Lab Write-Up

Q3: Use the previous functions to determine attribute trends across all data samples for a given activity. Which attributes best help distinguish the sensor traces of one activity compared to another?

Attributes: controller_right_pos_y, controller_left_pos_y, controller_right_pos_z, controller_left_pos_z, headset_pos_y, headset_pos_z

Originally, I elaborated on my choice of attributes in this question, however I found my elaboration to be more relevant to answering question 5 so please refer there. I assumed that this question is merely asking for my selection of attributes not my explanation. Below, is some of the data I generated from my code in order to evaluate and select the attributes that I deemed most useful in distinguishing the various activities from one another.

▼ Standing

	mean	variance
headset_vel.x	0.000010	0.000035
headset_vel.y	0.000113	0.000003
headset_vel.z	-0.001250	0.000054
headset_angularVel.x	0.001786	0.000322
headset_angularVel.y	-0.001866	0.000610
headset_angularVel.z	0.001452	0.000293
headset_pos.x	-0.107453	0.000019
headset_pos.y	0.040919	0.000001
headset_pos.z	0.148153	0.000038
headset_rot.x	353.825497	0.477386
headset_rot.y	191.303393	8578.371965
headset_rot.z	183.324614	10552.449600
controller_left_vel.x	-0.000649	0.000084
controller_left_vel.y	-0.001762	0.000023
controller_left_vel.z	-0.000581	0.000102
controller_left_angularVel.x	-0.003742	0.000638
controller_left_angularVel.y	-0.000694	0.001332
controller_left_angularVel.z	-0.004698	0.001412
controller_left_pos.x	-0.309674	0.000022
controller_left_pos.y	-0.699233	0.000004
controller_left_pos.z	0.185440	0.000023
controller_left_rot.x	63.685944	0.609566
controller_left_rot.y	306.108441	1.248049

▼ Sitting

	mean	variance
headset_vel.x	-0.000174	2.025692e-05
headset_vel.y	0.000012	4.568997e-06
headset_vel.z	-0.000275	1.118746e-05
headset_angularVel.x	0.001057	5.368059e-04
headset_angularVel.y	0.001160	9.043394e-04
headset_angularVel.z	-0.000552	3.027327e-04
headset_pos.x	0.153456	4.710389e-06
headset_pos.y	-0.152078	1.436504e-06
headset_pos.z	-0.747877	6.377553e-06
headset_rot.x	355.547031	7.383707e-01
headset_rot.y	9.463653	1.875016e+03
headset_rot.z	309.953603	1.103556e+04
controller_left_vel.x	0.000175	3.894532e-06
controller_left_vel.y	-0.000508	2.578329e-06
controller_left_vel.z	0.000089	1.360856e-06
controller_left_angularVel.x	0.000078	3.471478e-04
controller_left_angularVel.y	-0.000398	1.741999e-04
controller_left_angularVel.z	0.001202	2.048058e-04
controller_left_pos.x	0.163837	1.558673e-07
controller_left_pos.y	-0.596047	8.307124e-08
controller_left_pos.z	-0.401815	6.102387e-07
controller_left_rot.x	17.064821	3.356159e-02
controller_left_rot.y	15.369314	2.608496e-02

controller_left_rot.z	284.310194	4.48232
controller_right_vel.x	-0.003997	0.08475
controller_right_vel.y	0.006091	0.03530
controller_right_vel.z	-0.003001	0.00129
controller_right_angularVel.x	-0.019573	0.00294
controller_right_angularVel.y	0.013544	0.00452
controller_right_angularVel.z	-0.000755	0.00245
controller_right_pos.x	-0.889876	0.23330
controller_right_pos.y	-0.038102	0.11255
controller_right_pos.z	0.338406	0.00366
controller_right_rot.x	69.590942	0.88809
controller_right_rot.y	55.338685	9.34642
controller_right_rot.z	77.751201	5072.35299

controller_left_rot.z	17.511005	1.308851e-01
controller_right_vel.x	-0.000392	1.488126e-05
controller_right_vel.y	-0.000458	2.273976e-05
controller_right_vel.z	0.000177	1.665667e-06
controller_right_angularVel.x	-0.001299	1.810061e-03
controller_right_angularVel.y	0.001271	8.666638e-04
controller_right_angularVel.z	-0.001396	1.649438e-03
controller_right_pos.x	0.288711	2.149819e-07
controller_right_pos.y	-0.602589	5.048157e-07
controller_right_pos.z	-0.423812	3.825666e-07
controller_right_rot.x	27.753853	1.051391e-01
controller_right_rot.y	8.520042	3.006982e-01
controller_right_rot.z	150.991406	2.158443e+04

▼ Jogging

	mean	variance
headset_vel.x	0.019335	0.007629
headset_vel.y	0.002240	0.589140
headset_vel.z	0.024670	0.021012
headset_angularVel.x	0.001240	0.601245
headset_angularVel.y	0.004788	0.111584
headset_angularVel.z	-0.001696	0.070132
headset_pos.x	0.239152	0.006711
headset_pos.y	0.108004	0.002805
headset_pos.z	0.475942	0.023691
headset_rot.x	343.932706	2263.490167
headset_rot.y	297.479213	16106.396128
headset_rot.z	221.167224	27774.899871
controller_left_vel.x	0.031927	0.049344
controller_left_vel.y	-0.022816	1.601660
controller_left_vel.z	-0.002930	0.236787
controller_left_angularVel.x	0.138655	6.441572
controller_left_angularVel.y	0.110446	3.089515
controller_left_angularVel.z	-0.260377	10.868799
controller_left_pos.x	0.027703	0.007190

