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HW3
CSCI 545: Robotics

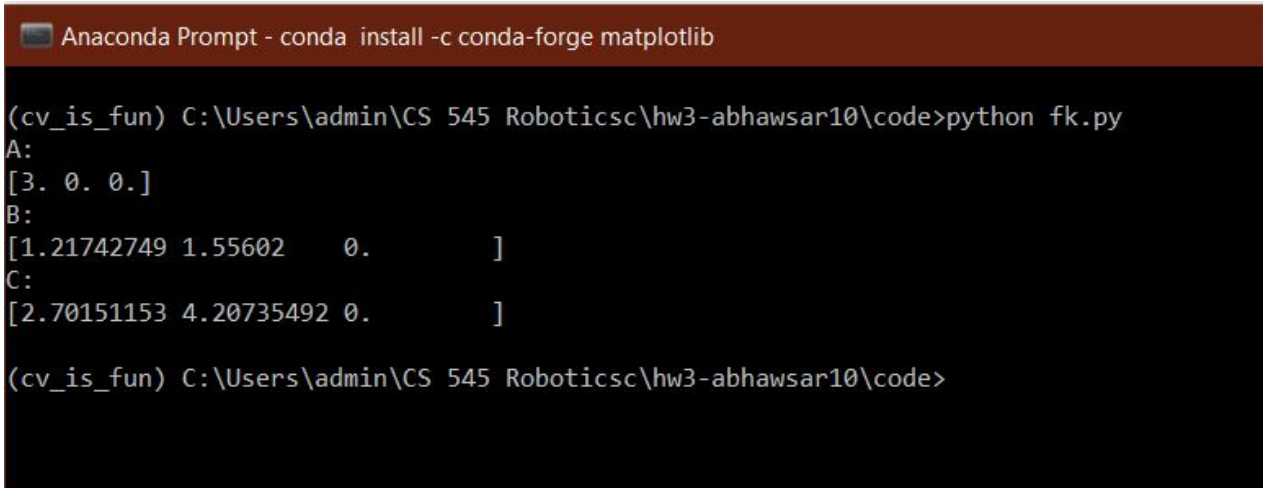
2021-11-05

1 Forward Kinematics:

For the fk function, I expressed the pose of each link using rigid transform matrix, with rotation about the x axis, and translation along the length of the link.:

$$T_i = \begin{bmatrix} cos(q_i) & -sin(q_i) & 0 & l_i * cos(q_i) \\ sin(q_i) & cos(q_i) & 0 & l_i * sin(q_i) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

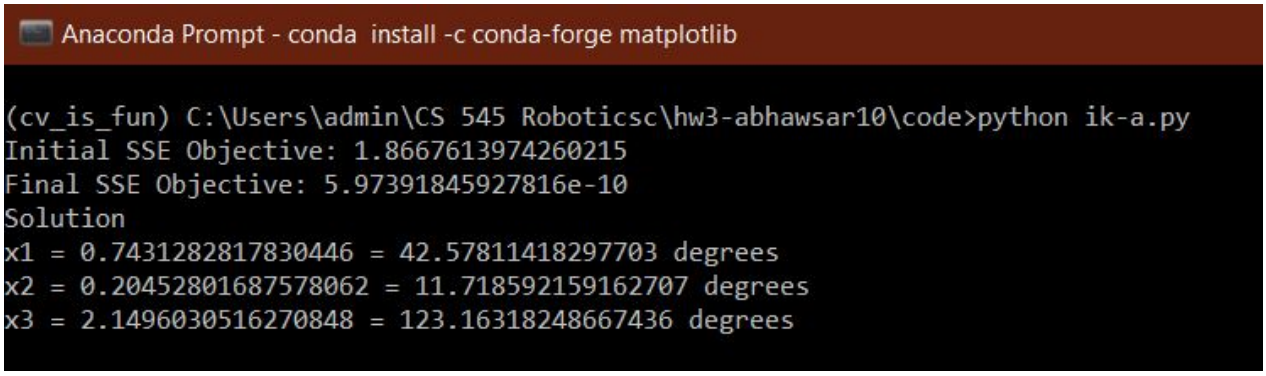
Multiplying the transform matrices of the 3 links, we get the final transform matrix and the translation gives the final position of the end vector.
Results of the given values:



