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 C:\GitHub\minivie\user_config.xml
[UserConfig.m] myoUdpRate=200
[UserConfig.m] myoUdpPort1=10001
[UserConfig.m] myoUdpPort2=10002

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 = 10.0009
```

```
% 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.
     0
     0
     0

     0
     0
     0

     0
     0
     0

     0
     0
     0

     0
     0
     0

     0
     0
     0

     0
     0
```

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

```
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
```

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

```
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
```

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

```
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
```

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

```
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
```

```
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
```

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0

```
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
```

```
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
```

0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0

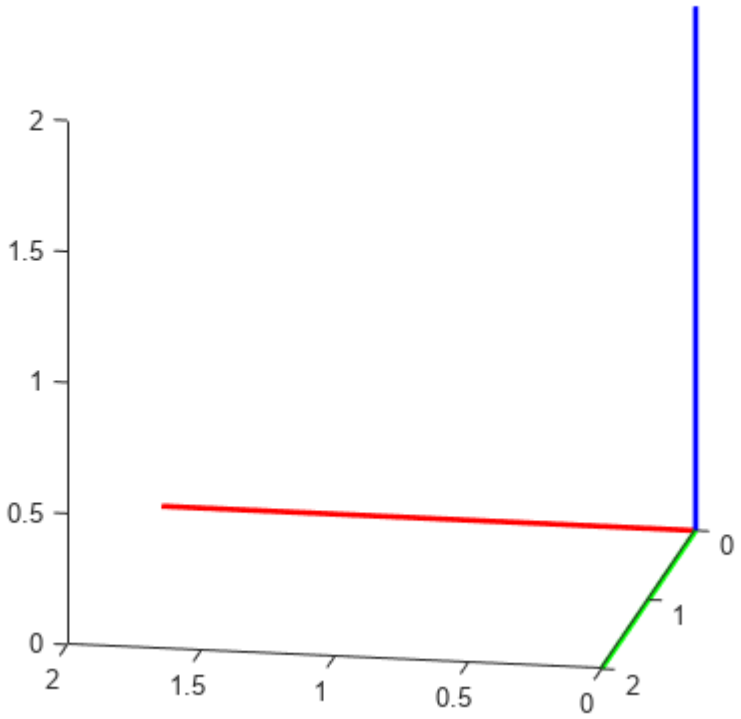
0
0
0

0
0
0

0
0
0

0
0

```
0

0
0
0

0
0
0

0
0
0

0
0
0

0
0
0
```




```
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
---------------------------------------
---------------------------------------
---------------------------------------
```

Questions:

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

The global position is [0 0 0] with a orientation of [0 0 0]

1. What is its local coordinate frame?

The position of the local coordinate frame is the same as the global, but the orientation moves with the orientation of the myoband

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

You would have to map the flexion of the elbow to the myoband sensor input for the angle of movement in reference to the global frame so that the orientation of the myoband maps to the orientation of the end effector on the elbow

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();
```

```
hMyo.initialize()
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
hMyo.close()
cleanup;
```