▼ Arms Chopping

	mean	variance
headset_vel.x	0.000139	0.000172
headset_vel.y	0.000578	0.000384
headset_vel.z	-0.000731	0.000585
headset_angularVel.x	0.006487	0.033157
headset_angularVel.y	0.001607	0.004510
headset_angularVel.z	0.001256	0.013243
headset_pos.x	0.349317	0.000045
headset_pos.y	0.028466	0.000014
headset_pos.z	-0.125028	0.000073
headset_rot.x	322.691313	8031.268966
headset_rot.y	345.585710	1.900437
headset_rot.z	9.822901	3064.807632
controller_left_vel.x	0.010696	0.040868
controller_left_vel.y	-0.011755	1.329222
controller_left_vel.z	-0.028739	0.354939
controller_left_angularVel.x	-0.130231	6.174735
controller_left_angularVel.y	0.396873	2.922649
controller_left_angularVel.z	0.095684	8.391716
controller_left_pos.x	0.140299	0.000831
controller_left_pos.y	-0.260953	0.030350

controller_left_pos.y	-0.271082	0.016645
controller_left_pos.z	0.591192	0.023933
controller_left_rot.x	212.889735	22520.681722
controller_left_rot.y	313.497497	352.657950
controller_left_rot.z	136.893656	22286.791224
controller_right_vel.x	0.011889	0.052722
controller_right_vel.y	0.017166	1.848984
controller_right_vel.z	-0.003996	0.298484
controller_right_angularVel.x	0.029972	14.613882
controller_right_angularVel.y	-0.083873	2.101567
controller_right_angularVel.z	0.363239	1.943004
controller_right_pos.x	0.425797	0.006484
controller_right_pos.y	-0.306082	0.022561
controller_right_pos.z	0.650021	0.026603
controller_right_rot.x	158.984508	23153.607165
controller_right_rot.y	81.886728	18839.813134
controller_right_rot.z	316.742385	7981.544364

controller_left_pos.z	0.074859	0.006263
controller_left_rot.x	230.019853	17412.244122
controller_left_rot.y	303.473926	346.527770
controller_left_rot.z	143.073830	22312.601349
controller_right_vel.x	0.006636	0.034295
controller_right_vel.y	-0.005709	1.420965
controller_right_vel.z	-0.030765	0.332750
controller_right_angularVel.x	-0.034324	14.009050
controller_right_angularVel.y	0.203068	0.788174
controller_right_angularVel.z	0.004688	1.720270
controller_right_pos.x	0.428859	0.000272
controller_right_pos.y	-0.258049	0.032316
controller_right_pos.z	0.152669	0.006238
controller_right_rot.x	217.888693	18784.020499
controller_right_rot.y	226.245338	26437.840601
controller_right_rot.z	234.797099	24604.444419

▼ Arms Stretching

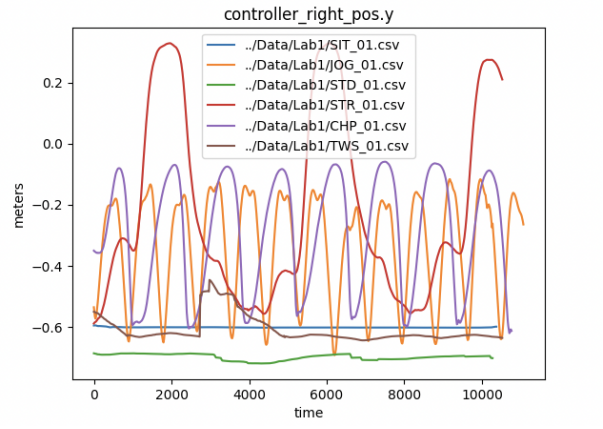
	mean	variance
headset_vel.x	-0.000230	0.000367
headset_vel.y	0.000353	0.000230
headset_vel.z	0.000834	0.007308
headset_angularVel.x	0.002930	0.014240
headset_angularVel.y	0.003668	0.010423
headset_angularVel.z	-0.001809	0.004774
headset_pos.x	0.150706	0.000060
headset_pos.y	0.020770	0.000027
headset_pos.z	0.036345	0.000748
headset_rot.x	250.207313	14526.600392
headset_rot.y	342.666962	4665.959490
headset_rot.z	146.097573	28751.538468
controller_left_vel.x	-0.007403	0.342616
controller_left_vel.y	0.017213	0.376463
controller_left_vel.z	-0.011105	0.440156
controller_left_angularVel.x	0.190701	1.230209
controller_left_angularVel.y	-0.080368	2.342897

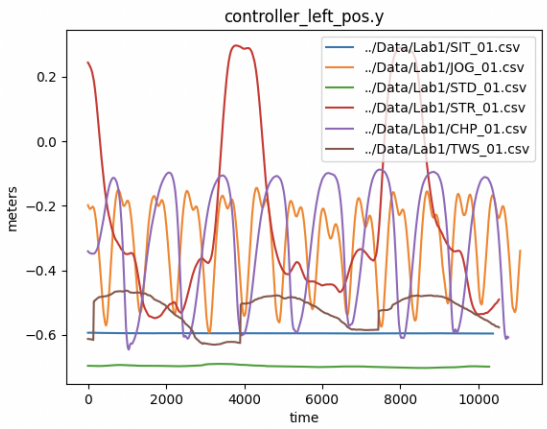
▼ Twisting

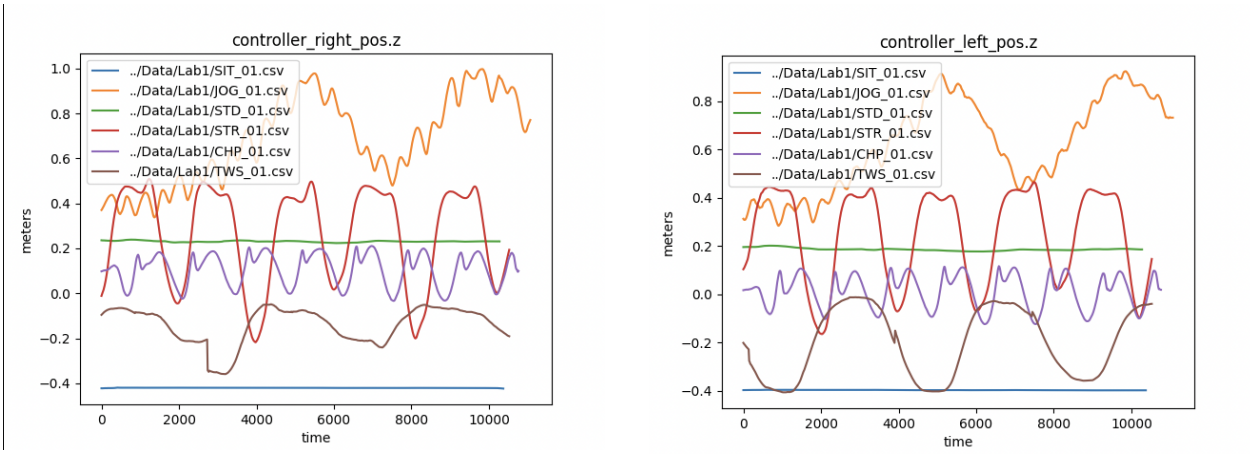
	mean	variance
headset_vel.x	0.006702	0.029722
headset_vel.y	-0.000664	0.001360
headset_vel.z	-0.005093	0.041771
headset_angularVel.x	-0.017478	0.095788
headset_angularVel.y	-0.085826	4.863783
headset_angularVel.z	0.036296	0.143205
headset_pos.x	0.289026	0.006596
headset_pos.y	0.013672	0.000136
headset_pos.z	-0.196507	0.005003
headset_rot.x	266.039289	20590.919138
headset_rot.y	198.698567	12871.452517
headset_rot.z	172.224729	30428.052129
controller_left_vel.x	0.035616	0.027990
controller_left_vel.y	-0.019011	0.003420
controller_left_vel.z	0.031240	0.056508
controller_left_angularVel.x	-0.089585	0.678666
controller_left_angularVel.y	-0.088285	2.235522

