# Report and result

**Data feature:**

Static phase:

1. In static phase there're 4 points we should pay attention to: ZGravity1, ZGravity2, AcLeft and AcRight (in the instruction there is a spelling error).
2. The coordinate of ZGravity1, ZGravity2, is much closer to AcLeft than AcRight.
3. The Z value, of average value of ZGravity1, ZGravity2, is similar to AcLeft and AcRight.

Dynamic phase:

1. The movement of head is defined only by the 4 points in 407ms.
2. The 3 'TripodThoraxPt' points coloured in red will not be used this time.

**Q1: establish the anatomical frame**

1. From the Information about static phase, I noticed there're 4 points colored in black, and the annotation that, the black points is used to compute an Anatomical frame for the Thorax, which means I could use these 4 points to set the anatomical frame.
2. I firstly calculate the average point at all time. Because I think that although the period of static phase (407 ms) and the dynamic phase (also 407 ms) are equal, I should not link them one to one, because they don't have any relationship, and assuming a case that, during a movement, the thorax and head could move together, and in this time when we are counting the relative motion of the head, it could be far less than actual motion data. So when building the anatomical frame, I only use 4 points ('avg_AcLeft', 'avg_AcRight', 'avg_ ZGravity1', 'avg_ ZGravity2') from the static phase dataset, not 4*407.
3. Then I calculate the geometric center of these 4 points called 'origin'. At this time the point 'origin', 'avg_AcLeft', 'avg_AcRight' can be seen as located in one plane. Then, I have Vx as the vector from 'origin' to 'avg_AcRight' and use it as the positive x_axis direction of the analytical frame (R1), the normalize it, because the distance from 'origin' to 'avg_AcRight' is much further than origin to 'avg_AcLeft', and if I use 'avg_AcLeft' to build the frame, the error could be bigger, any tiny absolute movement will lead to a huge relative movement. Then drawing the perpendicular line of this plane through ZGravity2, starting from the intersection of this perpendicular line and this plane, and reaching ZGravity2 can determine the positive direction of the z_axis and normalize it. Finally, the y_axis is done by using the cross product between x_axis and z_axis, then normalize, the unit vectors of the x, y, and z-axes in the analytical frame (R1) are obtained.
4. Here, the anatomical frame has been built. The binding angle can be shown in the rotation angle in z_axis, the flexion angle can be shown in the rotation angle in y_axis , the torsion angle can be shown in the rotation angle in x_axis.

**Q2: Computing the movement of the head by the anatomical frame in Q1**

Firstly I choose the z, x', y'' sequence to analyze the rotation, because I assume that the rotation in Z axis is the smallest. Then we compute the rotation angles' angle_z', ' angle_x', 'angle_y', and the rotation matrix 'R'.

In dynamic phase the realtime movement of the head is represented by the 4 points worn on the head 'TripodHeadPt1', 'TripodHeadPt2', 'TripodHeadPt3', 'TripodHeadPt4'. At each millisecond there will be a equation to calculate the average point of them, and the average point could be seen as the head.

Then plot the figure, in order to clearly see the relative movement of the head in the anatomical frame(R1), I plot all the points, and link them together, from last one to the next one. Then as the head moves, the colour of the point will be changed, so as to see the dynamic effect.

Results:

The anatomical frame is following, and because the unit vector is quite small compared to other scales, so this picture is an enlarged result.

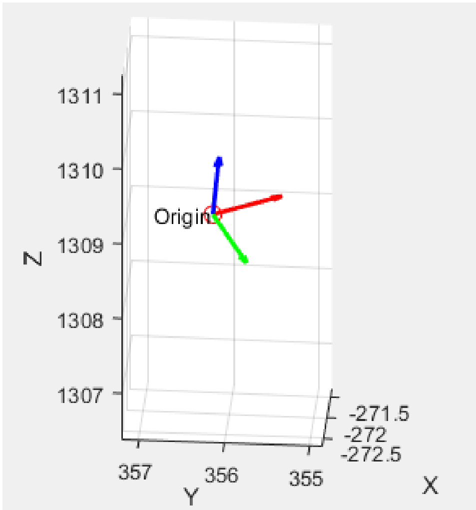


Figure1.1: the anatomical frame

This is the spatial relationship at initial time.

