UGV and UAV collaboration in an autonomous infrastructure scenario

Master thesis - Bibliography

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January 14, 2017

Advanced Robotics

- Different types of robots -> Different mobility
- Additional abilities -> Different view points of same object
- Decentralized approach -> Swarms
- Virtual loop closures -> Revisiting a certain place at different time and/or by a different unit

- Autonomous infrastructure
- Current developments
- Major programmes in place

01-robot-collaboration

- Robot collaboration
- UGV – Unmanned ground vehicle
- UAV – Unmanned air vehicle
- Process of coordinated actions performed by robots towards a specified goal
- Vehicle designed without support systems for humans, capable of similar performance as a manned vehicle

01-robot-collaboration **01-ugv**

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01-robot-collaboration 01-ugv 01-uav

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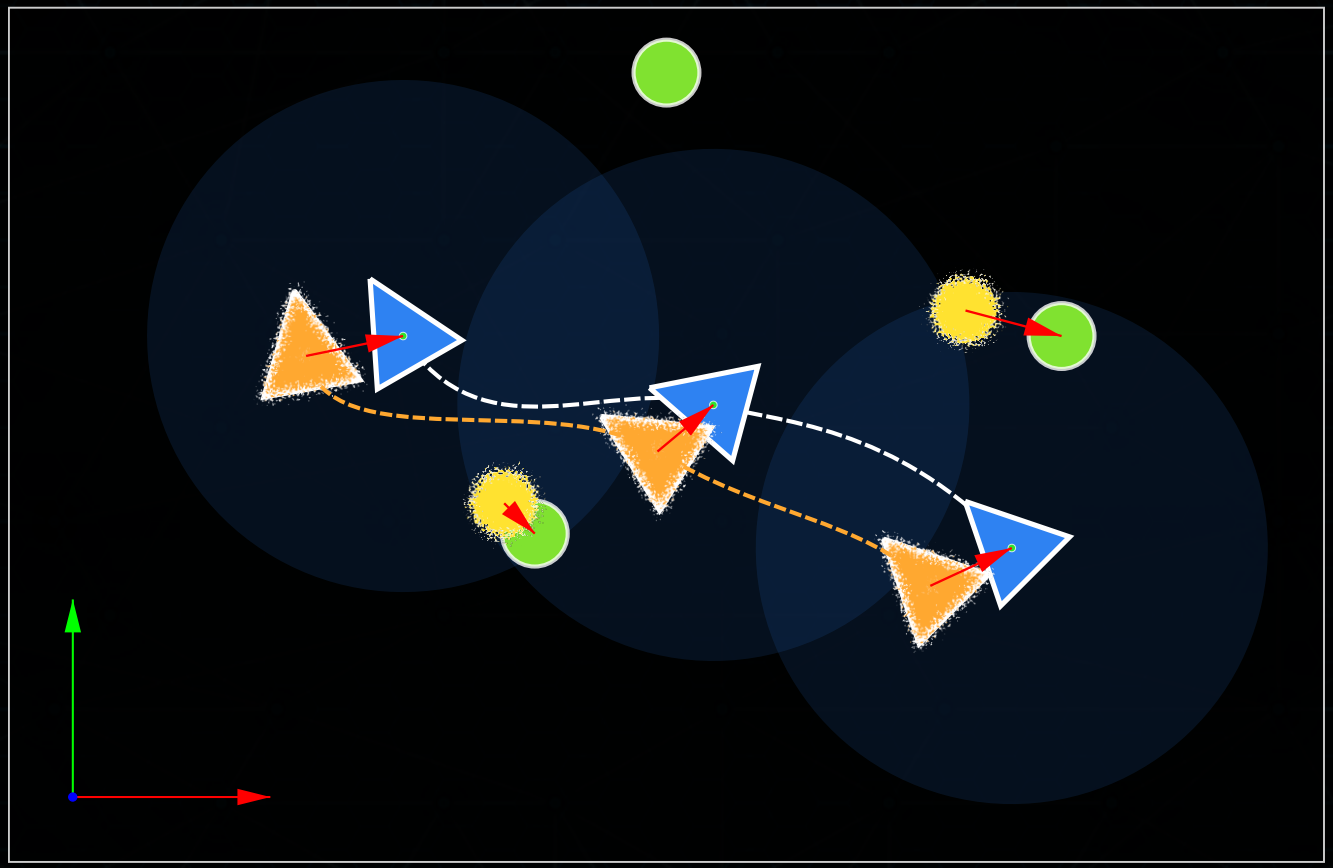
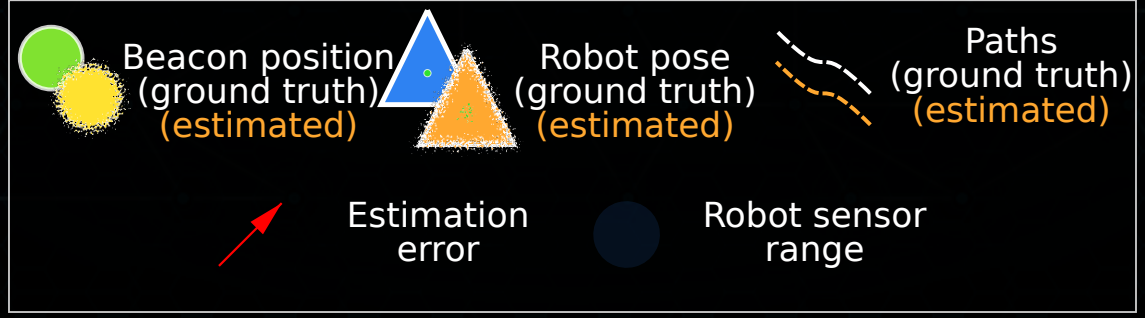
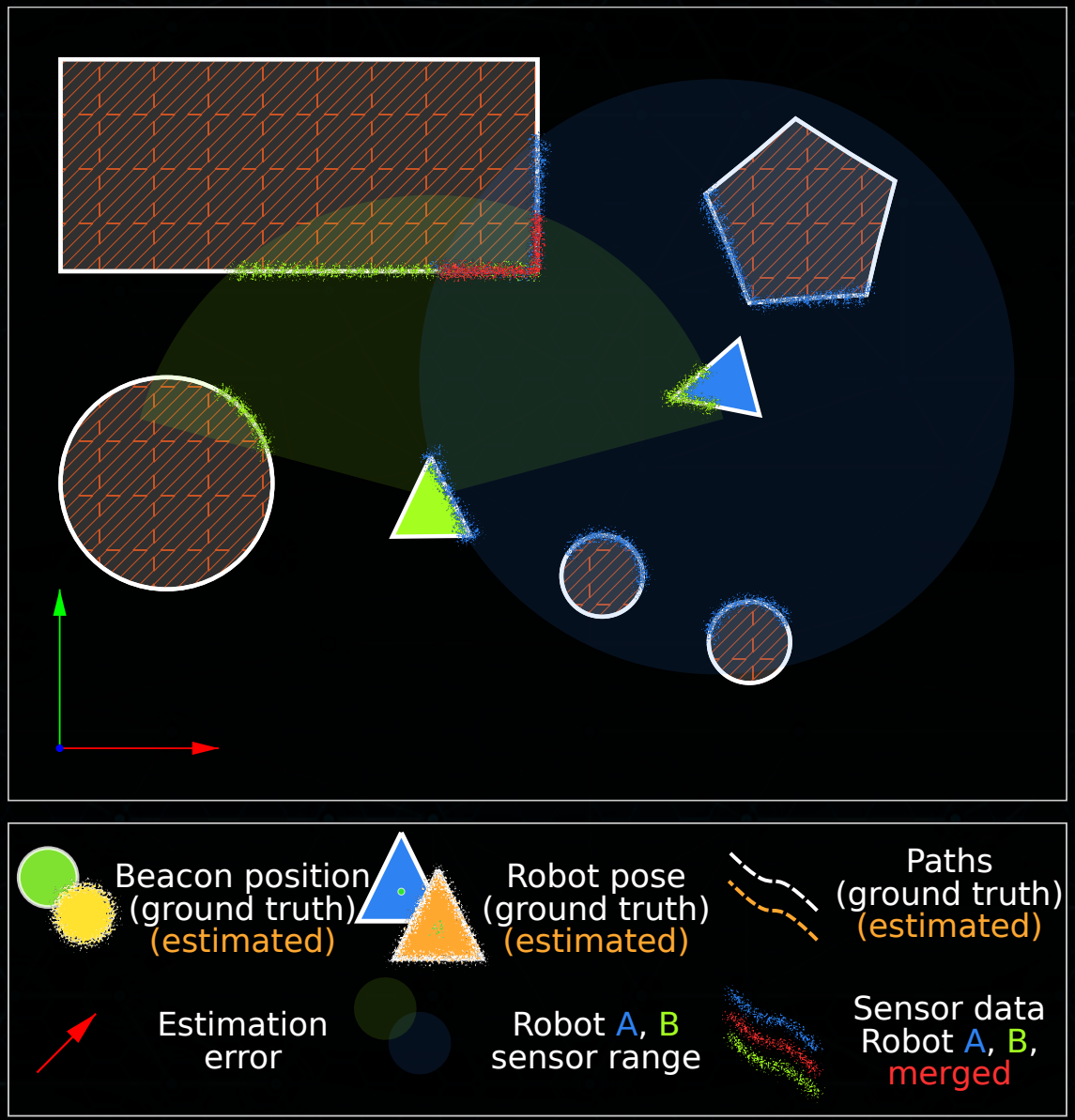
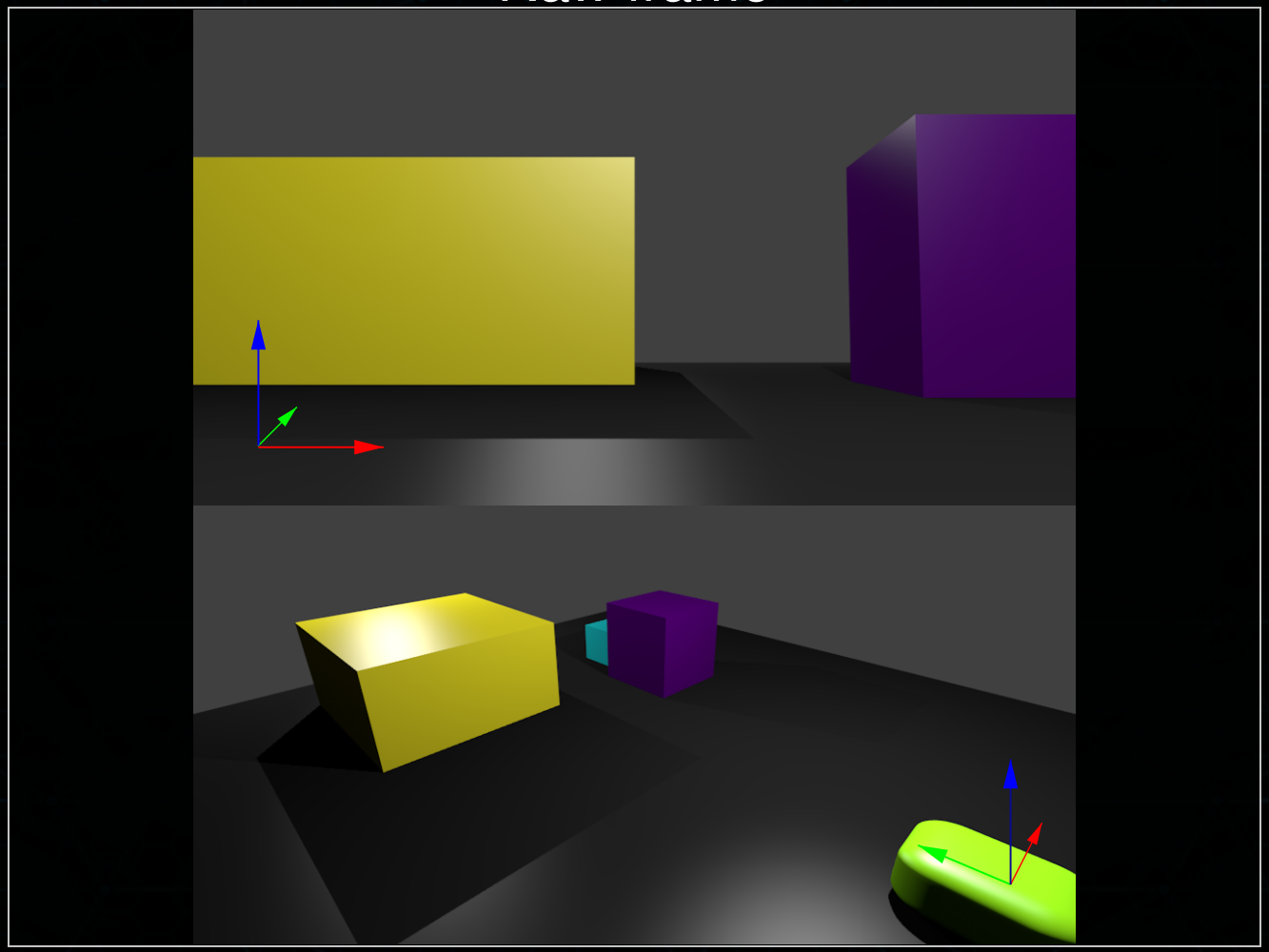
SLAM– *S*imultaneous *l*ocalization *a*nd *m*apping



