Vision-Guided Cooperative Object Manipulation with Humanoid Robots

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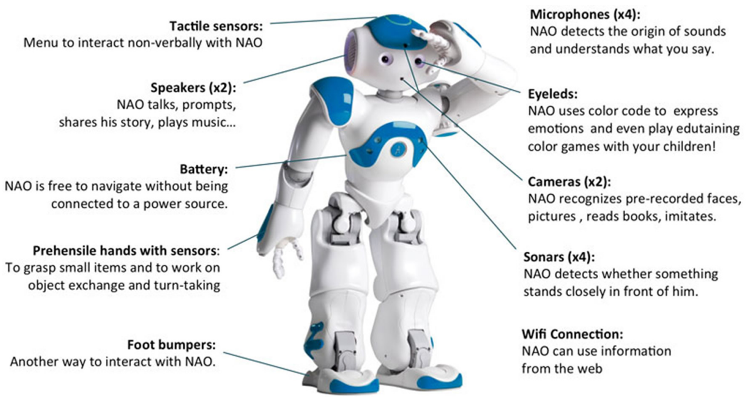
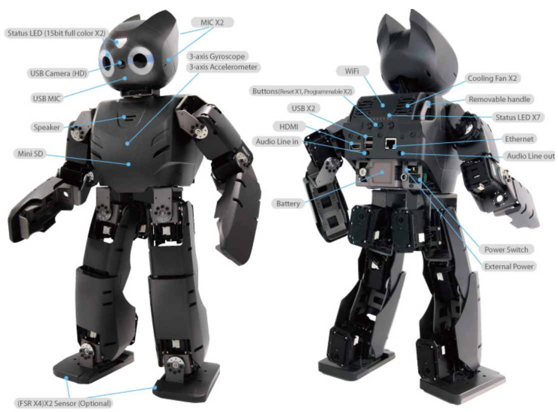
INTRODUCTION

The field of humanoid robotics is experiencing a shift from academic research on biped locomotion and stability to real-world applications, driven by the integration of robotics engineering and artificial intelligence (AI). Designed to resemble and mimic human behavior, these robots find several applications, including manufacturing, customer service, education and healthcare. The lastest developments point to the rapid growth of humanoid technology provided by companies like Boston Dynamics, Tesla, and Toyota, and startups like Agility Robotics and Figure AI. While these advancements show the potential of the technology, more accessible and affordable platforms, like the NAO [1] and the Darwin-OP [2] humanoid robots, offer suitable testbeds for exploring topics in the intersection of robotics and machine learning, such as vision/tactile-based grasping, motion planning, action coordination and human-robot interaction.

The NAO robot, a humanoid platform with 25 degrees of freedom, stands 57 cm tall and weighs 10 kg. It is equipped with high-resolution cameras for stereoscopic vision and object recognition, omnidirectional microphones for voice interaction and sound localization, and speakers that enable the robot to communicate with humans. The Darwin-OP is a more compact humanoid platform with 20 degrees of freedom, focused on exploring concepts like bipedal locomotion and control algorithms. It stands 45.5 cm tall and weighs 2.8 kg. Both robots feature Wi-Fi and Ethernet for communication with external computers and other robots.





NAO humanoid robot

Darwin-OP

OBJECTIVES

This dissertation aims to develop a framework enabling collaborative object manipulation by two humanoid robots (1× NAO and 1× Darwin-OP). Machine learning techniques will be explored as a promising approach to address the challenges of object recognition and task allocation. The work will be focused on three objectives:

1. Equip the humanoid robots with capabilities for identifying and manipulating objects in a shared workspace.
2. Design algorithms for the robots to collaboratively plan and execute manipulation tasks, developing strategies for task allocation and implementing communication protocols.
3. Explore methods for human-robot interaction during collaborative manipulation tasks, focusing on communication in both directions (i.e., human to robot and robot to human).

WORK PLAN

The main tasks to be carried out can be summarized in the following points:

1. **Literature Review and familiarization with the humanoid robots:** Conduct an up-to-date review of advancements in the intersection of humanoid robotics and machine learning, focusing on topics such as collaborative manipulation and human-robot interaction. This task will include becoming familiar with the hardware and software of the NAO and Darwin-OP humanoid robots.
2. **Vision-based object recognition and grasping.** The humanoid robots can use their cameras to identify objects and plan effective manipulation, including grasping and/or holding. This task aims to explore techniques for object recognition and manipulation strategies considering object shape and weight. The initial phase will involve simulating these algorithms in a controlled environment, such as Webots, Gazebo, or V-REP.
3. **Developing algorithms for task planning and coordination.** This task focuses on designing strategies for the humanoid robots to decide which does what and how they should approach the collaborative manipulation task. The robots will need to communicate their actions and intentions to each other. High-level task planning and coordination between the humanoid robots can be simulated to refine communication protocols and task allocation algorithms.
4. **Human-robot interaction.** This task will explore how a human can interact with the robots to provide them with instructions or goals for the manipulation task. Conversely, the robots should be able to interact with humans confirming task completion or asking for help.
5. **Dissertation and Documentation.** The final stage involves writing the master dissertation and additional documentation, such as code repositories and reports, to ensure reproducibility and facilitate future research.

REFERENCES

[1] Gouaillier, D., Hugel, V., Blazevic, P., Kilner, C., Monceaux, J., Lafourcade, P., ... & Maisonnier, B. (2009, May). Mechatronic design of NAO humanoid. In *2009 IEEE International Conference on Robotics and Automation* (pp. 769-774). IEEE.

[2] Ha, I., Tamura, Y., & Asama, H. (2013). Development of open platform humanoid robot DARwIn-OP. *Advanced Robotics*, *27*(3), 223-232.