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CISC 472

HW 2

1. **Transformer**

   To create the transformer, I looked at the picture given in the assignment showing different proportions of points in CT relative to fiducial cage points.
   Using the distances between different points in CT, I defined the points in fiducial cage.

   Since CT is a 2D slice, this picture only gives us the x and y component of each of the points. To find the z values I used the equation given to find scalar c on the diagonal part of each of the z parts of the cage. Using cos(45) and the c value, we can determine the z component of each of the middle points of the cages.

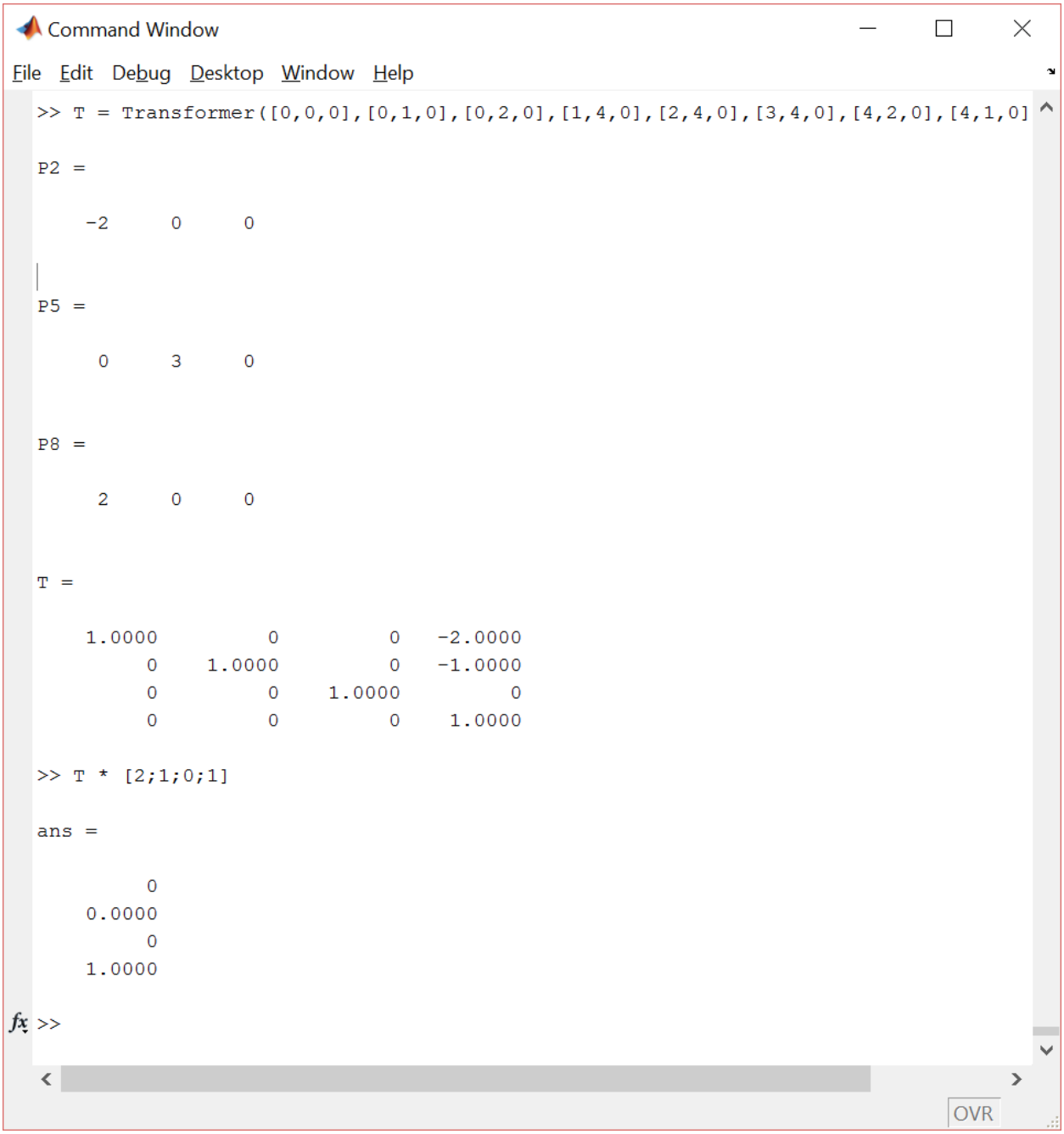
   Using the three points, one middle point in each of the three z parts of the cage, I defined the coordinate fiducial cage.

   I compared these new values to the original points given by the input (Points 2,5,8) using FidReg.m from HW1. This creates a 4x4 homogenous transformation matrix from CT frame to fiducial cage frame.

   My inputs for this function are the 9 points found in CT coordinates and a which is the size of a side of the Z fiducial cage given in mm.

