

Online large-scale SLAM with stereo visual-inertial sensors

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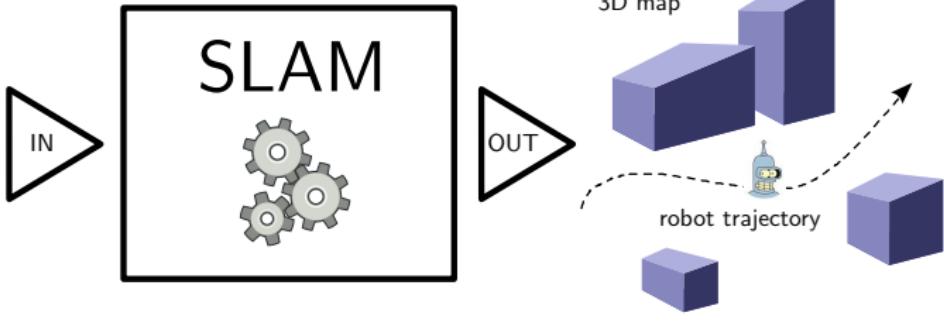
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich



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Our mission

Stereo image input



Required capabilities:

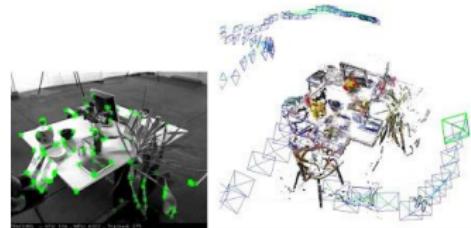
- ▶ Tracking (Landmark generation, Odometry)
- ▶ Local mapping (Key frame generation, Loop closing)
- ▶ Global mapping (Solving SLAM problem)

Related work and state of the art

Google (street) mapping



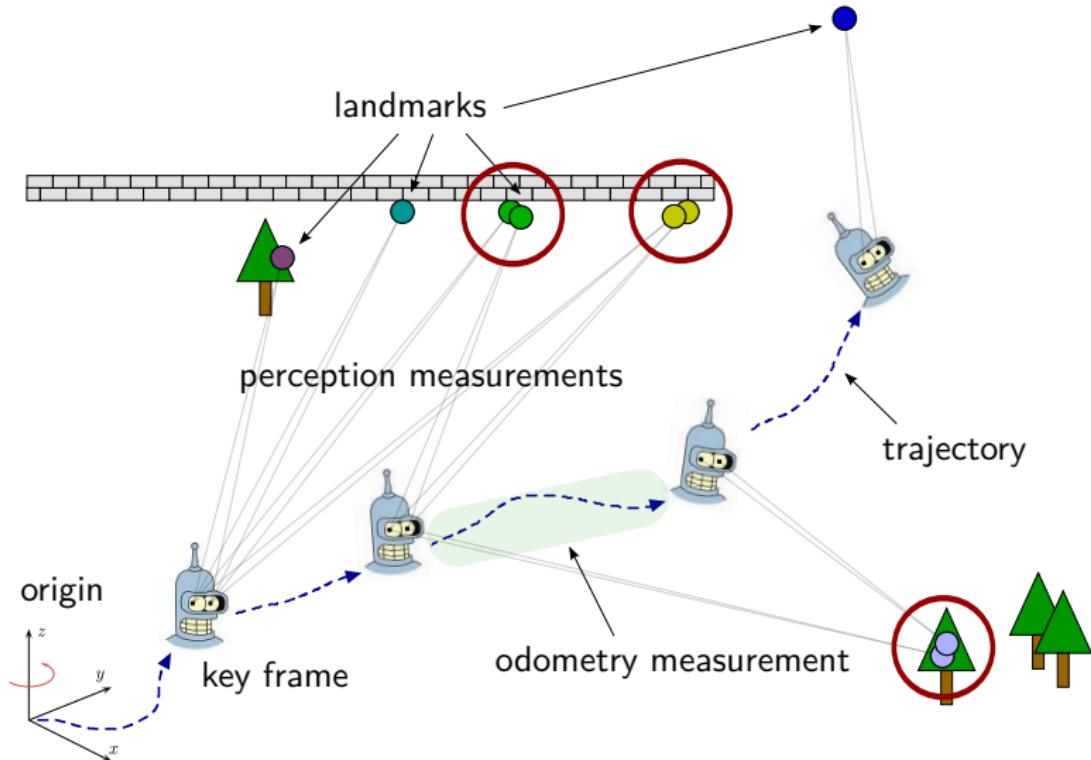
ORB-SLAM (Mur-Artal et al)



