Autonomous Navigation Support from Real-Time Visual Mapping

SARC Conference 2020

Daniel Sabel, dosabel@kth.se

Drones today

- Rapid development of drone technologies in last decade
- Examples of drone use today
  - support search and rescue,
  - situation assessment after natural disasters,
  - support law enforcement,
  - delivery of medical supplies.

Image credit: Zipline

Drones in the future

- Autonomous and ”intelligent” drones will provide societal benefits in future, such as
  - Autonomous drone swarms searching for missing people
  - Continuous monitoring and early warning of forest fires

Autonomous navigation

- Safety is crucial
- Currently relies heavily on
  - GPS and other Global Navigation Satellite Systems
  - inertial measurements
- GPS not always reliable
  - signal obstruction and multipath issues
  - radio frequency interference – also intentional
- Inertial measurements inaccurate for long-range flights
  - Provides relative position and attitude
  - Continuously accumulates errors

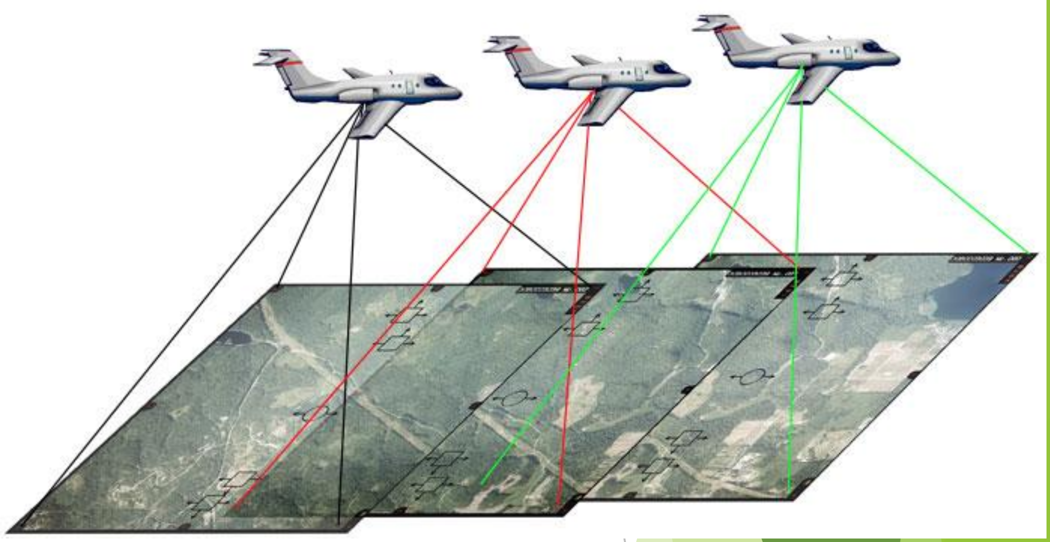
Our project

- Cooperation between Spacemetric AB and KTH in Stockholm
- Supervisors
  - KTH: Prof. Atsuto Maki
  - Spacemetric: Dr. Torbjörn Westin
- Scope
  - Track position and attitude of autonomous drones,
  - in outdoor GPS-denied situations,
  - with visual methods based on on-board sensors

Visual methods for localisation

- Visual methods exploit what the vechicle “sees”
- Rooted in photogrammetry and computer vision
- Previous research has focussed on
  - autonomous cars
  - urban environments
  - indoor environments
  - short-range drone flights (order of magnitude of 1 km)
- Less attention on “long-range” drone flights (>10 km) and diverse natural environments

Research topic



Real-time pose estimation with visual odometry

- Matches overlapping images taken by on-board camera,
- to estimate change of position and attitude relative previous image
- Challenges include
  - Minimizing accumulated errors in position, attitude and scale
  - Weak image texture and repetetive content
  - On-board real-time processing constraint
- Research focus
  - Reliability in low-populated areas (such as forests and farmland)
  - Both traditional image matching and machine learning approaches
  - GPU-processing for real-time performance

Image credit: duspviz.mit.edu

Research topic

Registration of drone images against satellite/aerial images

- Matches images from on-board camera against georeferenced satellite or aerial images,
- to estimate absolute position and attitude
- Not affected by accumulative drift errors
- Challenges include differences between drone image and reference image
  - seasonal vegetation changes
  - illumination, shadows
  - different camera perspectives
- Research focus
  - reliable and accurate image matching using machine/deep learning
  - on-board processing performance

Research topic

Terrain-aided pose estimation

- Can reliability be improved by exploiting 3D structural information?
- 3D point clouds computed on-board from drone images using motion stereo,
- Match against ground reference data such as Digital Terrain Model,
- to estimate absolute position and attitude
- Challenges include
  - Real-time computation of point clouds
  - Differences in structure e.g. due to construction or vegetation growth
- Research focus
  - Methods for matching point clouds with ground reference data
  - On-board generation of point clouds from drone imagery

Research topic

Synthetic Aperture Radar-supported pose estimation

- Synthetic Aperture Radar – high resolution imaging radar
- Would provide day-and-night all-weather capability
- Challenges include
  - Very different image content and geometry compared to optical imagery
  - Complex data processing
- Research focus
  - How to accurately match radar image with ground reference data?
  - Which ground reference data is most appropriate?

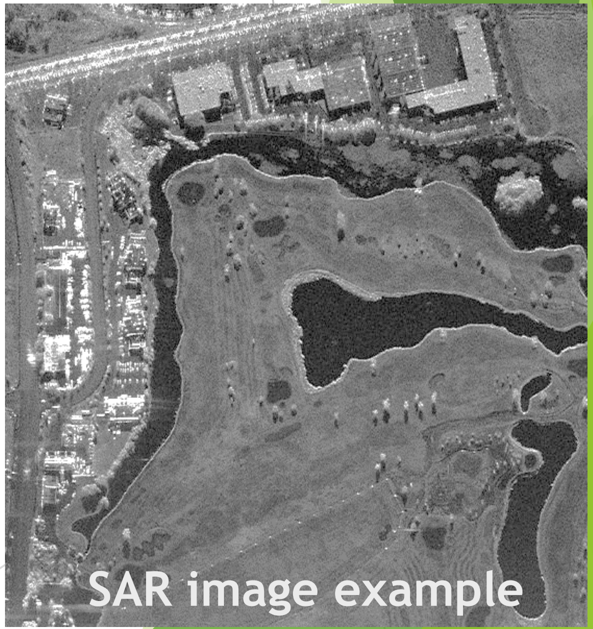


Image credit: IMSAR

Project goals

- A foundation for developing reliable vision-based navigation systems
- First publication expected early next year
- Project to conclude with proof-of-concept demonstration

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