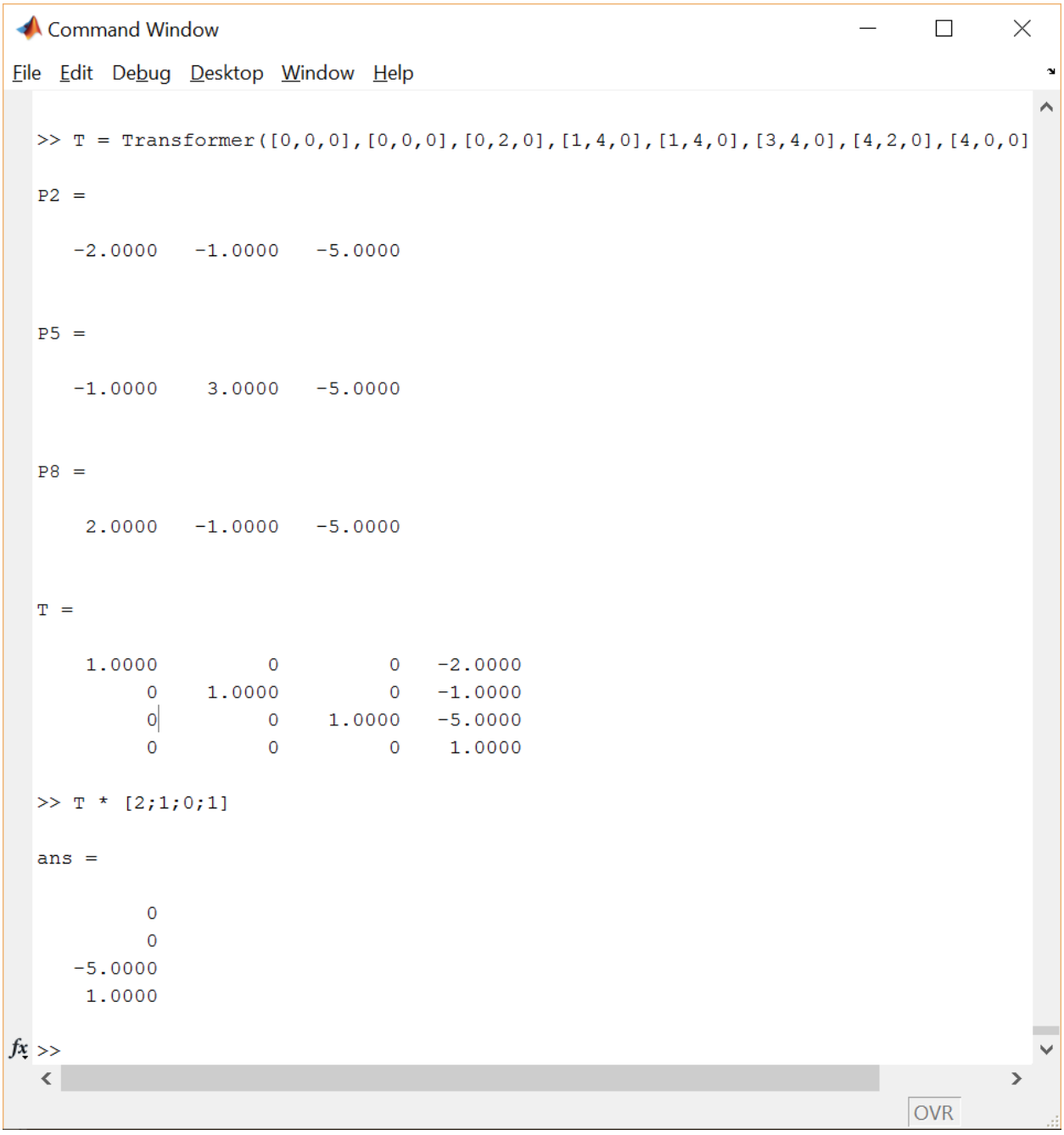
First test case: when CT scan is going straight through the cage, this should give us middle points right in the middle of the Z motifs of the cage. Points should all be equal distance apart.

Multiplying the transformation matrix by where the middle of the cage should be [2,1,0] should give [0,0,0]



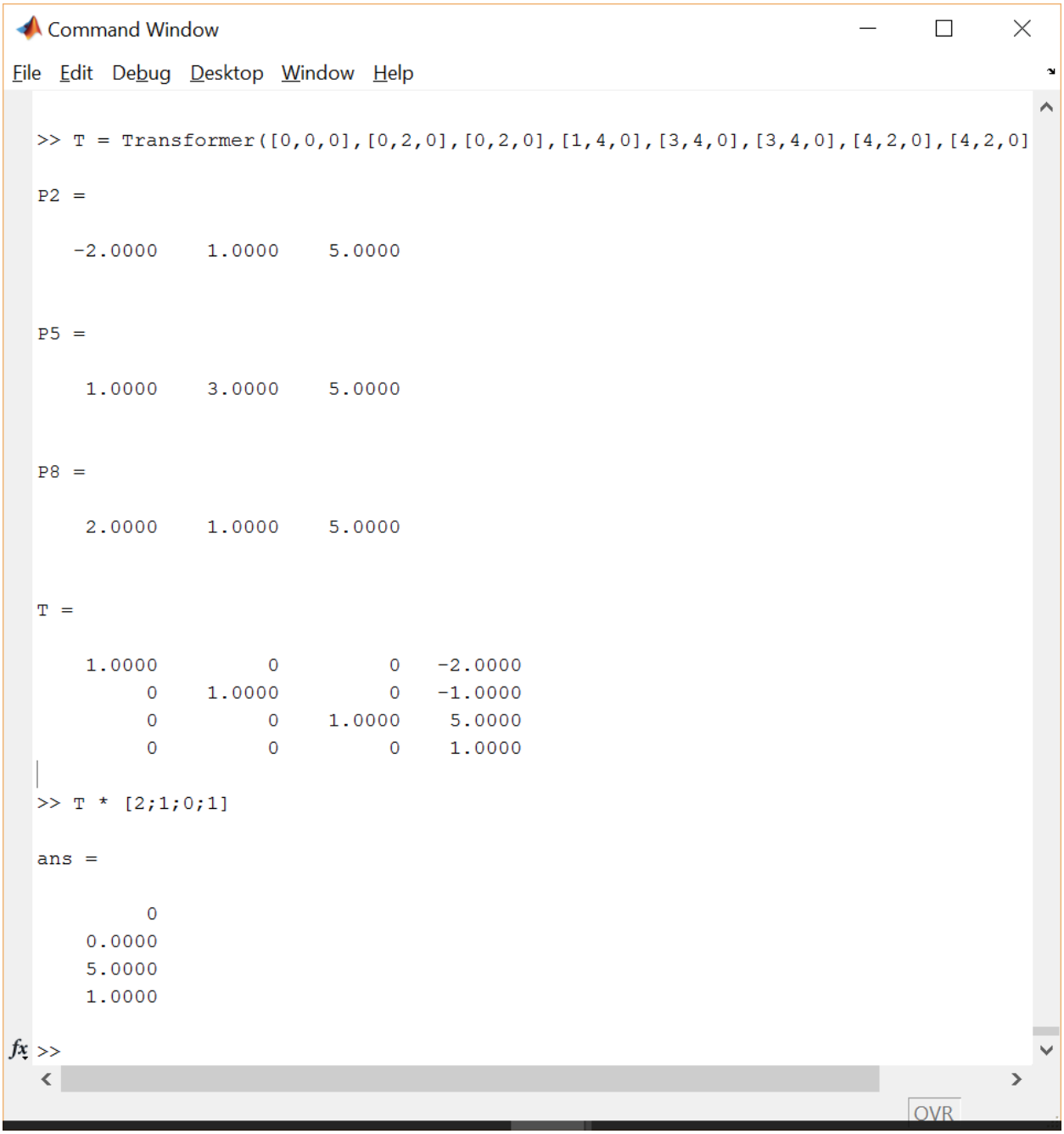
This is as we expected. As we can see, all the z values are 0 because the CT plane is going straight through the cages.

