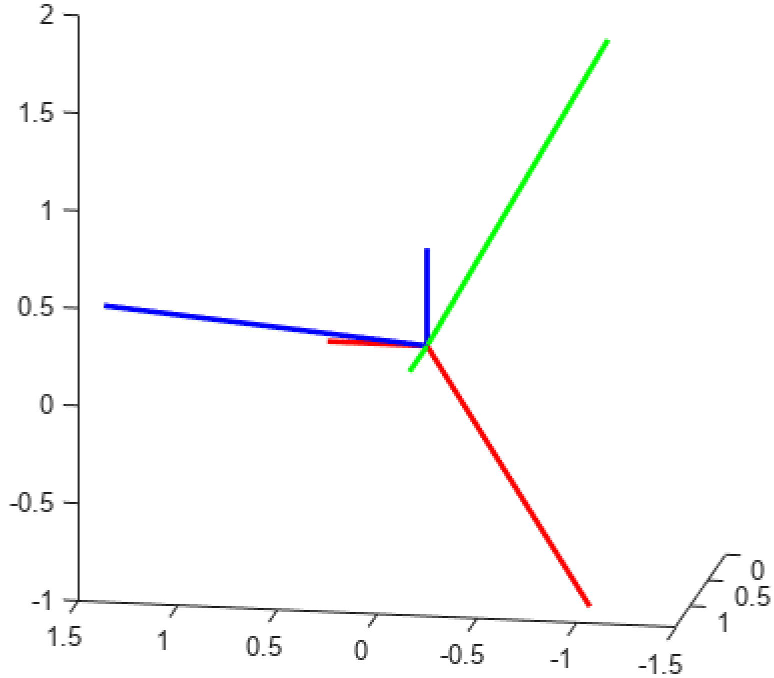
```
-102.5228

-138.1780
  85.0913
-103.2742

  42.5698
  70.1797
  64.8283

  43.0264
  68.0439
  64.5427

  46.9588
  60.3448
  63.1633

  53.3584
  54.5966
  62.3067

  55.5040
  56.6213
  63.3423

  54.8972
  60.4056
  66.1942

 117.3005
  81.0231
 127.9763

-158.3234
  50.4411
-151.7559

-163.8962
  38.9422
-151.3205

-171.4679
  19.9765
-146.6997

-178.7849
   4.8388
-141.2014

-179.6092
   2.1017
-138.9610

 177.5846
  -2.4812
-132.9506

 176.0393
  -3.9435
-127.3003

 175.6039
  -3.3380
```

```
-125.0037

 175.6702
  -3.3919
-125.1602

 175.9318
  -4.5312
-126.2860

 176.5928
  -4.6920
-127.0810

 178.7248
   4.9531
-135.4331

 179.6604
  26.1871
-151.3882

 178.5882
  32.6209
-155.6693

 162.1171
  55.6522
-174.6865

 113.5766
  68.4527
 139.2425

  92.4134
  67.1515
 118.4691

  97.8546
  70.6301
 112.7562

  92.5107
  70.9843
 103.9823

  89.8187
  71.4760
 101.5994

 119.9732
  77.6464
 134.1159

-167.6698
  57.4001
-151.7543

-173.2134
  29.5913
-152.6339

  75.4100
  75.3994
```

```
  86.5355

  45.2620
  61.3482
  69.6807

 110.8609
  73.2111
 120.2391

 162.9666
  33.5133
-174.7757

 147.7521
  25.6887
-165.9190

 133.1523
  48.6848
 176.6894

  71.7762
  50.9647
 114.9776

  65.9028
  46.0284
 107.4356

  95.8234
  23.5052
 112.4984

 114.2525
  17.1085
 129.2712

 116.1080
  14.6094
 159.6934

 121.8622
  26.7555
-176.1734

 121.7764
  34.0731
-175.3310

 119.9511
  35.3282
 178.2414

 109.0590
  36.6371
 151.8509

  27.7415
  22.2884
  97.6753

  26.2083
   5.5592
```

```
 97.6268

 27.1129
 -0.1918
 97.9521

 28.9687
  2.7400
 98.4333

 27.8752
  9.1972
 99.3393

 27.0054
 13.9434
 98.9383

 26.7978
 14.8774
 98.6172

 26.2548
 16.1677
 98.0449

 25.9386
 16.1484
 98.0007

 26.0438
 15.6348
 98.6266

 26.3197
 15.8291
 98.9474

 26.2587
 16.1677
 98.9432

 26.4961
 17.1428
 98.9697

 42.0058
 20.0655
 99.2850

 60.2212
 27.2182
110.7498

 61.1897
 27.6768
113.8391

 73.7195
 27.0507
126.8496

 78.4340
```

```
   26.4962
  132.4718
```




```
hMyo.close()
```

```
[MyoUdp] Deleting Udp comms object
[PnetClass.m] Closed pnet socket #0 at local port: 10001
[PnetClass.m] Closed pnet socket #1 at local port: 10002
```

```
cleanup;
```

```
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Loaded pnet Version  2.0.5  2003-09-16 Copyright (C) Peter Rydesäter, Sweden, et al. , 1998 - 2003
Warning: instrfindall will be removed in a future release. There is no simple replacement for this.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
```

```
cleanup
--------------------------------------
--------------------------------------
--------------------------------------
```

Questions:

1. What is the 'global' position of the myo armband?

The global position is (0,0,0)

1. What is its local coordinate frame?

The local coordinate frame is the orientation of the band relative to the global frame. The smaller axes represent the original axes of the myoband, where the local coordinate system sits in the middle of the myoband. The red axis runs horizontally through the middle of the band, the blue runs vertically through the band's logo, and the green runs orthogonally to both laterally.

1. What processing would you do to use the myo armband as a sensor to control the elbow flexion angle of a robotic device?

We would calculate the angles between the axes' orientations between the resting position of the arm and the final flexed position of the arm. We can use Linalg.Anglebetween to calculate this.

Use the Myo Orientation Sensors to Plot Arm Position

Edit the code below to show (in a streaming fashion) the real-time orientation and position of the forearm.

It might be more straightforward to run this in the Command Window (select, then hit F9)

```
hMyo = Inputs.MyoUdp.getInstance();
```

```
[MyoUdp] Returning existing object
```