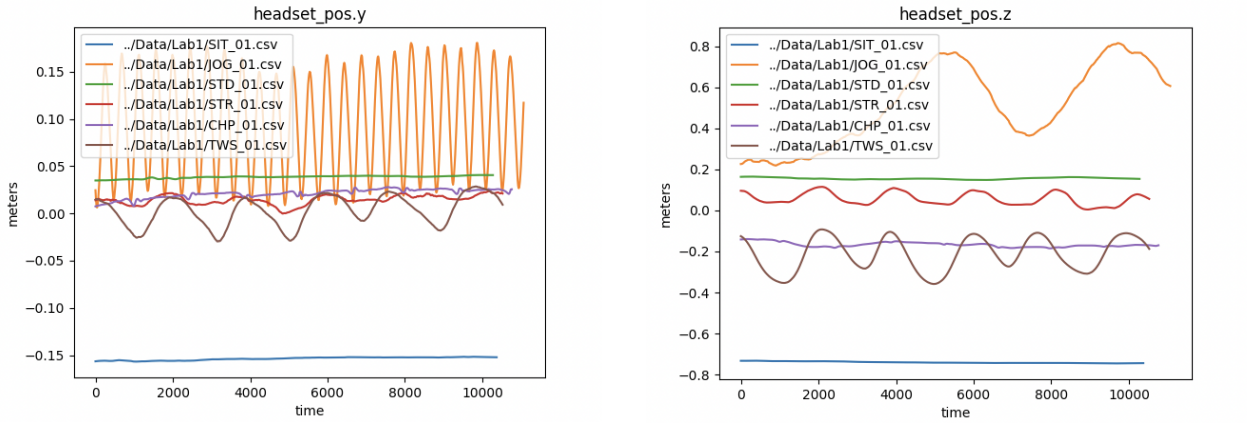
```
7
controller_left_angularVel.z     0.094566      0.84414
0
controller_left_pos.x           -0.195451      0.02799
9
controller_left_pos.y           -0.232776      0.07130
5
controller_left_pos.z            0.275097      0.02839
9
controller_left_rot.x          201.085270  24508.23378
7
controller_left_rot.y          312.988242   1044.35214
3
controller_left_rot.z          194.415901  26643.64987
7
controller_right_vel.x           0.005152      0.49172
7
controller_right_vel.y          -0.005774      0.38474
1
controller_right_vel.z          -0.024343      0.59187
9
controller_right_angularVel.x   -0.019572      1.74338
9
controller_right_angularVel.y   -0.052742      2.54889
7
controller_right_angularVel.z   -0.021458      1.02899
5
controller_right_pos.x           0.481817      0.03494
7
controller_right_pos.y          -0.248151      0.07547
4
controller_right_pos.z           0.267002      0.03943
3
controller_right_rot.x         132.028280  21262.46852
7
controller_right_rot.y         121.356991  17184.72207
8
controller_right_rot.z         166.144442  27213.00234
8
```

```
9
controller_left_angularVel.z    -0.026202      0.86724
1
controller_left_pos.x            0.185371      0.00395
4
controller_left_pos.y           -0.547144      0.00184
9
controller_left_pos.z           -0.176211      0.01659
2
controller_left_rot.x           34.831511    178.09087
8
controller_left_rot.y          191.523141  15371.36035
5
controller_left_rot.z           68.462971   6249.43259
9
controller_right_vel.x          -0.034676      0.02215
4
controller_right_vel.y          -0.015731      0.00161
2
controller_right_vel.z           0.002070      0.02718
7
controller_right_angularVel.x   -0.051953      0.79827
9
controller_right_angularVel.y   -0.049094      2.19042
2
controller_right_angularVel.z   -0.137427      0.75931
7
controller_right_pos.x           0.348277      0.01018
6
controller_right_pos.y          -0.584471      0.00215
2
controller_right_pos.z          -0.112539      0.01144
7
controller_right_rot.x          43.550112     95.32463
0
controller_right_rot.y         203.640563  15010.13406
5
controller_right_rot.z         189.637604  25495.53633
1
```

