Control in Robotics
Course Outline

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Contact

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Background

- Research Interests:
  - Advanced Control Theories for Robotic Manipulators
  - Medical Robotics
  - Nonlinear, Adaptive, and Robust Control
  - Cyber-Physical Systems
  - Internet of Thongs (IoT)
  - Computational Intelligence
- More Information:
  `https://engold.ui.ac.ir/~m.motaharifar/`
  `https://scholar.google.com/citations?user=au_KZ5cAAAAJ&hl=en`

Objective and Course Content

- The aim of this course is to introduce you to basics concepts, principles and techniques involved in control of robot manipulators.
- **Part 1**- Preliminaries:
  - History
  - Introduction to Robotics
  - Robot Classification
  - Associated Problems
  - Kinematics
  - Jacobians
  - Dynamics
  - Path planning and Trajectory Planning

Syllabus

- **Part 2**- Motion Control:
  - Linear Feedback Control
  - Feedforward Control
  - Control in Task Space and Joint Space
- **Part 3**- Nonlinear Control:
  - PD Control
  - Jacobian Transpose Control
  - Inverse Dynamics Control
  - Adaptive Inverse Dynamics Control
  - Robust Inverse Dynamics Control
  - Passivity based Control
  - Adaptive Passivity based Control
  - Robust Passivity based Control

Syllabus

- **Part 4**- Force Control:
  - Natural and Artificial Constraints
  - Impedance Operator
  - Impedance Control
  - Hybrid Position/Force Control
- **Part 5**- Telerobotics:
  - Introduction to Telerobotics
  - Haptic Systems
  - Control Theories for Single user Telerobotics Systems
  - Applications of Multi-User Telerobotics Systems
  - Control Theories for Multi-User Telerobotics Systems

Syllabus

- **Part 6**- Control of Under-Actuated Robots:
  - Flexible-Joint Manipulators
  - Flexible-Link Manipulators
  - Robot Manupulators with Faulty Actuators
- **Part 7**- Computer Vision:
  - Camera Calibration
  - Image Processing
  - Vision-Based Control

References

- J.J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd Edition, Pearson Prentice Hall, Upper Saddle River, NJ, 2004.
- Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robot Modeling and Control", Wiley 2005.
- Hamid D Taghirad. "Parallel robots: mechanics and control", CRC press, 2013.
- Carlos Canudas de Wit, Bruno Siciliano, and Georges Bastin. "Theory of robot control", Springer Science & Business Media, 2012.
- Suguru Arimoto. "Control Theory of Nonlinear Mechanical Systems", Oxford University Press, Inc., 1996.

Course Evaluation

- Class Activity: 10%
- Continuous Project: 20%
- Final Project: 20%
- Midterm: 25%
- Final Exam: 25%

Projects

- The project is intended to help students acquire a better understanding of the basic concepts and techniques introduced in the course. It is assumed that students have the ability to program in MATLAB.
- For your projects, you can utilize any paper from:
  - Jornals: IEEE, Elsevier, Springer, Wiley, etc.
  - Conferences: ICRA, IROS, ACC, CDC, AIM.
- More recent papers are preferred (after 2010).
- You have to prepare a project report in PDF format.
  - It is recommended to prepare your projects in the standard conference paper template.
  - It is recommended to use latex to prepare your reports.
- You have to present your project for the students.

Projects

Hint: It is better to use reputable journals in the robotics field such as:

- International Journal of Robotic Research
- IEEE Transactions on Robotics
- IEEE Transactions on Mechatronics
- IEEE Transactions on Control Systems Technology
- IEEE Robotics and Automation Letters
- IEEE Transactions on Automatic Control
- Mechatronics

Important Dates

- Midterm: week 8 or 9
- Project selection: week 12
- Project first report: week 16
- Project final report: after the exam