LINK-SIC — Autonomous Navigation

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Background

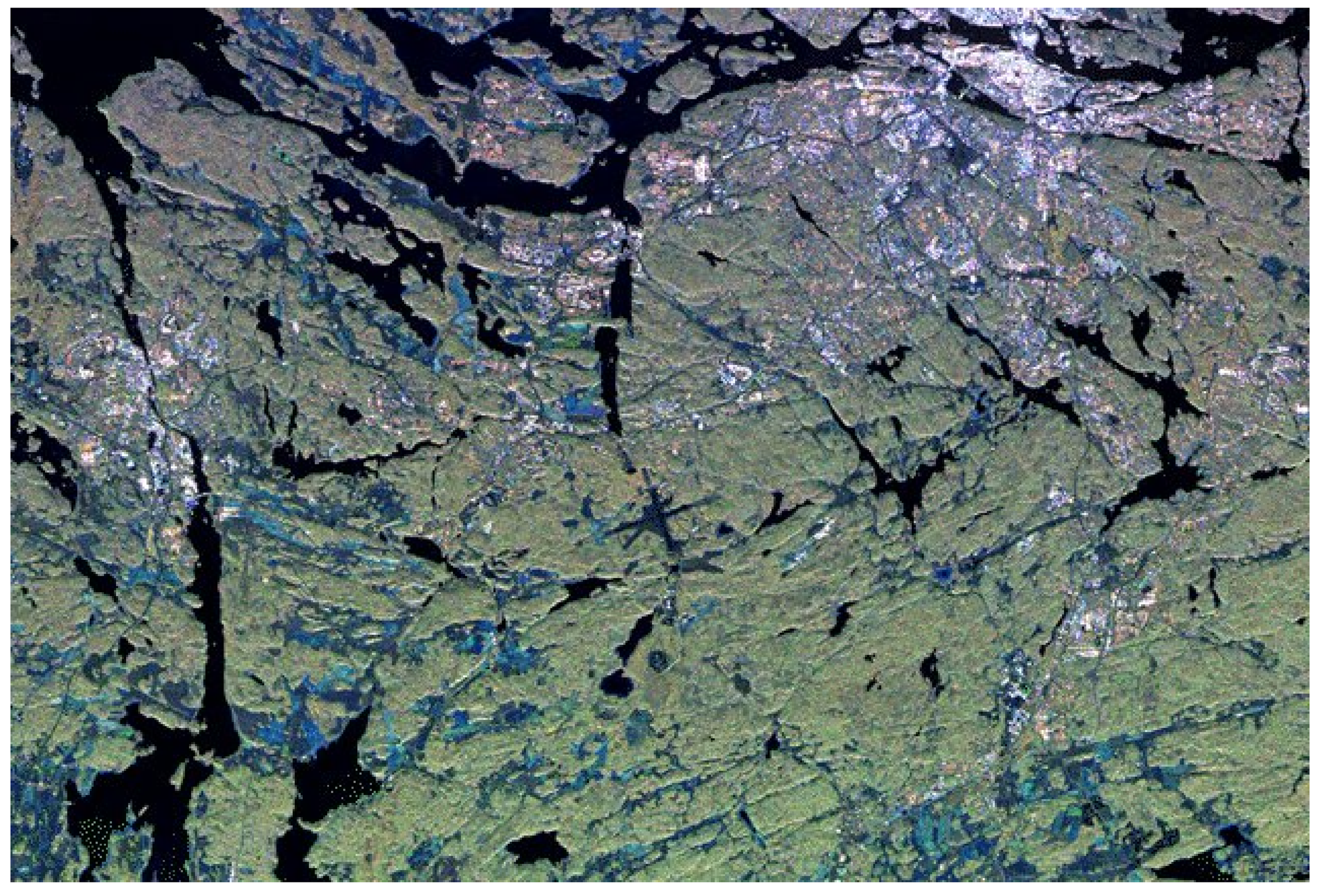
There are often very high demands on systems in aerospace applications and therefore, it is not surprising that many challenging research problems can be found in this area. Within LINK-SIC, research concerning aerial vehicles will be conducted in several joint projects between Saab AB and Linköping University.

Autonomous Navigation

There are several aspects of unmanned aerial vehicles (UAVs) that make them an interesting research topic. For example, a UAV navigates by integrating its on-board inertial sensors (accelerometers and gyros) to a position and orientation. Normally, the inherent drift in dead-reckoning systems is bounded by sensor fusion with satellite navigation (GPS) measurements, which provide the absolute position. There is a well-recognized need for support and backup systems in case GPS is not available, in particular to reach the requirements on integrity and accuracy for use in civil applications. To reach this goal, the navigation system should be able to estimate the position without infrastructure on the ground. Fusion with geographical information systems is one approach to solving this problem, and has been an area of active development at Saab and research at Linköping University. Simultaneous Localization and Mapping (SLAM) is an extension of this, where the GIS is created on the fly. This topic will be studied from different viewpoints in two LINK-SIC projects.