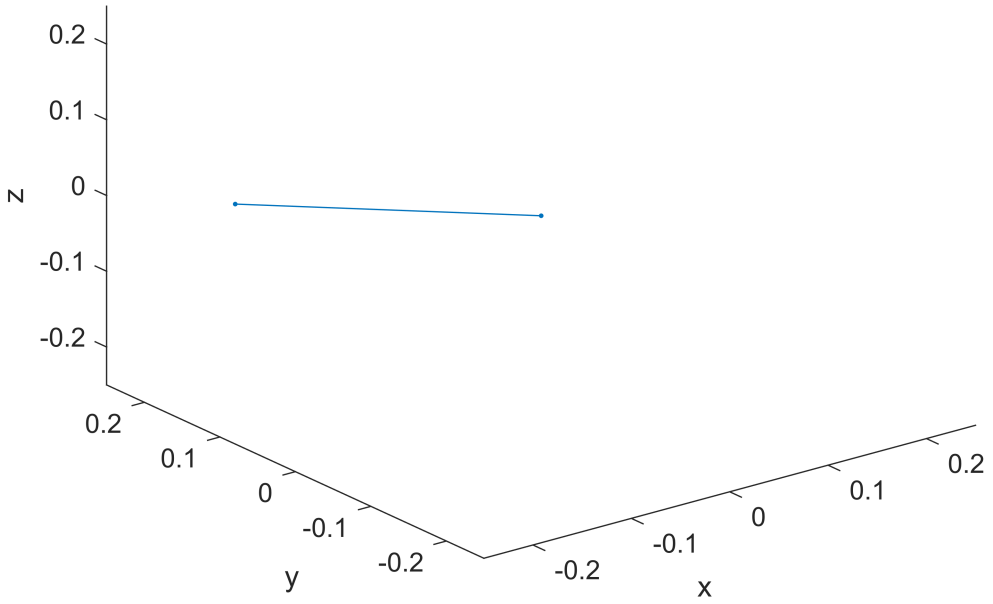
```
hMyo.initialize()
```

```
[UserConfig.m] No file  found
[MyoUdp] UDP Comms already initialized
ans = 0
```

```
pause(1)

% Ensure data is streaming
myoData = hMyo.getData();
if isempty(hMyo.Orientation)
    error('Setup Failed.  MyoUdp Running?');
end
```

```
% Can you create a real time plot of your hand's position in space using
% the real-time orientation matrix from the Myo?  assume the distance from
% Myo to hand is 25 cm.
myoOrigin = [0, 0, 0];
handPosStart = [0.25, 0, 0]; % in meters
figHandle = figure(1);
clf
daspect([1 1 1])
view(-170,15)

StartStopForm([])
while StartStopForm()


    hMyo.getData();
    Rxyz = hMyo.getEulerAngles;
    Rmat = LinAlg.makeRotationMtx(Rxyz);
    disp(Rmat)

    handPos = handPosStart * Rmat;


    plot3([0, handPos(1)], [0, handPos(2)], [0, handPos(3)], '.-');
    set(gca, 'XLim', [-0.25 0.25], 'YLim', [-0.25 0.25], 'ZLim', [-0.25 0.25]);
    xlabel('x'); ylabel('y'); zlabel('z');
    drawnow;

end
```

```
Warning: The JavaFrame figure property will be removed in a future release. For more information see UI
Alternatives for MATLAB Apps on mathworks.com.
   -0.8456    0.5201    0.1206
    0.0046   -0.2188    0.9758
    0.5339    0.8256    0.1826
```




```
-0.8518    0.5050    0.1391
 0.0090   -0.2515    0.9678
 0.5238    0.8257    0.2096

-0.8589    0.4878    0.1562
 0.0002   -0.3045    0.9525
 0.5122    0.8181    0.2615

-0.8538    0.4935    0.1658
 0.0155   -0.2943    0.9556
 0.5204    0.8185    0.2436

-0.8513    0.4977    0.1662
 0.0160   -0.2920    0.9563
 0.5245    0.8167    0.2406

-0.8713    0.4585    0.1750
-0.0001   -0.3566    0.9343
 0.4908    0.8140    0.3107

-0.8881    0.4292    0.1645
-0.0163   -0.3871    0.9219
 0.4593    0.8160    0.3508

-0.8983    0.4167    0.1394
-0.0321   -0.3787    0.9250
 0.4383    0.8264    0.3536

-0.8724    0.4730    0.1231
-0.0589   -0.3518    0.9342
 0.4852    0.8078    0.3348

-0.8687    0.4836    0.1074
-0.0629   -0.3227    0.9444
```

```
 0.4913    0.8136    0.3108

-0.8649    0.4919    0.1004
-0.0640   -0.3064    0.9498
 0.4979    0.8150    0.2965

-0.8670    0.4876    0.1028
-0.0620   -0.3102    0.9486
 0.4944    0.8161    0.2992

-0.8710    0.4804    0.1033
-0.0571   -0.3078    0.9498
 0.4880    0.8213    0.2955

-0.8719    0.4783    0.1048
-0.0536   -0.3060    0.9505
 0.4867    0.8232    0.2924

-0.8729    0.4756    0.1086
-0.0489   -0.3069    0.9505
 0.4854    0.8244    0.2912

-0.8736    0.4737    0.1118
-0.0437   -0.3051    0.9513
 0.4847    0.8262    0.2873

-0.8732    0.4744    0.1121
-0.0425   -0.3033    0.9519
 0.4856    0.8264    0.2850

-0.8758    0.4682    0.1177
-0.0325   -0.3004    0.9532
 0.4816    0.8310    0.2783

-0.8728    0.4749    0.1124
-0.0398   -0.2990    0.9534
 0.4864    0.8277    0.2799

-0.8775    0.4665    0.1114
-0.0464   -0.3137    0.9484
 0.4774    0.8270    0.2969

-0.9162    0.3817    0.1220
-0.0404   -0.3909    0.9196
 0.3986    0.8376    0.3736

-0.9636    0.2640    0.0416
-0.0890   -0.4636    0.8816
 0.2520    0.8458    0.4702

-0.9588    0.2835    0.0202
-0.1116   -0.4409    0.8906
 0.2613    0.8516    0.4544

-0.9527    0.3016    0.0377
-0.0922   -0.4052    0.9096
 0.2896    0.8631    0.4138

-0.9526    0.2949    0.0746
-0.0610   -0.4255    0.9029
 0.2980    0.8556    0.4233

-0.9677    0.2117    0.1366
 0.0618   -0.3263    0.9433
```

```
 0.2442    0.9213    0.3027

-0.9893   -0.0635    0.1316
 0.1379   -0.1093    0.9844
-0.0482    0.9920    0.1169

-0.6451   -0.4761    0.5976
 0.4517    0.3932    0.8009
-0.6163    0.7866   -0.0386

-0.4871   -0.5047    0.7128
 0.4868    0.5207    0.7013
-0.7251    0.6886   -0.0079

-0.3038   -0.5107    0.8043
 0.5969    0.5560    0.5784
-0.7426    0.6558    0.1359

-0.1668   -0.0573    0.9843
 0.9065    0.3838    0.1759
-0.3879    0.9216   -0.0120

-0.2639    0.1571    0.9517
 0.9602    0.1361    0.2438
-0.0913    0.9782   -0.1868

-0.7628    0.1320    0.6330
 0.6454    0.0953    0.7579
 0.0398    0.9867   -0.1579

-0.5880   -0.2832    0.7577
 0.5545    0.5408    0.6325
-0.5889    0.7920   -0.1610

-0.2800   -0.2861    0.9164
 0.7301    0.5563    0.3968
-0.6233    0.7802    0.0531

-0.0118    0.1032    0.9946
 0.9999   -0.0101    0.0129
 0.0114    0.9946   -0.1031

-0.1789    0.5688    0.8028
 0.8584   -0.3085    0.4098
 0.4808    0.7625   -0.4330

-0.5641    0.5941    0.5735
 0.5589   -0.2366    0.7948
 0.6079    0.7688   -0.1986

-0.6543    0.5941    0.4678
 0.4551   -0.1846    0.8711
 0.6039    0.7829   -0.1496

-0.7264    0.6309    0.2726
 0.2706   -0.1021    0.9573
 0.6318    0.7691   -0.0966

-0.6879    0.7100    0.1510
 0.1429   -0.0715    0.9872
 0.7116    0.7006   -0.0523

-0.6630    0.7359    0.1377
 0.1679   -0.0331    0.9852
```

```
 0.7296    0.6763   -0.1016

-0.5054    0.8190    0.2717
 0.4025   -0.0548    0.9138
 0.7633    0.5711   -0.3020

-0.3609    0.8781    0.3141
 0.5399   -0.0779    0.8381
 0.7605    0.4720   -0.4460

-0.1244    0.9079    0.4003
 0.6991   -0.2060    0.6847
 0.7041    0.3650   -0.6091

 0.1494    0.8440    0.5152
 0.8117   -0.4022    0.4235
 0.5646    0.3549   -0.7452

 0.3699    0.6778    0.6354
 0.8402   -0.5359    0.0826
 0.3965    0.5033   -0.7678

 0.5299    0.4447    0.7221
 0.8166   -0.4973   -0.2930
 0.2288    0.7450   -0.6266

 0.6332    0.2596    0.7292
 0.7734   -0.2492   -0.5829
 0.0304    0.9330   -0.3585

 0.5994    0.1741    0.7813
 0.7773    0.1067   -0.6201
-0.1913    0.9789   -0.0713

 0.5586    0.1496    0.8158
 0.7857    0.2198   -0.5783
-0.2658    0.9640    0.0053

 0.4203    0.1269    0.8985
 0.7909    0.4342   -0.4313
-0.4448    0.8918    0.0822

 0.0789    0.0298    0.9964
 0.6889    0.7208   -0.0761
-0.7205    0.6925    0.0363

-0.2581   -0.1141    0.9593
 0.4340    0.8735    0.2207
-0.8631    0.4733   -0.1759

-0.5625   -0.4883    0.6671
-0.1749    0.8590    0.4813
-0.8081    0.1541   -0.5686

-0.5351   -0.6421    0.5490
-0.3603    0.7613    0.5392
-0.7641    0.0907   -0.6387

-0.5630   -0.6329    0.5315
-0.2772    0.7504    0.6000
-0.7786    0.1904   -0.5979

-0.6030   -0.5808    0.5469
-0.2071    0.7760    0.5957
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-0.7704    0.2460   -0.5882

-0.6763   -0.5069    0.5345
-0.1669    0.8122    0.5590
-0.7174    0.2889   -0.6339

-0.7292   -0.4787    0.4889
-0.2024    0.8335    0.5142
-0.6536    0.2760   -0.7047

-0.8068   -0.4635    0.3663
-0.3131    0.8613    0.4002
-0.5010    0.2082   -0.8401

-0.8427   -0.5268    0.1111
-0.5010    0.8429    0.1962
-0.1970    0.1097   -0.9743

-0.7717   -0.5722   -0.2776
-0.6148    0.7828    0.0956
 0.1626    0.2445   -0.9559

-0.7537   -0.5206   -0.4012
-0.6168    0.7711    0.1581
 0.2270    0.3666   -0.9022

-0.8104   -0.4170   -0.4116
-0.5649    0.7424    0.3601
 0.1554    0.5243   -0.8372

-0.8928   -0.4499   -0.0211
-0.3587    0.6819    0.6374
-0.2724    0.5766   -0.7702

-0.8178   -0.4766    0.3225
-0.1369    0.7054    0.6955
-0.5590    0.5246   -0.6421

-0.4415   -0.3084    0.8426
 0.2329    0.8675    0.4395
-0.8665    0.3903   -0.3112

-0.2042   -0.1526    0.9670
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-0.8189    0.5678   -0.0833

 0.0995   -0.0283    0.9946
 0.7850    0.6165   -0.0610
-0.6115    0.7869    0.0835

 0.3741   -0.1135    0.9204
 0.8804    0.3553   -0.3140
-0.2914    0.9278    0.2329

 0.5928   -0.1981    0.7806
 0.7818   -0.0913   -0.6169
 0.1935    0.9759    0.1007

 0.6034   -0.1706    0.7790
 0.7370   -0.2537   -0.6265
 0.3045    0.9521   -0.0273

 0.5207   -0.1090    0.8468
 0.7391   -0.4389   -0.5110
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 0.3595    0.1322    0.9237
 0.7717   -0.5986   -0.2147
 0.5246    0.7900   -0.3172

 0.0125    0.5198    0.8542
 0.7530   -0.5670    0.3340
 0.6579    0.6390   -0.3985

-0.2986    0.6554    0.6937
 0.6475   -0.3949    0.6517
 0.7011    0.6438   -0.3065

-0.4693    0.6467    0.6013
 0.5187   -0.3492    0.7804
 0.7146    0.6781   -0.1716

-0.7756    0.5296    0.3435
 0.2616   -0.2256    0.9385
 0.5744    0.8177    0.0364

-0.9278    0.3477    0.1351
 0.0626   -0.2119    0.9753
 0.3677    0.9133    0.1749

-0.9456    0.3244    0.0241
-0.0525   -0.2254    0.9728
 0.3211    0.9186    0.2302

-0.9080    0.4178    0.0305
-0.0696   -0.2222    0.9725
 0.4131    0.8809    0.2308

-0.8290    0.5470    0.1164
 0.0219   -0.1762    0.9841
 0.5588    0.8184    0.1341

-0.6502    0.7176    0.2497
 0.2321   -0.1254    0.9646
 0.7235    0.6851   -0.0850

-0.4388    0.8250    0.3561
 0.4453   -0.1445    0.8836
 0.7805    0.5463   -0.3040

-0.1692    0.8470    0.5040
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 0.7599    0.4377   -0.4805

 0.0349    0.8087    0.5872
 0.7589   -0.4037    0.5109
 0.6502    0.4278   -0.6279

 0.2455    0.5408    0.8045
 0.8879   -0.4586    0.0374
 0.3892    0.7052   -0.5927

 0.4406    0.2589    0.8596
 0.8845   -0.2887   -0.3664
 0.1533    0.9218   -0.3562

 0.4901    0.0511    0.8701
 0.8711    0.0055   -0.4910
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 0.9195    0.3742   -0.1207
-0.3548    0.9219    0.1557

-0.2497   -0.1913    0.9492
 0.7306    0.6061    0.3144
-0.6355    0.7720   -0.0116

-0.4736   -0.3490    0.8087
 0.3917    0.7389    0.5483
-0.7888    0.5764   -0.2132

-0.5250   -0.5089    0.6822
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-0.8474    0.3872   -0.3632

-0.4662   -0.7078    0.5308
-0.1785    0.6629    0.7271
-0.8665    0.2442   -0.4354

-0.4404   -0.7543    0.4869
-0.1978    0.6105    0.7669
-0.8757    0.2414   -0.4181

-0.4459   -0.7990    0.4035
-0.1685    0.5176    0.8389
-0.8791    0.3060   -0.3654

-0.4433   -0.8299    0.3388
-0.1355    0.4356    0.8899
-0.8861    0.3485   -0.3056

-0.4150   -0.8880    0.1981
-0.1431    0.2787    0.9497
-0.8985    0.3658   -0.2427

-0.3412   -0.9398   -0.0215
-0.1940    0.0480    0.9798
-0.9198    0.3385   -0.1986

-0.2691   -0.9161   -0.2972
-0.2431   -0.2340    0.9414
-0.9319    0.3256   -0.1598

-0.2757   -0.8548   -0.4396
-0.2618   -0.3733    0.8900
-0.9249    0.3605   -0.1209

-0.3415   -0.7329   -0.5884
-0.3096   -0.5034    0.8067
-0.8874    0.4577   -0.0550

-0.5271   -0.5573   -0.6416
-0.3776   -0.5228    0.7643
-0.7613    0.6451    0.0651

-0.6931   -0.4725   -0.5444
-0.3054   -0.4916    0.8155
-0.6529    0.7315    0.1964

-0.8502   -0.4882   -0.1970
 0.0153   -0.3970    0.9177
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-0.8951   -0.4453   -0.0215
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-0.4158    0.8164    0.4009

-0.9199   -0.3621    0.1506
 0.2848   -0.3528    0.8913
-0.2696    0.8628    0.4276

-0.9212   -0.2695    0.2805
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-0.1232    0.8862    0.4467

-0.9109   -0.2038    0.3588
 0.4105   -0.3589    0.8382
-0.0421    0.9108    0.4106

-0.9109   -0.1813    0.3706
 0.4109   -0.3182    0.8544
-0.0370    0.9305    0.3643

-0.9345   -0.1817    0.3060
 0.3440   -0.2414    0.9074
-0.0910    0.9533    0.2881

-0.9431   -0.1997    0.2659
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-0.1280    0.9560    0.2640

-0.9451   -0.2159    0.2452
 0.2876   -0.1933    0.9381
-0.1552    0.9571    0.2448

-0.9442   -0.2183    0.2468
 0.2897   -0.1936    0.9373
-0.1569    0.9565    0.2460

-0.9430   -0.1824    0.2782
 0.3129   -0.2026    0.9279
-0.1129    0.9621    0.2481

-0.9409   -0.1424    0.3072
 0.3314   -0.2014    0.9217
-0.0694    0.9691    0.2367

-0.9320   -0.0646    0.3565
 0.3621   -0.1996    0.9105
 0.0123    0.9777    0.2095

-0.9041    0.0579    0.4234
 0.4027   -0.2162    0.8894
 0.1430    0.9746    0.1722

-0.8423    0.2121    0.4955
 0.4485   -0.2341    0.8626
 0.2990    0.9488    0.1020

-0.8149    0.2927    0.5003
 0.4506   -0.2232    0.8644
 0.3647    0.9298    0.0500

-0.8134    0.3399    0.4720
 0.4471   -0.1538    0.8812
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-0.8237    0.3787    0.4220
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 0.3721    0.9226   -0.1016

-0.8274    0.3844    0.4095
 0.4238   -0.0510    0.9043
 0.3684    0.9218   -0.1207

-0.8306    0.3871    0.4004
 0.4190   -0.0394    0.9071
 0.3669    0.9212   -0.1295

-0.8344    0.3856    0.3938
 0.4148   -0.0311    0.9094
 0.3629    0.9221   -0.1340

-0.8361    0.3907    0.3851
 0.4128   -0.0143    0.9107
 0.3613    0.9204   -0.1493

-0.8379    0.3975    0.3740
 0.4104    0.0073    0.9119
 0.3598    0.9176   -0.1693

-0.8392    0.3949    0.3739
 0.4091    0.0055    0.9125
 0.3583    0.9187   -0.1662

-0.8397    0.3954    0.3723
 0.4084    0.0080    0.9127
 0.3579    0.9185   -0.1682

-0.8388    0.3973    0.3722
 0.4094    0.0097    0.9123
 0.3589    0.9176   -0.1708

-0.8381    0.3955    0.3757
 0.4099    0.0022    0.9121
 0.3600    0.9184   -0.1640

-0.8344    0.3975    0.3819
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-0.8331    0.4028    0.3790
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 0.3643    0.9153   -0.1720

-0.8325    0.4035    0.3796
 0.4178    0.0072    0.9085
 0.3639    0.9149   -0.1745

-0.8312    0.4034    0.3826
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 0.3628    0.9150   -0.1765

-0.8299    0.4037    0.3851
 0.4228    0.0047    0.9062
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-0.8276    0.3954    0.3985
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-0.8195    0.3434    0.4588
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 0.3697    0.9285   -0.0346

-0.8398    0.2479    0.4829
 0.4111   -0.2903    0.8641
 0.3544    0.9243    0.1419

-0.9136    0.0919    0.3961
 0.3301   -0.4013    0.8544
 0.2375    0.9113    0.3363

-0.9598    0.0551    0.2752
 0.2324   -0.3933    0.8895
 0.1573    0.9177    0.3647

-0.9825    0.0268    0.1844
 0.1558   -0.4245    0.8919
 0.1022    0.9050    0.4129

-0.9928   -0.0252    0.1174
 0.1167   -0.4350    0.8929
 0.0286    0.9001    0.4348

-0.9832   -0.1817    0.0148
 0.0952   -0.4426    0.8917
-0.1554    0.8781    0.4525

-0.8548   -0.4759   -0.2070
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-0.5161    0.7372    0.4362

-0.6438   -0.6693   -0.3709
 0.0300   -0.5065    0.8617
-0.7646    0.5436    0.3461

-0.5418   -0.7296   -0.4173
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-0.8400    0.4530    0.2987

-0.6721   -0.6343   -0.3820
-0.0145   -0.5045    0.8633
-0.7403    0.5858    0.3299

-0.7851   -0.5057   -0.3577
-0.0737   -0.4972    0.8645
-0.6150    0.7051    0.3530

-0.9349   -0.2493   -0.2526
-0.1404   -0.3938    0.9084
-0.3260    0.8847    0.3332

-0.9852    0.0694   -0.1570
-0.1697   -0.2549    0.9520
 0.0261    0.9645    0.2629

-0.9212    0.3817   -0.0761
-0.1275   -0.1111    0.9856
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-0.0548    0.0542    0.9970
 0.6662    0.7457   -0.0039

-0.6361    0.7503   -0.1800
-0.0978    0.1530    0.9834
 0.7654    0.6431   -0.0239

-0.6404    0.7268   -0.2485
-0.1732    0.1785    0.9686
 0.7483    0.6633    0.0116

-0.6021    0.7299   -0.3238
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 0.7716    0.6361   -0.0008

-0.5468    0.7560   -0.3599
-0.2276    0.2795    0.9328
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-0.5443    0.7652   -0.3437
-0.2204    0.2649    0.9388
 0.8094    0.5867    0.0244

-0.5434    0.7759   -0.3203
-0.2061    0.2466    0.9470
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-0.5389    0.7857   -0.3039
-0.1922    0.2365    0.9524
 0.8202    0.5717    0.0235

-0.5480    0.8022   -0.2372
-0.1688    0.1717    0.9706
 0.8193    0.5719    0.0413

-0.5629    0.8087   -0.1707
-0.1443    0.1072    0.9837
 0.8138    0.5784    0.0564

-0.5956    0.8006   -0.0653
-0.1110   -0.0015    0.9938
 0.7956    0.5992    0.0898

-0.6478    0.7522    0.1207
-0.0356   -0.1881    0.9815
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-0.7090    0.6224    0.3316
 0.1030   -0.3737    0.9218
 0.6977    0.6877    0.2008

-0.7233    0.5837    0.3691
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 0.6792    0.6978    0.2275

-0.6534    0.7538    0.0704
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-0.6299    0.7767   -0.0034
-0.1119   -0.0864    0.9900
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-0.1494    0.0329    0.9882
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-0.8433    0.5372   -0.0169
-0.0971   -0.1214    0.9878
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-0.9953    0.0920   -0.0318
-0.0609   -0.3343    0.9405
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-0.9677   -0.1964   -0.1580
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-0.2418    0.9005    0.3615

-0.8728   -0.4104   -0.2643
-0.0707   -0.4294    0.9003
-0.4830    0.8045    0.3457

-0.8131   -0.4659   -0.3491
-0.0925   -0.4887    0.8676
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-0.6899    0.6409    0.3365

-0.5945   -0.5722   -0.5650
-0.1430   -0.6161    0.7745
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-0.5421   -0.6342   -0.5513
-0.0785   -0.6149    0.7847
-0.8366    0.4686    0.2836

-0.7704   -0.5283   -0.3569
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-0.6374    0.6502    0.4135

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-0.9716   -0.0507    0.2311
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-0.9452    0.1235    0.3023
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 0.2351    0.8999    0.3673

-0.9520    0.1266    0.2786
 0.2079   -0.4005    0.8924
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-0.9797    0.1243    0.1572
 0.0998   -0.3781    0.9204
 0.1739    0.9174    0.3580

-0.9914    0.0882    0.0970
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 0.1164    0.9323    0.3425

-0.9913    0.0951    0.0915
 0.0556   -0.3275    0.9432
 0.1197    0.9401    0.3193

-0.9920    0.0626    0.1097
 0.0829   -0.3324    0.9395
 0.0953    0.9411    0.3246

-0.9910   -0.0861    0.1026
 0.1287   -0.4002    0.9074
-0.0371    0.9124    0.4076

-0.9705   -0.2407   -0.0112
 0.0971   -0.4331    0.8961
-0.2205    0.8686    0.4437

-0.9190   -0.3617   -0.1572
 0.0284   -0.4583    0.8883
-0.3933    0.8119    0.4315

-0.7708   -0.5620   -0.3001
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-0.6370    0.6715    0.3785

-0.5518   -0.7203   -0.4204
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-0.8340    0.4731    0.2840

-0.4569   -0.7585   -0.4647
 0.0026   -0.5235    0.8520
-0.8895    0.3881    0.2411

-0.3166   -0.7865   -0.5304
 0.0001   -0.5591    0.8291
-0.9486    0.2624    0.1770

-0.2315   -0.7719   -0.5921
-0.0311   -0.6025    0.7975
-0.9723    0.2031    0.1155

-0.3356   -0.7461   -0.5751
-0.0764   -0.5869    0.8061
-0.9389    0.3145    0.1400

-0.6303   -0.5857   -0.5096
-0.1184   -0.5762    0.8087
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-0.8971   -0.3815   -0.2227
-0.0400   -0.4320    0.9010
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-0.1491    0.9206    0.3610

-0.9985    0.0262    0.0473
 0.0364   -0.3208    0.9464
 0.0400    0.9468    0.3194

-0.9684    0.2281   -0.1006
-0.1654   -0.2862    0.9438
 0.1865    0.9306    0.3148

-0.9137    0.3650   -0.1789
-0.2661   -0.2043    0.9420
 0.3073    0.9083    0.2838

-0.8485    0.4816   -0.2196
-0.2953   -0.0865    0.9515
 0.4392    0.8721    0.2156

-0.7866    0.6060   -0.1183
-0.1490   -0.0003    0.9888
 0.5992    0.7955    0.0905

-0.6835    0.7297   -0.0166
 0.0656    0.0841    0.9943
 0.7269    0.6786   -0.1054

-0.5128    0.8571    0.0482
 0.2528    0.0971    0.9626
 0.8204    0.5059   -0.2665

-0.2629    0.9513    0.1611
 0.4836   -0.0146    0.8752
 0.8349    0.3080   -0.4562

 0.0304    0.9797    0.1981
 0.6218   -0.1737    0.7637
 0.7826    0.1000   -0.6144

 0.1848    0.9627    0.1979
 0.6924   -0.2704    0.6689
 0.6974    0.0134   -0.7165

 0.2592    0.9504    0.1718
 0.7277   -0.3091    0.6123
 0.6350   -0.0336   -0.7718

 0.0170    0.9901    0.1395
 0.6146   -0.1204    0.7796
 0.7887    0.0724   -0.6105

-0.3194    0.9332    0.1646
 0.4274   -0.0132    0.9040
 0.8458    0.3590   -0.3946

-0.7079    0.7022    0.0757
 0.1243    0.0184    0.9921
 0.6953    0.7117   -0.1003

-0.7990    0.6012    0.0110
 0.0110   -0.0037    0.9999
```

