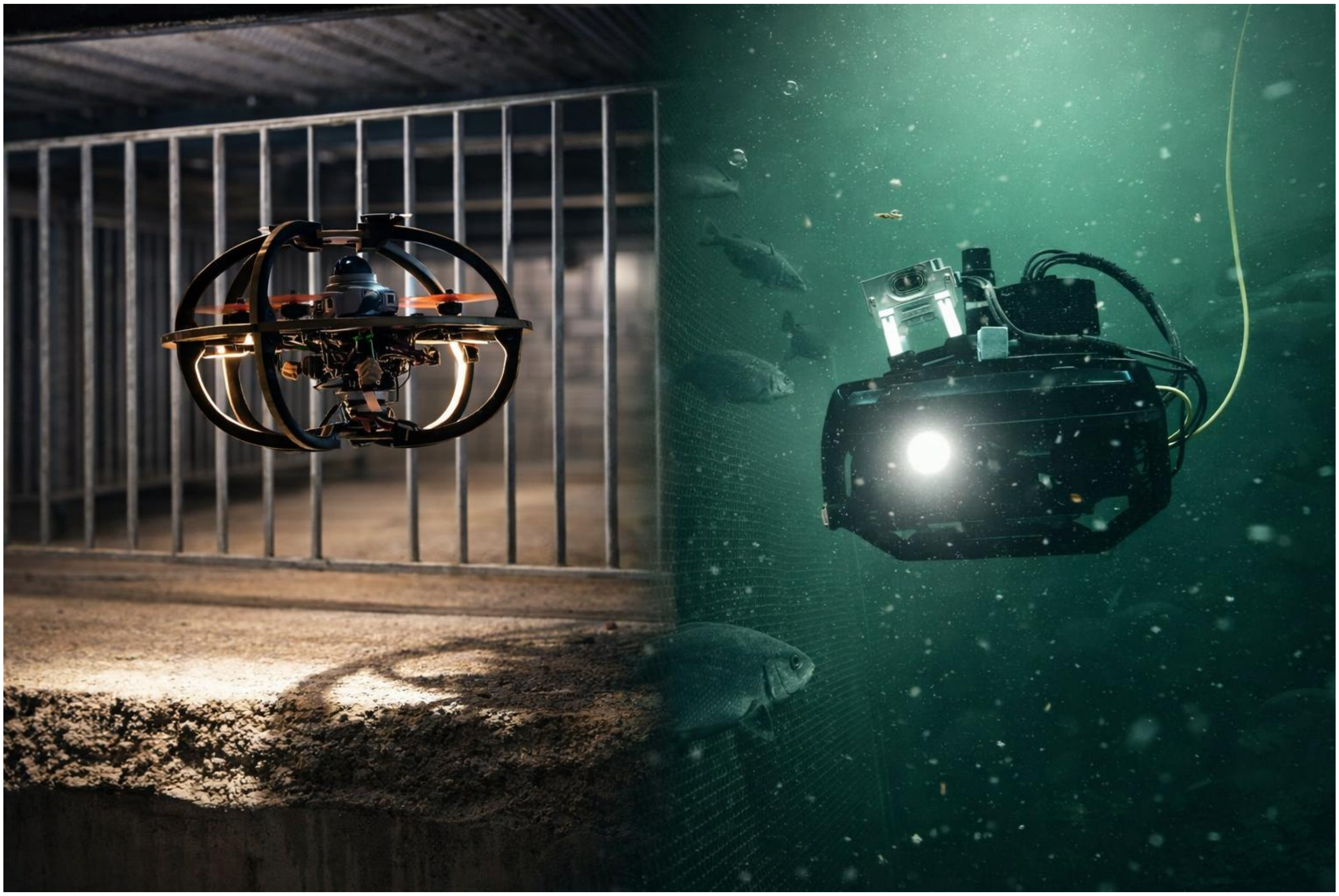
Unified Control for Floating-base Robots

Abstract: Floating-base robots – such as rotorcraft aerial vehicles and underwater ROVs – share a common characteristic: their motion is governed by fully actuated or underactuated dynamics in free space, without direct support contacts. Despite this shared structure, control strategies are typically developed in a robot-specific manner, limiting transferability across morphologies and environments.

This project aims to develop a **unified control policy** for floating-base robots, leveraging recent advances in reinforcement learning and foundation models. The goal is to design a generalist control policy capable of achieving high performance across different robot morphologies by incorporating explicit morphology conditioning. This approach aligns with the broader vision of a unified autonomy architecture capable of generalizing across embodiments while retaining high performance.

The project will explore how shared structure in dynamics and perception can be exploited to enable cross-platform generalization, targeting both aerial and underwater robotic systems.

Relevant Projects: Norwegian Centre for Embodied AI



Tasks:

- Review control methods for floating-base robots (e.g., geometric control, model-based control, RL-based approaches).
- Analyze similarities and differences in dynamics between aerial and underwater systems.
- Design a learning-based control framework with explicit morphology conditioning.

- Implement reinforcement learning pipelines for training control policies across multiple robot types.
- Investigate sim-to-real transfer strategies for robust deployment.
- Integrate the learned controller within ARL's autonomy framework.
- Evaluate performance across different robot morphologies and tasks (e.g., stabilization, trajectory tracking).

Literature (indicative):

[1] Firoozi, R., Tucker, J., Tian, S., Majumdar, A., Sun, J., Liu, W., Zhu, Y., Song, S., Kapoor, A., Hausman, K. and Ichter, B., 2025. Foundation models in robotics: Applications, challenges, and the future. The International Journal of Robotics Research, 44(5), pp.701-739.

[2] Kawaharazuka, K., Matsushima, T., Gambardella, A., Guo, J., Paxton, C. and Zeng, A., 2024. Real-world robot applications of foundation models: A review. Advanced Robotics, 38(18), pp.1232-1254.

[3] Hu, Y., Xie, Q., Jain, V., Francis, J., Patrikar, J., Keetha, N., Kim, S., Xie, Y., Zhang, T., Fang, H.S. and Zhao, S., 2023. Toward general-purpose robots via foundation models: A survey and meta-analysis. *arXiv preprint arXiv:2312.08782*.

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