Second test case: when the CT scan is going straight through the very tip (top) of the cage. This would mean that the middle points for all the Z motifs will be the same point as the first one. We would expect that all the z values would be the height of the bar (50 mm).



This is also correct if we relate it to the diagram. The z value is facing down the body and away from the tipped points of the z so the z values are all negative.

Third test case: When the CT scan is touching the very bottom of the z motifs. Here the middle points will be on the points (3, 6, and 7) which correspond to the “bottom” parts of the Z



This is as we would expect because the z direction is towards the “bottom” of the z components.

2. Simulator

To create the simulator I found all the points that the cage is defined by from looking at the picture showing the dimensions using the input of the length of a rod, a.

I then transformed these points by the given transformation matrix, T.

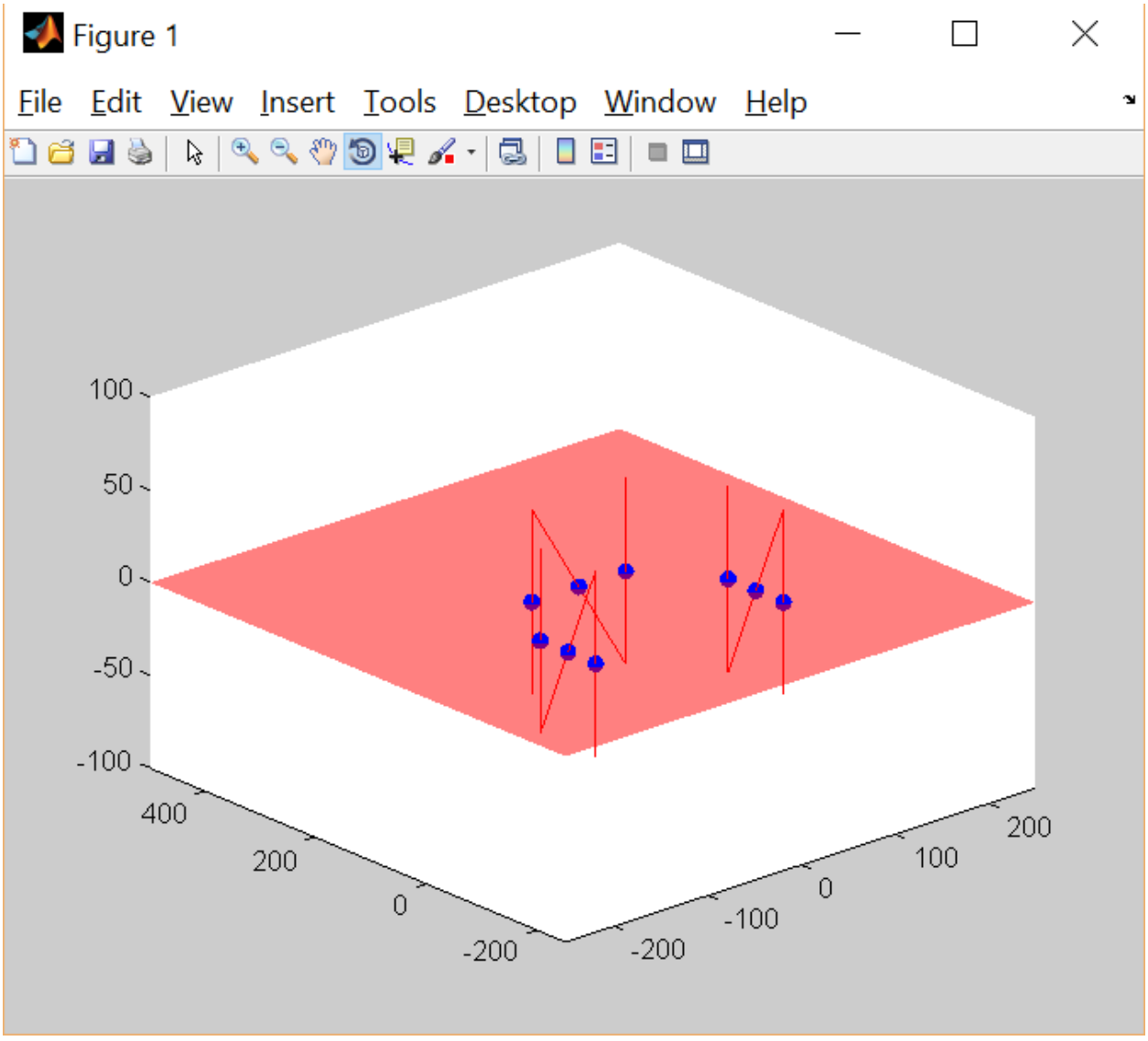
After defining the transformed points, I created each of the bars between the two points.

