

3D Perception for Autonomous Navigation of a Low-Cost MAV using Minimal Landmarks

Benjamin Ranft, Jean-Luc Dugelay, Ludovic Apvrille

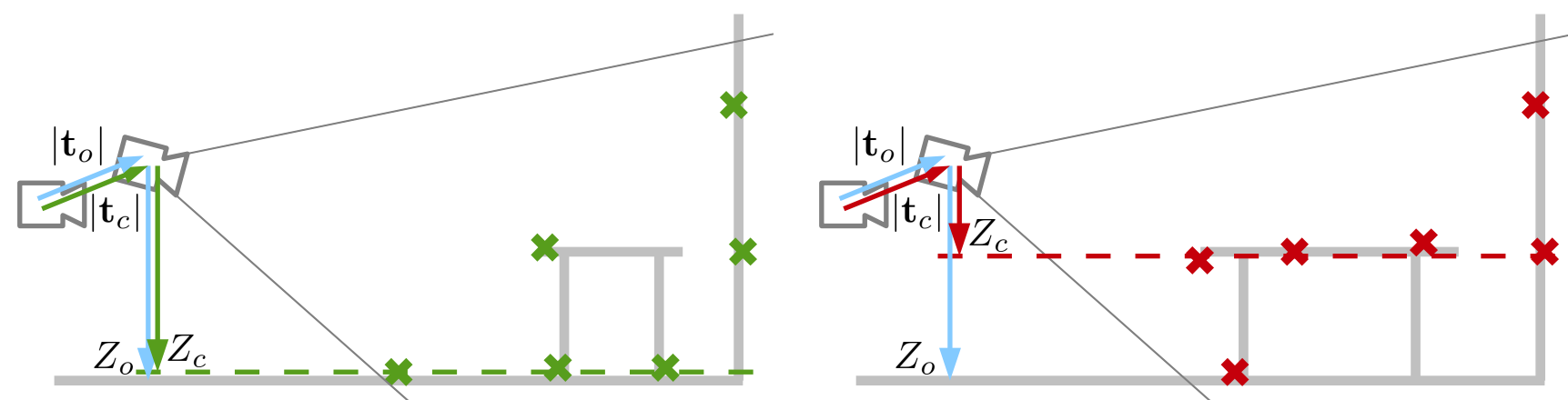
We present a complete system for fully-autonomous indoor navigation of a *Parrot AR.Drone 2.0* quadcopter. Its monocular forward camera is used by two complementary methods for metric 3D environmental perception. Artificial landmarks are only required at corridor crossings or junctions in order to define the further flight path.



Sparse 3D Reconstruction and „Corkscrew“ Flight

Perception: extension of *LibViso2* [1] for use with UAV, also suitable for embedded on-board PCs