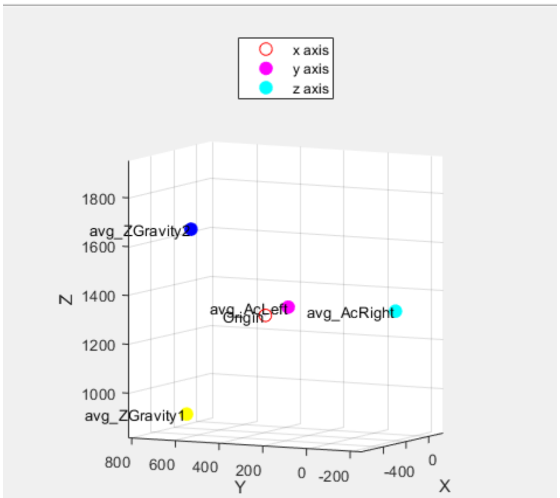


Figure1.2: several points used to build the frame

Given the sequence of z, x', y'', the rotation angles and rotation matrix are following:

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Z rotation angle: 13.642
X rotation angle: -59.698
Y rotation angle: 66.2785
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Figure2.2 Rotation angles

| | | |
|---|---|---|
| 0.9934 | 0.0908 | 0.0703 |
| -0.1123 | 0.8963 | 0.4290 |
| -0.0241 | -0.4341 | 0.9005 |

Figure2.2 Rotation matrix

The trajectory in R1 of the head over time is coloured by rainbow gradient.

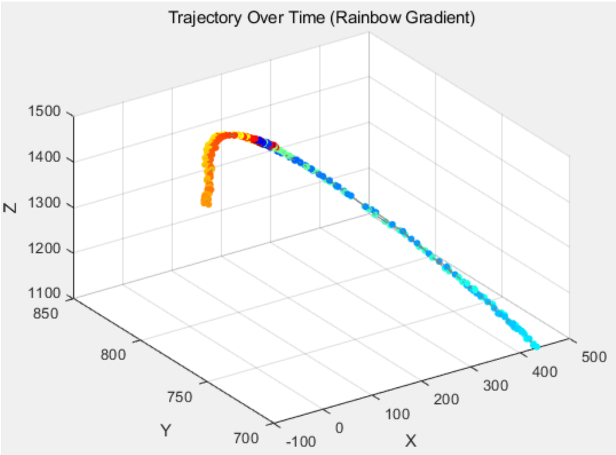


Figure2.3 the movement of the head in the anatomical frame

From this detailed image we can clearly see the back-and-forth movement.

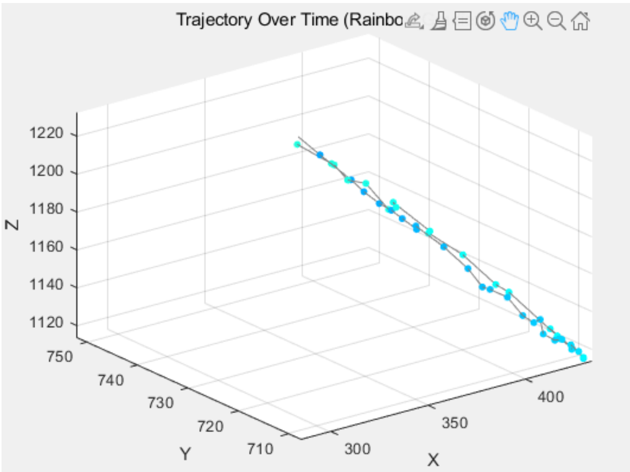


Figure2.4 a detailed look

Then, calculate the head's movement in X axis, Y axis, Z axis (in the anatomical frame), velocity, and the total distance from 'origin'.