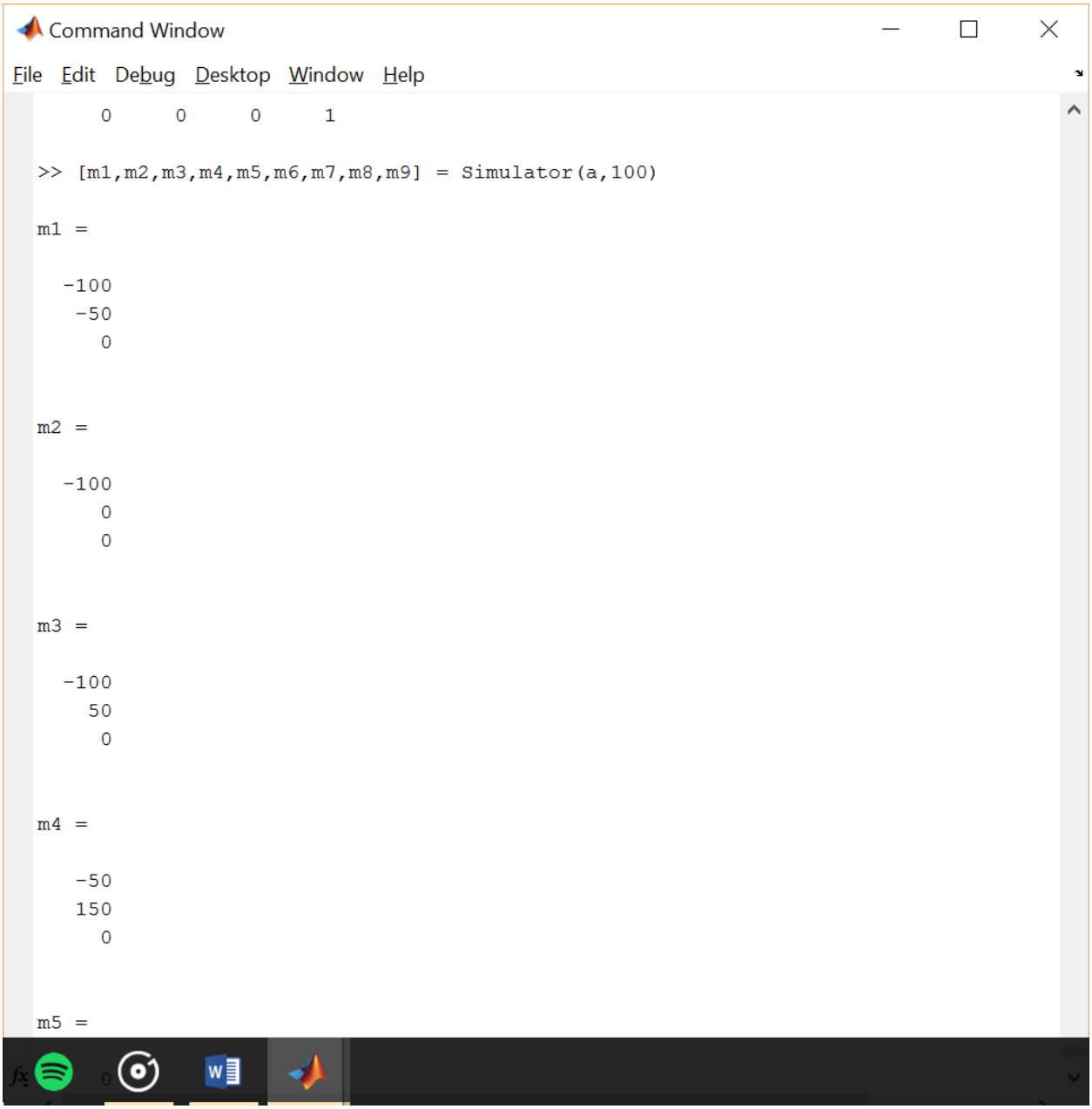
Then, I defined the CT plane as a point on the plane ([0,0,0]) and a normal vector ([0,0,1]).

I found all the intersections of these 9 rods and the plane using the function Q1A1.m. This takes in two points of a line, a point on a plane and a normal of the plane and finds the intersection point.

I then plotted the plane, the rods, and the intersection points to see if the intersection points did fall where the plane met the rods.

Here is the first test case of the identity matrix: no transformation.





These points are where we would expect them, given the picture in the assignment.