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 0.6012    0.7991   -0.0037

-0.8980    0.4393   -0.0252
-0.0564   -0.0581    0.9967
 0.4364    0.8965    0.0770

-0.9321    0.3616   -0.0226
-0.0665   -0.1094    0.9918
 0.3561    0.9259    0.1260

-0.9618    0.2737    0.0097
-0.0331   -0.1512    0.9880
 0.2719    0.9499    0.1544

-0.9409    0.3341    0.0555
-0.0079   -0.1853    0.9826
 0.3386    0.9241    0.1770

-0.8778    0.4709    0.0876
-0.0213   -0.2212    0.9750
 0.4785    0.8540    0.2042

-0.7680    0.6210    0.1565
-0.0326   -0.2820    0.9588
 0.6396    0.7313    0.2369

-0.6639    0.7198    0.2028
-0.0648   -0.3256    0.9433
 0.7450    0.6131    0.2628

-0.6503    0.7266    0.2218
-0.1044   -0.3747    0.9213
 0.7525    0.5760    0.3195

-0.6101    0.7737    0.1710
-0.1839   -0.3482    0.9192
 0.7707    0.5293    0.3547

-0.5885    0.8012    0.1082
-0.2647   -0.3174    0.9106
 0.7639    0.5073    0.3989

-0.5846    0.8065    0.0884
-0.2955   -0.3132    0.9025
 0.7556    0.5015    0.4214

-0.5796    0.8115    0.0753
-0.3136   -0.3073    0.8984
 0.7522    0.4971    0.4326

-0.5711    0.8184    0.0635
-0.3326   -0.3015    0.8936
 0.7505    0.4892    0.4444

-0.5656    0.8222    0.0631
-0.3399   -0.3021    0.8906
 0.7513    0.4823    0.4504

-0.5613    0.8258    0.0539
-0.3442   -0.2922    0.8923
 0.7526    0.4823    0.4483

-0.5532    0.8313    0.0543
-0.3320   -0.2798    0.9008
```

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 0.7640    0.4803    0.4308

-0.5600    0.8261    0.0636
-0.3218   -0.2876    0.9021
 0.7635    0.4847    0.4268

-0.5653    0.8224    0.0641
-0.3173   -0.2885    0.9034
 0.7614    0.4903    0.4240

-0.5734    0.8166    0.0660
-0.3137   -0.2932    0.9031
 0.7569    0.4971    0.4243

-0.5819    0.8107    0.0650
-0.3087   -0.2941    0.9045
 0.7524    0.5063    0.4214

-0.5873    0.8067    0.0654
-0.3065   -0.2964    0.9045
 0.7491    0.5112    0.4214

-0.5916    0.8038    0.0628
-0.3064   -0.2963    0.9046
 0.7457    0.5159    0.4216

-0.5932    0.8030    0.0572
-0.3079   -0.2919    0.9055
 0.7439    0.5195    0.4204

-0.5958    0.8012    0.0552
-0.3059   -0.2899    0.9068
 0.7426    0.5234    0.4179

-0.5973    0.8000    0.0568
-0.3006   -0.2890    0.9089
 0.7435    0.5258    0.4131

-0.5974    0.7997    0.0596
-0.2920   -0.2862    0.9126
 0.7469    0.5278    0.4045

-0.5973    0.7998    0.0604
-0.2802   -0.2786    0.9186
 0.7515    0.5317    0.3905

-0.5957    0.8010    0.0603
-0.2686   -0.2694    0.9248
 0.7570    0.5347    0.3756

-0.5963    0.8006    0.0593
-0.2565   -0.2600    0.9309
 0.7607    0.5399    0.3604

-0.6078    0.7914    0.0651
-0.2350   -0.2576    0.9372
 0.7585    0.5543    0.3426

-0.6345    0.7659    0.1039
-0.1894   -0.2843    0.9398
 0.7494    0.5767    0.3255

-0.6426    0.7536    0.1385
-0.1633   -0.3113    0.9362
```

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 0.7486    0.5790    0.3231

-0.6222    0.7536    0.2119
-0.0196   -0.2856    0.9581
 0.7826    0.5920    0.1925

-0.5102    0.7869    0.3471
 0.2252   -0.2673    0.9369
 0.8301    0.5562   -0.0408

-0.4321    0.8239    0.3668
 0.3210   -0.2395    0.9163
 0.8428    0.5136   -0.1610

-0.2136    0.9007    0.3782
 0.4891   -0.2365    0.8395
 0.8456    0.3644   -0.3900

 0.1309    0.9104    0.3925
 0.6952   -0.3665    0.6184
 0.7068    0.1919   -0.6809

 0.3518    0.6058    0.7137
 0.8237   -0.5625    0.0715
 0.4448    0.5627   -0.6968

 0.4041    0.1841    0.8960
 0.9045   -0.2266   -0.3613
 0.1365    0.9564   -0.2581

 0.3173   -0.0055    0.9483
 0.9267    0.2141   -0.3088
-0.2014    0.9768    0.0730

 0.2051   -0.0872    0.9748
 0.7944    0.5967   -0.1138
-0.5718    0.7977    0.1917

 0.0038   -0.1685    0.9857
 0.5538    0.8211    0.1382
-0.8327    0.5453    0.0965

-0.2420   -0.2636    0.9338
 0.2785    0.9030    0.3271
-0.9294    0.3392   -0.1451

-0.4989   -0.4141    0.7613
-0.0164    0.8828    0.4695
-0.8665    0.2218   -0.4472