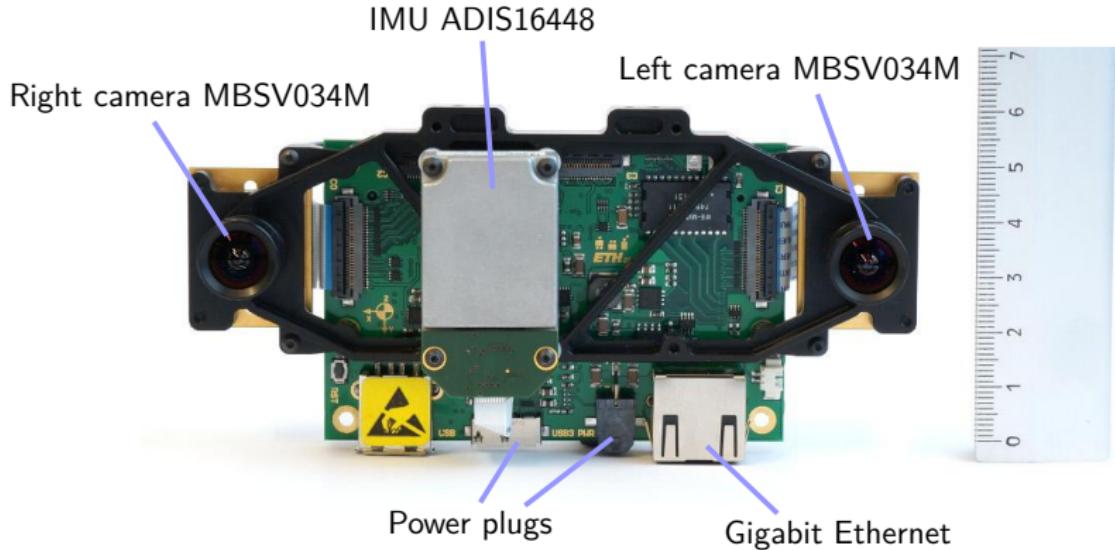
ROVINA (Grisetti et al)