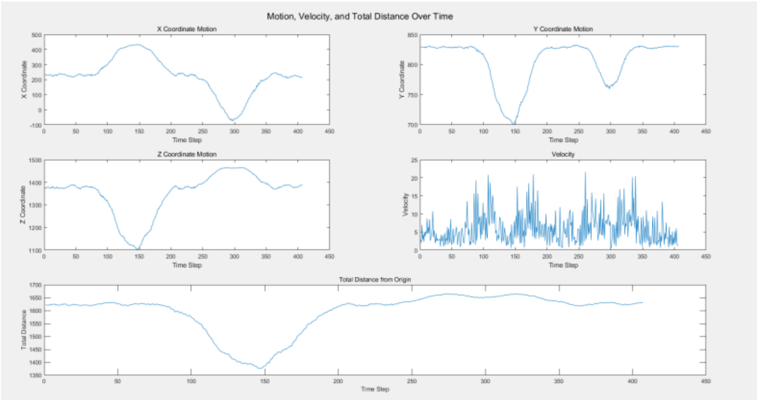


Figure2.5 the movement data of head

Finally, I make a vector, defined by the ‘origin’ and the point of head after rotation ‘headAfterRotation’ (static at time 0) be initial vector, and another vector defined by ’origin’ and the point of ‘headAfterRotation’ (varying with time). Then calculate their angles which will vary from time.

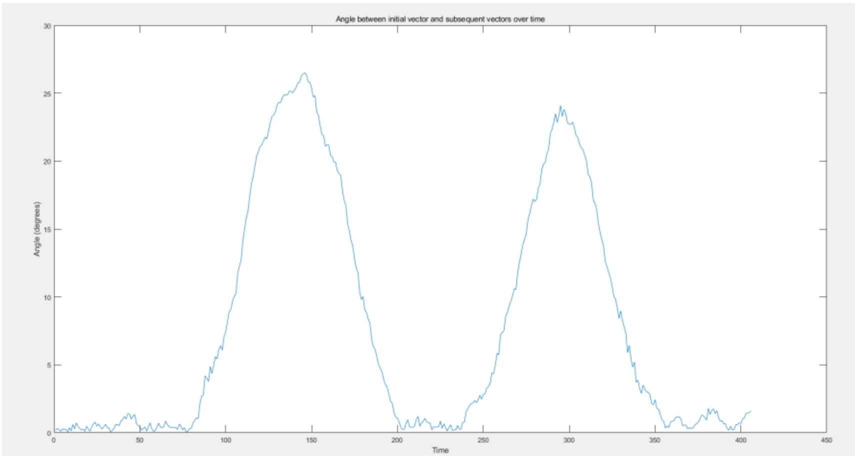


Figure2.6 the relative moving angle of head

A hypothesis: as the figure above, we could see during the back-and-forth movement, the messy zone could contain 2 more times of back-and-forth movement in local field.

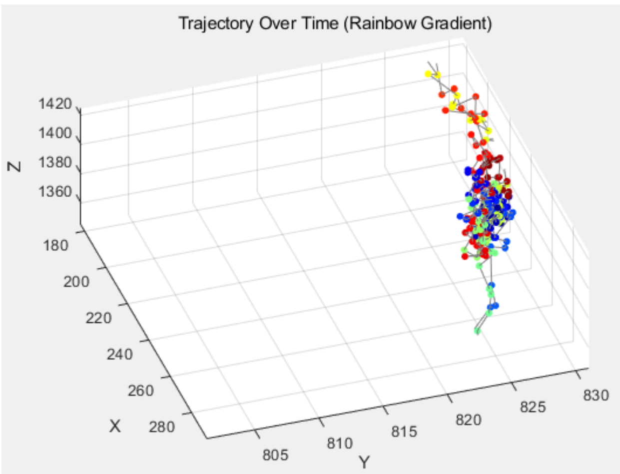


Figure2.7 the messy zone