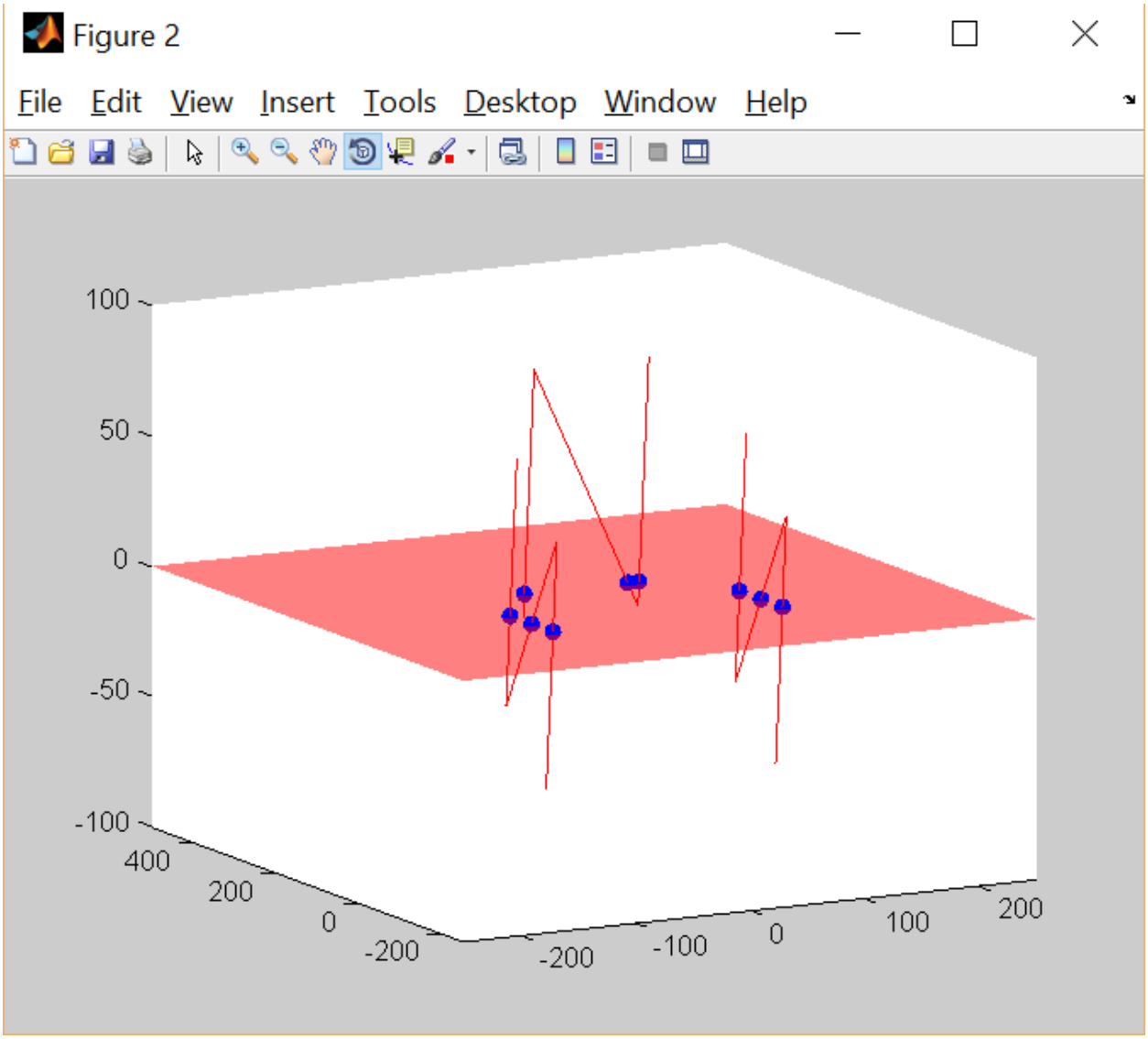
The second base case is rotating about the x axis by a known degree (20).

I created the rotation matrix using degtorad(20) and inserting in the rotation about the x axis transformation matrix.