Results of Forward Kinematics

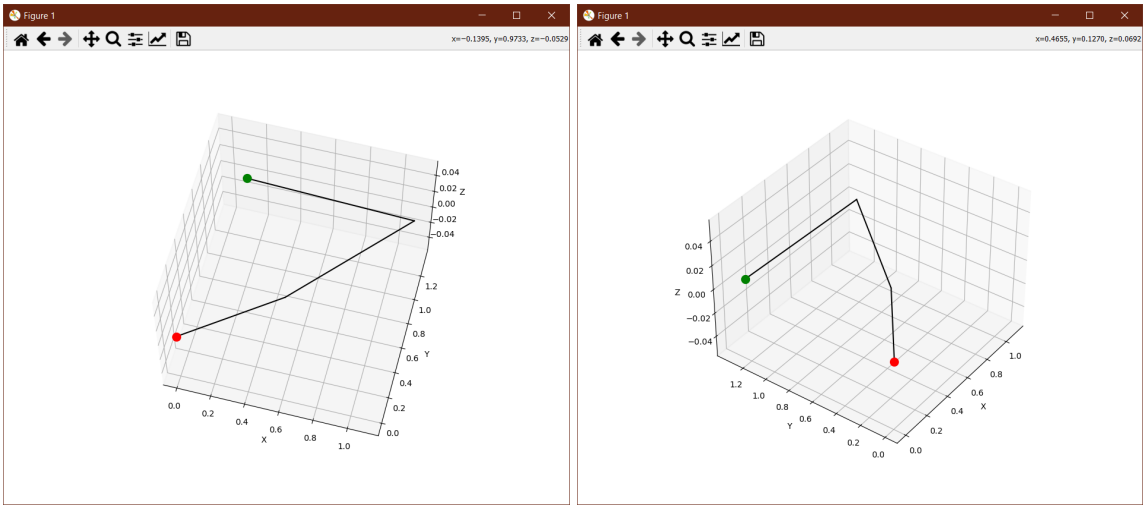
2 Inverse Kinematics:

Result of the Inverse Kinematics program, for the given problems values:



Results of Inverse Kinematics

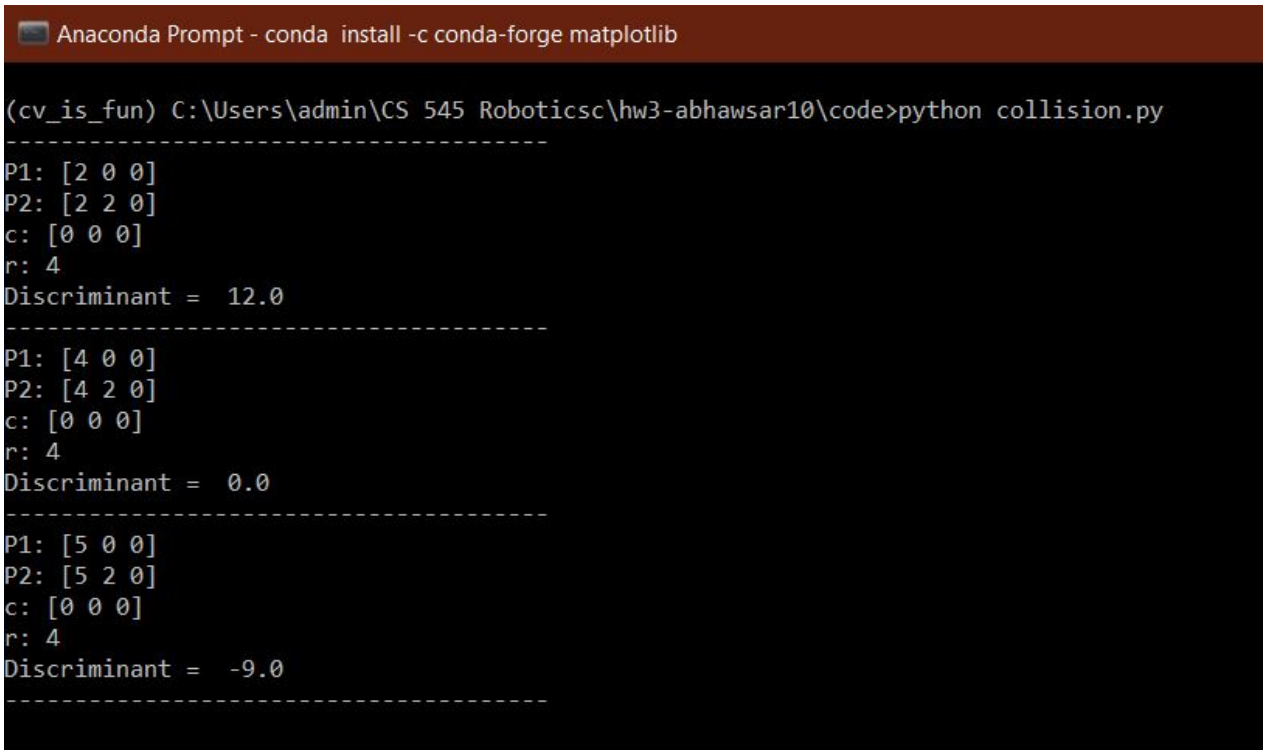
Resulting Visualization:



ik-a_solution.png

3 Obstacle

Three Examples to illustrate discriminant:



Result of collision.py for 2 point intersection, 1 point intersection, and no intersection

4 Obstacle Avoidance

To find a feasible solution, I handled the 3 different possible values that collision.py can return: negative, zero, and positive.

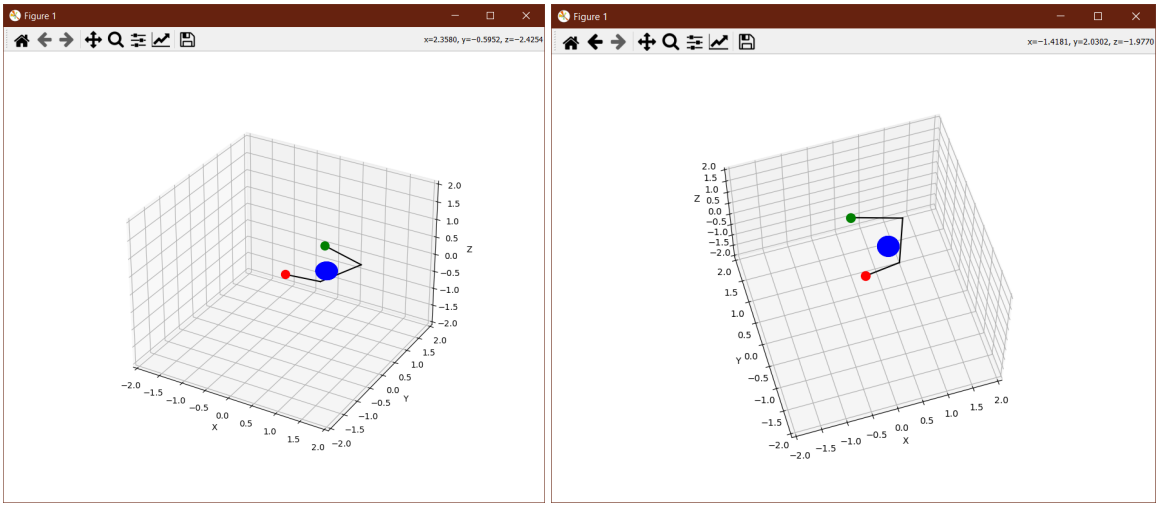
Results:

```
Anaconda Prompt - conda  install -c conda-forge matplotlib - python  ik-b.py

(cv_is_fun) C:\Users\admin\CS 545 Roboticsc\hw3-abhawsar10\code>python ik-b.py
Initial SSE Objective: 1.8667613974260215
Final SSE Objective: 4.54646746596048e-10
Solution
x1 = 0.13467820509769923 = 7.716492744495455 degrees
x2 = 1.068502043573604 = 61.22065749787109 degrees
x3 = 1.630740252176396 = 93.43453393180705 degrees
Link 1 Collides =  False
Link 2 Collides =  False
Link 3 Collides =  False
```

