Introduction to Humanoid Robotics

The field of humanoid robotics has seen a remarkable evolution over the past 25 years, beginning with the developments of pioneering humanoids including Honda's ASIMO and Boston Dynamics' Atlas. More recently, companies like Tesla, Figure, and many of Chinese firms have further advanced the capabilities of humanoid robots, pushing the boundaries of what these systems can achieve. These milestones have sparked widespread interest in humanoid robots, particularly in applications ranging from companion robots in homes to rescue robots in hazardous environments. This growing fascination underscores the need for a robust education in humanoid robotics to meet the increasing demand for innovation and research in this field.

This course offers a comprehensive introduction to both foundational knowledge and cutting-edge research topics in humanoid robotics, with a special focus on humanoid systems and whole-body motions. Students will explore the principles of humanoid systems, engage with simulation tools, and apply their learning through hands-on assignments and a final project. By the end of the course, students will have a thorough understanding of the complexities involved in designing, controlling, and interacting with humanoid robots.

Course Schedule:

- **Weeks 1–2:** Introduction to humanoid robotics course and basic knowledge. Overview of humanoid robot systems.
- **Weeks 3–4:** Introduction to toy-sized robots and the use of simulation tools to support assignments and projects. Practical sessions to familiarize students with these tools.
- **Weeks 5–7:** Kinematics and dynamics of legged locomotion, including simple models for bipedal walking and advanced control algorithms. Focus on the principles behind stability and movement.
- **Week 8:** Hierarchical approaches to motion control. Techniques for generating complex movements for humanoid robots.
- **Week 9: Spring Break**
- **Week 10:** Project Pitch. Students will pitch their projects, outlining goals, methods, and expected challenges.

- **Weeks 11–14:** Motion data and its application in humanoid robots, humanoid perception, manipulation, localization, navigation, and human-humanoid interaction.
- **Week 15:** Final project presentations. Students will present their projects, demonstrating their ability to apply concepts learned throughout the course.
- **Week 16:** Robot return and wrap-up.

Grading:

- **Reading Papers:** 20%
  Students will be assigned one research paper per week, totaling approximately 10 papers over the course. These papers will be discussed in the following class sessions to facilitate understanding and stimulate in-depth discussions on key topics.
- **Assignments:** 35%
  There will be 4 assignments throughout the course that focus on using the robot kit and simulation tools. These assignments will require practical application of the concepts learned in class.
- **Project:** 45%
  The project is an open-ended research project where teams choose their topics through discussions with team members and instructors. The project has the following deliverables:
    - **Proposal and Proposal Pitch (10%)**: A 1-2 page proposal, including a statement of the problem, literature survey, potential solution, and timeline. Teams will also deliver a proposal.
    - **Progress Report (10%)**: A 2-page progress report outlining the team's progress, including any adjustments to the project.
    - **Project Presentation (10%)**: A final presentation showcasing the results of the project.
    - **Final Report (15%)**: A final report in IEEE conference paper style, summarizing the research and results.

There will be no traditional exam in this course.