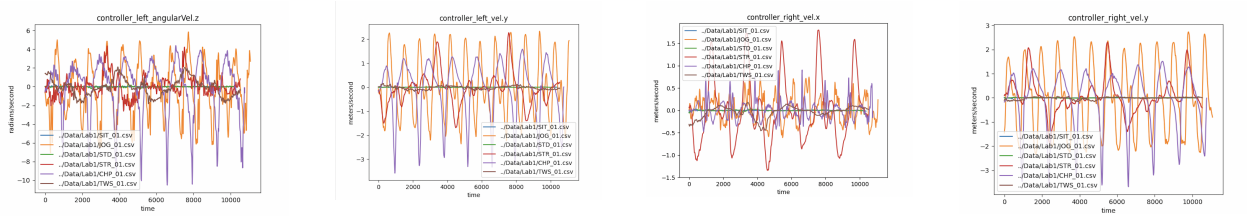






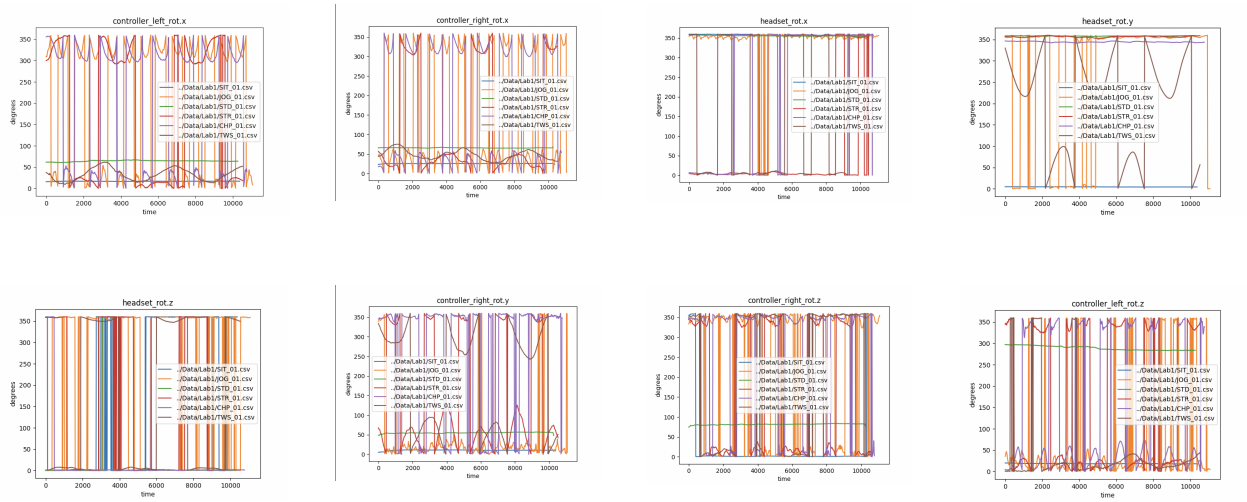


Additionally,

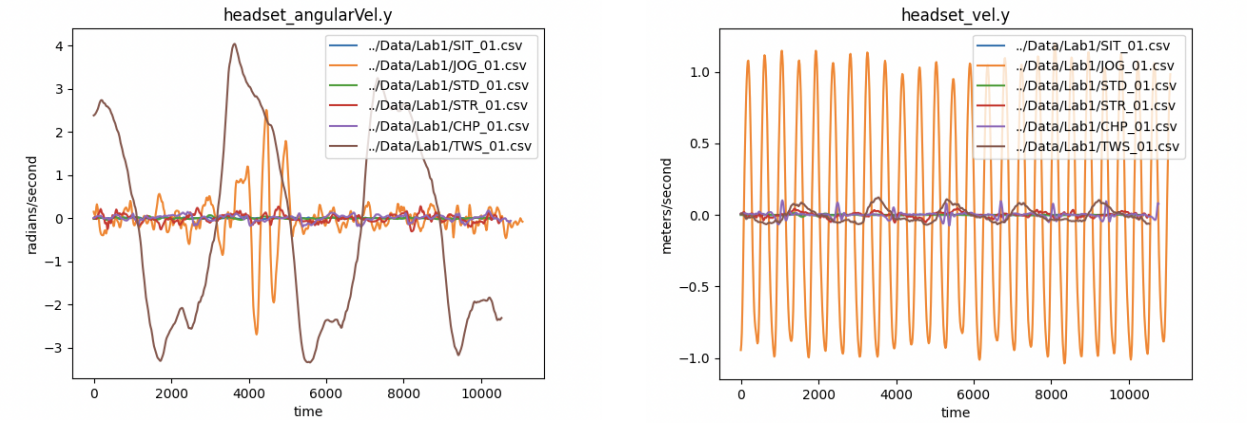


While measurements of controller velocity did provided helpful distinctions for certain activities such as jogging, for stationary activities such as sitting and standing these measurements are unable to aid in distinguishing between the two activities whereas other attributes display activity patterns that aid in the discrimination of all 6 activities.

Q4: Which attributes are less useful for distinguishing the differences between activities? Why?



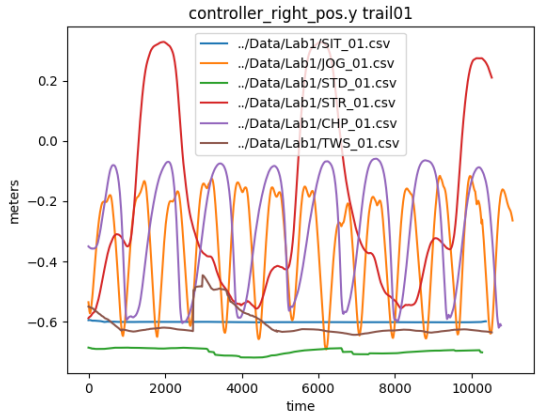
Measurements of rotation across most sensors (headset, left controller, and right controller) and most dimensions (x, y, and z) are less helpful for distinguishing between activities. Upon generating graphs to display the patterns of activity for the first trial of each activity, the patterns displayed in the graph are incredibly hard to interpret. Aside from being difficult to interpret due to the numerous vertical lines displayed, there is not an easily distinguishable difference between the patterns displayed for rotation across the different sensors and dimensions for most of the activities recorded. Due to the difficulty in interpretation as well as pattern identification and distinction, measurements of rotation are less useful compared to other attributes when attempting to disguise between the activities recorded.

