Module 6: Robot manipulators kinematics

Lecture 19: D-H representation of kinematics linkages

Objectives

In this course you will learn the following

- D-H Parameters of general manipulators

- Application to simple manipulator as example

Dimentberg, Denavit, Hartenberg's parameters of kinematics linkages:

For general mechanism shown above, linkage parameters \( a_i, \alpha_i, d_{i,i+1}, \theta_i \) are defined as follows:

- Common normal length between \( i-1 \) & \( i \) link is \( a_i \) and the twist angle is \( \alpha_i \). These are usually fixed parameters of linkages.

- The other parameters are \( d_{i,i+1} \), the offset distance between perpendiculars and \( \theta_i \), the angle of perpendiculars.

Here for revolute pairs, offset distance \( d \) is fixed and its angle, \( \theta_i \) is variable. And for prismatic pairs, offset distance is variable and the angle fixed. **Denavit, Hartenberg's** defines the reference frames \( X_1 \) & \( Z_1 \) as follows. (Conventions to be used while deciding kinematic parameters of a robot)

- At joint \( J_{i+1} \), define \( Z_1 \) along joint axis and suitable \( X_1 \) to start with & \( Y_1 = X_1 \times Z_1 \)

- \( a_i \) & \( \alpha_i \) are obtained as; take \( Z_{i+1} \) to \( Z_1 \) along \( X_i \)

- \( d_i \) & \( \theta_i \) are obtained as; Take \( X_{i+1} \) to \( X_i \) along \( Z_{i+1} \)

- Set Direction of \( Z \) axis along any +ve or −ve direction.

- For position of \( Z \) axis for prismatic joint à choose convenient position

- Choose position of common normal on 2 parallel axis, conveniently

- Robot is serial chain of binary links except base & EE.

- For reference frame on unary link, set \( Z_0 \) along joint 1 axis.
Figure 19.1

These conventions are used in PUMA robot as follows (Refer figure 19.2)

Example of PUMA Robot: This is all revolute pair robot as follows: $\overline{R} \ | \overline{R} || \overline{R} \ | \overline{R} || \overline{R}$. 

Fig. 19.2 PUMA robot kinematics using D-H parameters
<table>
<thead>
<tr>
<th>i</th>
<th>ai</th>
<th>αi</th>
<th>di</th>
<th>θ_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>90</td>
<td>d1</td>
<td>θ_1</td>
</tr>
<tr>
<td>2</td>
<td>a2</td>
<td>0</td>
<td>d2</td>
<td>θ_2</td>
</tr>
<tr>
<td>3</td>
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<tr>
<td>4</td>
<td>0</td>
<td>90</td>
<td>d4</td>
<td>θ_4</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>90</td>
<td>0</td>
<td>θ_5</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>d6</td>
<td>θ_6</td>
</tr>
</tbody>
</table>

Set the parameters of PUMA robot as per conventions mentioned above. i.e.

- Set $X_0, Y_0, Z_0$ along joint 1 as shown.

- $Z_1$ along axis of joint 2

- $X_1$ along common normal.

- Similarly other parameters are to be set to get table shown where $θ_1$ to $θ_6$ are joint variables.

**Recap**

In this course you will learn the following

- How D-H parameters are represented for general manipulator

- Application of D-H parameters for PUMA robot

Congratulations, you have finished Lecture 19. To view the next lecture select it from the left hand side menu of the page