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ME 639: Introduction to Robotics

Assignment 1

Types of robots:

1. **Manipulators:**

   Kuka robot :

   The KUKA robotic arm is a versatile industrial tool used in manufacturing and automation. It performs tasks with precision, employing multiple joints and advanced control systems to handle processes such as welding, painting, and assembly. The Duel: Timo Boll vs. KUKA Robot

   Boston Dynamics' Stretch :

   Boston Dynamics' Stretch is a cutting-edge robotic system designed for material handling in warehouses and distribution centers. It uses advanced sensors and machine learning to efficiently move and sort items, enhancing logistics operations. Introducing Stretch | Boston Dynamics

2. **Mobile robots:**

   Dingo :

   The Dingo is an autonomous robotic vehicle used for a variety of tasks, including remote sensing, mapping, and data collection in outdoor environments. Equipped with sensors and navigation capabilities, it's designed to operate in rugged terrains, aiding in tasks like environmental monitoring and exploration.

   Meet DINGO | Indoor Mobile Robot for Research & Education

Turtlebot:

The TurtleBot is a popular open-source robot platform designed for research and education in robotics. It combines a mobile base with sensors and computation, enabling developers and students to experiment with various algorithms and create innovative robotic applications.

TurtleBot3 - Official Product Video

3. **UAVs:**

   Puma LE :

   The Puma LE (Long Endurance) UAV is a small unmanned aerial vehicle developed by AeroVironment. It's designed for surveillance, reconnaissance, and data gathering missions, offering an extended flight time and advanced imaging capabilities for military and commercial applications.

   Puma LE Unmanned Aircraft System

   MQ9 Reaper :

   The MQ-9 Reaper is a versatile remotely piloted aircraft used primarily by the United States Air Force for surveillance, reconnaissance, and strike missions. It's equipped with advanced sensors and weaponry, making it capable of both intelligence gathering and precision airstrikes in various operational scenarios.

   General Atomics MQ-9 Reaper

4. **AUVs:**

   Bluefin 9 :

   The Bluefin-9 is an autonomous underwater vehicle (AUV) designed for marine exploration and surveying tasks. Equipped with advanced sensors and navigation systems, it's used for mapping the ocean floor, collecting scientific data, and conducting underwater research in challenging environments.

Introducing the Brand New Bluefin-9 UUV

Hydroid REMUS 100 :

The Hydroid REMUS 100 is an autonomous underwater vehicle (AUV) renowned for its compact design and versatility in marine applications. It's utilized for tasks such as underwater mapping, environmental monitoring, and underwater search operations, offering a robust platform for various aquatic research and exploration needs. Podvodna vozila Remus 100

5. **Soft bots**

Octobot :

The Octobot is a soft-bodied underwater robot designed to mimic the movements and flexibility of an octopus. Utilizing soft and flexible materials, it aims to provide a more adaptable and maneuverable robotic platform for underwater exploration and research.

‘Octobot’ is the world’s first soft-bodied robot

SnakeBot :

The Snakebot is a soft-bodied robot inspired by the movement of snakes, designed for underwater environments. Its flexible and articulated body allows it to navigate complex underwater spaces, making it suitable for tasks like inspection, search and rescue, and marine exploration.

A soft robot that moves like a snake

6. **Microbots**

   RoboBee :

   The RoboBee is a miniature robotic insect developed by researchers at Harvard University. It's designed to mimic the flight behavior of bees and other flying insects, serving as a platform for studying aerial mobility, collective behaviors, and potential applications in areas like environmental monitoring and pollination.

   Tiny, Robotic Bees Could Change the World | National Geographic

   Microgripper :

   A microgripper is a tiny robotic tool or mechanism designed to manipulate and grasp objects at a very small scale, often at the micro or nanometer level. It finds applications in fields such as microassembly, microsurgery, and microelectronics, enabling precise handling and manipulation of delicate materials and components.

   Microgripper Plug-in for the MM3A-EM

7. **Exoskeleton**

   Harmony :

   The Harmony exoskeleton is a wearable robotic device developed by ReWalk Robotics to assist individuals with mobility impairments due to spinal cord injuries. It provides powered hip and knee movement to enable individuals to stand, walk, and navigate various environments, enhancing their mobility and quality of life. Harmony: Upper-limb Exoskeleton for Stroke Rehabilitation

Rewalk :

The ReWalk robotic exoskeleton is a wearable medical device designed to help individuals with spinal cord injuries regain the ability to stand up, walk, and navigate their surroundings. It uses motion sensors and motorized joints to provide support and assistive movement for users, contributing to improved mobility and independence. ReWalk Exoskeleton from ReWalk Robotics

Types of motors:

1. **Synchronous Motor:**

   A synchronous motor is an AC (alternating current) motor where the rotation of the rotor is synchronized with the frequency of the AC power supply. It operates at a constant speed determined by the frequency of the supplied AC voltage and the number of poles in the motor.