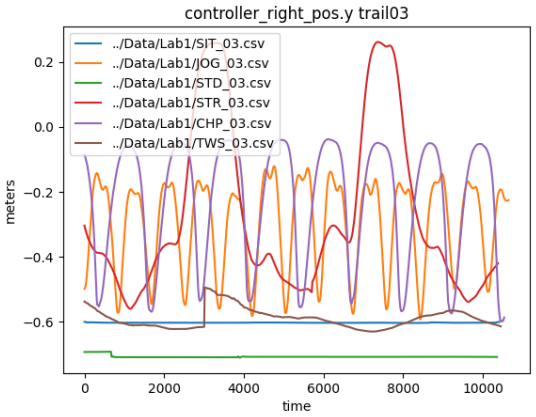


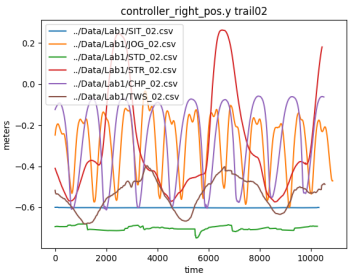
Additionally, it is worth mentioning attributes that provide helpful distinctions for a singular activity, but not for the other 5 activities. An example is the angular velocity for y for the headset which provides a clear pattern distinction for twisting in the generate graph, but does not display distinct patterns to help distinguish between the remaining 5 activities. Similar is the headset velocity for y which provides a clear pattern distinction for jogging, but does not display distinguishable patterns of activity for the remaining 5 activities. While these attributes are helpful in identifying a singular activity, since they are unable to effectively distinguish between the remain 5 activities recorded this renders them less helpful when compared to attributes that can be used individually to distinguish between all 6 activities.

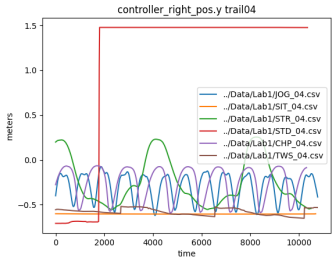
Q5: Compute the mean and variance of the significant attributes across all data samples, then present them in a table for all six activities. Also, include visualizations that highlight how motion patterns differ between activities for certain attributes in your report. Explain how the statistics and visualizations support your answer to #3