Graph-based SLAM



Sensor setup: the VI-Sensor



First steps

GUI: Visual tracking



GUI: Live map viewer



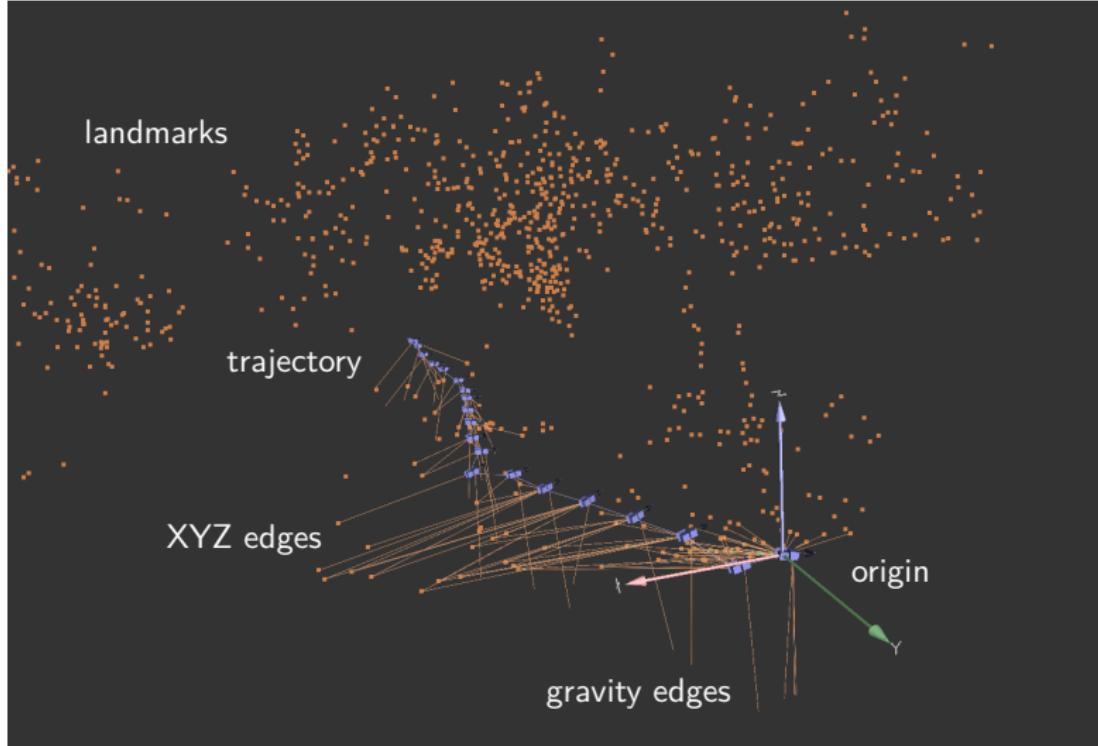
Many simplifications:

- ▶ Indoor datasets with slow steady movement
- ▶ Odometry by Alberto™
- ▶ Minimal range and disturbance

Least squares state optimization

- ▶ StereoUV → Landmark position
 - State: Positions $\mathbf{x}(x, y, z)$
 - Measurements: Projections p_L, p_R
- ▶ StereoPosit → Odometry
 - State: Transformation $T_{21}(R, \mathbf{t})$
 - Measurements: Positions \mathbf{x} , projections p_L, p_R
- ▶ ICP (Besl et al) → Loop closures
 - State: Transformation T_{BA}
 - Measurements: Positions $\mathbf{x}_A, \mathbf{x}_B$

g2o: graph-based SLAM optimization (Kümmerle et al)



