University of Tehran

College of Engineering

School of Electrical and Computer Engineering (ECE)

School of Mechanical Engineering (ME)

Mechatronics & Robotics

Homework 1

Teaching Assistants:

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Deadline: 4 March 2025 (14 Esfand), 23:59

List of Problems

Problem 1: Robots vs. Waste: Smarter Cleanup

Designing a robotic waste management system requires understanding various factors, including system requirements, types of robots, waste classification methods, necessary sensors, and real-world implementations. Provide a comprehensive analysis of the system, citing relevant references.

Instructions: Address the following:

- What are the key requirements for a robotic waste management system?
- What types of robots are required for the system?
- How many waste categories should be considered, and why?
- What sensors are required for garbage classification, and how should they be used?
- Explain the entire waste management pipeline, including collection, sorting, and disposal, with references.

Table for References:

Requirement/Aspect	Description	Country	Reference	Year

Problem 2: Get a Grip: Robotics in Action

Grasping is a critical area in robotics that involves various types of grippers and methods for object manipulation. Conduct research and explain the different approaches to grasping.

Instructions: Address the following:

- What are the different types of robotic grippers?
- What methods are used in grasping technology?
- What are the major challenges in robotic grasping?
- What are the future prospects in this area?
- Analyze the advantages and disadvantages of each gripper type.

Gripper Type	Advantages	Disadvantages	Example Usage

Problem 3: Axis/Angle Representation

A rigid body rotates from an initial orientation $\mathbf{R}_i$ to a final orientation $\mathbf{R}_f$, as specified by

$$\mathbf{R}_i = \begin{pmatrix} 0 & 1 & 0 \\ 0.5 & 0 & \frac{\sqrt{3}}{2} \\ \frac{\sqrt{3}}{2} & 0 & -0.5 \end{pmatrix}, \quad \mathbf{R}_f = \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix}.$$

Find an axis/angle representation $(\mathbf{r}, \theta)$ of the rotation. Is the solution unique in this case?

Problem 4: Yaw-Pitch-Roll

Suppose R is generated by a rotation of α about z_0 followed by a rotation of β about y_1 followed by a rotation of γ about x_2. (in local coordination)

1. Find the axis/angle representation of R
2. Which matrix could be a possible answer for the acquired rotation matrix?
   - $$R_1 = \begin{bmatrix} 0.3659 & -0.9061 & 0.2142 \\ 0.7848 & 0.4232 & 0.4531 \\ -0.5000 & 0.0152 & 0.8659 \end{bmatrix}$$
   - $$R_2 = \begin{bmatrix} 0.4784 & -1.2061 & 0.2896 \\ 1.2001 & 0.4232 & 0.4551 \\ -0.5000 & 0.178 & 0.6722 \end{bmatrix}$$
3. Based on your choice, calculate α, β, γ

Problem 5: Homogeneous Transformation Matrix

Find the homogeneous transformation matrix **H** for the following sequence of transformations:

1. A rotation by α about the current x-axis.
2. A translation of b units along the current x-axis.
3. A translation of d units along the current z-axis.
4. A rotation by Θ about the current z-axis.

Problem 6: Euler-Rodrigues Parameters

Given a rotation of 120° about the unit axis $\mathbf{u} = \frac{1}{\sqrt{14}}(1, 2, 3)$,

1. Compute the Euler-Rodrigues parameters.
2. Find the corresponding rotation matrix.
3. Show that the obtained rotation matrix is a valid one.

Homework Guidelines and Instructions

- The deadlines are fixed and cannot be changed. If you need extra time, you can use your grace period (14 days) and upload your answers up to 5 days after the deadline.
- If you write your report of this homework in LaTeX, you will be rewarded 5% extra points.
- Programming problems can either be completed in Python or MATLAB and your codes must be executable and uploaded along with the report.
- This exercise is done by one person.
- If any similarity is observed in the work report or implementation codes, this will be considered as fraud for the parties.
- Using ready-made codes without mentioning the source and without changing them will constitute cheating and your practice score will be considered zero.
- If you do not follow the format of the work report, you will not be awarded the grade of the report.
- Handwritten exercise delivery is not acceptable. Only mathematical procedures and formulas are allowed to be handwritten.
- All pictures and tables used in the work report must have captions and numbers.
- A large part of your grade is related to the work report and problem solving process.
- Please upload the report, code file and other required attachments in the following format in the system: `HW1_[Lastname]_[StudentNumber].zip`
  For example: `HW1_Ahmadi_123456789.zip`
- You can ask your questions or doubts either via Telegram group or sending an email directly to the teaching assistants of this homework.
- The questions that are asked in Telegram PV of teaching assistants will not be answered as they are not traceable for the chief TA.
- If you wanted to ask your questions or doubts via email, use the following subject: "Robotics_HW1_[Lastname]_[StudentNumber]" and make sure to cc the chief TA at shayanahmadi9999@gmail.com:
  - Question#1,2,3: shayanahmadi9999@gmail.com (Shayan Ahmadi)
  - Question#4,5,6: shirinjamshidi2001@gmail.com (Shirin Jamshidi)
- Be happy and healthy