Total No. of Questions: 6 *Total No. of Printed Pages:3*

Enrollment No.....

Faculty of Engineering

End Sem Examination May-2024

RA3CO33 Robot System Design & SLAM

Programme: B.Tech. Branch/Specialisation: RA

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d. Assume suitable data if necessary. Notations and symbols have their usual meaning.

Q.1 i. What is the purpose of free open source software for robot simulation? **1**

(a) To increase the cost of robot simulation

(b) To provide a platform for robot simulation that is freely accessible and modifiable

(c) To restrict access to robot simulation tools

(d) To limit the features available in robot simulation software

ii. Which operating system is commonly used in conjunction with ROS (Robotic Operating System)? **1**

(a) Windows (b) MacOS (c) Ubuntu (d) iOS

iii. What does ROS stand for? **1**

(a) Reactive Operating System (b) Robotic Operating System

(c) Real-time Operating System (d) Robot Observation System

iv. Which component of ROS is responsible for facilitating communication between different nodes in a robotic system? **1**

(a) ROS Services (b) ROS Actions

(c) ROS Master (d) ROS Nodes

v. What is SLAM? **1**

(a) Simultaneous Localization and Mapping

(b) Sensor Location and Movement

(c) Sensing Light and Movement

(d) Simultaneous Light and Movement

vi. What is the primary purpose of path planning in robot navigation? **1**

(a) To determine the robot's current location

(b) To generate a collision-free path from a start point to a goal point

(c) To identify obstacles in the environment

(d) To estimate the distance to nearby objects

P.T.O.

vii. What is manipulation planning? **1**
(a) Planning the movement of a robot's end-effector to grasp objects
(b) Planning the movement of a robot's wheels for navigation
(c) Planning the movement of a robot's sensors for perception
(d) Planning the movement of a robot's joints for locomotion

viii. What is prehension in the context of manipulation? **1**
(a) The ability to plan movements efficiently
(b) The ability to perceive objects in the environment
(c) The ability to grasp and manipulate objects with precision
(d) The ability to navigate around obstacles

ix. What is object detection in robot vision? **1**
(a) The process of identifying and locating objects in images or video frames
(b) The process of classifying objects based on their appearance
(c) The process of tracking objects as they move through a scene
(d) The process of measuring the distance to objects in a scene

x. Which of the following is used for converting 3D points to 2D image coordinates in computer vision? **1**
(a) Forward kinematics (b) Inverse kinematics
(c) Homography transformation (d) Jacobian matrix

Q.2 i. List out the constraints commonly encountered in industrial environments that can impact robot operations. **2**

ii. Describe the key features of the ROS and its importance in robotics development. **3**

iii. Discuss the process and steps involved in installing and configuring simulation software like Gazebo and MoveIt on an Ubuntu system. **5**

OR iv. Explain the significance of using Python in robot simulation and development. Provide examples of Python libraries commonly used in robotics and how they contribute to the development process. **5**

Q.3 i. What are ROS Services? How do they differ from ROS Actions? **2**

ii. Discuss the advantages of using ROS for robotics development, highlighting its flexibility and modular architecture. Give examples. **8**

OR iii. Explain the process of creating and integrating a custom robot model using URDF within a ROS environment. Give steps for defining links, joints, and visual representations. **8**

Q.4 i. Explain the concept of occupancy grid mapping and its role in robot navigation. **3**

ii. Explain the process of implementing SLAM with ROS2 packages and C++. Discuss the key steps involved and the role of mapping algorithms in localization concepts. **7**

OR iii. Derive the update equations for the Extended Kalman Filter (EKF) used in SLAM algorithms, explaining each term and its significance in the context of simultaneous localization and mapping. **7**

Q.5 i. Describe the key algorithms used in manipulation planning and their role in enabling robots to perform complex manipulation tasks. **4**

ii. Explain how software tools are utilized in manipulation tasks in robotics. Give examples of commonly used software tools and their functionalities in manipulation planning and execution. **6**

OR iii. Derive the Jacobian matrix for a robotic manipulator arm with multiple degrees of freedom, explaining its significance in manipulation planning and control. **6**

Q.6 Attempt any two:

i. Describe the logical camera in the context of robot vision. How does it differ from physical cameras? **5**

ii. Discuss the role of ROS tools in facilitating vision-based tasks in robotics, such as object detection and pose estimation. **5**

iii. Discuss the challenges associated with pose estimation in robotics, considering factors such as occlusion, lighting conditions, and object complexity. **5**

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Marking Scheme

RA3CO33 (T) RobotSystemDesignand SLAM(Simultaneous Localization andArea Maping)

Q.1	i)	B	**1**
	ii)	C	**1**
	iii)	B	**1**
	iv)	C	**1**
	v)	A	**1**
	vi)	B	**1**
	vii)	A	**1**
	viii)	C	**1**
	ix)	A	**1**
	x)	C	**1**
Q.2	i.	List of constraints	**2**
	ii.	key features of the Robotic Operating System (ROS)	**1.5**
		Importance in robotics development.	**1.5**
	iii.	Explanation of process	**3**
		Steps involved with chart	**2**
OR	iv.	Significance of using Python in robot simulation and development.	**3**
		examples of Python libraries	**2**
Q.3	i.	Explanation of ROS Services	**2**
	ii.	advantages of using ROS for robotics development,	**3**
		Highlighting its flexibility and modular architecture.	**3**
		example	**2**
OR	iii.	Process explanation of creating and integrating a custom robot model using URDF within a ROS environment.	**5**
		Steps for defining links, joints, and visual representations.	**3**
Q.4	i.	concept of Occupancy Grid Mapping	**3**
	ii.	Process of implementing SLAM with ROS2 packages and C++.	**4**
		key steps involved and the role of mapping algorithms in localization concepts.	**3**
OR	iii.	equations for the Extended Kalman Filter (EKF) used in SLAM algorithms,	**4**
		Explaining each term and its significance in the context of simultaneous localization and mapping.	**3**
Q.5	i.	key algorithms used in manipulation planning	**2**
		role in enabling robots to perform complex manipulation tasks	**2**
	ii.	Explanation on how software tools are utilized in manipulation tasks in robotics.	**4**
		examples and their functionalities	**2**
OR	iii.	Derivation with step marking	**6**
Q.6		Attempt any two:	
	i.	Describe the logical camera in the context of robot vision.	**5**
	ii.	the role of ROS tools (01 mark for each step)	**5**
	iii.	challenges (01 mark for each challenge explanation)	**5**

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