Part 2: Kinect

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

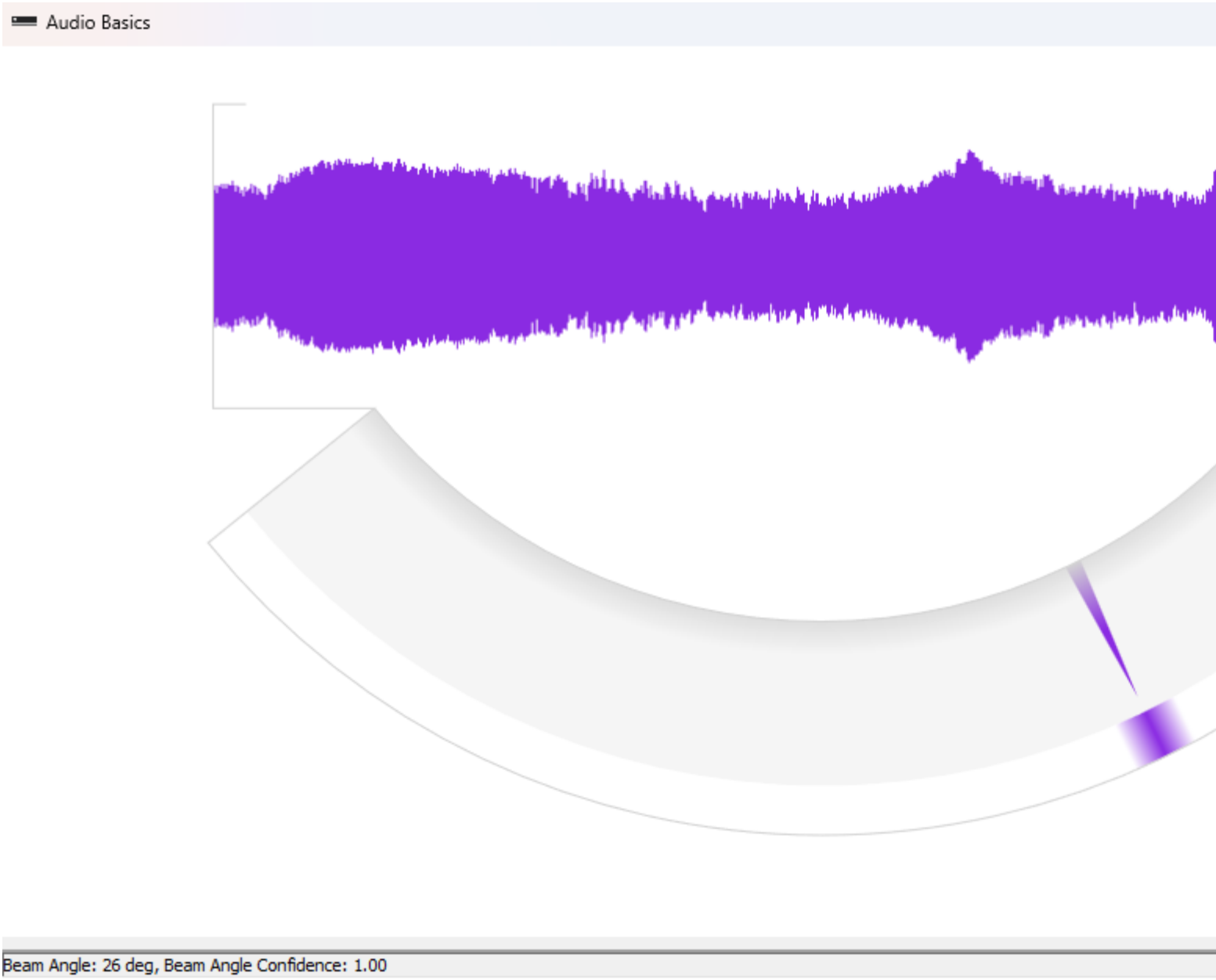
Run the following examples:

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

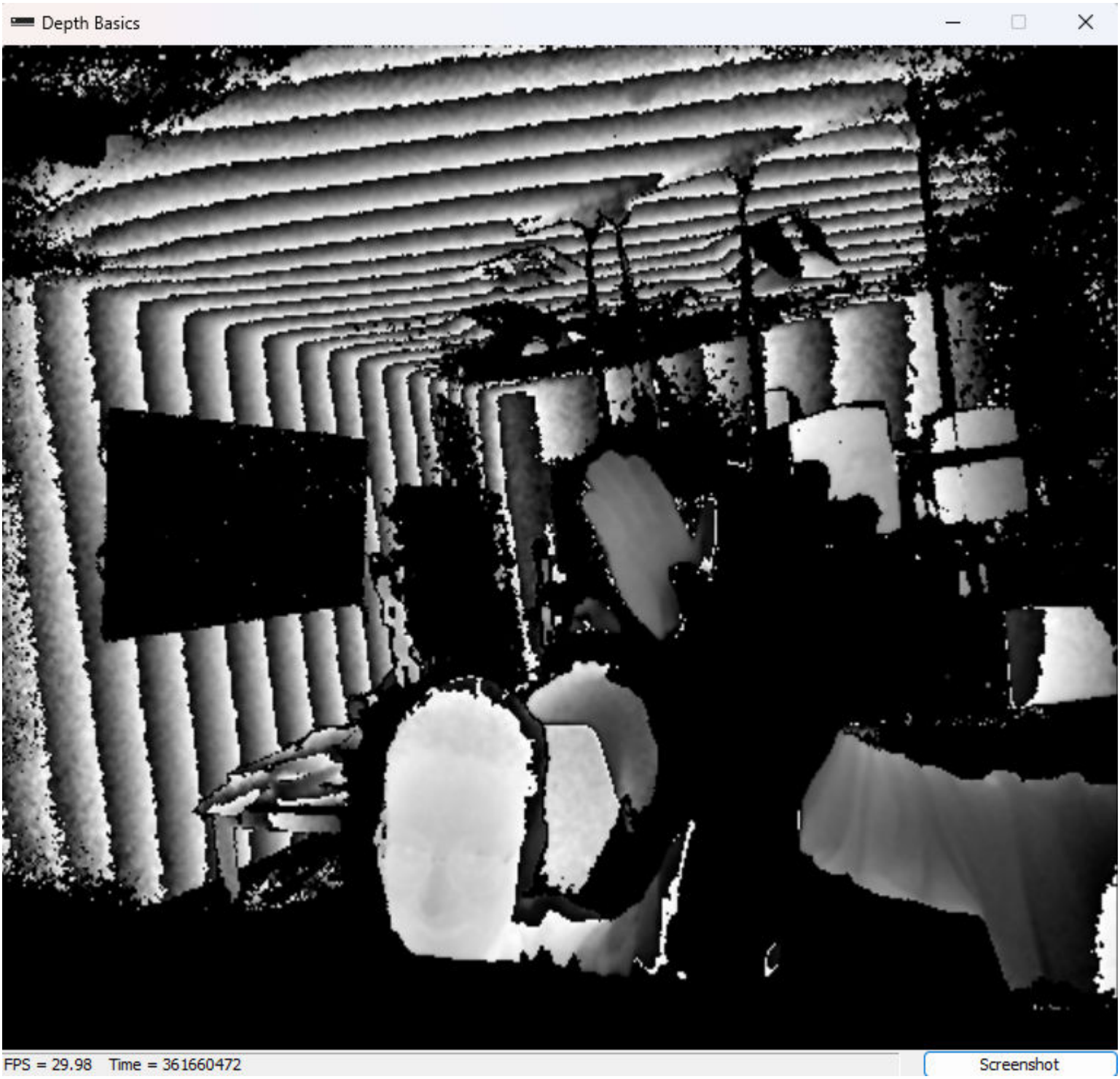
4. Skeletal Basics

Copy and paste window screenshots from each:

