Final Project: A Comparative Study of Three Inverse Kinematic Methods For Serial Manipulators

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**Introduction**

First and foremost, the study of any aspects of robotic mechanical systems requires a comprehensive investigation on their inverse and forward kinematics. Inverse kinematics are important to perform tasks in the robot’s operational workspace. However, solving the inverse kinematics has been studied very long before, but yet it is interested to be studied and find most effective and optimal solvers. There are two main groups of inverse kinematics problems: (1) analytical method (closed solution), and (2) numerical methods. Obviously, all robots have not analytical solution and using the numerical methods are inevitable. Through this project, you should study some numerical methods and provide a comparative results about each method for a serial manipulator. Obviously, the first step of the project is calculating the forward kinematics model of the robot.

**Robotic Manipulator**

The ABB IRB 6600-175/2.8 robotics system is very flexible with bend-over-backwards capability. Available in five versions with a handling capacity of up to 225 kg, reach of up to 3200 mm, and a wrist torque of up to 1320 Nm. The IRB 6600 S4C comes with a built-in Service Information System, allowing for it to easier plan service and maintenance.

![Figure 1: ABB IRB 6600, an industrial manipulator.](image)
Objectives

Implement and compare the following methods for the manipulator, which is described in the last section:

1. Jacobian Transpose (JT)
2. Damped Least Square (DLS)
3. DLS with SVD

The following trajectories are given in reference frame $F_0$, as shown in Figure 2:

\[
x(t) = 25.62t^4 - 60.58t^3 - 555.6t^2 + 1229t + 1473
\]
\[
y(t) = 5t - 10
\]
\[
z(t) = -19.17t^3 + 94.79t^2 + 649.5t + 119.8
\]
\[
Q = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}
\]

where $t = [0, 4]$.

In order to verify the inverse kinematics model, the obtained solutions should be passed through the forward kinematics model and compare outputs with the reference trajectories.
Project Components

1. Project report: The project reports should be written like conference papers. In this report you should:
   (a) Describe the problem that you have solved.
   (b) Denavit-Hartenberg parameters and forward kinematics.
   (c) Explain why the solved problem is interesting or important.
   (d) Describe the technical approaches you took.
   (e) Provide a well-defined pseudocode for each method.
   (f) Explain the importance and features of those methods.
   (g) Report results.
   (h) Compare all approaches and provides advantages and disadvantages of each approach.
   (i) Cite all sources that you have been used in your work.

2. Codes: All methods should be implemented in Matlab and m-file format.

3. Reference: All sources that are cited in the report should be provided in a zip file.

NOTE: This report can be written in Persian or English. Providing a comprehensive and complete document about your work is the most important point that you should consider.

Academic Honesty

You should know that your honest act and hardworking are more important than completing all items of the project. Thus, answer the problems honestly and avoid plagiarism:

"Plagiarism is defined as use of intellectual material produced by another person without acknowledging its source, for example:

1. Wholesale copying of passages from works of others into your homework, essay, term paper, or dissertation without acknowledgment.

2. Use of the views, opinions, or insights of another without acknowledgment.

3. Paraphrasing of another person’s characteristic or original phraseology, metaphor, or other literary device without acknowledgment."

Recommended Reading Materials


1 IEEE conference template is recommended.
Reference