-0.7329   -0.5400    0.4139
-0.1925    0.7481    0.6350
-0.6526    0.3857   -0.6522

-0.8482   -0.3966    0.3510
-0.0260    0.6932    0.7203
-0.5290    0.6018   -0.5983

-0.9872   -0.0749    0.1408
 0.0905    0.4637    0.8813
-0.1314    0.8828   -0.4510

-0.8352    0.5252    0.1628
 0.1614   -0.0488    0.9857
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 0.5256    0.8496   -0.0440

-0.5369    0.8251    0.1762
-0.0651   -0.2487    0.9664
 0.8412    0.5074    0.1872

-0.5581    0.8174    0.1426
-0.1001   -0.2369    0.9664
 0.8237    0.5251    0.2141

-0.5067    0.8529    0.1255
-0.1460   -0.2283    0.9626
 0.8497    0.4694    0.2403

-0.4524    0.8901   -0.0547
-0.3789   -0.1363    0.9153
 0.8073    0.4349    0.3989

-0.4633    0.8855   -0.0345
-0.4147   -0.1823    0.8915
 0.7831    0.4273    0.4517

-0.5563    0.8300    0.0394
-0.3948   -0.3058    0.8664
 0.7312    0.4664    0.4978

-0.5873    0.8044    0.0897
-0.3692   -0.3648    0.8548
 0.7203    0.4688    0.5112

-0.5705    0.8161    0.0924
-0.3744   -0.3586    0.8551
 0.7310    0.4532    0.5101

-0.5523    0.8284    0.0932
-0.3828   -0.3513    0.8544
 0.7405    0.4363    0.5112

-0.5485    0.8309    0.0935
-0.3812   -0.3481    0.8565
 0.7442    0.4342    0.5077

-0.5487    0.8304    0.0968
-0.3785   -0.3501    0.8568
 0.7454    0.4335    0.5064

-0.5518    0.8288    0.0926
-0.3757   -0.3462    0.8597
 0.7446    0.4396    0.5024

-0.5546    0.8271    0.0915
-0.3731   -0.3455    0.8611
 0.7438    0.4434    0.5002

-0.5667    0.8171    0.1062
-0.3582   -0.3604    0.8613
 0.7420    0.4500    0.4969

-0.5747    0.8107    0.1119
-0.3488   -0.3663    0.8627
 0.7403    0.4567    0.4932

-0.5782    0.8080    0.1129
-0.3458   -0.3681    0.8631
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 0.7390    0.4600    0.4923

-0.5794    0.8061    0.1206
-0.3411   -0.3743    0.8623
 0.7402    0.4584    0.4918

-0.5793    0.8059    0.1219
-0.3406   -0.3753    0.8620
 0.7405    0.4579    0.4920

-0.5787    0.8062    0.1228
-0.3401   -0.3755    0.8621
 0.7412    0.4572    0.4916

-0.5784    0.8061    0.1251
-0.3398   -0.3774    0.8614
 0.7416    0.4558    0.4922

-0.5787    0.8052    0.1292
-0.3359   -0.3797    0.8620
 0.7432    0.4554    0.4902

-0.5775    0.8054    0.1334
-0.3325   -0.3813    0.8626
 0.7456    0.4537    0.4880

-0.5745    0.8072    0.1357
-0.3311   -0.3808    0.8634
 0.7485    0.4511    0.4860

-0.5750    0.8073    0.1327
-0.3336   -0.3794    0.8630
 0.7470    0.4520    0.4875

-0.5776    0.8077    0.1184
-0.3371   -0.3680    0.8665
 0.7435    0.4606    0.4849

-0.5776    0.8093    0.1064
-0.3445   -0.3598    0.8671
 0.7401    0.4642    0.4866

-0.5784    0.8114    0.0847
-0.3569   -0.3451    0.8681
 0.7336    0.4718    0.4892

-0.5827    0.8088    0.0791
-0.3494   -0.3372    0.8742
 0.7337    0.4818    0.4791

-0.5885    0.8065    0.0566
-0.3370   -0.3083    0.8896
 0.7349    0.5045    0.4532

-0.5951    0.8013    0.0615
-0.3111   -0.3002    0.9017
 0.7410    0.5175    0.4279

-0.5852    0.7999    0.1329
-0.2427   -0.3292    0.9126
 0.7737    0.5018    0.3867

-0.5729    0.7947    0.2006
-0.1922   -0.3682    0.9097
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 0.7968    0.4826    0.3637

-0.5480    0.7791    0.3045
-0.1145   -0.4305    0.8953
 0.8286    0.4557    0.3252

-0.5306    0.7580    0.3794
-0.0571   -0.4785    0.8762
 0.8457    0.4432    0.2971

-0.5100    0.7588    0.4052
-0.0524   -0.4976    0.8658
 0.8586    0.4203    0.2935

-0.4927    0.7623    0.4196
-0.0828   -0.5211    0.8495
 0.8662    0.3838    0.3198

-0.4937    0.7590    0.4245
-0.0879   -0.5292    0.8439
 0.8652    0.3793    0.3280

-0.5300    0.7431    0.4085
-0.0687   -0.5178    0.8527
 0.8452    0.4239    0.3255

-0.5243    0.7217    0.4519
-0.0658   -0.5635    0.8235
 0.8490    0.4021    0.3429

-0.5148    0.7238    0.4595
-0.0589   -0.5646    0.8233
 0.8553    0.3968    0.3332

-0.4950    0.7452    0.4468
-0.0662   -0.5451    0.8358
 0.8664    0.3841    0.3192

-0.4820    0.7571    0.4410
-0.0693   -0.5347    0.8422
 0.8734    0.3754    0.3102

-0.4806    0.7594    0.4387
-0.0663   -0.5303    0.8452
 0.8744    0.3771    0.3052

-0.4821    0.7571    0.4409
-0.0590   -0.5302    0.8458
 0.8741    0.3818    0.3003

-0.4763    0.7639    0.4354
-0.0643   -0.5242    0.8492
 0.8769    0.3765    0.2988

-0.4673    0.7751    0.4252
-0.0776   -0.5151    0.8536
 0.8807    0.3659    0.3009

-0.4671    0.7721    0.4310
-0.0751   -0.5203    0.8507
 0.8810    0.3649    0.3011

-0.4673    0.7690    0.4363
-0.0701   -0.5242    0.8487
```

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 0.8813    0.3660    0.2988

-0.4668    0.7692    0.4363
-0.0707   -0.5243    0.8486
 0.8815    0.3653    0.2992

-0.4628    0.7700    0.4391
-0.0752   -0.5277    0.8461
 0.8833    0.3586    0.3021

-0.4603    0.7725    0.4374
-0.0789   -0.5264    0.8466
 0.8842    0.3552    0.3032

-0.4600    0.7722    0.4383
-0.0795   -0.5275    0.8459
 0.8844    0.3543    0.3040

-0.4607    0.7713    0.4392
-0.0786   -0.5283    0.8454
 0.8841    0.3549    0.3040

-0.4607    0.7715    0.4389
-0.0782   -0.5278    0.8457
 0.8841    0.3553    0.3035

-0.4607    0.7715    0.4389
-0.0782   -0.5278    0.8457
 0.8841    0.3553    0.3035

-0.4593    0.7702    0.4425
-0.0748   -0.5300    0.8447
 0.8851    0.3549    0.3010

-0.4595    0.7699    0.4429
-0.0744   -0.5303    0.8445
 0.8851    0.3551    0.3010

-0.4594    0.7699    0.4429
-0.0743   -0.5302    0.8446
 0.8851    0.3551    0.3008

-0.4595    0.7693    0.4438
-0.0738   -0.5311    0.8441
 0.8851    0.3551    0.3008

-0.4601    0.7682    0.4452
-0.0730   -0.5325    0.8433
 0.8849    0.3555    0.3010

-0.4598    0.7679    0.4459
-0.0729   -0.5331    0.8429
 0.8850    0.3551    0.3011

-0.4575    0.7701    0.4446
-0.0751   -0.5317    0.8436
 0.8860    0.3526    0.3011

-0.4547    0.7714    0.4452
-0.0754   -0.5314    0.8438
 0.8874    0.3501    0.2998

-0.4530    0.7712    0.4472
-0.0715   -0.5314    0.8441
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 0.8886    0.3504    0.2959

-0.4532    0.7705    0.4483
-0.0696   -0.5320    0.8439
 0.8887    0.3512    0.2948

-0.4543    0.7690    0.4497
-0.0680   -0.5333    0.8432
 0.8883    0.3525    0.2946

-0.4548    0.7688    0.4495
-0.0689   -0.5336    0.8430
 0.8879    0.3524    0.2956

-0.4553    0.7691    0.4486
-0.0697   -0.5331    0.8432
 0.8876    0.3526    0.2963

-0.4572    0.7653    0.4531
-0.0646   -0.5367    0.8413
 0.8870    0.3554    0.2948

-0.4534    0.7689    0.4508
-0.0637   -0.5324    0.8441
 0.8890    0.3540    0.2904

-0.4503    0.7729    0.4470
-0.0678   -0.5287    0.8461
 0.8903    0.3507    0.2905

-0.4511    0.7716    0.4485
-0.0669   -0.5303    0.8452
 0.8900    0.3512    0.2908

-0.4524    0.7705    0.4491
-0.0658   -0.5311    0.8448
 0.8894    0.3526    0.2910

-0.4534    0.7700    0.4489
-0.0660   -0.5313    0.8446
 0.8888    0.3534    0.2917

-0.4537    0.7697    0.4492
-0.0666   -0.5319    0.8442
 0.8887    0.3531    0.2926

-0.4538    0.7691    0.4500
-0.0670   -0.5330    0.8434
 0.8886    0.3526    0.2934

-0.4539    0.7690    0.4500
-0.0671   -0.5331    0.8434
 0.8885    0.3526    0.2936

-0.4541    0.7687    0.4504
-0.0668   -0.5335    0.8432
 0.8885    0.3528    0.2936

-0.4539    0.7681    0.4516
-0.0664   -0.5346    0.8425
 0.8886    0.3524    0.2937

-0.4537    0.7681    0.4519
-0.0664   -0.5348    0.8424
```

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 0.8887    0.3522    0.2936

-0.4537    0.7680    0.4520
-0.0664   -0.5349    0.8423
 0.8887    0.3521    0.2937

-0.4543    0.7666    0.4538
-0.0654   -0.5368    0.8412
 0.8884    0.3525    0.2940

-0.4541    0.7667    0.4539
-0.0654   -0.5367    0.8412
 0.8886    0.3523    0.2939

-0.4539    0.7663    0.4546
-0.0651   -0.5374    0.8408
 0.8887    0.3521    0.2938

-0.4540    0.7663    0.4546
-0.0652   -0.5375    0.8408
 0.8886    0.3521    0.2940

-0.4578    0.7631    0.4563
-0.0641   -0.5402    0.8391
 0.8867    0.3549    0.2962

-0.4678    0.7546    0.4601
-0.0565   -0.5451    0.8365
 0.8820    0.3653    0.2976

-0.5040    0.7394    0.4464
-0.0366   -0.5346    0.8443
 0.8629    0.4092    0.2965

-0.5570    0.7235    0.4078
-0.0170   -0.5008    0.8654
 0.8303    0.4751    0.2912

-0.5995    0.6948    0.3972
-0.0012   -0.4971    0.8677
 0.8003    0.5198    0.2989

-0.6871    0.6657    0.2909
-0.0253   -0.4221    0.9062
 0.7261    0.6153    0.3069

-0.7337    0.6463    0.2097
-0.0383   -0.3476    0.9369
 0.6784    0.6794    0.2798

-0.7774    0.6058    0.1691
-0.0166   -0.2885    0.9573
 0.6288    0.7414    0.2343

-0.8031    0.5821    0.1275
-0.0325   -0.2564    0.9660
 0.5950    0.7717    0.2248

-0.7738    0.6297    0.0689
-0.0492   -0.1682    0.9845
 0.6316    0.7584    0.1611

-0.7489    0.6548    0.1019
-0.0149   -0.1703    0.9853
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 0.6626    0.7363    0.1373

-0.6381    0.7360    0.2262
 0.0397   -0.2619    0.9643
 0.7690    0.6242    0.1379

-0.6339    0.7274    0.2627
 0.0660   -0.2876    0.9555
 0.7706    0.6230    0.1343

-0.6100    0.7621    0.2170
 0.0268   -0.2539    0.9669
 0.7919    0.5956    0.1345

-0.6078    0.7625    0.2217
 0.0131   -0.2696    0.9629
 0.7940    0.5881    0.1538

-0.6179    0.7465    0.2470
 0.0241   -0.2960    0.9549
 0.7859    0.5959    0.1649

-0.6199    0.7442    0.2486
 0.0270   -0.2964    0.9547
 0.7842    0.5985    0.1636

-0.6167    0.7497    0.2401
 0.0198   -0.2902    0.9568
 0.7869    0.5948    0.1641

-0.6117    0.7568    0.2304
 0.0061   -0.2867    0.9580
 0.7910    0.5874    0.1708