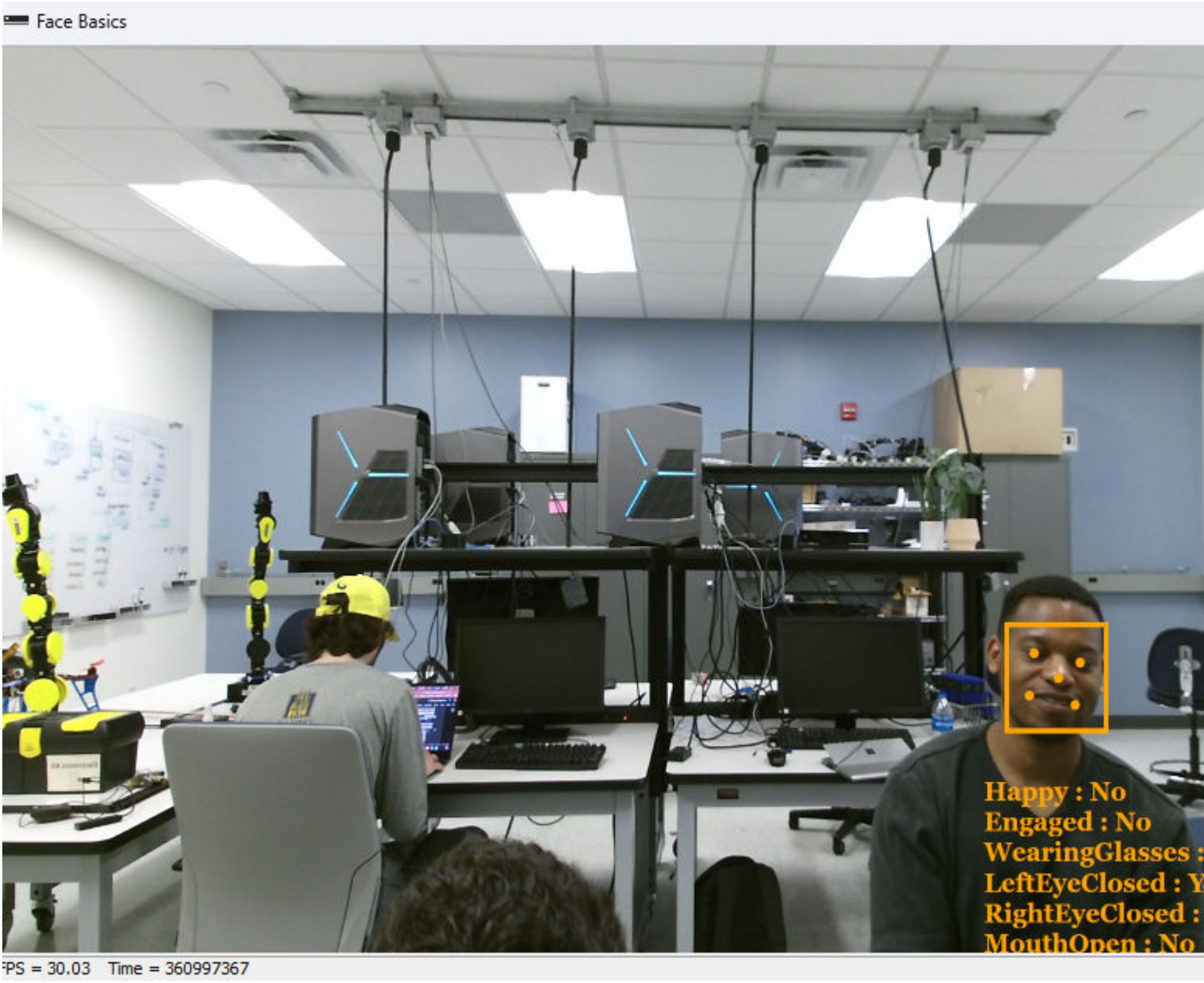
1. **Audio Basic**



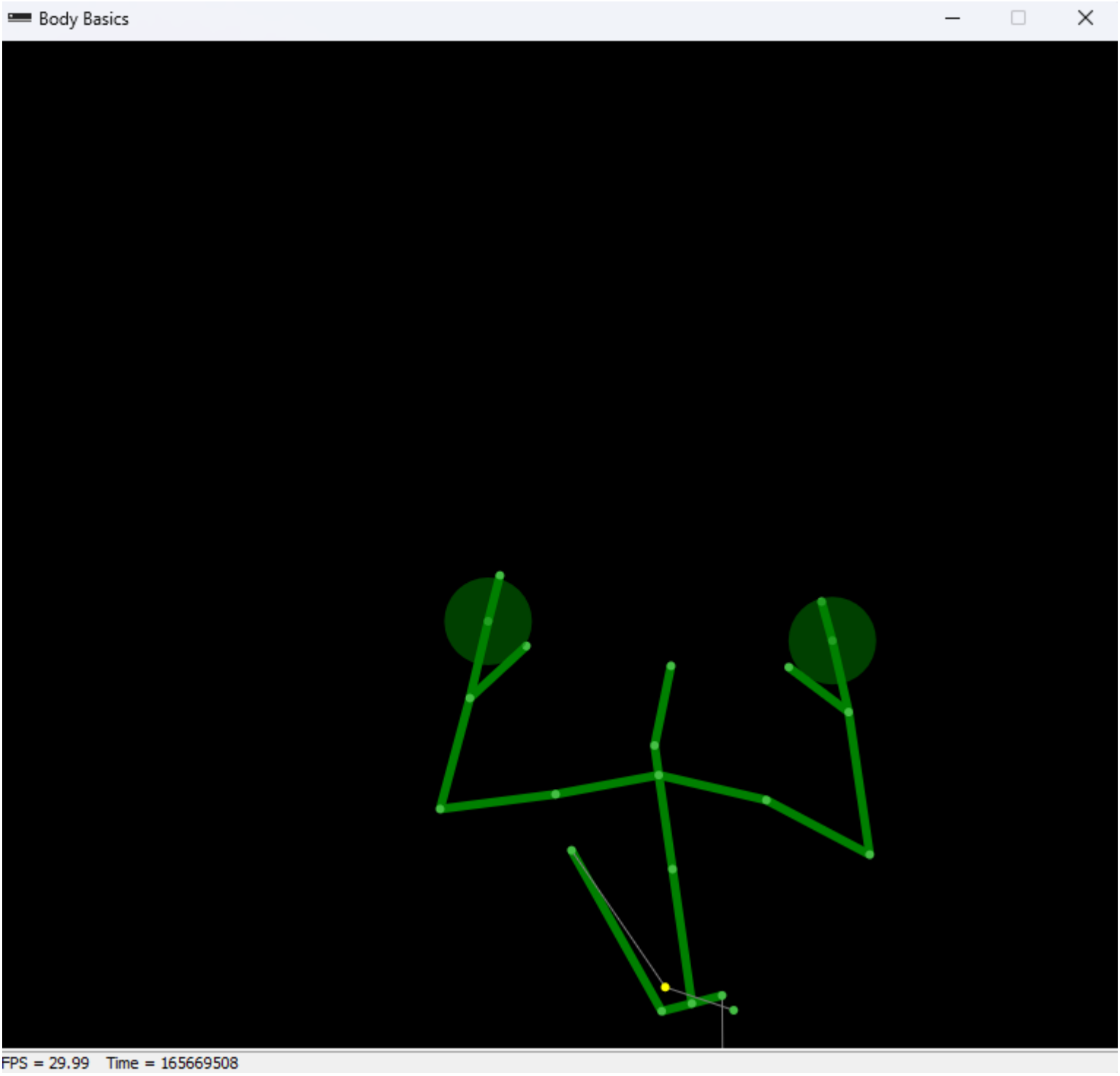
2. Depth Basic



3. Face Tracking Basic



4. Skeletal Basic



Questions:

- What advantage do microphone arrays have over traditional microphones / speech input devices?

It allows you to estimate the location of the noise with triangulation and it can better filter out noise.

- At what range is the face tracking effective? How might this be used as a robot controller?

