Assignment 3 (7 Marks)

MCEN90028 Robotics Systems 2021

Due date: as shown on Canvas LMS

1 Overview

This assignment will focus on the construction of trajectories with which to move the end effector from a given initial pose x_0 and initial velocity $\dot{x}_0$ to a given final pose x_f and final velocity $\dot{x}_f$. Note that the variable x is generic, but in this assessment, specific to the project, we will be designing the trajectory for the end-effector required in playing chess.

1.1 Objectives

The following are the objectives of this assessment. You are to address these objectives **explicitly**.

1. To construct a trajectory generation algorithm, given the initial and final end-effector pose and velocities.
2. To apply the trajectory generation algorithm to the chess playing robot arm problem in your project, taking into account the context of the problem by considering the constraints and the goals of the exercise.
3. To relate the outcome of the trajectory generation algorithm to the material from previous assignment(s), but performing inverse kinematics on the resulting end-effector pose in the generated trajectory into a set of joint space trajectories.
4. To train the ability to communicate effectively in written form the purpose and the finding of exercise, as well as the ability to convince the reader of the accuracy of the outcomes. The evaluation of this aspect is implicit in the presentation of your answers to the other objectives.

2 Task to carry out: Trajectory Generation (up to 7 marks)

You are first advised to think through the kind of movement that a robotic end-effector needs to produce in playing chess. There are 8×8 locations you will need to reach, plus potentially 2 other poses: (1) a ready pose, where the robot rests (outside

the board) when not moving (the other player's turn) and (2) a location where captured pieces are placed outside the board. You can assume that the location for (2) is given.
You will also need to consider that in describing your end-effector pose, it needs to be described in 3D space, that means it involved the location of the gripping point of the end-effector (in x, y, z with respect to a coordinate frame) as well as 3 degrees of freedom of orientation. The trajectory for the orientation also needs to be generated in this assessment.

1. For a given initial and final position and velocities ($x_i, \dot{x}_i, x_f, \dot{x}_f$, present the algorithm needed to produce the sets of polynomial coefficients for the trajectory for the 3 dof of the translational motion and the 3dof of the orientation displacement. (up to 1 mark)
   Note: The length of time to move from the initial to final position can be selected arbitrarily, but somewhere around 2-5 seconds is recommended.

2. Improve your resulting robot movement in the previous point by considering the use of via points. It is likely you will need to use one or two via-points, as your robot needs to lift a piece over the other pieces, to a height that would allow it to clear other pieces that may be in the way. Present the reasoning in the design of your trajectory. Derive the $S \times 6$ sets of polynomial coefficients for the S segments of trajectory needed to perform this move. In other words, S is the number of segments you decided to use in your trajectory. (up to 2 marks)

3. Plot the following sample trajectory generated using your answers in Part 2: The trajectory will move your rook from one square to another that is 4 squares away in the positive or negative X direction as shown in Fig 1. You can select your starting location and whether your trajectory moves the rook to the right or left direction (as long as it is along the X axis). Note that the distance it actually travels depends on the size of your chessboard. A knight is located in the square immediately adjacent the initial pose, immediate in the way of the rook that is being moved. Plot the resulting trajectory in the following manner: (up to 2 marks)

   - Plot 1: Plot the x, y, z location of the end-effector vs time, from time $t = 0$ (initial) to time $t = t_f$ (final: when it arrives at the intended pose). Indicate on our plot the points representing the via points.
   - Plot 2: Plot the resulting spatial motion on the XY plane (i.e. the view from above) (without the time component, only the position of the end-effector from start to end of trajectory)
   - Plot 3: Plot the resulting spatial motion on the ZX plane (i.e. the side view, showing the displacement of the end-effector and the representation of the piece in its end effector, moving to clear the knight and arriving at the intended location).

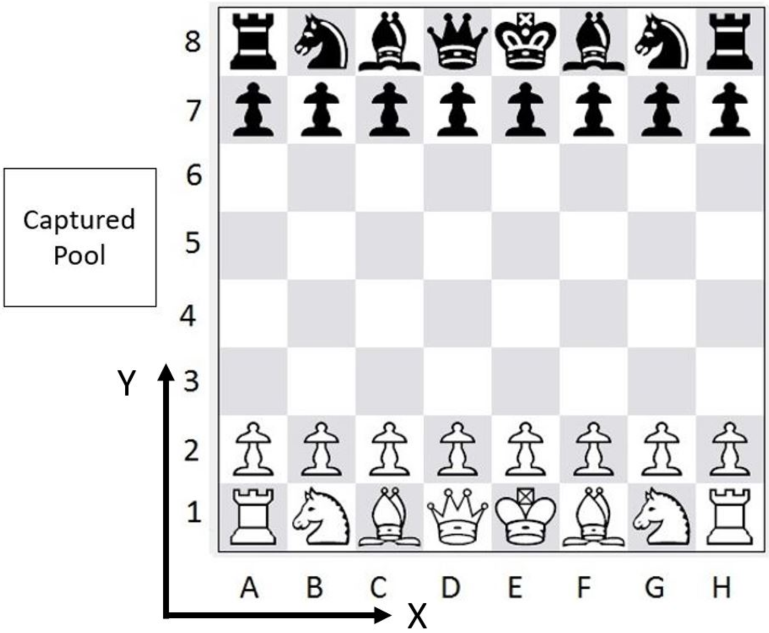

Figure 1:

4. Finally, produce Plot 4: Copy Plot 3 above and superimpose upon it the stick figures representing the robot, using the joint configuration calculated using the inverse kinematics function from your assignment 2, at $t = kt_f/10$, where $k = 0, 1, 2, ..10$. (up to 2 marks)

In your report, do not include the MATLAB codes in the body of the report. Include only the pseudocode if necessary and explain the logic. In your report, start your report with an overview (so that the report is self-contained) and provide the relevant information such as the dimension of your robot from Assignment 1 and the dimension of your chessboard, including the size of the squares on your chessboard. This has to be the same as the chessboard you presented in Assignment 1 (that you selected for your project), but it allows the tutors to save some time from having to find it in your assignment 1.

3 Submission

You need to submit one report and one Matlab script (and any necessary functions) to run your code per assignment group of 3 students. All files are to be submitted in a single ZIP file.

The report should be submitted as a PDF of **no more than 20 pages** (everything included) with **12pt font size**.

Submit them on Canvas LMS submission page as ONE .zip file which includes the one pdf file of the report and the matlab files).
Please name your files as follows:

- the .zip file should be "Assignment1_AG[#]";
- the report should be "Assignment1_Report_AG[#]";
- the main MATLAB file should be "Assignment1_Matlab_AG[#]"

NOTE: put your Assignment Group (AG) number in "[#]", eg. AG07.

Submission checklist:

☐ Report is no more than 20 pages

☐ Report has 12pt font size

☐ Report saved as PDF

☐ File names are in the right format

☐ Files are compressed into ONE .zip file