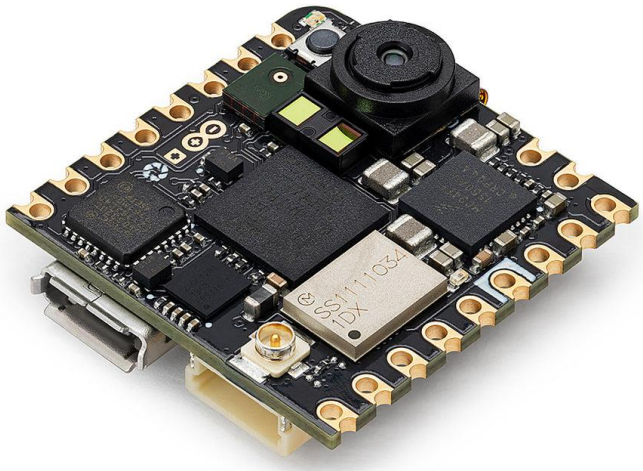
Tiny Visual-Inertial Odometry System

Abstract: Visual-inertial odometry systems have long been researched with significant success. Exploiting relevant advances in vision systems and processors, as well as breakthroughs in the knowledge domains of state estimation and computer vision, the community has developed robust and high-performance visual-inertial estimation systems presenting drift that grows as slowly as 1% over the robot path. However, such systems are often computationally demanding and they rely on high-quality camera sensors. This prohibits the potential for their ubiquitous utilization in particularly miniaturized systems. In this project you are asked to develop a miniaturized visual-inertial system that exploits an integrated system that offers a monocular camera, an Inertial Measurement Unit, a 1D distance sensor (time-of-flight), alongside a processing solution integrating 1x Arm® Cortex® M7 @ 480 MHz and 1x Arm® Cortex® M4 core @ 240 MHz. Your solution should fit well in the M7 core of this system and perform visual-inertial odometry at 20FPS.



Tasks:

- Study visual-inertial odometry literature.
- Understand what components are the most computationally demanding and accordingly design or modify a certain Visual-Inertial Odometry (VIO) algorithm such that it would fit in the provided constraints.
- Implement this "Tiny VIO" algorithm in the provided hardware.
- Study the effects of reduced camera quality in visual-inertial odometry.
- Derive a dataset with ground-truth (use systems of our lab) and provide an assessment on the performance of the developed Tiny VIO system.

Literature (indicative):

[1] Mourikis, A.I. and Roumeliotis, S.I., 2007, April. A Multi-State Constraint Kalman Filter for Vision-aided Inertial Navigation. In ICRA (Vol. 2, p. 6).

[2] Li, M. and Mourikis, A.I., 2013. High-precision, consistent EKF-based visual-inertial odometry. The International Journal of Robotics Research, 32(6), pp.690-711.

[3] Bloesch, M., Omari, S., Hutter, M. and Siegwart, R., 2015, September. Robust visual inertial odometry using a direct EKF-based approach. In 2015 IEEE/RSJ international conference on intelligent robots and systems (IROS) (pp. 298-304). IEEE.

[4] Leutenegger, S., Lynen, S., Bosse, M., Siegwart, R. and Furgale, P., 2015. Keyframe-based visual–inertial odometry using nonlinear optimization. The International Journal of Robotics Research, 34(3), pp.314-334.

[5] Forster, C., Pizzoli, M. and Scaramuzza, D., 2014, May. SVO: Fast semi-direct monocular visual odometry. In 2014 IEEE international conference on robotics and automation (ICRA) (pp. 15-22). IEEE.

[6] Scaramuzza, D. and Fraundorfer, F., 2011. Visual odometry [tutorial]. IEEE robotics & automation magazine, 18(4), pp.80-92.

[7] Hesch, J.A., Kottas, D.G., Bowman, S.L. and Roumeliotis, S.I., 2014. Camera-IMU-based localization: Observability analysis and consistency improvement. The International Journal of Robotics Research, 33(1), pp.182-201.

[8] Kottas, D.G., DuToit, R.C., Ahmed, A., Guo, C.X., Georgiou, G., Li, R. and Roumeliotis, S.I., 2014, May. A resource-aware vision-aided inertial navigation system for wearable and portable computers. In 2014 IEEE International Conference on Robotics and Automation (ICRA).

Main supervisor: Kostas Alexis, Professor, NTNU