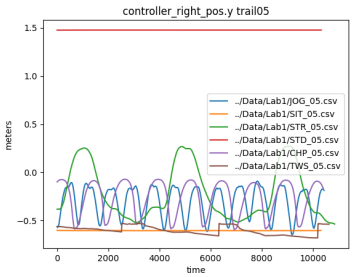
controller_right_pos.y



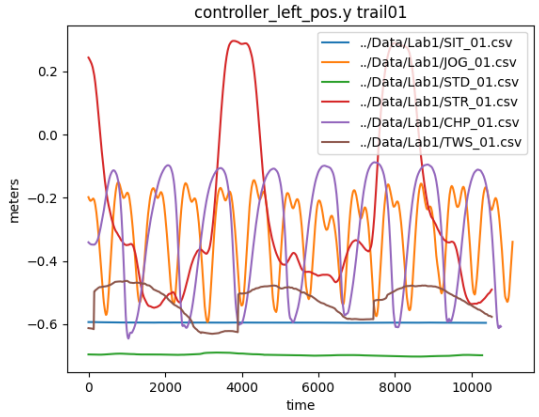


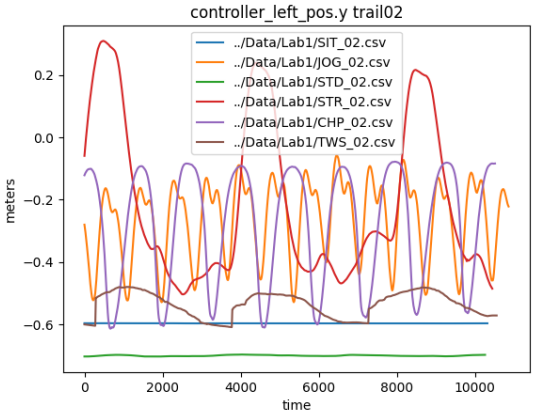


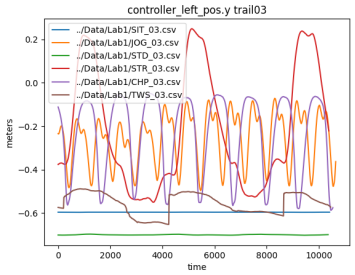


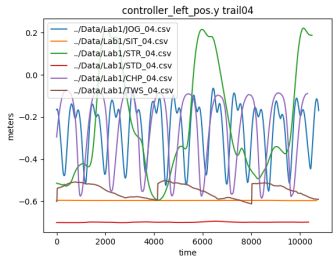


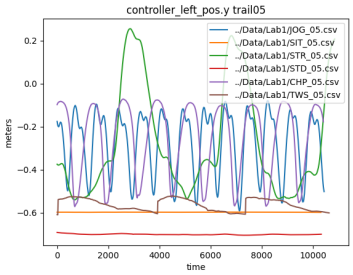
controller_left_pos.y





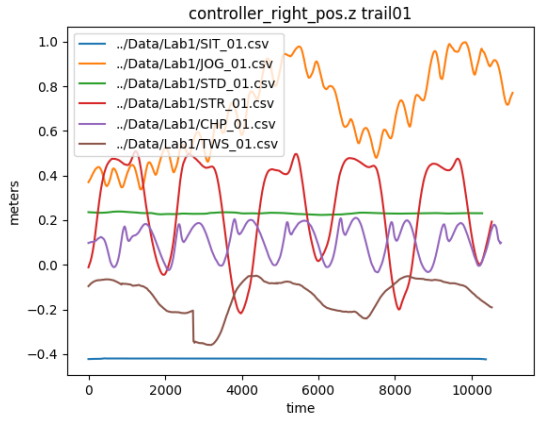


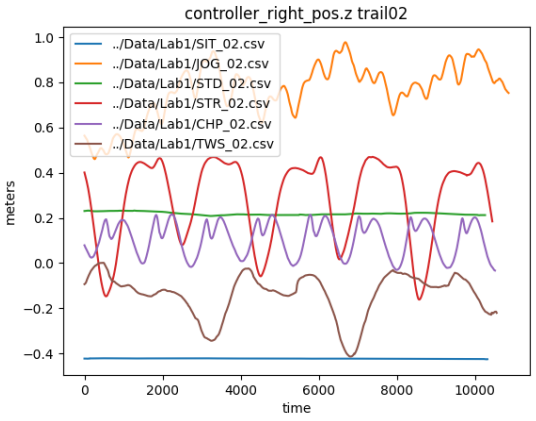


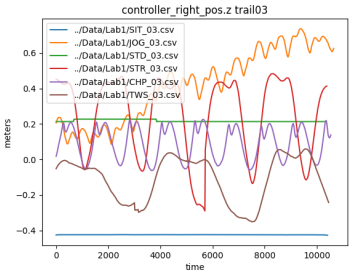


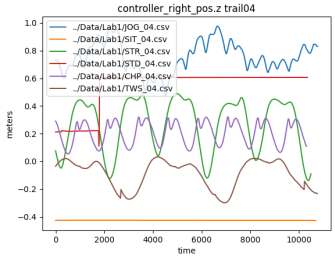
By graphing the y position for both controllers (right and left) for the recorded trials, this attribute displays patterns of activity that aid in distinguishing the sensor traces of the different activity. Both standing and sitting display a straight line since they involve little hand movement, however sitting is lower due to the change in body position. An important consideration for analyzing future data as well as designed a ML model, is how to distinguish between sitting and standing using positional data when accounting for standing on platforms or sitting on surfaces at different heights. The pattern displayed for stretching demonstrates the highest peaks/amplitude which makes sense since the stretching motion required the furthest extension of the arms/hands in terms of vertical direction. Twisting displays a pattern of peaks, however, the peaks for twisting are the shortest out of the various patterns displayed for the activities measured which makes sense since twisting did not require hand movement. The peaks displayed by the measurements for jogging and chopping are similar in height, midway between stretching and twisting, which makes sense since they require moderate vertical movement of the hands. Additionally, you can distinguish between the two because the graph for chopping is smoother while the peaks for jogging display small disturbances which makes sense given the volatility of jogging where's chopping is a more controlled movement. Thus, the y position of the controller proves helpful in distinguishing between the sensor traces of the 6 activities measured. However, it appears the data for trial 4 and 5 for controller_right_pos_y has some variations/discrepancies which have led to deviations from these trends that should be accounted for during future testing and data analyzation.