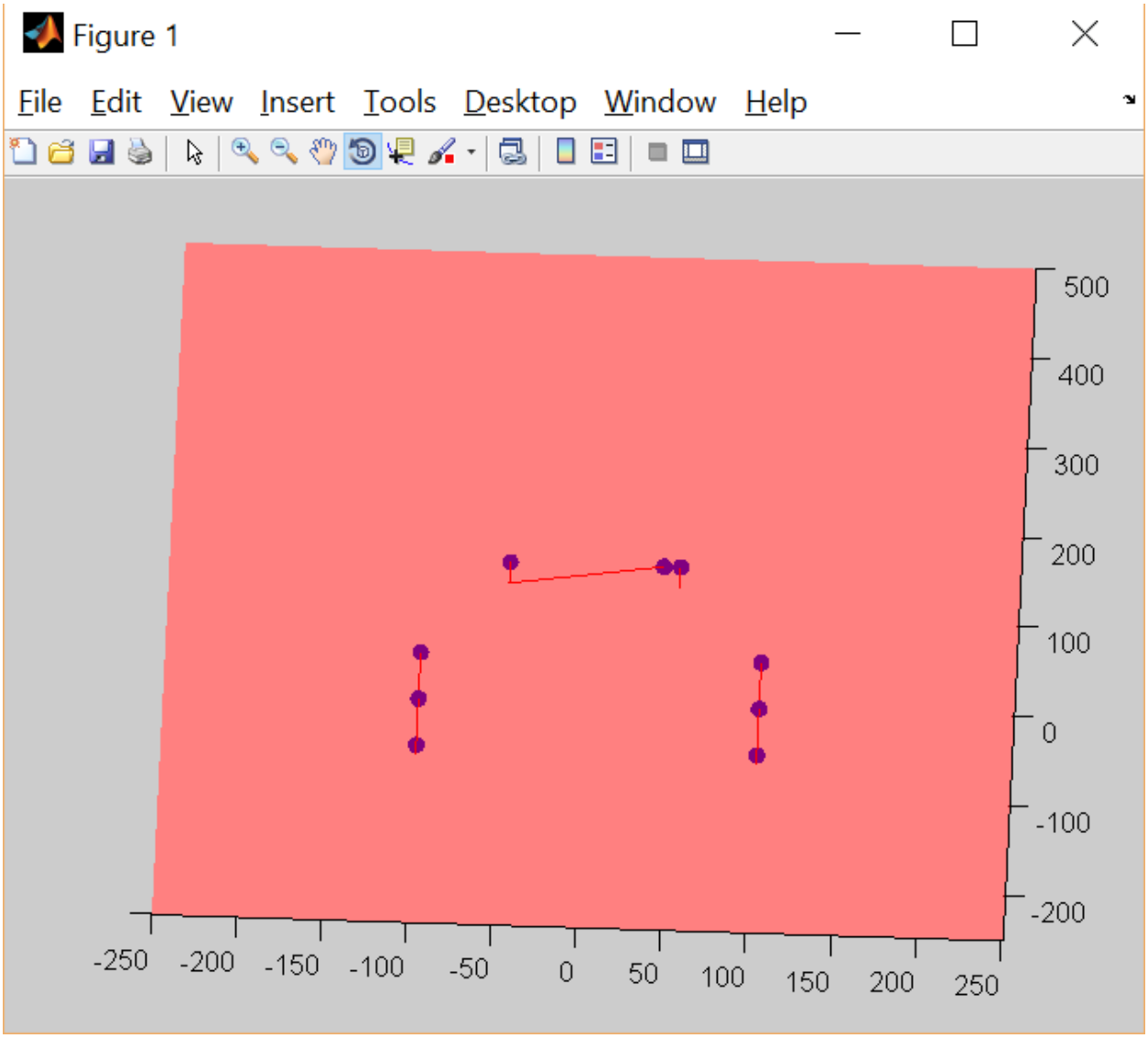
I then used this as an input along with the size of the cage (100) for a.

We would expect the fiducial cages to rotate clockwise.

This should bring only the anterior middle point closer to the left side because the other two would not be effected by a x rotation.



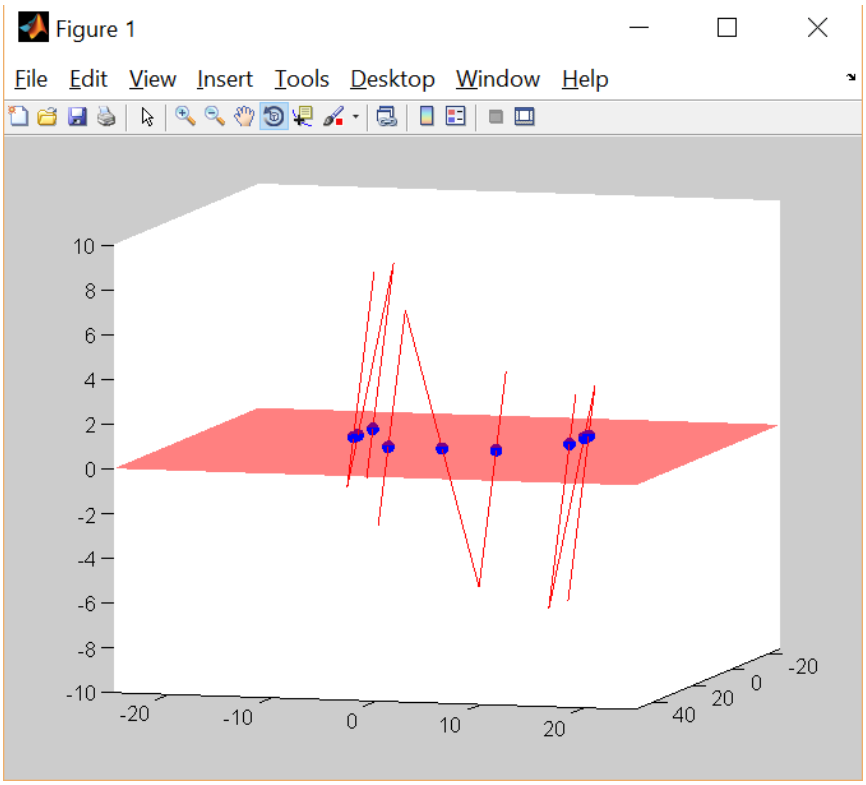
This is the image after being rotated by 20 degrees around the x-axis.