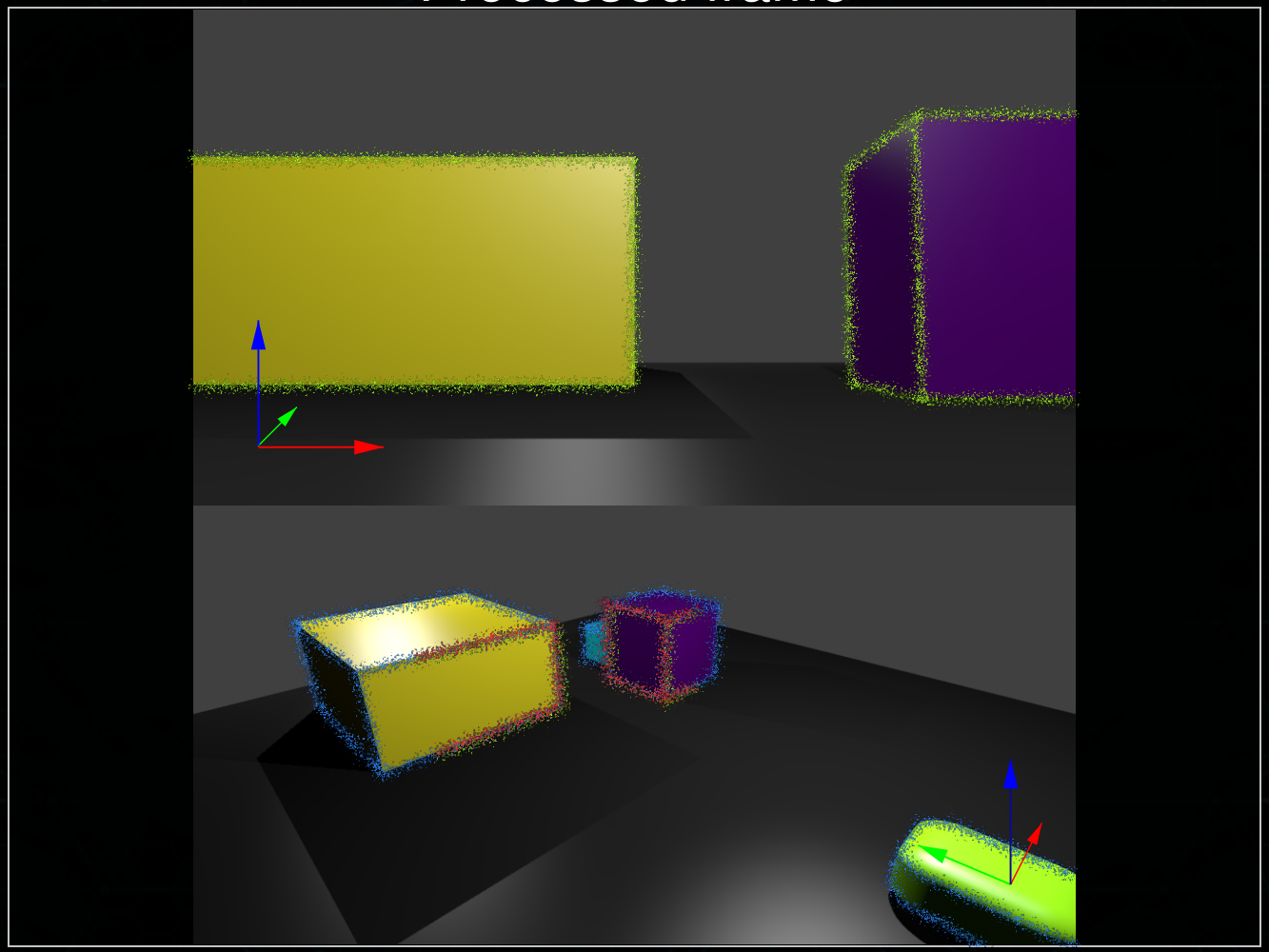



Beacon position
(ground truth)
(estimated)
Robot pose
(ground truth)
(estimated)
Paths
(ground truth)
(estimated)
Estimation
error
Robot A, B
sensor range
Sensor data
Robot A, B,
merged

