Assignment #2 CSC376 Fall 2020

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We declare that this assignment is solely our own work, and is in accordance with the University of Toronto Code of Behaviour on Academic Matters.

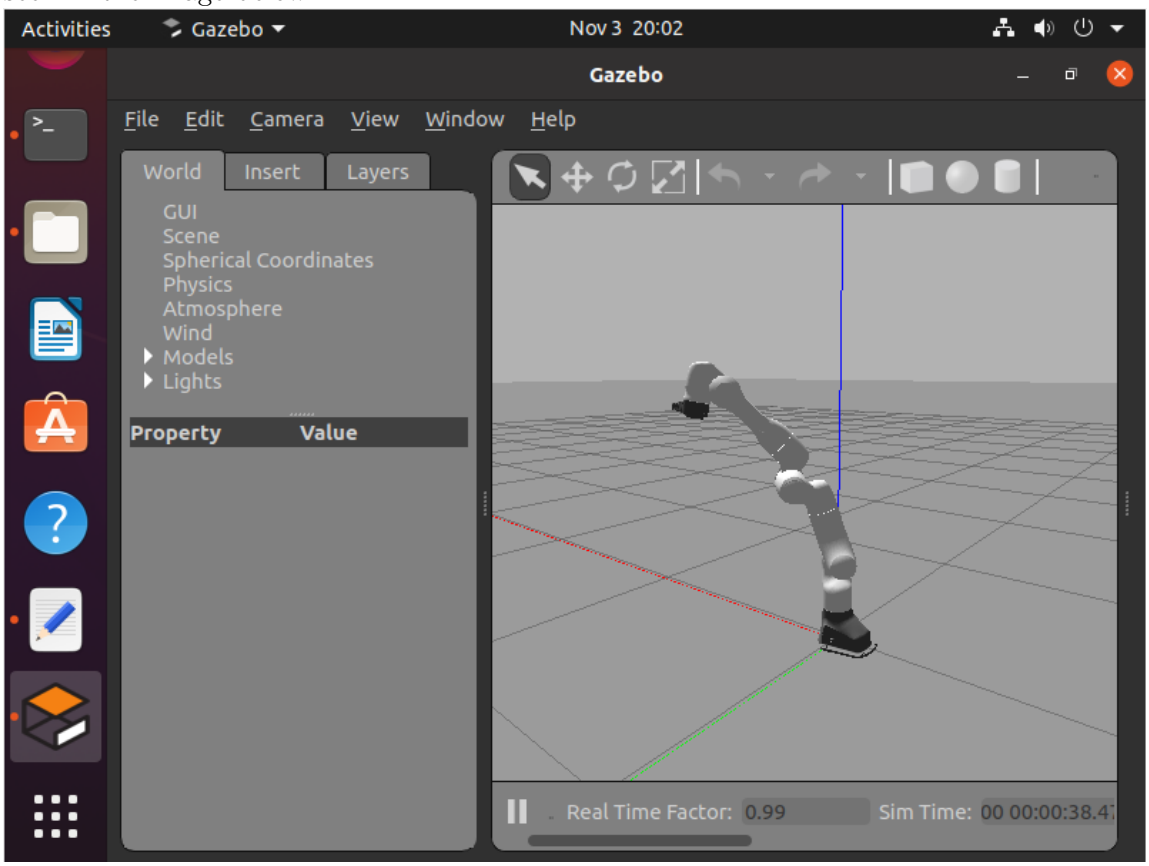
This submission has been prepared using LaTeX.

QUESTION 1:

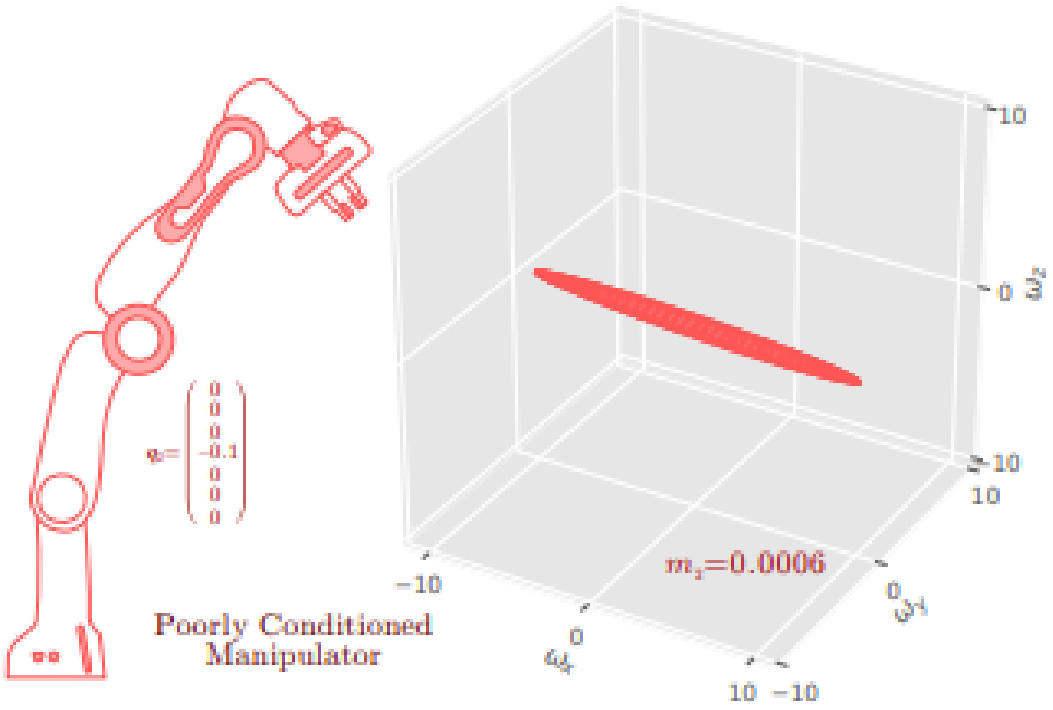
2. There are a couple differences that were noticed during the implementation of the forward kinematics using PoE rather than DH parameters. The first difference is that the PoE method required more matrices used to have cleaner code, since 2 were required per frame to maintain clear code. The second difference is that the calls to the *sin* and *cos* functions are done outside of the actual exponential matrices thanks to Rodrigues' rotation formula and are inserted in R, using the formula 3.63 from the textbook. The final difference is that in the PoE implementation, there is the presence of the transformation matrix M, for the end-effector frame, which is not included for the DH parameters implementation.

QUESTION 3:

2. Unfortunately due to errors in the PoE code, I was not able to obtain the ellipsoids as seen in the image below.



However, I will analyze the manipulability ellipsoid of the Panda arm in a similar configuration, quoted from a research paper (sourced below).



There are 3 main measures for the ellipsoid: the ratio of longest and shortest axes, the condition number and the volume of the ellipsoid. As the image posted in the research paper is in a similar position as that from the assignment, I will analyze this. As can be seen in this picture, the ratio of the longest and shortest axes is quite large, thus it is difficult to move in several directions and the arm is not isotropic. As the manipulability ellipsoid has quite a small volume, it can be deduced that the eigenvalues are a small value.

For the manipulability ellipsoid to be ideal, the ratio of longest and shortest axes should be close to 1 so that each direction is equally easy to visit and the volume of the ellipsoid should also be large, so that the robot is able to reach more areas.

Source for image of ellipsoid: https://arxiv.org/pdf/2002.11901.pdf