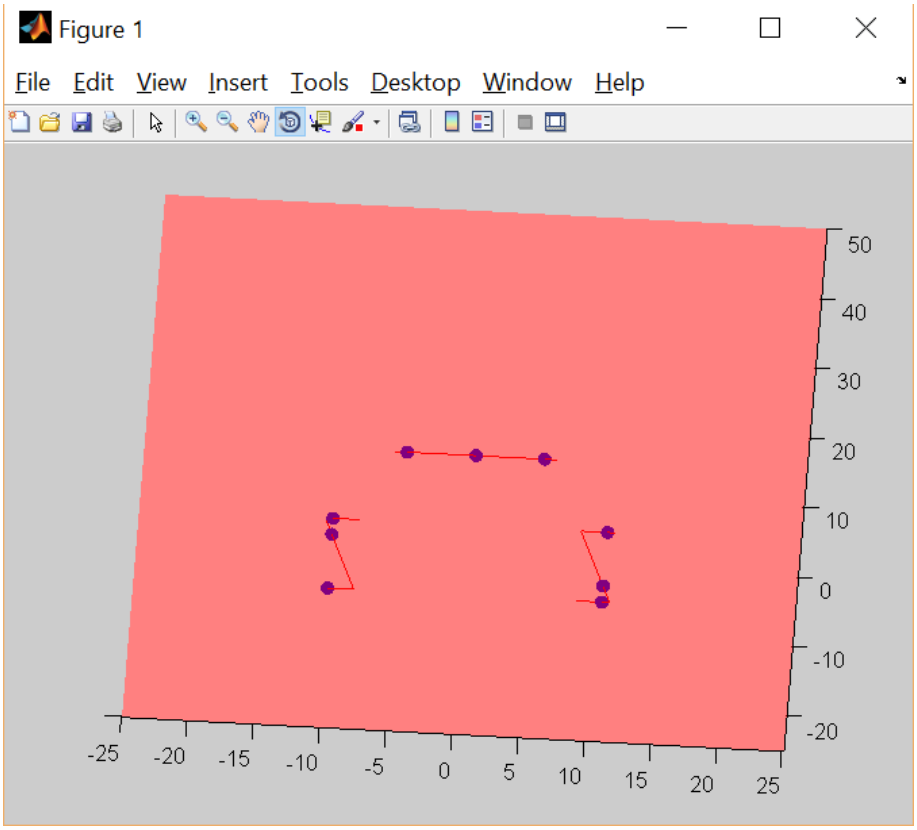


This is what we had expected to happen. The left and right fiducial points seem to be mostly unaffected.

Test case three: next I will rotate only about the y axis for a known rotation (15 degrees). This should cause the fiducial cages to rotates towards the posterior side.

This should only affect the left and right sides, bringing the middle point of the left closer to the posterior while pushing the middle of the right away, also , while the anterior side remains the same:





This matches with what we had predicted.

3. Analyzer

This will be considered my test file as it uses all my functions.

For analyzer I created random degrees between -15 and 15 degrees to rotate the CT frame by.

Anything greater than this I noticed the points were falling off of the frame.

I then used these random angles to create a rotation matrix that I read into the Simulator to create CT points from the intersection of CT plane and fiducial rods.

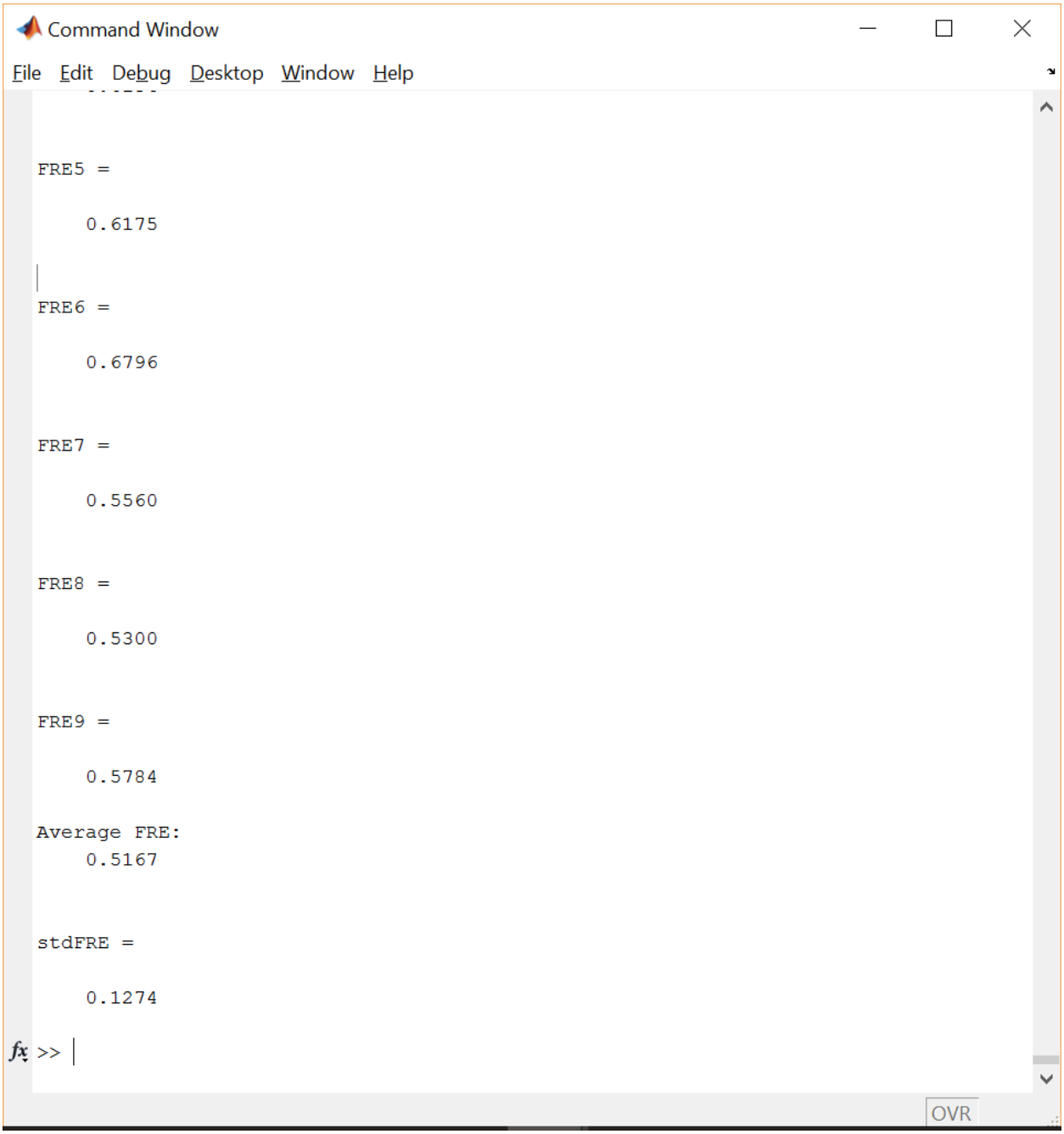
I spoiled the points created in CT by some value less than FLEmax in the x and y axis rotation because with a CT scan revolving around the points would never be skewed around the z axis. However, the could be found higher or lower on the bars.

