

Unified Autonomy Stack > transition to Humanoid Robots

Abstract: The Autonomous Robots Lab has developed an autonomy stack that has been verified to operate across aerial, ground and partially underwater robots: https://ntnu-arl.github.io/unified_autonomy_stack/

This project aims to extend the application of this stack to humanoid robots, systems expected to dominate in the future of robotics. You will be provided a humanoid robot and the autonomy hardware reference module of the lab with the goal to enable the high-performance integration of the two targeting tasks such as autonomous navigation, exploration, area inspection, and object-level scene reasoning.

The used hardware shall be a Unitree humanoid.

Relevant Projects: Norwegian Centre for Embodied AI, SPEAR



Tasks:

- Study the architecture and components of ARL's Unified Autonomy Stack.
- Analyze the key challenges in transferring autonomy frameworks to humanoid platforms (e.g., locomotion constraints, perception-action coupling).
- Integrate the autonomy hardware module with the humanoid robot platform.
- Adapt perception, mapping, and planning modules for operation under humanoid kinematics and sensing configurations.
- Enable autonomous navigation and exploration in indoor or semi-structured environments.
- Extend capabilities toward object-level understanding and scene reasoning.
- Evaluate system performance in real-world experiments.

Literature (indicative):

- [1] Cao, L., 2025. Humanoid robots and humanoid AI: Review, perspectives and directions. *ACM Computing Surveys*, 58(4), pp.1-37.
- [2] Bjorck, J., Castañeda, F., Cherniadev, N., Da, X., Ding, R., Fan, L., Fang, Y., Fox, D., Hu, F., Huang, S. and Jang, J., 2025. Gr00t n1: An open foundation model for generalist humanoid robots. *arXiv preprint arXiv:2503.14734*.
- [3] Tedrake, R., 2009. Underactuated robotics: Learning, planning, and control for efficient and agile machines: Course notes for mit 6.832. Working draft edition, 3(4), p.2.
- [4] Carpentier, J. and Mansard, N., 2018. Multicontact locomotion of legged robots. *IEEE Transactions on Robotics*, 34(6), pp.1441-1460.
- [5] Unified Autonomy Stack, https://ntnu-arl.github.io/unified_autonomy_stack/

Main supervisor: Kostas Alexis, Professor, NTNU | **Co-supervisor:** Dr. Mihir Kulkarni