-0.6111    0.7594    0.2232
-0.0001   -0.2820    0.9594
 0.7915    0.5863    0.1724

-0.6128    0.7608    0.2135
-0.0086   -0.2766    0.9609
 0.7902    0.5871    0.1761

-0.6204    0.7538    0.2165
-0.0092   -0.2830    0.9591
 0.7842    0.5930    0.1825

-0.6308    0.7451    0.2166
-0.0126   -0.2889    0.9573
 0.7758    0.6011    0.1917

-0.6303    0.7445    0.2199
-0.0166   -0.2960    0.9550
 0.7762    0.5983    0.1989

-0.6360    0.7385    0.2238
-0.0345   -0.3169    0.9478
 0.7709    0.5951    0.2271

-0.6286    0.7518    0.1991
-0.0698   -0.3095    0.9484
 0.7746    0.5823    0.2470

-0.6340    0.7545    0.1695
-0.1104   -0.3053    0.9458
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-0.6665    0.7263    0.1680
-0.1172   -0.3246    0.9386
 0.7362    0.6059    0.3015

-0.6867    0.7080    0.1645
-0.1204   -0.3340    0.9349
 0.7169    0.6222    0.3146

-0.7060    0.6917    0.1520
-0.1328   -0.3402    0.9309
 0.6956    0.6371    0.3320

-0.7221    0.6766    0.1444
-0.1478   -0.3547    0.9232
 0.6759    0.6453    0.3561

-0.7310    0.6679    0.1399
-0.1582   -0.3654    0.9173
 0.6638    0.6484    0.3728

-0.7365    0.6645    0.1265
-0.1833   -0.3760    0.9083
 0.6512    0.6458    0.3987

-0.7377    0.6642    0.1207
-0.1922   -0.3780    0.9056
 0.6472    0.6449    0.4066

-0.7366    0.6665    0.1154
-0.1982   -0.3758    0.9053
 0.6467    0.6439    0.4089

-0.7351    0.6686    0.1126
-0.1988   -0.3713    0.9070
 0.6482    0.6443    0.4059

-0.7356    0.6679    0.1133
-0.1949   -0.3688    0.9089
 0.6488    0.6465    0.4014

-0.7389    0.6637    0.1162
-0.1841   -0.3647    0.9127
 0.6482    0.6530    0.3917

-0.7365    0.6660    0.1183
-0.1758   -0.3574    0.9172
 0.6532    0.6548    0.3803

-0.7316    0.6713    0.1189
-0.1737   -0.3522    0.9197
 0.6592    0.6522    0.3743

-0.7313    0.6715    0.1191
-0.1731   -0.3517    0.9200
 0.6597    0.6522    0.3734

-0.7314    0.6715    0.1192
-0.1727   -0.3515    0.9201
 0.6597    0.6524    0.3731

-0.7342    0.6683    0.1201
-0.1721   -0.3543    0.9192
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-0.7361    0.6666    0.1176
-0.1768   -0.3571    0.9172
 0.6534    0.6543    0.3807

-0.7369    0.6658    0.1168
-0.1782   -0.3581    0.9165
 0.6521    0.6546    0.3826

-0.7413    0.6605    0.1194
-0.1778   -0.3647    0.9140
 0.6472    0.6563    0.3878

-0.7445    0.6565    0.1219
-0.1887   -0.3820    0.9047
 0.6405    0.6505    0.4082

-0.7209    0.6823    0.1212
-0.2116   -0.3833    0.8991
 0.6599    0.6225    0.4207

-0.6909    0.7153    0.1047
-0.2311   -0.3558    0.9055
 0.6850    0.6014    0.4111

-0.6912    0.7129    0.1184
-0.2230   -0.3663    0.9034
 0.6874    0.5980    0.4121

-0.6934    0.7059    0.1448
-0.1810   -0.3652    0.9132
 0.6975    0.6069    0.3810

-0.6895    0.7071    0.1569
-0.1650   -0.3643    0.9166
 0.7052    0.6061    0.3678

-0.6822    0.7130    0.1617
-0.1666   -0.3670    0.9152
 0.7119    0.5974    0.3692

-0.6709    0.7177    0.1866
-0.1514   -0.3790    0.9129
 0.7259    0.5842    0.3629

-0.6547    0.7272    0.2062
-0.1476   -0.3905    0.9087
 0.7413    0.5645    0.3630

-0.6493    0.7288    0.2172
-0.1487   -0.4018    0.9036
 0.7458    0.5544    0.3693

-0.6482    0.7276    0.2245
-0.1454   -0.4077    0.9015
 0.7474    0.5517    0.3701

-0.6477    0.7255    0.2327
-0.1386   -0.4125    0.9003
 0.7492    0.5509    0.3677

-0.6459    0.7256    0.2371
-0.1347   -0.4140    0.9002
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-0.1349   -0.4126    0.9009
 0.7516    0.5498    0.3644

-0.6449    0.7274    0.2343
-0.1354   -0.4104    0.9018
 0.7521    0.5499    0.3632

-0.6436    0.7285    0.2347
-0.1320   -0.4076    0.9036
 0.7539    0.5506    0.3585

-0.6419    0.7306    0.2330
-0.1306   -0.4035    0.9056
 0.7556    0.5508    0.3544

-0.6395    0.7332    0.2311
-0.1293   -0.3990    0.9078
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-0.6382    0.7341    0.2321
-0.1262   -0.3971    0.9090
 0.7595    0.5508    0.3461

-0.6369    0.7350    0.2326
-0.1226   -0.3944    0.9107
 0.7611    0.5515    0.3413

-0.6365    0.7356    0.2319
-0.1215   -0.3925    0.9117
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-0.6378    0.7346    0.2313
-0.1202   -0.3916    0.9123
 0.7607    0.5541    0.3381

-0.6403    0.7323    0.2320
-0.1178   -0.3921    0.9124
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-0.6426    0.7300    0.2327
-0.1148   -0.3921    0.9127
 0.7575    0.5598    0.3358

-0.6429    0.7297    0.2328
-0.1146   -0.3923    0.9127
 0.7573    0.5601    0.3358

-0.6431    0.7296    0.2327
-0.1145   -0.3921    0.9128
 0.7572    0.5603    0.3356

-0.6432    0.7298    0.2317
-0.1141   -0.3906    0.9135
 0.7571    0.5611    0.3345

-0.6463    0.7266    0.2329
-0.1121   -0.3924    0.9129
 0.7548    0.5639    0.3351

-0.6481    0.7242    0.2355
-0.1099   -0.3950    0.9121
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-0.1078   -0.3959    0.9119
 0.7534    0.5660    0.3348

-0.6479    0.7240    0.2368
-0.1091   -0.3958    0.9119
 0.7539    0.5649    0.3354

-0.6478    0.7241    0.2368
-0.1090   -0.3957    0.9119
 0.7540    0.5649    0.3352

-0.6475    0.7243    0.2368
-0.1092   -0.3957    0.9119
 0.7542    0.5646    0.3353

-0.6447    0.7290    0.2300
-0.1159   -0.3906    0.9132
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-0.6440    0.7300    0.2288
-0.1175   -0.3899    0.9133
 0.7559    0.5613    0.3369

-0.6444    0.7290    0.2308
-0.1154   -0.3910    0.9131
 0.7559    0.5618    0.3361

-0.6454    0.7273    0.2335
-0.1115   -0.3921    0.9131
 0.7557    0.5633    0.3341

-0.6477    0.7243    0.2366
-0.1068   -0.3938    0.9130
 0.7544    0.5660    0.3324

-0.6476    0.7244    0.2363
-0.1067   -0.3932    0.9132
 0.7545    0.5662    0.3319

-0.6476    0.7246    0.2359
-0.1068   -0.3929    0.9134
 0.7545    0.5663    0.3318

-0.6476    0.7246    0.2359
-0.1068   -0.3929    0.9134
 0.7545    0.5663    0.3318

-0.6479    0.7237    0.2377
-0.1055   -0.3943    0.9129
 0.7544    0.5664    0.3319

-0.6479    0.7237    0.2377
-0.1054   -0.3943    0.9129
 0.7544    0.5665    0.3317

-0.6470    0.7246    0.2373
-0.1058   -0.3936    0.9132
 0.7551    0.5658    0.3313

-0.6463    0.7254    0.2368
-0.1063   -0.3928    0.9134
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-0.6462    0.7255    0.2368
-0.1063   -0.3928    0.9134
 0.7558    0.5650    0.3310

-0.6461    0.7256    0.2368
-0.1061   -0.3926    0.9136
 0.7558    0.5652    0.3306

-0.6458    0.7254    0.2381
-0.1048   -0.3931    0.9135
 0.7563    0.5650    0.3299

-0.6293    0.6976    0.3425
 0.0308   -0.4180    0.9079
 0.7766    0.5819    0.2416

-0.5144    0.7004    0.4948
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 0.8316    0.5484    0.0881

-0.5138    0.6929    0.5059
 0.2355   -0.4532    0.8598
 0.8250    0.5608    0.0697

-0.6676    0.6153    0.4193
 0.1716   -0.4208    0.8908
 0.7245    0.6666    0.1753

-0.8107    0.4949    0.3127
 0.1486   -0.3428    0.9276
 0.5663    0.7985    0.2044

-0.8527    0.4422    0.2781
 0.1793   -0.2522    0.9509
 0.4906    0.8607    0.1358

-0.8880    0.3730    0.2688
 0.2551   -0.0868    0.9630
 0.3826    0.9237   -0.0181

-0.9570    0.1178    0.2652
 0.2877    0.2664    0.9199
 0.0377    0.9566   -0.2889

-0.9211   -0.2331    0.3119
 0.1112    0.6102    0.7844
-0.3731    0.7572   -0.5361

-0.8010   -0.5433    0.2516
-0.2337    0.6706    0.7040
-0.5512    0.5051   -0.6641

-0.7338   -0.6740    0.0858
-0.4505    0.5772    0.6812
-0.5086    0.4611   -0.7271

-0.7112   -0.7001   -0.0642
-0.5604    0.5094    0.6530
-0.4244    0.5004   -0.7546

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-0.5688    0.4812    0.6670
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-0.7373   -0.6652   -0.1174
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-0.3932    0.5640   -0.7262

-0.7365   -0.6659   -0.1189
-0.5494    0.4863    0.6795
-0.3947    0.5658   -0.7240

-0.7374   -0.6672   -0.1052
-0.5375    0.4854    0.6896
-0.4090    0.5651   -0.7165

-0.7443   -0.6614   -0.0924
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-0.5092    0.4967    0.7028
-0.4260    0.5641   -0.7073

-0.7416   -0.6663   -0.0786
-0.5159    0.4915    0.7016
-0.4288    0.5608   -0.7083

-0.7438   -0.6650   -0.0676
-0.5049    0.4927    0.7087
-0.4380    0.5613   -0.7023

-0.7402   -0.6716   -0.0315
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-0.4676    0.5479   -0.6937

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-0.5081    0.4732   -0.7196

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-0.5178    0.4438   -0.7313

-0.6824   -0.7264    0.0814
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-0.5261    0.4108   -0.7446

-0.6900   -0.7182    0.0894
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-0.6936   -0.7138    0.0968
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-0.4972    0.4130   -0.7631

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-0.4502    0.6544    0.6075
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-0.4468    0.6646    0.5989
-0.4926    0.3760   -0.7848

-0.7437   -0.6481    0.1639
-0.4474    0.6646    0.5984
-0.4968    0.3717   -0.7843

-0.7147   -0.6793    0.1666
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-0.5196    0.3561   -0.7767

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-0.5043    0.3482   -0.7902

-0.6978   -0.7101    0.0938
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-0.4278    0.3932   -0.8139

-0.6976   -0.7165    0.0076
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-0.7068   -0.7074   -0.0097
-0.5759    0.5673    0.5886
-0.4109    0.4216   -0.8083