I then created 50 points around the center of the CT image (125,125,0) using RandomPoints.m.

Then I created the transformation matrix between CT and FC cage by using the transformer.m

Then I compute FRE by finding the difference between translating the spoiled by the transformation we created from random angles and the compute from transformer.m

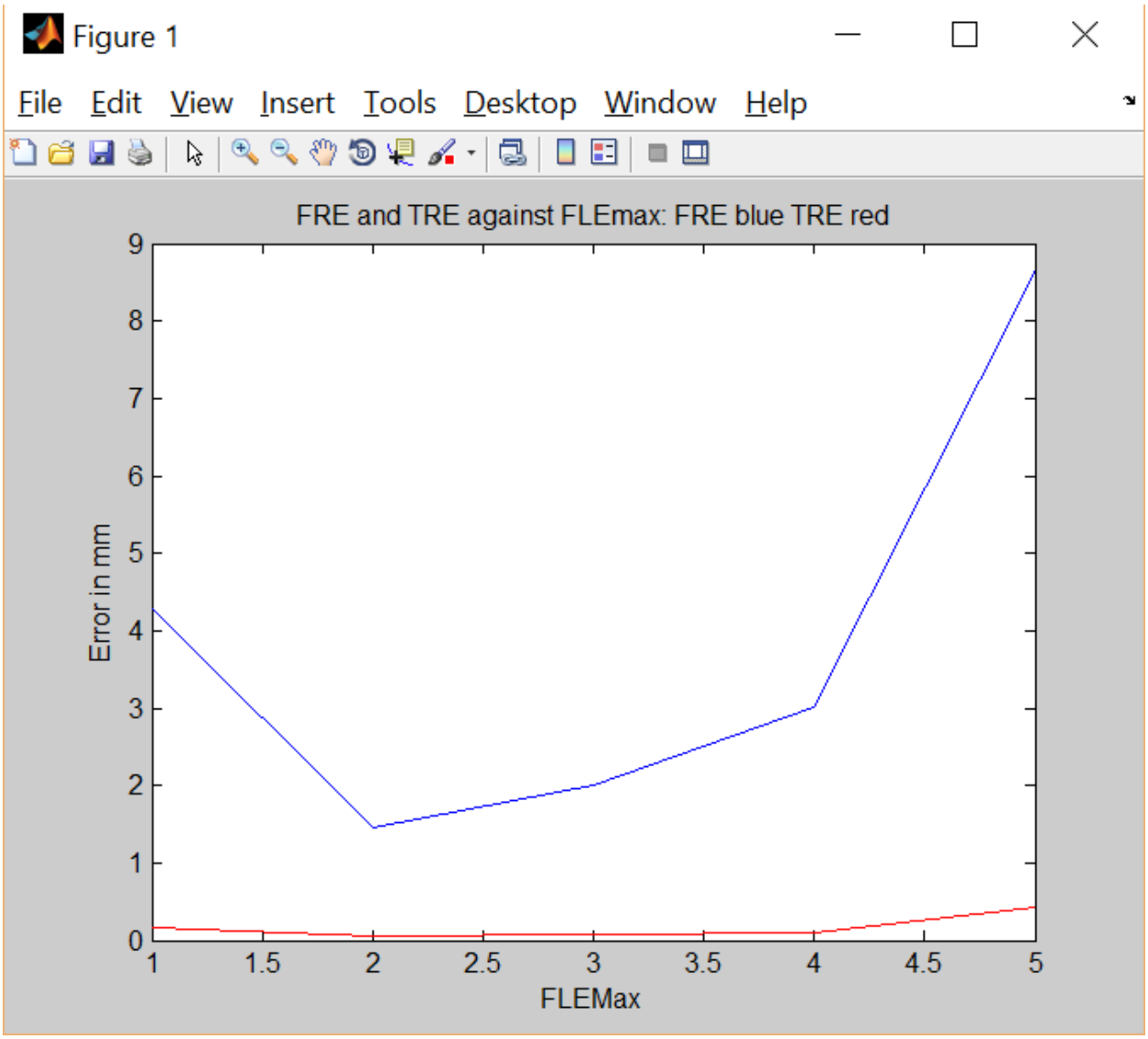
Running with FLEMax = 0 I get these results:



As we can see there is error that I believe comes from the way I define the fiducial cage in Transformer.

I went back and tried defining it in numerous ways but could not figure out how or why this error was appearing.

I displayed the average and standard deviation of the residuals.



This is one of the results I got from running my FRE and TRE against FLEMax.

Running this more, it becomes clear the FRE is pretty random, which probably comes from the Transformer function.

However, the target residual error still remains very small, which is good for us.

Because the residual markers are so far off, I would probably rule this radiosurgery not safe, but if we look at just the target, it is much less than 3mm.