Values of Angles found after optimization, along with whether the link is colliding with the sphere

Bot Avoids the sphere completely:

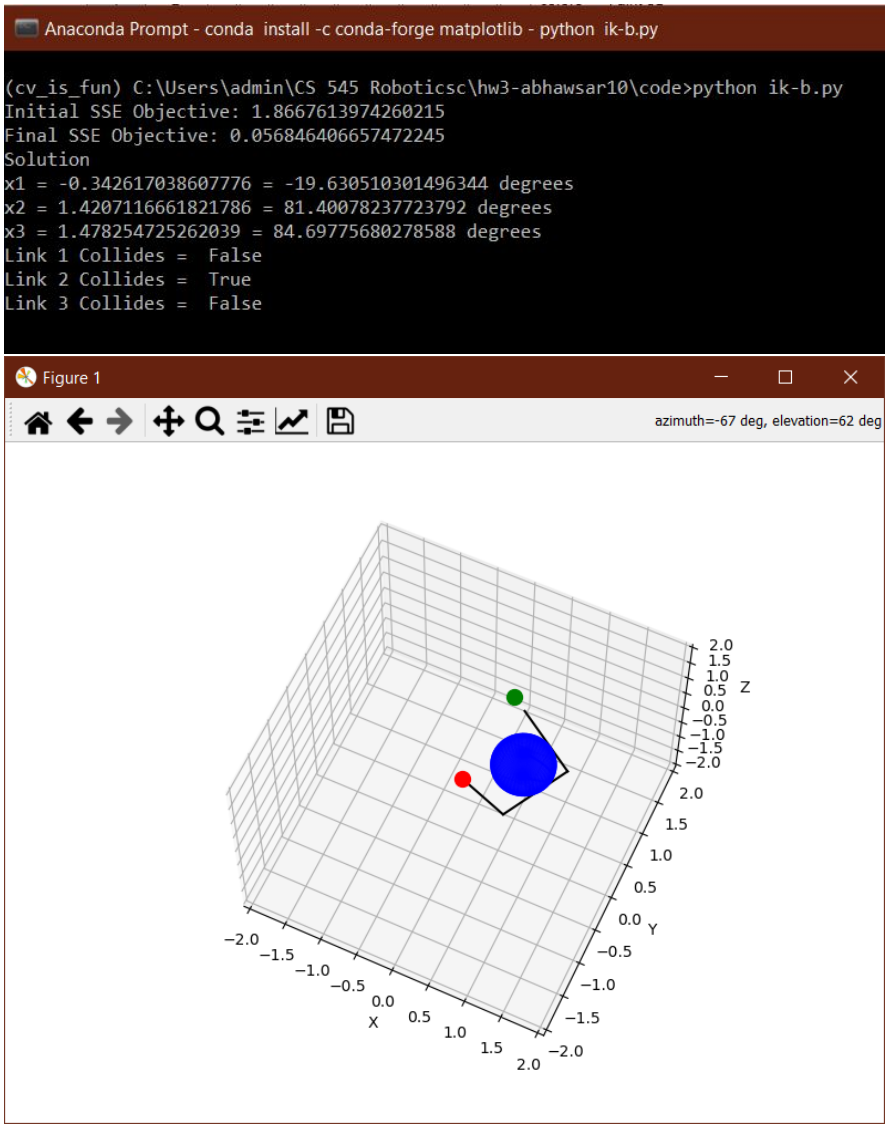


ik-b_solution.png

5 Variations:

5.1 Larger Radius of Sphere

When we increase the radius of the sphere from 0.2 to 0.4 without changing the center of sphere or the initial pose of the links, the robot cannot avoid the sphere and collides. The end-effector does not manage to reach the destination position.
Result:

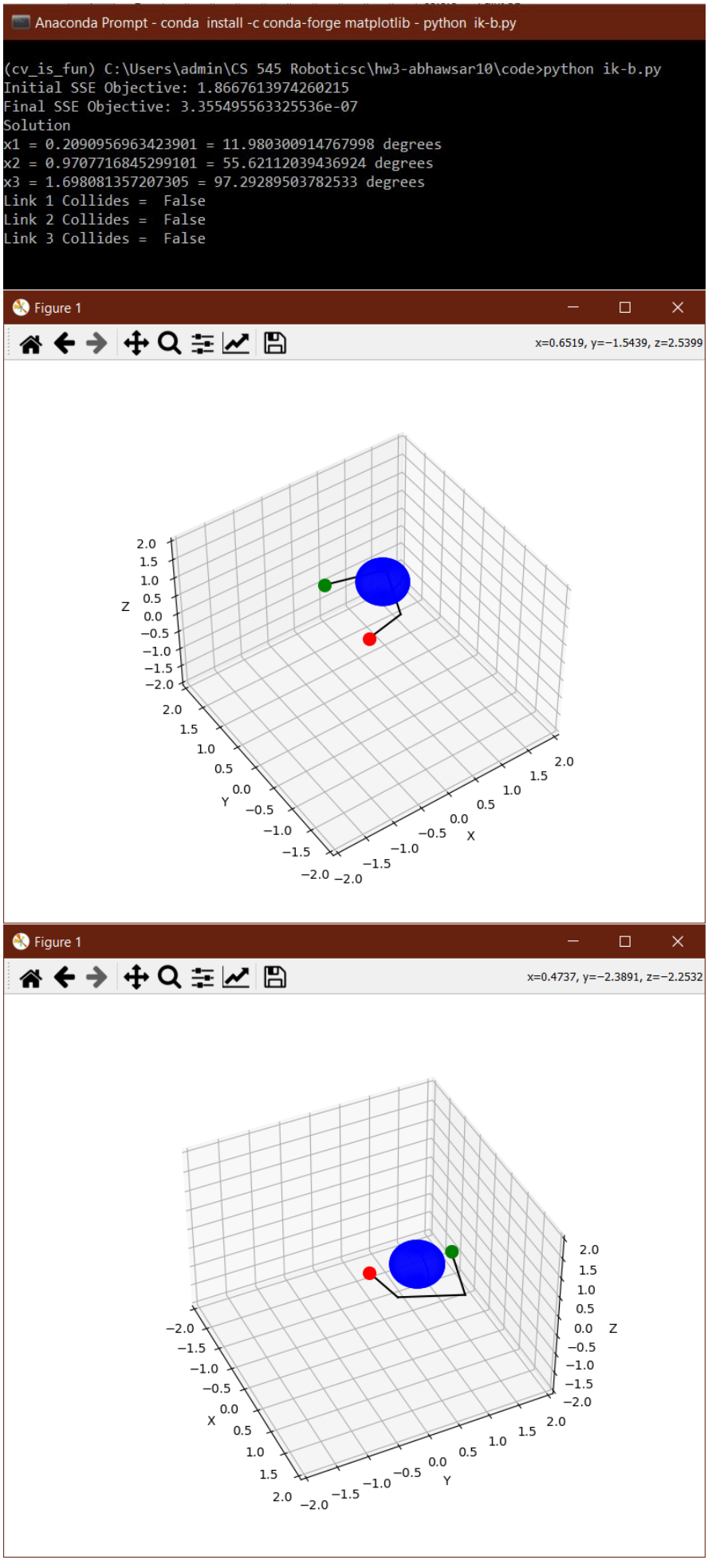


Second Link Collides with Sphere

5.2 Larger Radius of Sphere with Different Center

When we increase the radius of the sphere and change the center of sphere along the z-axis from 0.0 to 0.6, the robot can avoid the sphere and does not collides. The end-effector does manages to reach the destination position.