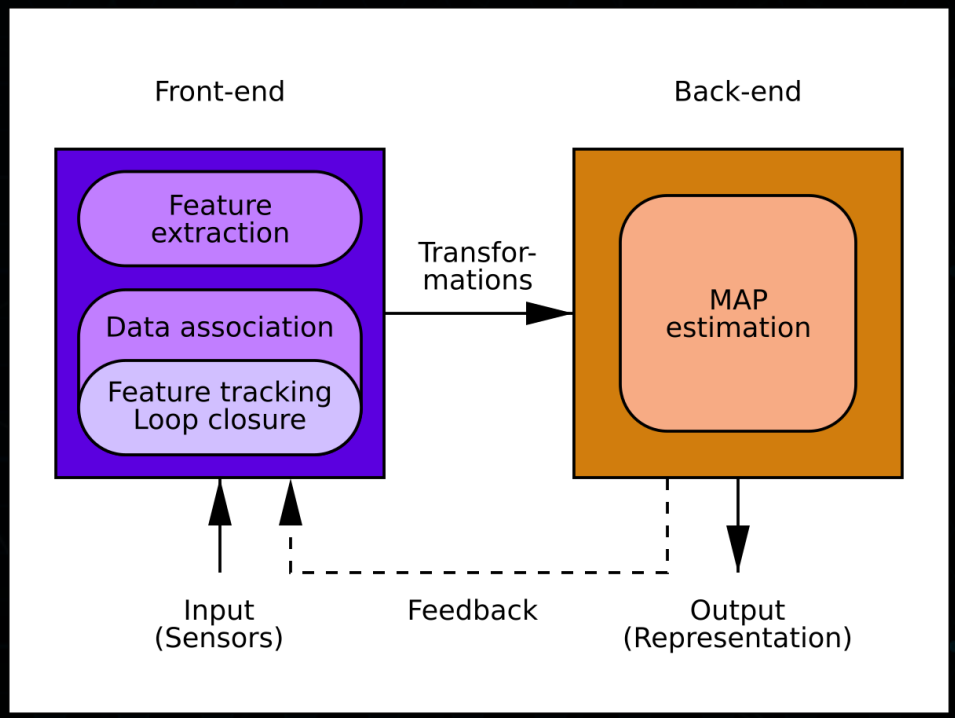
Raw frame



Processed frame



- Anatomy of SLAM systems
  - Front-end
    - Feature extraction
    - Data association
  - Back-end
    - Map estimation



- Dense – Full resolution of sensors used
- Sparse – Feature detection and extraction
- Semi-Dense/Semi-Sparse – A combination between dense and sparse approaches

- MAP (Maximum a posteriori) estimation
- Often used with *factor graph formalism*
- Usually feeds back information to front-end

- Sensor dependent preprocessing
- Feature or regions of interest detection and extraction
- Association of measurement to landmarks

- Metric representations
  - Sparse representation based on landmarks
  - Low level raw dense representation
  - Boundary and spatial partitioning dense representation
  - High level representation based on objects
- Metric representations

1. Long term autonomy
   - Robustness
     - Harsh environments
     - Noisy environments
     - Dynamic environments
   - Scalability
2. Representations

1. Robustness
   - Failsafe SLAM and recovery
   - Robustness to hardware failure
   - Metric relocalization (shortcomings of cameras - lightning conditions)
   - Time varying and deformable maps
   - Automatic parameter tuning
2. Representations
   - High level expressive representation
     - Map compression
     - Large scale mapping
     - Higher description of objects
     - Interaction with existing standards
3. Optimal representation Automatic and adaptive representation

ugv turtlebots uav pelican

Collaborative visual SLAM framework

- Keyframes representation with camera pose
- Centralized approach
- Same or similar type of robots
- Each unit performs monocular SLAM
- Global map at central processing unit

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10-centralized-multi-slam-approach

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1. Visual SLAM:
   - LSD SLAM (*L*arge-Scale *S*emi-Dense *D*irect Monocular SLAM)
   1. Tracking
   2. Depth map estimation
   3. Map management and optimization
2. Place recognizer
   - FAB-MAP (*F*ast *A*ppearance-*b*ased *Map*ping)
   - Virtual loop closure
3. Map merge
   1. Initial transformation estimate (Horn's method)
   2. Refining estimate using Sim3 tracker
   3. Correction using ICP (*I*terative *C*losest *P*oint)
   4. Global map update
   5. Overall feedback system
      - Virtual loop closures
      - Updated maps transferred to all units

- Offline approach
- Consecutive images with a different translation and rotation as input
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- Rendezvous
- Storage issue
- Communication issue

Thank you for your attention

Please state your questions