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-0.4438    0.4082   -0.7977

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-0.9207   -0.3450    0.1824
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-0.9947    0.0130    0.1017
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-0.6122    0.7475    0.2578
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-0.0997   -0.1638    0.9814
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-0.0925   -0.1986    0.9757
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-0.6011    0.7932    0.0976
-0.0979   -0.1943    0.9760
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-0.1158   -0.1813    0.9766
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-0.5760    0.8133    0.0819
-0.1143   -0.1794    0.9771
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-0.5781    0.8107    0.0930
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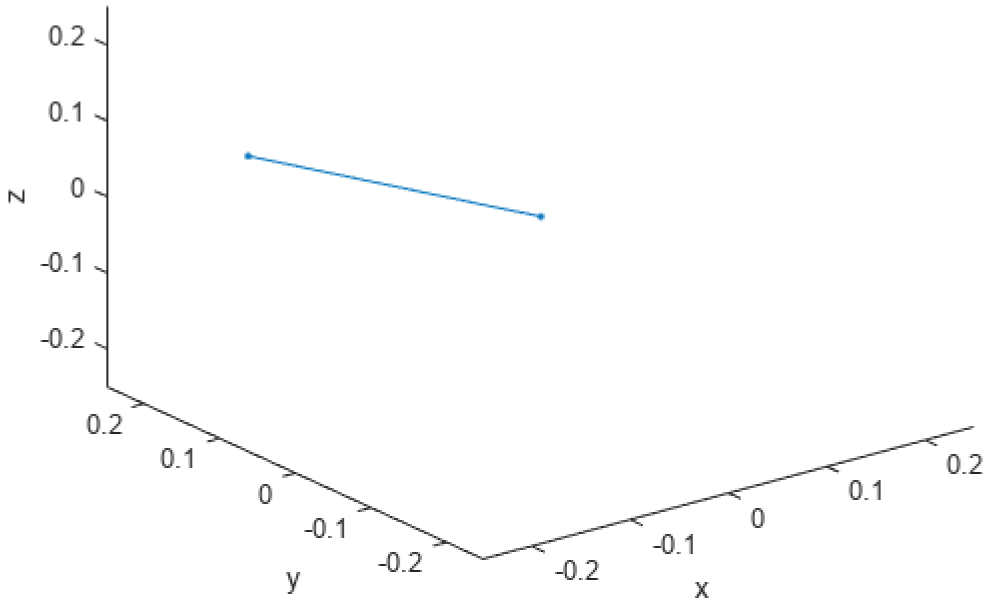
```
 0.8269    0.5316    0.1836

-0.5573    0.8252    0.0921
-0.1013   -0.1777    0.9789
 0.8241    0.5362    0.1827

-0.5614    0.8217    0.0985
-0.0956   -0.1825    0.9785
 0.8220    0.5399    0.1810

-0.5576    0.8257    0.0859
-0.1025   -0.1712    0.9799
 0.8238    0.5376    0.1801

-0.5596    0.8236    0.0923
-0.1019   -0.1789    0.9786
 0.8225    0.5382    0.1840

-0.5641    0.8200    0.0968
-0.0986   -0.1833    0.9781
 0.8198    0.5422    0.1843

-0.5650    0.8191    0.0993
-0.0969   -0.1855    0.9779
 0.8194    0.5429    0.1842

-0.5611    0.8224    0.0943
-0.0999   -0.1803    0.9785
 0.8217    0.5396    0.1833

-0.5536    0.8277    0.0922
-0.1005   -0.1763    0.9792
 0.8267    0.5328    0.1808

-0.5598    0.8212    0.1111
-0.0881   -0.1923    0.9774
 0.8240    0.5373    0.1800

-0.5724    0.8063    0.1489
-0.0716   -0.2301    0.9705
 0.8169    0.5448    0.1894

-0.5506    0.8290    0.0980
-0.0995   -0.1817    0.9783
 0.8288    0.5289    0.1825

-0.5114    0.8592    0.0179
-0.1482   -0.1087    0.9830
 0.8465    0.5000    0.1829

-0.4906    0.8714   -0.0006
-0.1745   -0.0976    0.9798
 0.8538    0.4807    0.2000

-0.4977    0.8672    0.0189
-0.1687   -0.1182    0.9786
 0.8508    0.4838    0.2051

-0.5178    0.8531    0.0634
-0.1370   -0.1559    0.9782
 0.8444    0.4978    0.1976

-0.5263    0.8459    0.0871
-0.1265   -0.1791    0.9757
```

```
 0.8409    0.5024    0.2013

-0.5212    0.8500    0.0767
-0.1402   -0.1740    0.9747
 0.8418    0.4973    0.2098

-0.5094    0.8584    0.0608
-0.1619   -0.1650    0.9729
 0.8451    0.4858    0.2231

-0.5125    0.8559    0.0692
-0.1658   -0.1777    0.9700
 0.8425    0.4856    0.2330

-0.5193    0.8515    0.0727
-0.1605   -0.1808    0.9703
 0.8394    0.4922    0.2306

-0.5179    0.8530    0.0642
-0.1591   -0.1698    0.9726
 0.8405    0.4935    0.2236

-0.5147    0.8553    0.0593
-0.1565   -0.1617    0.9743
 0.8430    0.4922    0.2171

-0.5137    0.8560    0.0587
-0.1563   -0.1607    0.9745
 0.8436    0.4914    0.2164

-0.5133    0.8562    0.0591
-0.1566   -0.1612    0.9744
 0.8438    0.4909    0.2168

-0.5172    0.8536    0.0615
-0.1513   -0.1619    0.9751
 0.8424    0.4951    0.2129

-0.5325    0.8435    0.0707
-0.1467   -0.1742    0.9737
 0.8336    0.5082    0.2165

-0.5495    0.8316    0.0798
-0.1318   -0.1805    0.9747
 0.8250    0.5251    0.2088

-0.5605    0.8212    0.1075
-0.0996   -0.1957    0.9756
 0.8221    0.5361    0.1915

-0.5686    0.8134    0.1228
-0.0857   -0.2071    0.9746
 0.8181    0.5436    0.1875

-0.5719    0.8077    0.1432
-0.0616   -0.2163    0.9744
 0.8180    0.5484    0.1735

-0.5668    0.8106    0.1468
-0.0533   -0.2139    0.9754
 0.8221    0.5451    0.1645
```




```
hMyo.close()
```

```
[MyoUdp] Deleting Udp comms object
[PnetClass.m] Closed pnet socket #0 at local port: 10001
[PnetClass.m] Closed pnet socket #1 at local port: 10002
```

```
cleanup;
```

```
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Loaded pnet Version  2.0.5  2003-09-16 Copyright (C) Peter Rydesäter, Sweden, et al. , 1998 - 2003
Warning: instrfindall will be removed in a future release. There is no simple replacement for this.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
Warning: Objects of 'onCleanup' class exist.  Cannot clear this class or any of its superclasses.
cleanup
--------------------------------------
```


Part 2: Kinect

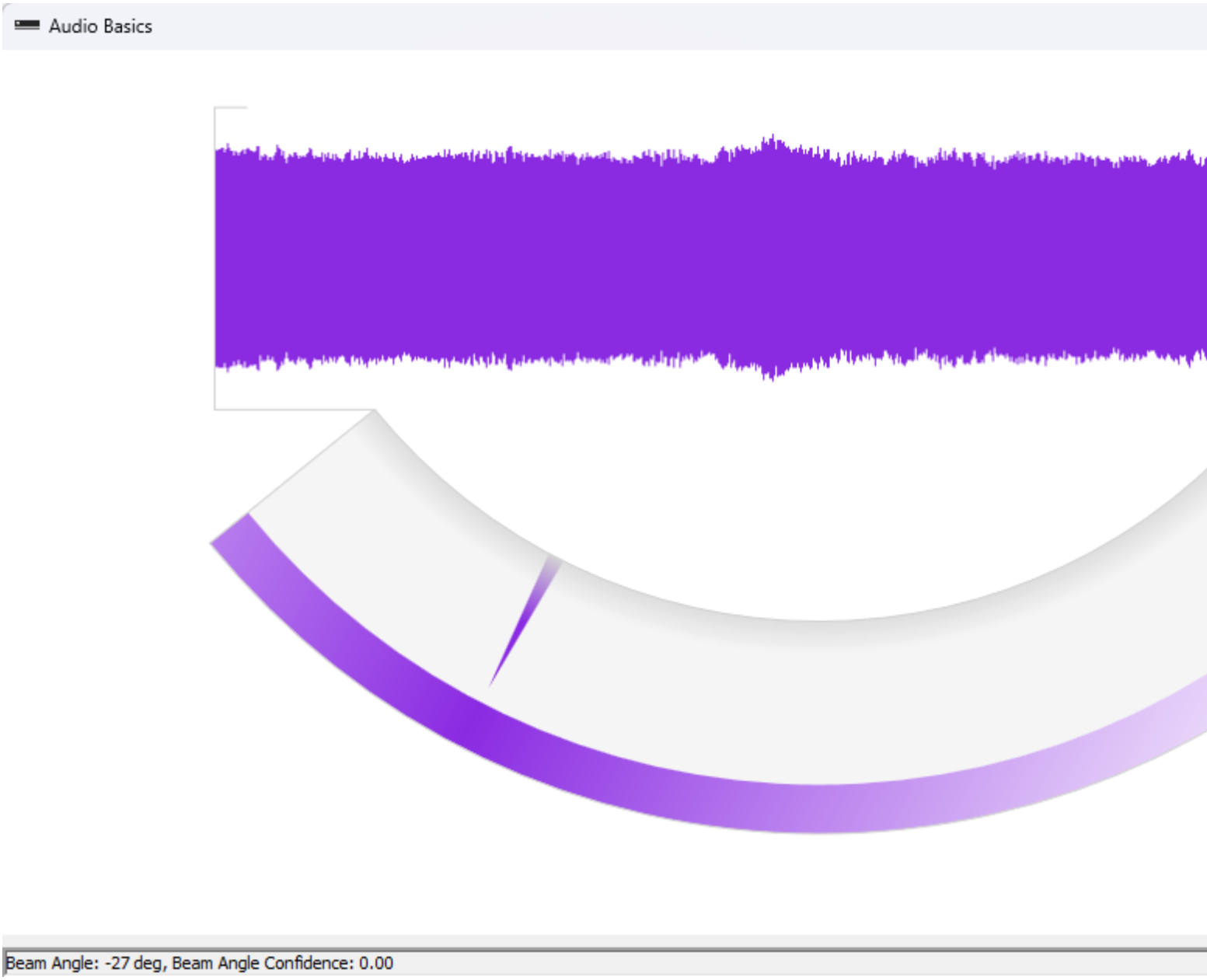
Open "SDK Browser for Kinect" (search in Windows Start Menu)

Run the following examples:

1. Audio Basics
2. Depth Basics
3. Face Tracking Basics
4. Skeletal Basics

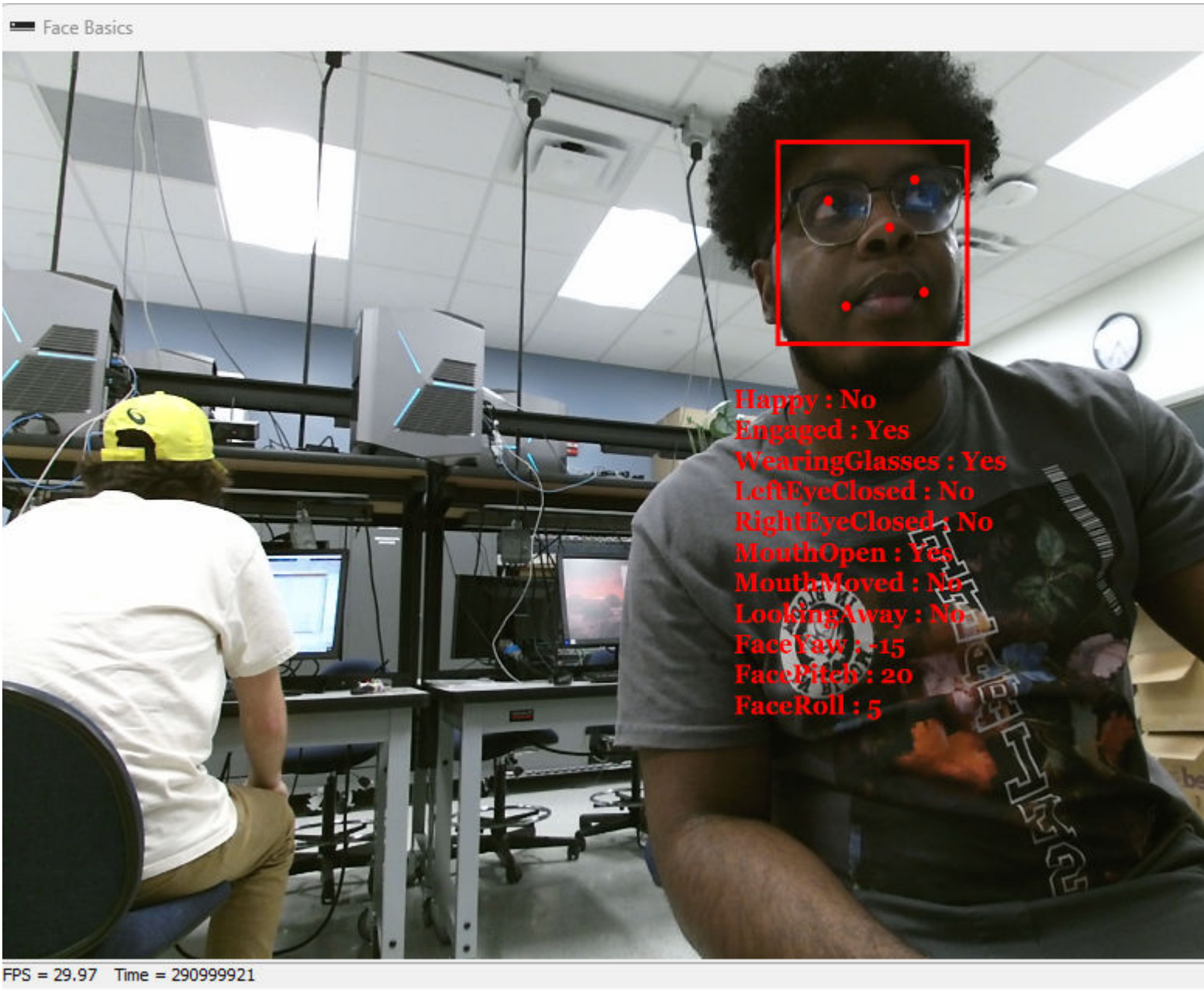
Copy and paste window screenshots from each:

1. **Audio Basic**

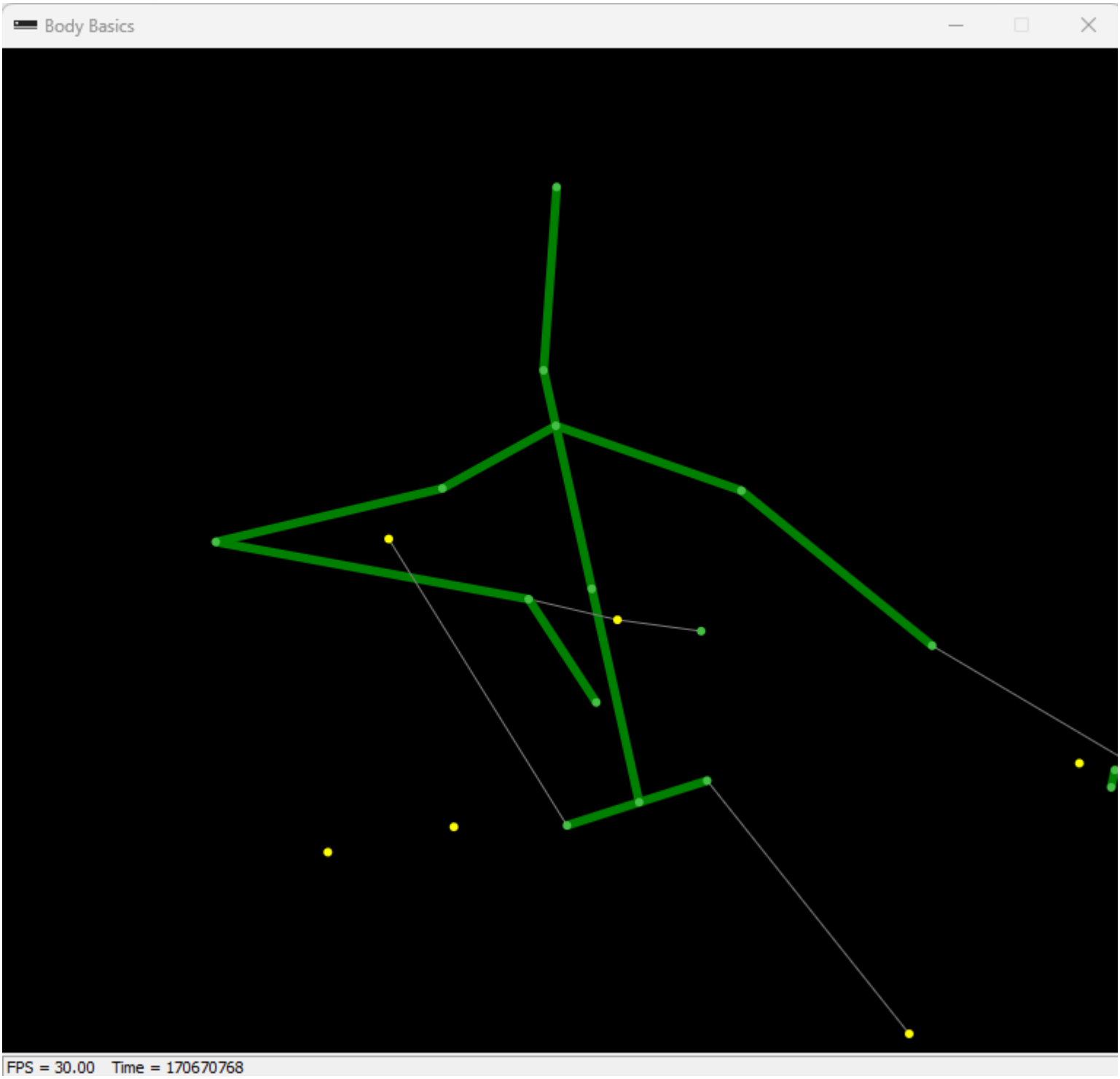


2. Depth Basic

3. Face Tracking Basic



4. Skeletal Basic



Questions:

- What advantage do microphone arrays have over traditional microphones / speech input devices?
  Arrays provide directionality and depth, while traditional mics and speech input devices do not.

- At what range is the face tracking effective? How might this be used as a robot controller? **Face tracking seems to be limited to between 1 and 15 feet. The further away the face, the harder more complex facial attributes (such as mood) are to detect. This can be used for close-range facial recognition for access. If a robot has a face, you can control its face.**
- What kind of motions and postures does the skeletal model capture? When does it break down? **The skeletal model captures the full body, mapping out major joints and links. it can break down based on variations in angles, based on the angle of the optical sensor, and has trouble with occluded body parts to this end. This also leads to inaccurate representations of joints.**

Kinect sampling from MATLAB

derived from: https://www.mathworks.com/help/imaq/examples/using-the-kinect-r-for-windows-r-from-image-acquisition-toolbox-tm.html

required MATLAB Support Package for Kinect: https://www.mathworks.com/hardware-support/kinect-windows.html

It might be more straightforward to run this in the Command Window (select, then hit F9)

```
utilpath =
'C:\ProgramData\MATLAB\SupportPackages\R2019b\toolbox\imaq\supportpackages\kinectruntime\kinectforwindowsruntimeexamples';
addpath(utilpath);

% The Kinect for Windows Sensor shows up as two separate devices in IMAQHWINFO.
hwInfo = imaqhwinfo('kinect')
```

```
hwInfo = struct with fields:
       AdaptorDllName: 'C:\ProgramData\MATLAB\SupportPackages\R2023a\toolbox\imaq\supportpackages\kinectruntime\adap
    AdaptorDllVersion: '6.7.1 (R2023a)'
          AdaptorName: 'kinect'
            DeviceIDs: {[1]  [2]}
           DeviceInfo: [1×2 struct]
```

```
hwInfo.DeviceInfo(1)
```

```
ans = struct with fields:
              DefaultFormat: 'BGR_1920x1080'
       DeviceFileSupported: 0
                DeviceName: 'Kinect V2 Color Sensor'
                  DeviceID: 1
     VideoInputConstructor: 'videoinput('kinect', 1)'
    VideoDeviceConstructor: 'imaq.VideoDevice('kinect', 1)'
          SupportedFormats: {'BGR_1920x1080'}
```

```
hwInfo.DeviceInfo(2)
```

```
ans = struct with fields:
              DefaultFormat: 'Depth_512x424'
       DeviceFileSupported: 0
                DeviceName: 'Kinect V2 Depth Sensor'
                  DeviceID: 2
     VideoInputConstructor: 'videoinput('kinect', 2)'
```

```
    VideoDeviceConstructor: 'imaq.VideoDevice('kinect', 2)'
          SupportedFormats: {'Depth_512x424'}
```

```
% Create the VIDEOINPUT objects for the two streams
colorVid = videoinput('kinect',1)
```

```
Summary of Video Input Object Using 'Kinect V2 Color Sensor'.

   Acquisition Source(s):  Kinect V2 Color Source is available.

  Acquisition Parameters:  'Kinect V2 Color Source' is the current selected source.
                           10 frames per trigger using the selected source.
                           'BGR_1920x1080' video data to be logged upon START.
                           Grabbing first of every 1 frame(s).
                           Log data to 'memory' on trigger.

      Trigger Parameters:  1 'immediate' trigger(s) on START.

                  Status:  Waiting for START.
                           0 frames acquired since starting.
                           0 frames available for GETDATA.
```

```
depthVid = videoinput('kinect',2)
```

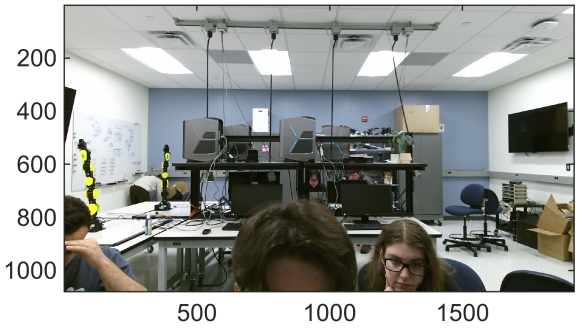
```
Summary of Video Input Object Using 'Kinect V2 Depth Sensor'.

   Acquisition Source(s):  Kinect V2 Depth Source is available.

  Acquisition Parameters:  'Kinect V2 Depth Source' is the current selected source.
                           10 frames per trigger using the selected source.
                           'Depth_512x424' video data to be logged upon START.
                           Grabbing first of every 1 frame(s).
                           Log data to 'memory' on trigger.

      Trigger Parameters:  1 'immediate' trigger(s) on START.

                  Status:  Waiting for START.
                           0 frames acquired since starting.
                           0 frames available for GETDATA.
```

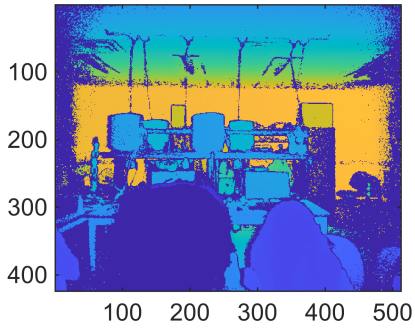
```
% Set the triggering mode to 'manual'
triggerconfig([colorVid depthVid],'manual');
colorVid.FramesPerTrigger = 100;
depthVid.FramesPerTrigger = 100;

% Start the color and depth device. This begins acquisition, but does not
% start logging of acquired data.
start([colorVid depthVid]);

% Trigger the devices to start logging of data.
trigger([colorVid depthVid]);

% Retrieve the acquired data
[colorFrameData,colorTimeData,colorMetaData] = getdata(colorVid);
```

```
ans =
```

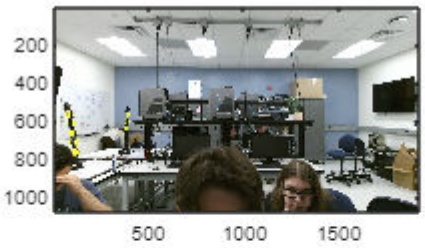
```
  ToolboxPreferencesManager with properties:

    GetPrefListener: [1×1 handle.listener]
    SetPrefListener: [1×1 handle.listener]
```

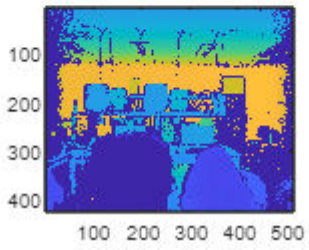
```
[depthFrameData,depthTimeData,depthMetaData] = getdata(depthVid);

% Stop the devices
stop([colorVid depthVid]);

% display one of the frames
figure(1);
subplot(2, 1, 1);
imagesc(colorFrameData(:, :, :, 50));axis equal tight;
subplot(2, 1, 2);
imagesc(depthFrameData(:, :, :, 50)); axis equal tight;
```





Copy and the screenshots of your RGB and depth maps:





Skeletal tracking

Grab a frame including a person's body (i.e., "skeleton" in Kinect terms)

```
depthSrc = getselectedsource(depthVid)
```

```
depthSrc =
   Display Summary for Video Source Object:

      General Settings:
        Parent = [1x1 videoinput]
        Selected = on
        SourceName = Kinect V2 Depth Source
        Tag = [0x0 string]
        Type = videosource

      Device Specific Properties:
        EnableBodyTracking = on
```

```
% Turn on skeletal tracking.
depthSrc.EnableBodyTracking = 'on';

% Acquire 100 frames with tracking turned on.
% Remember to have a person in person in front of the
% Kinect for Windows to see valid tracking data.
colorVid.FramesPerTrigger = 100;
depthVid.FramesPerTrigger = 100;

start([colorVid depthVid]);
trigger([colorVid depthVid]);

% Retrieve the frames and check if any Skeletons are tracked
[frameDataColor] = getdata(colorVid);
```

```
[frameDataDepth, timeDataDepth, metaDataDepth] = getdata(depthVid);

% View skeletal data from depth metadata
metaDataDepth
```

```
metaDataDepth = 100×1 struct
```

...