Imaging Sensors for UAV Navigation

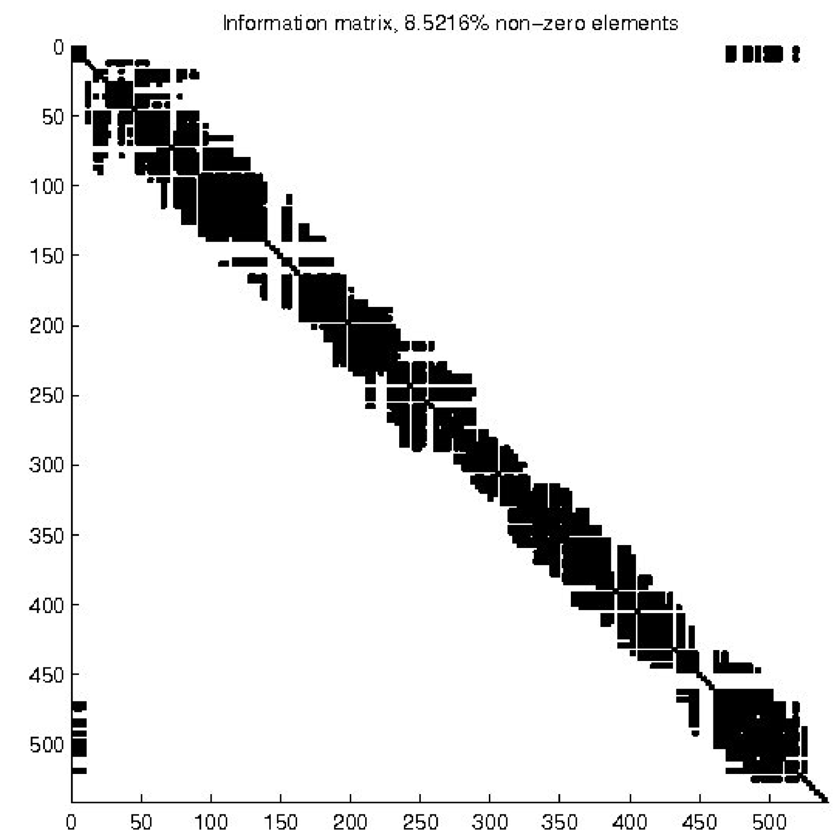
For both the SLAM and GIS based approaches to autonomous UAV navigation, an imaging sensor is needed. The two alternatives that will be examined in this project are electro-optical (EO) sensors (cameras) and radar. The TERNAV system, which is used in Gripen today, is an example of how a radar altitude is compared to a terrain altitude profile to compute the position of the vehicle. A radar can also be used to create a high-resolution image using the synthetic aperture radar (SAR) concept. The idea is that the motion of the platform is used to increase the aperture angle of the radar sensor, such that the resolution in the resulting image is much better than the radar lobe that hits the ground in each measurement. The obtained image is at first glance similar to a gray-scale image, but it has a number of distinctive features: it works in all weather conditions (clouds, rain, snow, fog, darkness), it is sensitive to texture in contrast to a EO image, etc. The project aims at investigating different aspects of EO and SAR images for UAV navigation.



Open Questions

- SAR requires accurate information of speed and azimuth angles. With cheap sensors and a small platform, the estimation inaccuracy is not negligible. How does the quality of a SAR image depend on ego-motion parameters?
- SAR has a high potential in recognizing ground vegetation areas of different types. Can this information be compared to a GIS? Potentially, if a planar region is correctly associated between GIS and SAR, all six degrees of freedoms can be computed.
- Correct landmark association is an important step in SLAM, and robust features that are easy to recognize is an important research issue. Airborne pictures is a new application area of SLAM, so this is an open problem. One question is how to represent landmarks: feature points, image patches, lines or line polygons. More advanced features require more memory and computations, but facilitate association.

SLAM for UAV Navigation



This project aims at examining the potential of SLAM for UAV navigation. SLAM is a landmark-based algorithm suitable for electro-optical (camera) sensors, where local features in the image are used as temporal landmarks. These stabilize the drift in the dead-reckoning system, and if the so-called loop closure problem can be satisfactorily solved when the UAV comes back to a previously visited position, then potentially all drift can be removed. Another advantage with SLAM is the mapping module which by itself can be used for exploration missions. In his master thesis project, Martin Skoglund used the SEIF-SLAM algorithm by Sebastian Thrun. This resulted in a implementation that is ready for usage in Saab's simulators.

Open Questions

- Comparison of the Kalman filter based SEIF and particle filter based fastSLAM algorithms. Application to real data from the MOVIII project.
- Map handling becomes important when the number of feature points increases to thousands and even higher order of magnitudes. There are many suggestions in literature, but which are best suited for airborne applications?
- Distinction of stationary landmarks and moving targets is important. If this can be solved, the idea of joint implementation of SLAM and target tracking can be solved.