Assignment - 3&4
ITR

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1. A singular configuration refers to a specific configuration of robot's joints where it loses it's ability to move in a particular direction or perform a certain motion. In a singular configuration, the robot's degree of freedom become limited & it may experience issues such as Redundant/Uncontrollable motion, loss of dexterity, & Increased Joint variables.

To find singular configurations in a robot's workspace, 2 common methods are:

a) Jacobian Matrix Analysis:
At a singular configuration, the determinant of the Jacobian matrix becomes zero.

b) ~~Singular~~ Numerical method:
Singular configurations can also be found using numerical optimization techniques. By iteratively, exploring the robot's joint space & checking for conditions such as joint limits and the rank of the Jacobian matrix it's possible to find singular points.

Also, we can detect if a particular configuration is close to a singular configuration using the manipulator Jacobian:

↳ Condition Number: The condition number of Jacobian matrix is a measure of how close the robot is to a singularity. A high condition number indicates that robot is close to a singularity.

↳ Rank deficiency: If the rank of the Jacobian is less than the number of degrees of freedom it indicates that the robot is at or near a singularity.

↳ Eigen values & Eigen vectors:
If some eigen values are close to zero, it suggests that the robot is approaching a singular configuration.

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7. The three common configurations for the 2R manipulator are:

a) Direct Drive configuration (2R):
↳ Here, both joints are actuated directly, i.e each joint has its own motor or actuator.

Advantages:
- Precise control:
- Versatility:

Disadvantages
- complexity
- Size & weight

b) Remotely-Driven configuration (2R):

Here, one joint is actuated and the motion is transmitted to the second joint through a mechanical linkage or pully system.

Advantages
- Simplicity
- Reduced weight & size

Disadvantages
- Limited control
- Less precise control

c) 5-Bar Parallelogram Arrangement

Here, two links of the manipulator are connected in a ~~parallel~~ parallelogram arrangement with a fixed base. Both joints are actuated.

Advantages
- Rigidity
- Reduced weight

Disadvantages
- Limited workspace
- Reduced versatility

10- Using D(q) and V(q), we have to derive equations of motion for a robotic system, by using following steps:

a) Define Variables & Parameters

b) Write Kinematic equations

c) Compute the Jacobian

d) Formulate the Lagrangian

e) Compute Euler-Lagrange equations

f) Express Inertia matrix D(q).

g) Express velocity Dependent Forces (V(q)).

h) Simplify equations & solve.

i) obtain Generalized forces (Q).

j) Implement & simulate

Q. 18, 19.

For a 3-D printer with a PPP, the D-H parameters are:

$P_1, P_2, P_3$ are 3 Prismatic joints

a) $P_1$:

- Link length ($a_1$) : 0
- Link twist ($\alpha_1$) : 0
- Link offset ($d_1$) : $d_1$
- Joint angle ($\theta_1$) : 0

b) $P_2$:

- Link length ($a_2$) : 0
- Link twist ($\alpha_2$) : 0
- Link offset ($d_1$) : $d_1$
- Joint angle ($\theta_1$) : 0

c) $P_3$:

- Link length ($a_3$) : 0
- Link twist ($\alpha_3$) : 0
- Link offset ($d_1$) : $d_3$
- Joint angle ($\theta_1$) : 0