Fields	AbsTime	BodyIndexFrame	BodyTrackingID
1	[2025,4,1,19,35,30...	424×512 double	[72058000000000000,720580000000...
2	[2025,4,1,19,35,30...	424×512 double	[72058000000000000,720580000000...
3	[2025,4,1,19,35,30...	424×512 double	[72058000000000000,720580000000...
4	[2025,4,1,19,35,30...	424×512 double	[72058000000000000,720580000000...
5	[2025,4,1,19,35,30...	424×512 double	[72058000000000000,720580000000...
6	[2025,4,1,19,35,30...	424×512 double	[72058000000000000,720580000000...
7	[2025,4,1,19,35,30...	424×512 double	[72058000000000000,720580000000...
8	[2025,4,1,19,35,30...	424×512 double	[72058000000000000,720580000000...
9	[2025,4,1,19,35,30...	424×512 double	[72058000000000000,720580000000...
10	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
11	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
12	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
13	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
14	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
15	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
16	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
17	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
18	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
19	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
20	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
21	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
22	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
23	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
24	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
25	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
26	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
27	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
28	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
29	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...

Fields	AbsTime	BodyIndexFrame	BodyTrackingID
30	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
31	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
32	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
33	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
34	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
35	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
36	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
37	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
38	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
39	[2025,4,1,19,35,31...	424×512 double	[72058000000000000,720580000000...
40	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
41	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
42	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
43	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
44	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
45	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
46	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
47	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
48	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
49	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
50	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
51	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
52	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
53	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
54	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
55	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
56	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
57	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
58	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
59	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
60	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
61	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
62	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...

Fields	AbsTime	BodyIndexFrame	BodyTrackingID
63	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
64	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
65	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
66	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
67	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
68	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
69	[2025,4,1,19,35,32...	424×512 double	[72058000000000000,720580000000...
70	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
71	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
72	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
73	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
74	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
75	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
76	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
77	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
78	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
79	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
80	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
81	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
82	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
83	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
84	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
85	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
86	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
87	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
88	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
89	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
90	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
91	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
92	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
93	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
94	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
95	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...

Fields	AbsTime	BodyIndexFrame	BodyTrackingID
96	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
97	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
98	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
99	[2025,4,1,19,35,33...	424×512 double	[72058000000000000,720580000000...
100	[2025,4,1,19,35,34...	424×512 double	[72058000000000000,720580000000...

```
% Check for tracked skeletons from depth metadata
anyBodiesTracked = any(metaDataDepth(95).IsBodyTracked ~= 0)
```

```
anyBodiesTracked = logical
   1
```

```
% See which skeletons were tracked.
trackedBodies = find(metaDataDepth(95).IsBodyTracked)
```

```
trackedBodies = 1×3
     1     2     3
```

```
jointCoordinates = metaDataDepth(95).JointPositions(:, :, trackedBodies)
```

```
jointCoordinates =
jointCoordinates(:,:,1) =

    0.0185   -0.5616    2.1072
    0.0166   -0.2543    2.1349
    0.0155    0.0455    2.1476
    0.0194    0.1722    2.1557
   -0.1466   -0.0499    2.1186
   -0.1961   -0.2489    2.0356
   -0.1483   -0.0969    1.8941
   -0.1491   -0.0798    1.8880
    0.1383   -0.0404    2.1069
    0.2046   -0.2376    2.0219
    0.1843   -0.0671    1.8969
    0.1809   -0.0730    1.9006
   -0.0496   -0.5533    2.0762
   -0.0964   -0.9136    2.0587
   -0.1010   -1.1802    2.1010
   -0.0747   -1.2363    2.0194
    0.0862   -0.5509    2.0679
    0.1425   -0.9306    2.0598
    0.1652   -1.1942    2.1008
    0.0919   -1.1536    2.0149
    0.0157   -0.0285    2.1469
   -0.1365   -0.0379    1.8757
   -0.1300   -0.0281    1.8860
    0.1735   -0.0221    1.8848
    0.1883   -0.0227    1.9017


jointCoordinates(:,:,2) =
```

```
    0.7351   -0.6069    1.9229
    0.7615   -0.3108    1.9407
    0.7819   -0.0214    1.9451
    0.7619    0.1240    1.9347
    0.5914   -0.1229    2.0198
    0.4730   -0.3320    1.8846
    0.3774   -0.4573    1.7555
    0.3634   -0.5095    1.6673
    0.9165   -0.1087    1.8375
    0.9506   -0.2737    1.7186
    0.8740   -0.4208    1.5499
    0.8138   -0.4877    1.4687
    0.6500   -0.6025    1.9304
    0.6655   -0.9726    1.9534
    0.6891   -1.3376    2.0012
    0.6276   -1.3606    1.8804
    0.7962   -0.5915    1.8527
    0.8289   -0.9050    1.8307
    0.8877   -1.3300    1.8381
    0.8232   -1.3526    1.7188
    0.7778   -0.0929    1.9462
    0.3467   -0.5548    1.6098
    0.3742   -0.4436    1.6199
    0.7710   -0.5496    1.4145
    0.8021   -0.5637    1.5224


jointCoordinates(:,:,3) =

   -0.8195   -0.5064    1.9914
   -0.8423   -0.2280    2.0238
   -0.8590    0.0445    2.0420
   -0.8728    0.1970    2.0615
   -1.0165   -0.0688    1.9552
   -1.0688   -0.2784    1.8945
   -1.1795   -0.2259    1.7167
   -1.1576   -0.1738    1.6790
   -0.6689   -0.0692    2.0655
   -0.6228   -0.3522    2.0484
   -0.4461   -0.2195    1.9164
   -0.3824   -0.1577    1.8828
   -0.8849   -0.4978    1.9325
   -1.1038   -0.6219    1.8626
   -0.7543   -0.6205    1.8013
   -0.7082   -0.6516    1.6599
   -0.7259   -0.4975    1.9825
   -0.6790   -0.7576    1.9752
   -0.5892   -1.0600    2.1009
   -0.6071   -0.9184    2.0140
   -0.8558   -0.0226    2.0400
   -1.1528   -0.1375    1.6211
   -1.1507   -0.1668    1.7087
   -0.3277   -0.0987    1.8602
   -0.3414   -0.1505    1.9269
```

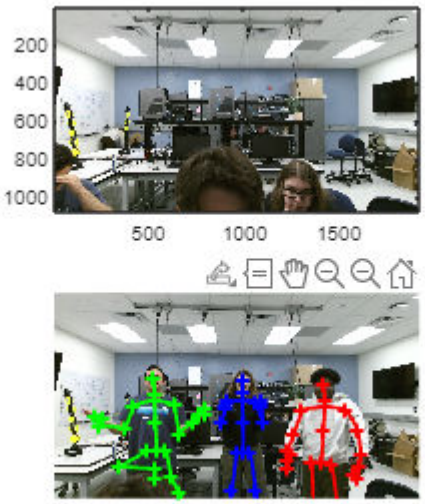
```
% Skeleton's joint indices with respect to the color image
jointIndices = metaDataDepth(95).ColorJointIndices(:, :, trackedBodies)
```

```
jointIndices =
jointIndices(:,:,1) =

   1.0e+03 *
```

```
    0.9950    0.8372
    0.9928    0.6767
    0.9912    0.5242
    0.9927    0.4604
    0.9087    0.5732
    0.8808    0.6806
    0.9020    0.6033
    0.9013    0.5936
    1.0556    0.5677
    1.0961    0.6745
    1.0930    0.5852
    1.0908    0.5885
    0.9599    0.8373
    0.9360    1.0315
    0.9347    1.1617
    0.9481    1.2177
    1.0314    0.8370
    1.0626    1.0401
    1.0730    1.1689
    1.0381    1.1735
    0.9915    0.5616
    0.9082    0.5696
    0.9122    0.5638
    1.0875    0.5595
    1.0948    0.5597


jointIndices(:,:,2) =

   1.0e+03 *

    1.4064    0.8900
    1.4162    0.7199
    1.4258    0.5572
    1.4165    0.4754
    1.3052    0.6120
    1.2621    0.7378
    1.2254    0.8300
    1.2306    0.8793
    1.5344    0.6093
    1.5972    0.7185
    1.6135    0.8414
    1.6050    0.9080
    1.3562    0.8862
    1.3615    1.0907
    1.3660    1.2805
    1.3566    1.3424
    1.4597    0.8940
    1.4868    1.0870
    1.5218    1.3430
    1.5201    1.4146
    1.4234    0.5972
    1.2293    0.9221
    1.2457    0.8445
    1.5969    0.9702
    1.5739    0.9501


jointIndices(:,:,3) =

   1.0e+03 *

    0.5391    0.8260
    0.5328    0.6719
```

```
    0.5269    0.5260
    0.5232    0.4459
    0.4203    0.5884
    0.3735    0.7102
    0.2420    0.6943
    0.2400    0.6638
    0.6324    0.5855
    0.6549    0.7357
    0.7340    0.6729
    0.7667    0.6393
    0.4894    0.8299
    0.3437    0.9142
    0.5345    0.9245
    0.5287    0.9772
    0.5886    0.8221
    0.6136    0.9668
    0.6813    1.0995
    0.6594    1.0461
    0.5284    0.5617
    0.2173    0.6436
    0.2569    0.6573
    0.7961    0.6058
    0.7941    0.6330
```

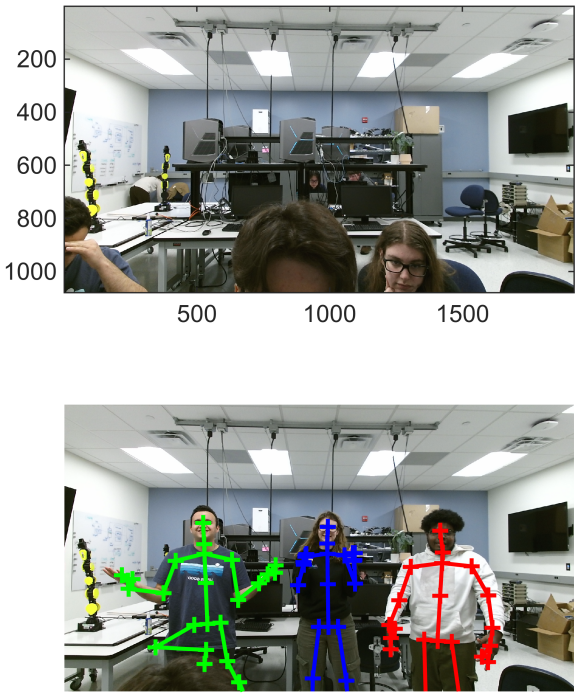
```
% Pull out the 95th color frame
image = frameDataColor(:, :, :, 95);

% Find number of Skeletons tracked
nBodies = length(trackedBodies);
```



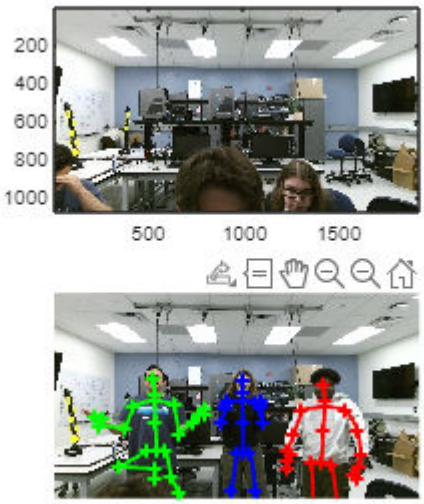
Now plot the skeleton over the RGB image

```
% Create skeleton connection map to link the joints.
SkeletonConnectionMap = [ [4 3];  % Neck
                          [3 21]; % Head
                          [21 2]; % Right Leg
                          [2 1];
```

```
                          [21 9];
                          [9 10];  % Hip
                          [10 11];
                          [11 12]; % Left Leg
                          [12 24];
                          [12 25];
                          [21 5];  % Spine
                          [5 6];
                          [6 7];   % Left Hand
                          [7 8];
                          [8 22];
                          [8 23];
                          [1 17];
                          [17 18];
                          [18 19];  % Right Hand
                          [19 20];
                          [1 13];
                          [13 14];
                          [14 15];
                          [15 16];
                        ];

% Marker colors for up to 6 bodies.
colors = ['b';'r';'g';'c';'y';'m'];

% Display the RGB image.
imshow(image);

% Overlay the skeleton on this RGB frame.
for i = 1:24
     for body = 1:nBodies
         X1 = [jointIndices(SkeletonConnectionMap(i,1),1,body)
jointIndices(SkeletonConnectionMap(i,2),1,body)];
         Y1 = [jointIndices(SkeletonConnectionMap(i,1),2,body)
jointIndices(SkeletonConnectionMap(i,2),2,body)];
         line(X1,Y1, 'LineWidth', 1.5, 'LineStyle', '-', 'Marker', '+', 'Color',
colors(body));
     end

    hold on;
 end
 hold off;
```



Copy and paste a screenshot overlaid with the extracted skeleton:



Tasks/Questions:

- Did the skeleton model accurately capture your body geometry? **Yes, the joints on each person are clearly noted in the image**
- How would you estimate the elbow angle from the skeletal model? **Use the angles between the upper and lower arms to calculate this.**

Submitting This Lab

Export this *.mlx file as Lab7_##_<LastName1>_<LastName2>_<LastName3>_<LastName4>.pdf (## should be your computer number) and email to Lauren.Diaz@jhuapl.edu