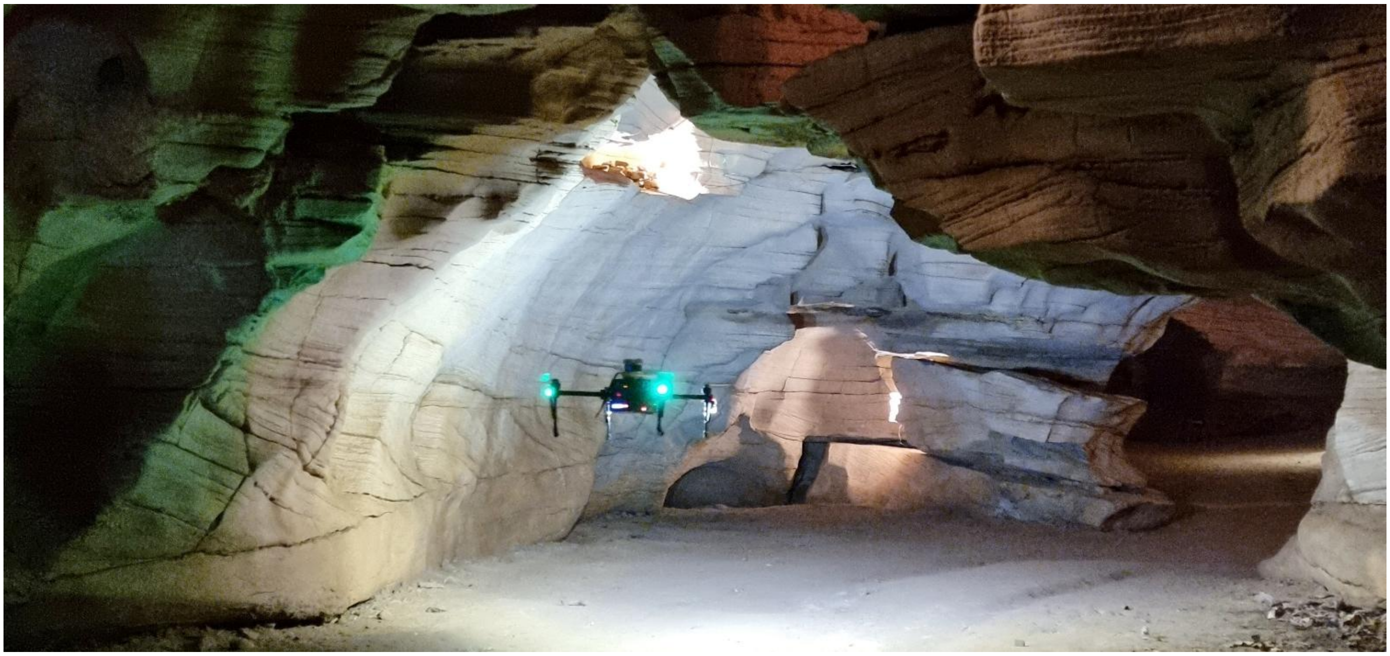
Very-Long-Range Vision-based Navigation for Aerial Robots

Abstract: Conventional visual- and visual-inertial methods for odometry estimation on aerial robots perform well in short-range missions, typically below few kilometers. Simultaneously, they are mostly verified with the robot/camera observing the scene from close proximity. On the other hand conventional vision-based localization for larger systems - such as in the defense domain - relies on a priori known maps on which localization takes place. This work targets the development of a (a) robust and (b) high-performance Visual-Inertial Odometry solution for fixed-wing UAVs capable of flying missions in the range of 20-50km with minimal error. We aim to investigate the collective potential from increased camera sensors, high-performance yet increasingly more low-cost MEMS IMUs, time-synchronization and importantly high-quality visual registration especially through progress in deep learning.

Relevant Projects: Norwegian Centre for Embodied AI, SPEAR, AUTOASSESS



Tasks:

- Review state-of-the-art visual-inertial odometry methods and their limitations in long-range scenarios.
- Analyze sources of drift and failure in long-duration, high-speed fixed-wing flight.
- Design and implement a multi-camera VIO system for improved robustness and field-of-view coverage.
- Investigate the role of high-quality IMU data and tight time synchronization in long-range estimation.
- Explore learning-based visual registration methods for improved feature matching across large viewpoint changes.
- Integrate the system within ARL's autonomy framework.
- Evaluate performance in simulation and real-world datasets, targeting long-distance trajectories.

Literature (indicative):

[1] Cadena, C., Carlone, L., Carrillo, H., Latif, Y., Scaramuzza, D., Neira, J., Reid, I. and Leonard, J.J., 2017. Past, present, and future of simultaneous localization and mapping: Toward the robust-perception age. IEEE Transactions on robotics, 32(6), pp.1309-1332.

[2] Ebadi, K., Bernreiter, L., Biggie, H., Catt, G., Chang, Y., Chatterjee, A., Denniston, C.E., Deschênes, S.P., Harlow, K., Khattak, S. and Nogueira, L., 2023. Present and future of SLAM in extreme environments: The DARPA SubT challenge. IEEE Transactions on Robotics, 40, pp.936-959.

[3] Carlone, L., Kim, A., Barfoot, T., Cremers, D. and Dellaert, F., 2025. Slam handbook: From localization and mapping to spatial intelligence. [4] Carpentier, J. and Mansard, N., 2018. Multicontact locomotion of legged robots. IEEE Transactions on Robotics, 34(6), pp.1441-1460.

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