Result:

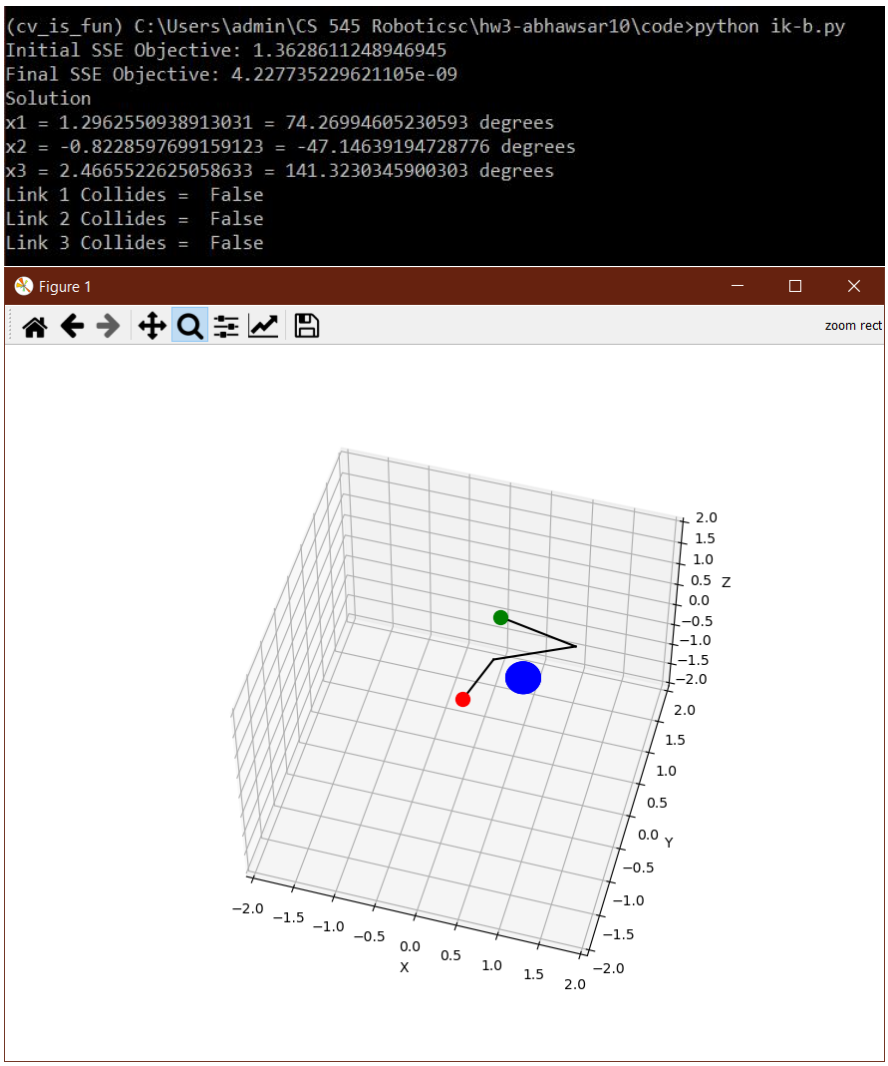


Links do not collide with Sphere

5.3 Different Starting Configuration q_0

When we change the starting configuration q_0 to start at [1.5, 0, 1.86] instead of [0, 0, 1.86], the bot begins from the 1.5 radian angle w.r.t x axis. The program starts optimizing from this position and thus finds a different feasible solution.

Result:



Robot finds different way around the sphere