It works at approximately 1-3 yards from the kinnect.

- What kind of motions and postures does the skeletal model capture? When does it break down?

The skeletal model captures the spine/core, upper leg, arm and hand position such as wether the fist is clenched, but not individual finger movements.

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

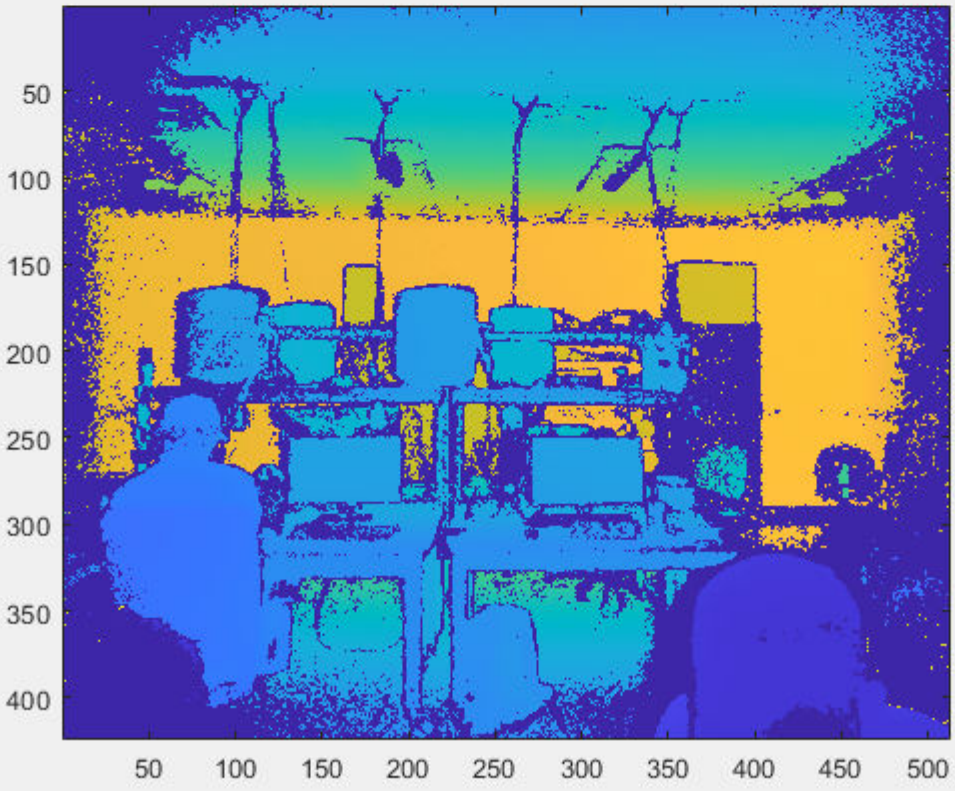
It might be more straightforward to run this in the Command Window (select, then hit F9)

