Robótica Espacial
Space Robotics

Presentation

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Main objectives

- Understanding the fundamentals of space robotics
  - Provide students with a solid foundation in the principles and concepts of space robotics.
- Developing practical skills in space robotics
  - Equip students with practical skills necessary for working with space robotics.
- Analyzing and solving complex space robotics problems
  - Develop the students' ability to analyze and solve complex problems related to space robotics.

Course syllabus

- Introduction to Space Robotics
- Kinematics of Robotic Manipulators
- Statics and Dynamics of Robotic Manipulators
- Control Techniques for Space Robots
- Sensing and Perception in Space Robotics
- Autonomous Operations in Space
  - Autonomy in space robotics: planning and decision-making
  - Localization and mapping techniques in space exploration
- Space Robotics for Planetary Exploration
  - Rover systems and mobility in planetary environments
  - Sample collection and analysis with robotic systems
- Space Manipulation and Assembly
  - Robotic manipulation in space: assembly and maintenance
  - Grasping and docking techniques for space manipulators
- Human-Robot Interaction in Space
  - Collaborative robots for human space exploration
  - Teleoperation and telerobotics in space missions

This is a generic plan. The precise extension and duration of each chapter will be established during the course

Potential challenges to be addressed by students

- Forward and Inverse Kinematics
  - Implement functions to calculate the forward and inverse kinematics of a robotic manipulator. Students can simulate the movement of a robotic arm in 3D space and compute the end-effector position and orientation given joint angles, or vice versa.
- Trajectory Planning
  - Develop scripts to generate smooth and feasible trajectories for space robotic systems. Students can explore different trajectory planning techniques, such as polynomial or cubic splines, and visualize the robot's motion through various waypoints or obstacles.
- Robot Control
  - Implement a PID controller to regulate the motion of a space robot. Students can experiment with different control gains and observe the effects on the robot's response to external disturbances or desired trajectories.
- Sensor Fusion
  - Fuse data from multiple sensors, such as cameras and IMUs, for perception and localization in space robotics. Students can develop algorithms to perform sensor calibration, sensor fusion, and generate 3D maps or estimate the robot's pose.
- Simulating Planetary Rover
  - Create a simulation environment for a planetary rover exploring a terrain. Students can program the rover's navigation and path planning algorithms, incorporating constraints to optimize its exploration path.
- Image Processing and Object Recognition
  - Utilize image processing to implement algorithms for object recognition and tracking in space robotics. Students can implement techniques like feature extraction, template matching, or machine learning algorithms to detect and track objects in simulated space environments.
- Path Planning and Obstacle Avoidance
  - Implement algorithms for path planning and obstacle avoidance in space robotics. Students can implement algorithms like potential fields, RRT (Rapidly-Exploring Random Trees), or A* search to find collision-free paths for the robot in complex environments.

Assessment

- P Component
  - 2 mini-projects throughout the semester
- TP component
  - Written test in the end of the semester
- Final Grade = 2P/3 + TP/3

Examples of potential mini-project assignments

- **On-Orbit Satellite Servicing**
  - Create a scenario where a malfunctioning satellite in orbit needs servicing using space robotics.
    - Students can design and simulate a mission to repair or replace a faulty component on the satellite using a robotic arm.
    - The use case can involve tasks such as satellite capture, alignment, and fastening.
    - Students can develop control algorithms to perform precise manipulation tasks in a simulated microgravity environment, considering factors like joint limitations, dynamics, or communication latency.
- **Lunar Rover Exploration**
  - Design and simulate a lunar rover mission using a software like MATLAB.
    - Students can create a virtual lunar environment with rough terrain, craters, and obstacles.
    - The use case can involve developing algorithms for autonomous navigation, terrain mapping, obstacle detection and avoidance, and sample collection.
    - Students can implement path planning techniques to optimize the rover's trajectory and analyze the efficiency of their algorithms in a simulated lunar exploration scenario.

These are only indicative examples. The actual projects will be defined later.

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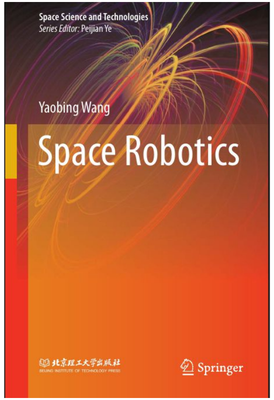

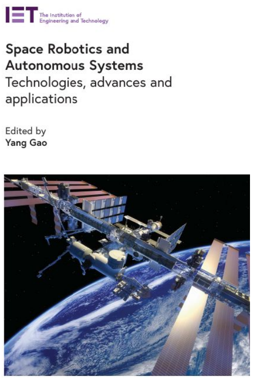

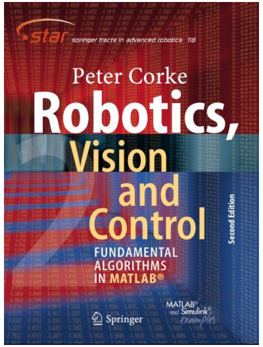

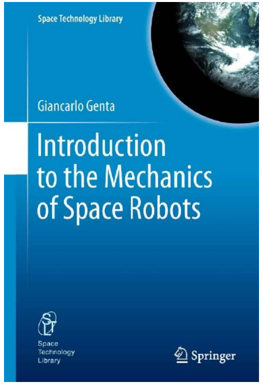

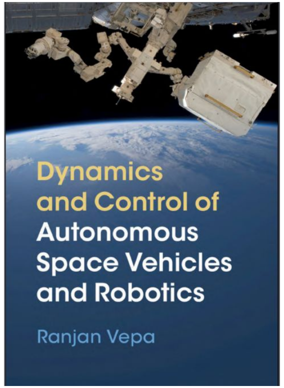

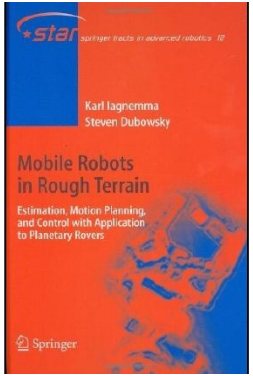

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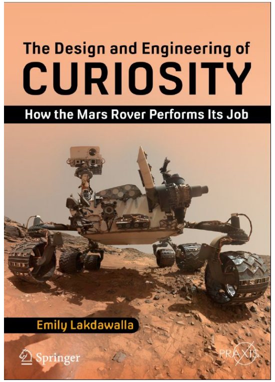

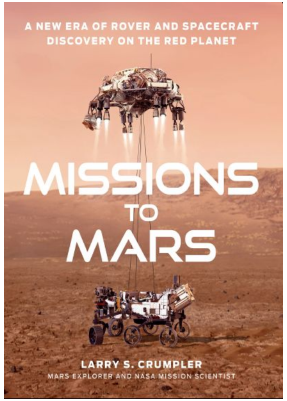

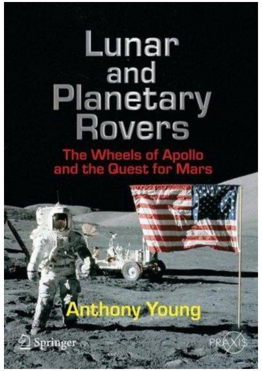

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