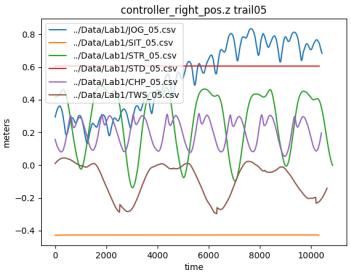
controller_right_pos.z



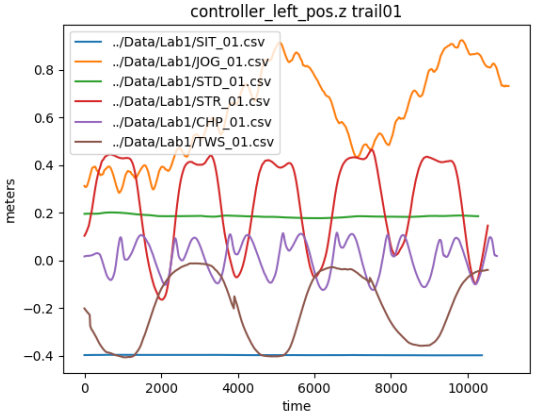


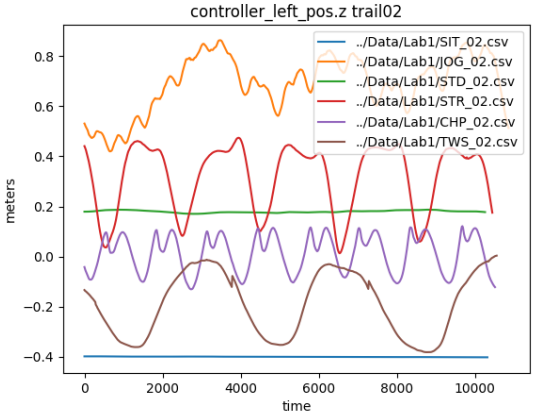


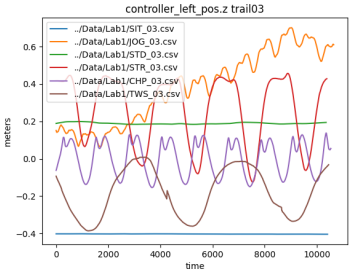


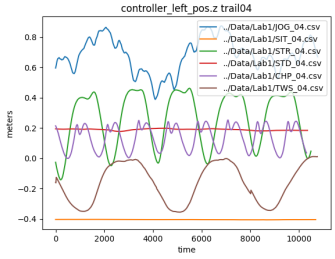


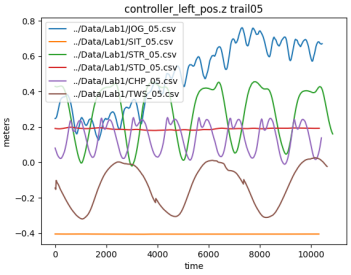
controller_left_pos.z





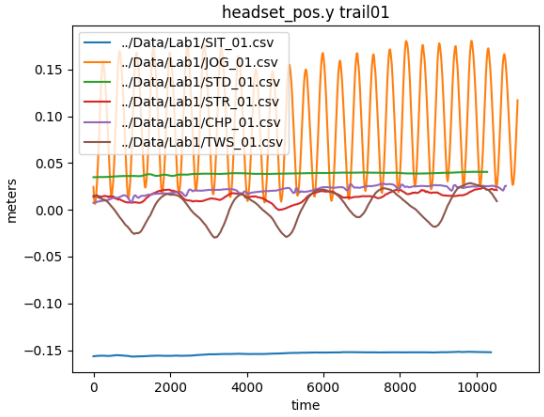


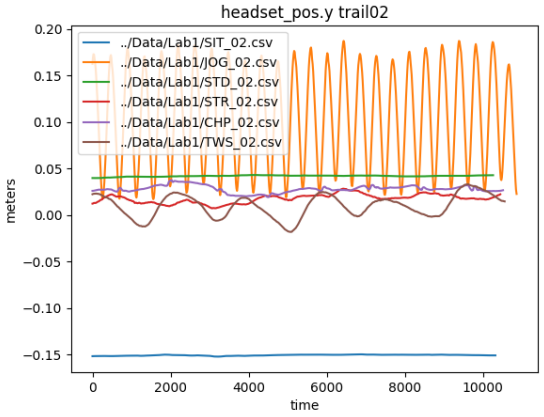


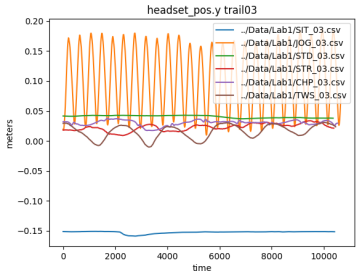


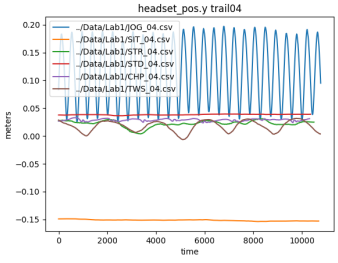
Controller position z for both the right and left controller also proved helpful in distinguishing between the sensor traces between different activity types. Again, both standing and sitting display horizontal lines with sitting towards the bottom of the graph and standing displayed higher above it towards the midline of the graph. Jogging is centered towards the top of the graph and displays large, wide peaking with volatility demonstrated by the continuous little peaks. Stretching is center more towards the midline of the graph and displays more frequent peaking as well as a smoother line. Chopping is centered below the midline and displays short peaks at a higher frequency than the other activities with small dips at the top of each peak. Twisting is centered close to the bottom and displays larger and less frequent peaks compared to some of the other activities. The distinctness of each of the patterns displayed enables controller position z as one of the more helpful attributes in distinguishing activities based on the provided sensor traces.

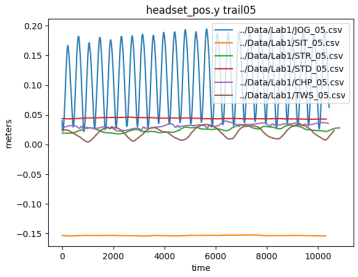
headset_pos.y





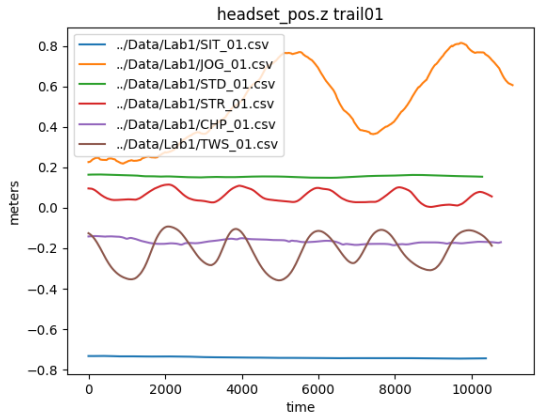


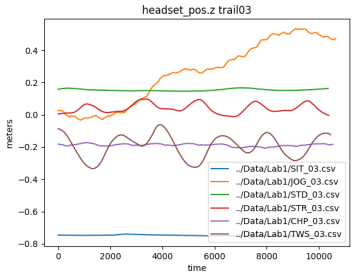


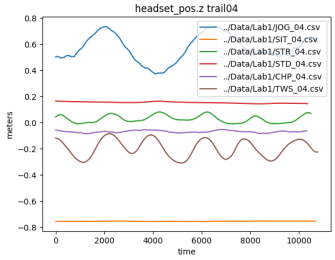


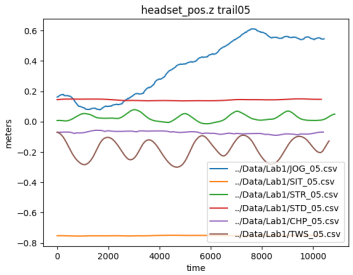
Headset position y is also helpful for distinguishing between the sensor traits for the various activities. Headset position y is the lowest for sitting, displayed a straight unchanging line near the bottom of the graphs around -0.15 meters. This makes sense as the position of the head during the trials for sitting was lower relative to all other activities and sitting is a stationary activity. Contrarily, standing also displays a straight line since it as also a stationary activity but is located closer to the top of the graphs around 0.04 meters. Additionally, it is centered closer to the data for the other 4 activities excluding sitting which makes sense given all 4 of those activities required standing which placed the head at a similar vertical height. Jogging likewise displays a very unique and distinguishable pattern. It displays frequent peaks with high amplitude relative to all of the other data plotted which makes sense since the jogging invokes and up/down movement of the body during the activity and consequently results in variation of the vertical position of the head during the activity unlike the other activities. Twisting also displayed a distinct peaking pattern however, with a much lower amplitude than jogging which make sense sense twisting is a more stationary movement and thus results in less variation in the vertical position of the head. Arms stretching and chopping display relatively similar data patterns centered close to the data for standing which make sense since all three activities involved standing at equal height. However, arms stretching and chopping do not display straight lines and instead display like standing which makes sense since standing is completely stationary however arms chopping and stretching do involve movement and are likely to invoke small displacements of head position during activity.

headset_pos.z









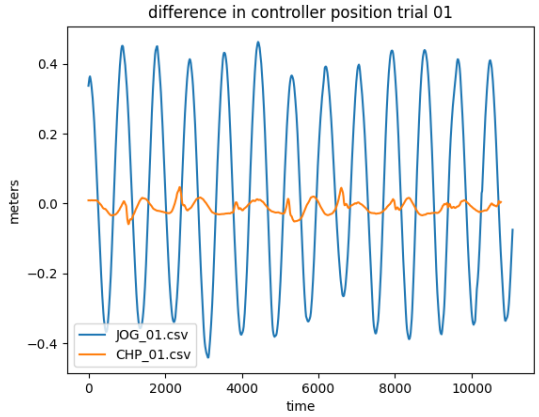
Headset position z also displayed patterns useful for distinguishing between the sensor traits for the various activities. Again, sitting and standing are straight lines with sitting towards the bottom of the graph at negative y-value and standing much higher on the graph in the positive y-values. Jogging displays wider peaks centered towards the top of the graph. Twisting displayed moderately sized more frequent peaks centered closed toward the midline of the graph around -0.2 meters. Arms stretching displays peaks with very short aptitude's centered around the midline of the graph at approximately 0.05 meters. Arms chopping displays a relatively straight line with minor disturbances centered between sitting and standing at approximately -0.1 meters.