2. **Asynchronous Motor (Induction Motor):**

   Also known as an induction motor, this is the most common type of AC motor. It operates at a speed slightly below synchronous speed. The rotation of the rotor is induced by the rotating magnetic field of the stator.

3. **Brushed DC Motor:**

   A brushed DC motor is a type of direct current motor where the rotation is achieved using a commutator and brushes to change the direction of current flow in the motor windings.

4. **BLDC Motor (Brushless DC Motor):**

   A brushless DC motor is a type of electric motor that doesn't use brushes for commutation. Instead, it relies on electronic controllers to switch the current direction in the motor windings.

5. **Servo Motor:**

   A servo motor is a type of motor that is designed for precise control of angular or linear position, velocity, and acceleration. It usually consists of a DC motor, gears, and a feedback control system (such as an encoder) that provides information about the motor's actual position.

6. **Stepper Motor:**

   A stepper motor is a type of motor that moves in discrete steps or increments. It doesn't rotate continuously like other motors; instead, it moves in fixed angular increments or steps based on the input signals it receives.

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Que. 6.

$$R_0^1 = \begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 & \hat{j}_1 \cdot \hat{i}_0 & \hat{k}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 & \hat{j}_1 \cdot \hat{j}_0 & \hat{k}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 & \hat{j}_1 \cdot \hat{k}_0 & \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix}$$

We know that $R_0^1 (R_0^1)^T = I$

$$\therefore \begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 & \hat{j}_1 \cdot \hat{i}_0 & \hat{k}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 & \hat{j}_1 \cdot \hat{j}_0 & \hat{k}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 & \hat{j}_1 \cdot \hat{k}_0 & \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix} \times \begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 & \hat{i}_1 \cdot \hat{j}_0 & \hat{i}_1 \cdot \hat{k}_0 \\ \hat{j}_1 \cdot \hat{i}_0 & \hat{j}_1 \cdot \hat{j}_0 & \hat{j}_1 \cdot \hat{k}_0 \\ \hat{k}_1 \cdot \hat{i}_0 & \hat{k}_1 \cdot \hat{j}_0 & \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$\therefore (\hat{i}_1 \cdot \hat{i}_0)^2 + (\hat{j}_1 \cdot \hat{i}_0)^2 + (\hat{k}_1 \cdot \hat{i}_0)^2 = 1$ — (1)

$\therefore (\hat{i}_1 \hat{j}_0)^2 + (\hat{j}_1 \cdot \hat{j}_0)^2 + (\hat{k}_1 \cdot \hat{j}_0)^2 = 1$ — (2)

$\therefore (\hat{i} \cdot \hat{k}_0)^2 + (\hat{j}_1 \cdot \hat{k}_0)^2 + (\hat{k}_1 \cdot \hat{k}_0)^2 = 1$ — (3)

$\therefore (\hat{i}_1 \cdot \hat{i}_0) \times (\hat{i}_1 \cdot \hat{j}_0) + (\hat{j}_1 \cdot \hat{i}_0) \times (\hat{j}_1 \cdot \hat{j}_0) + (\hat{k}_1 \cdot \hat{i}_0) \times (\hat{k}_1 \cdot \hat{j}_0) = 0$ — (4)

$\therefore (\hat{i}_1 \cdot \hat{i}_0) \times (\hat{k}_0 \hat{i}_0) + (\hat{j}_1 \hat{i}_0) \times (\hat{j}_1 \hat{k}_0) + (\hat{k}_1 \cdot \hat{i}_0) \times (\hat{k}_1 \hat{k}_0) = 0$ — (5)

$\therefore (i_1 j_0) \times (i_1 k_0) + (j_1 i_0) \times (j_1 k_0) + (k_1 j_0) \times (k_1 k_0) = 0$ — (6)

As the matrix is orthogonal

$\hat{i}_1 \cdot \hat{j}_0 = -\hat{j}_1 \cdot \hat{i}_0$; $\hat{i}_1 \cdot \hat{k}_0 = -\hat{k}_1 \cdot \hat{i}_0$, $\hat{j}_1 \cdot \hat{k}_0 = -\hat{j}_0 \cdot \hat{k}_1$

Column 1 × Column 2 $= (i_1 i_0) \cdot (j_1 i_0) + (i_1 j_0) \cdot (j_1 j_0) + (i_1 k_0)(j_1 k_0)$

$= -(i_1 i_0)(i_1 j_0) + [+(j_1 i_0)(j_1 j_0)] + (i_0 k_0)(k_1 j_0)$

$= 0$ .... (from eq^n (4))

Similarly Column 2 × column 3 = Column 1 × column 3

$\therefore$ Orthogonality proved

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Que.7.

R_0' is an orthogonal matrix.

$\therefore R_0' \cdot (R_0')^T = I$

$\therefore |R_0'| \, |R_0'^T| = |I|$

$\therefore (R_0')^2 = |I|$

$\therefore |R_0'| = \sqrt{1}$

$\therefore |R_0'| = \pm 1$

Hence proved.