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

% The Kinect for Windows Sensor shows up as two separate devices in IMAQHWINFO.
hwInfo = imaqhwinfo('kinect')
hwInfo.DeviceInfo(1)
hwInfo.DeviceInfo(2)

% Create the VIDEOINPUT objects for the two streams
colorVid = videoinput('kinect',1)
depthVid = videoinput('kinect',2)

% 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);
[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:


100
200
300
400
500
600
700
800
900
1000
200
400
600
800
1000
1200
1400
1600
1800


50
100
150
200
250
300
350
400
50
100
150
200
250
300
350
400
450
500

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 = off
```

```
% 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	ColorJointIndices
1	[2025,4,5,17,6,35...	424×512 double	[0,0,0,0,0,0]	25×2×6 double
2	[2025,4,5,17,6,35...	424×512 double	[0,0,0,0,0,0]	25×2×6 double
3	[2025,4,5,17,6,35...	424×512 double	[0,0,0,0,0,0]	25×2×6 double
4	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
5	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
6	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double

Fields	AbsTime	BodyIndexFrame	BodyTrackingID	ColorJointIndices
7	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
8	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
9	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
10	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
11	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
12	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
13	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
14	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
15	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
16	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
17	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
18	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
19	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
20	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
21	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
22	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
23	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
24	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
25	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
26	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
27	[2025,4,5,17,6,35...	424×512 double	[720580000000000...	25×2×6 double
28	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
29	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
30	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
31	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
32	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
33	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
34	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
35	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
36	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
37	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
38	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
39	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double

Fields	AbsTime	BodyIndexFrame	BodyTrackingID	ColorJointIndices
40	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
41	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
42	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
43	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
44	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
45	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
46	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
47	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
48	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
49	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
50	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
51	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
52	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
53	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
54	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
55	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
56	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
57	[2025,4,5,17,6,36...	424×512 double	[720580000000000...	25×2×6 double
58	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
59	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
60	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
61	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
62	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
63	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
64	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
65	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
66	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
67	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
68	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
69	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
70	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
71	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
72	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double

Fields	AbsTime	BodyIndexFrame	BodyTrackingID	ColorJointIndices
73	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
74	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
75	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
76	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
77	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
78	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
79	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
80	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
81	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
82	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
83	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
84	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
85	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
86	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
87	[2025,4,5,17,6,37...	424×512 double	[720580000000000...	25×2×6 double
88	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
89	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
90	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
91	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
92	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
93	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
94	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
95	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
96	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
97	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
98	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
99	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double
100	[2025,4,5,17,6,38...	424×512 double	[720580000000000...	25×2×6 double

```
% 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
```

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

```
jointCoordinates = 25×3
    0.2430   -0.7548    1.4857
    0.2547   -0.5556    1.5198
    0.2647   -0.3579    1.5445
    0.2651   -0.2669    1.5464
    0.0936   -0.4471    1.5462
    0.0542   -0.6110    1.4932
    0.0575   -0.7436    1.3959
    0.0466   -0.7704    1.3789
    0.4159   -0.4343    1.4651
    0.4413   -0.5948    1.3940
     ⋮
```

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

```
jointIndices = 25×2
10^3 ×
    1.1765    1.1019
    1.1792    0.9451
    1.1819    0.7987
    1.1816    0.7342
    1.0613    0.8617
    1.0368    0.9933
    1.0454    1.1294
    1.0380    1.1582
    1.3074    0.8692
    1.3460    1.0121
     ⋮
```

```
% 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?

Fairly accurately, but it's a little off. The right arm skeleton was not centered on the arm and the neck was off to the side, but the core and one arm was fairly close.

- How would you estimate the elbow angle from the skeletal model?

You could estimate it by taking the angle between the upper arm and lower arm lines.

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