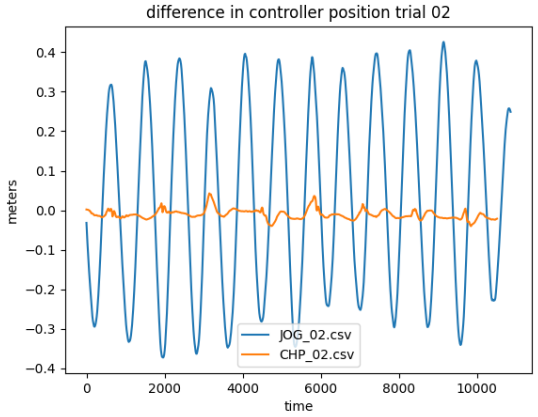
```
standing
                            mean  variance
controller_right_pos.y -0.038102  0.112552
controller_left_pos.y  -0.699233  0.000004
controller_right_pos.z  0.338406  0.003662
controller_left_pos.z   0.185440  0.000023
headset_pos.y           0.040919  0.000001
headset_pos.z           0.148153  0.000038


sitting
                            mean      variance
controller_right_pos.y -0.602589  5.048157e-07
controller_left_pos.y  -0.596047  8.307124e-08
controller_right_pos.z -0.423812  3.825666e-07
controller_left_pos.z  -0.401815  6.102387e-07
headset_pos.y          -0.152078  1.436504e-06
headset_pos.z          -0.747877  6.377553e-06


jogging
                            mean  variance
controller_right_pos.y -0.306082  0.022561
controller_left_pos.y  -0.271082  0.016645
controller_right_pos.z  0.650021  0.026603
controller_left_pos.z   0.591192  0.023933
headset_pos.y           0.108004  0.002805
headset_pos.z           0.475942  0.023691
```

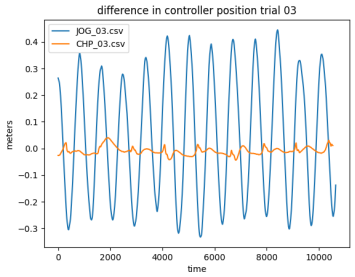
```
arms chopping
                            mean  variance
controller_right_pos.y -0.258049  0.032316
controller_left_pos.y  -0.260953  0.030356
controller_right_pos.z  0.152669  0.006238
controller_left_pos.z   0.074859  0.006263
headset_pos.y           0.028466  0.000014
headset_pos.z          -0.125028  0.000073


arms stretching
                            mean  variance
controller_right_pos.y -0.248151  0.075474
controller_left_pos.y  -0.232776  0.071305
controller_right_pos.z  0.267002  0.039433
controller_left_pos.z   0.275097  0.028399
headset_pos.y           0.020770  0.000027
headset_pos.z           0.036345  0.000748


twisting
                            mean  variance
controller_right_pos.y -0.584471  0.002152
controller_left_pos.y  -0.547144  0.001849
controller_right_pos.z -0.112539  0.011447
controller_left_pos.z  -0.176211  0.016592
headset_pos.y           0.013672  0.000136
headset_pos.z          -0.196507  0.005003
```

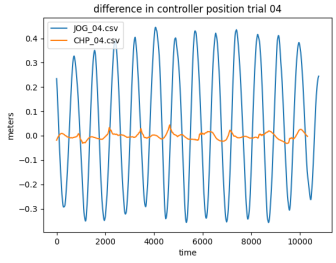
	Standing	Sitting	Jogging	Arms Chopping	Arms Stretching	Twisting
controller_right_pos.y Mean	-0.038102	-0.602589	-0.306082	-0.258049	-0.248151	-0.584471
controller_right_pos.y Var	0.112552	5.048157e-07	0.022561	0.032316	0.075474	0.002152
controller_left_pos.y Mean	-0.699233	-0.596047	-0.271082	-0.260953	-0.232776	-0.547144
controller_left_pos.y Var	0.000004	8.307124e-08	0.016645	0.030356	0.071305	0.001849
controller_right_pos.z Mean	0.338406	-0.423812	0.650021	0.152669	0.267002	- 0.112539
controller_right_pos.z Var	0.003662	3.825666e-07	0.026603	0.006238	0.039433	0.011447
controller_left_pos.z Mean	0.185440	-0.401815	0.591192	0.074859	0.275097	-0.176211
controller_left_pos.z Var	0.000023	6.102387e-07	0.023933	0.006263	0.028399	0.016592
headset_pos.y Mean	0.040919	-0.152078	0.108004	0.028466	0.020770	0.013672
headset_pos.y Var	0.000001	1.436504e-06	0.002805	0.000014	0.000027	0.000136
headset_pos.z Mean	0.148153	0.747877	0.475942	-0.125028	0.036345	-0.196507
headset_pos.z Var	0.000038	6.377553e-06	0.023691	0.000073	0.000748	0.005003

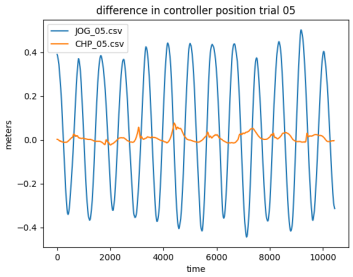
Q6: What additional features you could derive from the provided raw data that would be helpful for distinguishing between activity types? Compute at least one feature, then graph it and show how it can be used to distinguish between two different activities. (hint: think of attributes used in physics that can be derived from the raw data)











An additional feature that could be derived from the raw data collection is the difference between the y position for the controllers. This feature specifically looks at the difference between the position of the left controller and the right controller on the y-axis at specific time intervals. This additional feature would prove useful in helping to distinguish between activities due to the difference in arm positioning during different activities. While the singular position of each controller as a function of time can provide effective insights that allow for detecting the corresponding activity, a feature that evaluates the position of the controllers along the y-axis in relation to each other provides an additional level of specificity to aid in activity detection. The example demonstrated above analyzes the differences in controller position for the activities of jogging and chopping specially. This feature is particularly useful in comparing these two activities as the motions of jogging and chopping recruit a similar span of the y-axis, leading to similar patterns of motion displayed from sensor tracking for the individual controllers. However, in the arms chopping motion that arms move in coordination whereas in the jogging motion that arms move opposite to each other. Thus, the y-position of two controller in the arms chopping motion should be relatively similar throughout the activity as measured through the sensors whereas in jogging the y-position of the two controllers will repeatedly become closer and further away from each other throughout the movement. The expected results are demonstrated in the above graphs which visualize this new feature. The graphs display a clear distinction between the activity of chopping which displayed relatively low variability in the position of the two controllers throughout the movement whereas the activity of jogging displays a continually changing (growing and shrinking) distance between the two controllers.