ROBOTICS TOOLBOX

MAE 547 Project

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DEC 2019

MAE 547 Final Project

Robotics Toolbox

Contributions –

Homogeneous Transformation	Tanmay Dhanote
Euler Angles	Amaan Khan
Forward Kinematics	Laukik Mujumdar
Workspace	Malay Nagda
Inverse Kinematics	Ravendra Raghavendra
Differential Kinematics	Malay Nagda
Inverse Diff. and Inverse using Jacobians	Ravendra Raghavendra
Manipulator Dynamics	Laukik Mujumdar
Manipulator Control	Laukik Mujumdar, Ravendra Raghavendra
GUI	All Member starting with Tanmay Dhanote

To get started with the toolbox you need have MATLAB 2019 with Peter Corke's Robotic toolbox 9.10. Open the Main_Window.mlapp to initialize the toolbox, here you will find various operations that can be performed by the developed toolbox. Below you can find the step by step guide about the different parts of the toolbox and how to use them.

How to use the Toolbox –

1. Description of Frame
    a. First enter the number of rotations to be performed.
    b. Then enter the rotation number.
    c. Enter the axis and angle of rotation and press update.
    d. Repeat step b-c for each rotation to be performed.
    e. Enter the translational position of the frame (i) with respect to (i-1)
    f. Press Fixed Frame or Current Frame button to obtain the transformation matrix and plot.

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2. Transformation Operator
    a. First enter the number of rotations to be performed.
    b. Then enter the rotation number.
    c. Enter the axis and angle of rotation and press update.
    d. Repeat step b-c for each rotation to be performed.
    e. Enter the Vector A position
    f. Press Transform Vector button to obtain the transformation matrix and plot.

3. Transformation Mapping
    a. First enter the number of rotations to be performed.
    b. Then enter the rotation number.
    c. Enter the axis and angle of rotation and press update.
    d. Repeat step b-c for each rotation to be performed.
    e. Enter the position vector of frame B with respect to A
    f. Enter vector position in frame B
    g. Press map button to obtain the transformation matrix and plot.

4. Rotation Matrix
    a. First enter the number of rotations to be performed.
    b. Then enter the rotation number.
    c. Enter the axis and angle of rotation and press update.
    d. Repeat step b-c for each rotation to be performed.
    e. Press Fixed Frame or Current Frame button to obtain the rotational matrix and plot.
5. Euler Angles

    TAB 1: Euler Angle from Rotation Matrix
    a. Enter rotational matrix
    b. Select the Current frame or Fixed frame from drop down menu
    c. Press Run button to obtain the Phi, Theta and Psi Value and the Plot

    TAB 2: Rotation Matrix from Euler Angle
    a. Enter Phi, Theta and Psi Value
    b. Select the Current frame or Fixed frame from drop down menu
    c. Press Run button to obtain the rotational matrix and the Plot

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6. Forward Kinematics
    a. First Select either you know DH parameters of robot or not before clicking on Forward Kinematics button
    b. Enter the robot definition accordingly that is being asked under link definition panel, remember value of link type is case sensitive.
    c. Click update after entering each links definition, when the link no. reaches same value as number of links the DH parameters will be displayed.
    d. After that enter the joint variables one by one and run after each, when joint number reaches same value as number of links transformation will given and plots will be plotted.

7. Inverse Kinematics
    a. First Select either you know DH parameters of robot or not before clicking on Forward Kinematics button
    b. Enter the robot definition accordingly that is being asked under link definition panel, remember value of link type is case sensitive.
    c. Click update after entering each links definition, when the link no. reaches same value as number of links the DH parameters will be displayed.
    d. Enter the end effector pose and select which Euler angles describe the end pose and click on run
    e. The values for the joint variables will be displayed accordingly from joint 1 - n

8. Differential Kinematics
    a. First Select either you know DH parameters of robot or not before clicking on Forward Kinematics button
    b. Enter the robot definition accordingly that is being asked under link definition panel, remember value of link type is case sensitive.
    c. Click update after entering each links definition, when the link no. reaches same value as number of links the DH parameters will be displayed.
    d. Click on run above Jacobian to display it
    e. Then enter a pose of end effector to calculate singularity for that defined pose.

9. Inverse Differential Kinematics
   a. First Select either you know DH parameters of robot or not before clicking on Forward Kinematics button
   b. Enter the robot definition accordingly that is being asked under link definition panel, remember value of link type is case sensitive.
   c. Click update after entering each links definition, when the link no. reaches same value as number of links the DH parameters will be displayed.
   d. Enter the end effector Final velocities, and click on run
   e. The values for the joint velocities will be displayed from joint 1 - n

10. Inverse Kinematics using Jacobians
    a. First Select either you know DH parameters of robot or not before clicking on Forward Kinematics button
    b. Enter the robot definition accordingly that is being asked under link definition panel, remember value of link type is case sensitive.
    c. Click update after entering each links definition, when the link no. reaches same value as number of links the DH parameters will be displayed.
    d. Enter the end effector pose in X, Y, Z directions and click on run.
    e. The values for the joint variables will be displayed accordingly from joint 1 - n

11. Workspace
    a. Enter the DH parameters along with the joint limits of the robot you wish to view the workspace of.
    b. Click update after entering each link definition and joint limits. When the link no. reaches same value as number of links the DH parameters will be displayed.
    c. Click on plot workspace to see the workspace of the desired robot.
    d. Two plots will pop up, figure 1 shows the 3D work envelope of the defined robot and the figure 2 shows animation of the robot as the end-effector motions around its plotted workspace.
    e. You can pan around the work envelope and the robot animation in its workspace to see the plots from all possible views. If the plots appear in 2D simply click on the ‘View’ button in the plot window and select ‘Rotate 3D’ option to see and pan the plots in 3D.

12. Manipulator Dynamics
    a. Enter the robot definition accordingly that is being asked under link definition panel.
    b. After defining the robot specify the gravity vector and enter the link parameter for each link accordingly and click on update.
    c. As everything is defined, by entering y/n you can obtain the dynamics equations, or you can enter end time, torque as function of time t, initial joint variables and joint rates. Remember to enter torque, variables and rates as row vector respectively, e.g. [t exp(t) sin(t)].
    d. click on run simulation to obtain the graphs for joint variables and joint rates for the respective time.

13. Manipulator Control
    a. The robot being considered is 2R Planar.
    b. Enter the link parameters for both links one by one accordingly but enter the value of gravity vector only once and click on UPDATE.
    c. Now enter the initial condition for joint variables and joint rates, also enter the desired position of the end effector.
    d. Now enter the value of time for calculation. Enter the value of force only if calculating force compliance control.
    e. Click on either button to calculate the graphs for the manipulator control.

REFERENCES-

1. Peter Corke Robotics Toolbox 9.10