Data acquisition

Hand-held



Bike mounted

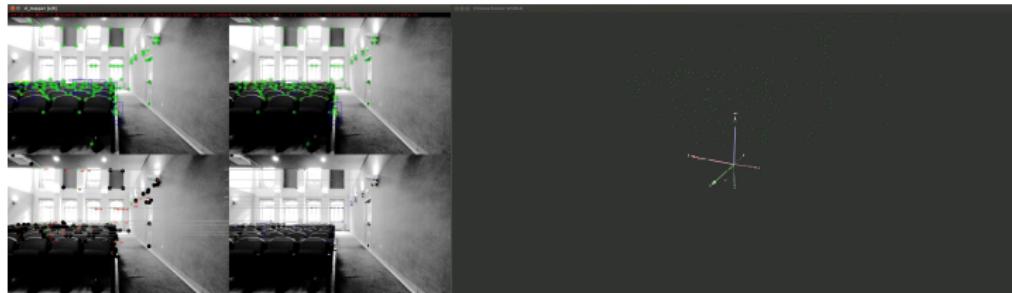


KITTI Annieway

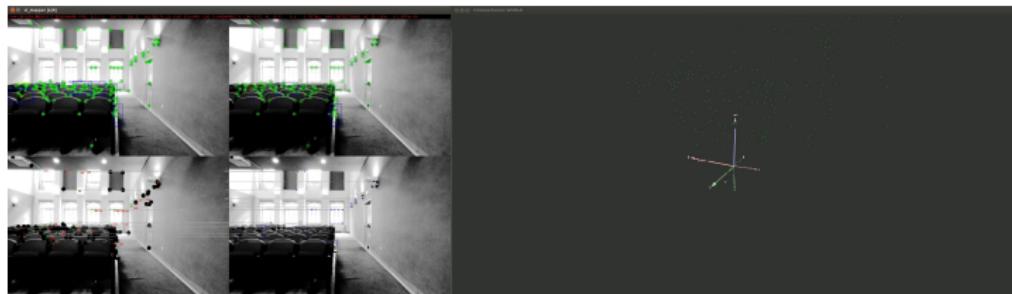


System in action

Hand-held dataset: Aula Magna

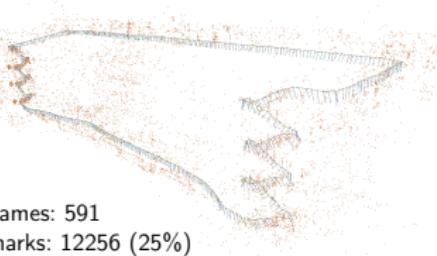


Bike mounted dataset: Streets in San Lorenzo



Results: hand-held

Stairs DIAG



Key frames: 591
Landmarks: 12256 (25%)

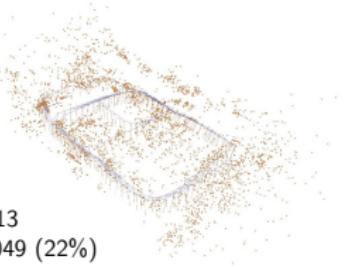
Full graph

Trajectory



Recording time: 443s
Trajectory length: 394m

Aula Magna



Key frames: 213
Landmarks: 4049 (22%)

Full graph

Trajectory



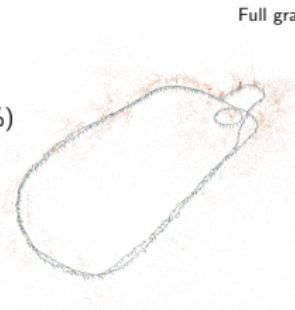
Recording time: 192s
Trajectory length: 126m

Results: bike mounted

Parco San Lorenzo

Key frames: 591
Landmarks: 12256 (25%)

Recording time: 443s
Trajectory length: 394m



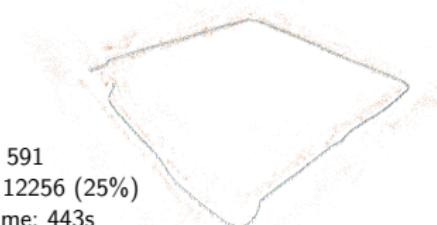
Full graph

Trajectory (Google maps overlay)



Block San Lorenzo

Key frames: 591
Landmarks: 12256 (25%)
Recording time: 443s
Trajectory length: 394m



Full graph

Trajectory (Google maps overlay)

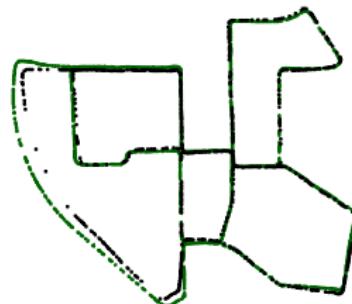


Results: KITTI odometry benchmark (without IMU)

Full graph



Trajectory



- ▶ Trajectory length: 3697m
- ▶ Duration: 454s
- ▶ Total relative error: 6%

Conclusions and final remarks

Regarding our final system:

- ▶ It works!
- ▶ It works well
- ▶ It works on a bike in streets and parks
- ▶ It works without IMU

What could've made things faster:

- ▶ Start off with mocked system
- ▶ Clear environment definition
- ▶ Deeper read-in phase

Future work

Urgent:

- ▶ Filter integration (IMU)
- ▶ Parallelization
- ▶ Programmatic and cosmetic refactoring
- ▶ Open source publication

Optional:

- ▶ Improved feature handling
- ▶ Improved graph optimization

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