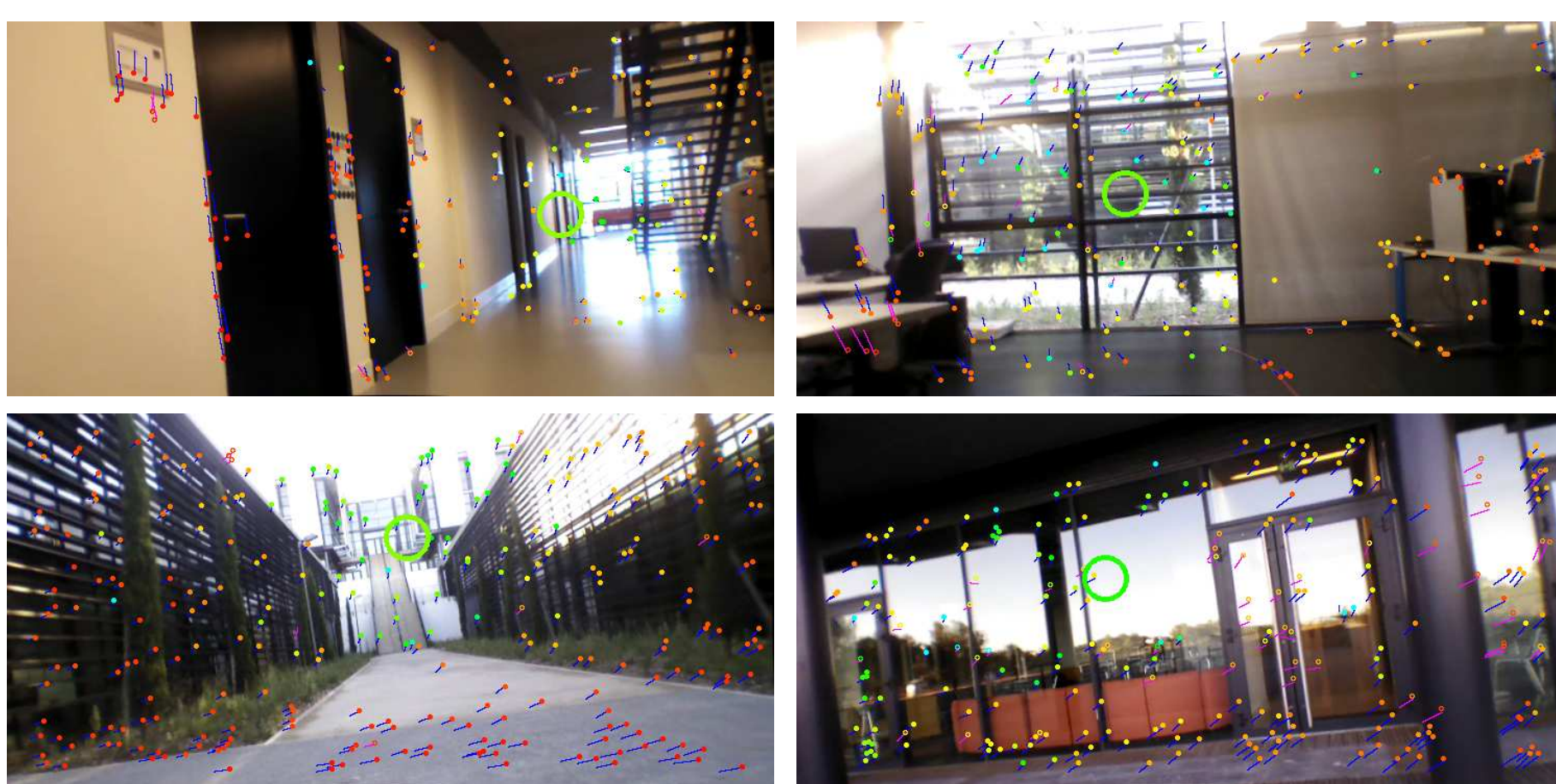
- multi-class two-stage feature matching
- camera motion (up to scale) via 8-point algorithm
- 3D points (up to scale) via triangulation
- preferred scale estimation via ground plane fitting, using directly-measured altitude, pitch and roll
- fall-back scale estimation using inertial sensors



Flight control

- vertical and lateral oscillation (0.3 m, 0.33 Hz) for sufficient camera motion → „corkscrew“-shaped trajectory
- yaw rotation and forward speed based on 3D points

[1] A. Geiger et al. StereoScan: Dense 3D Reconstruction in Real-time



Base System

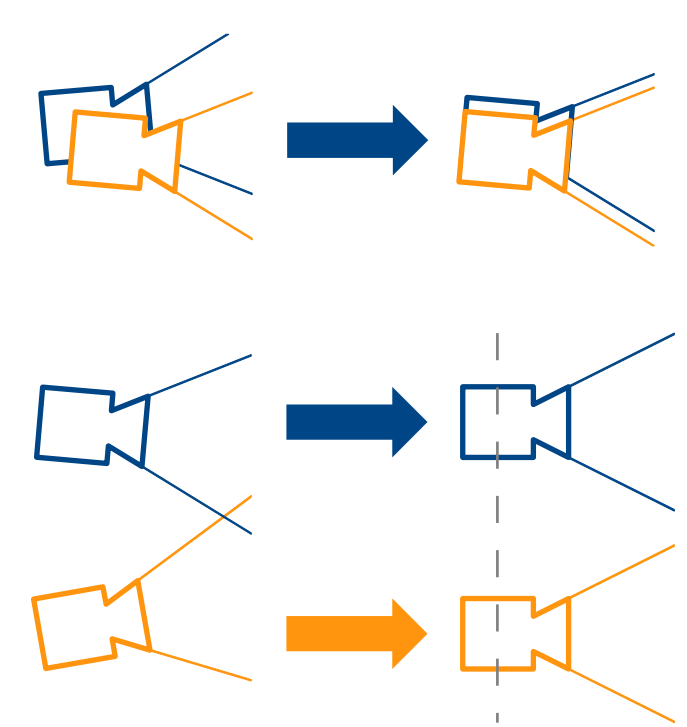
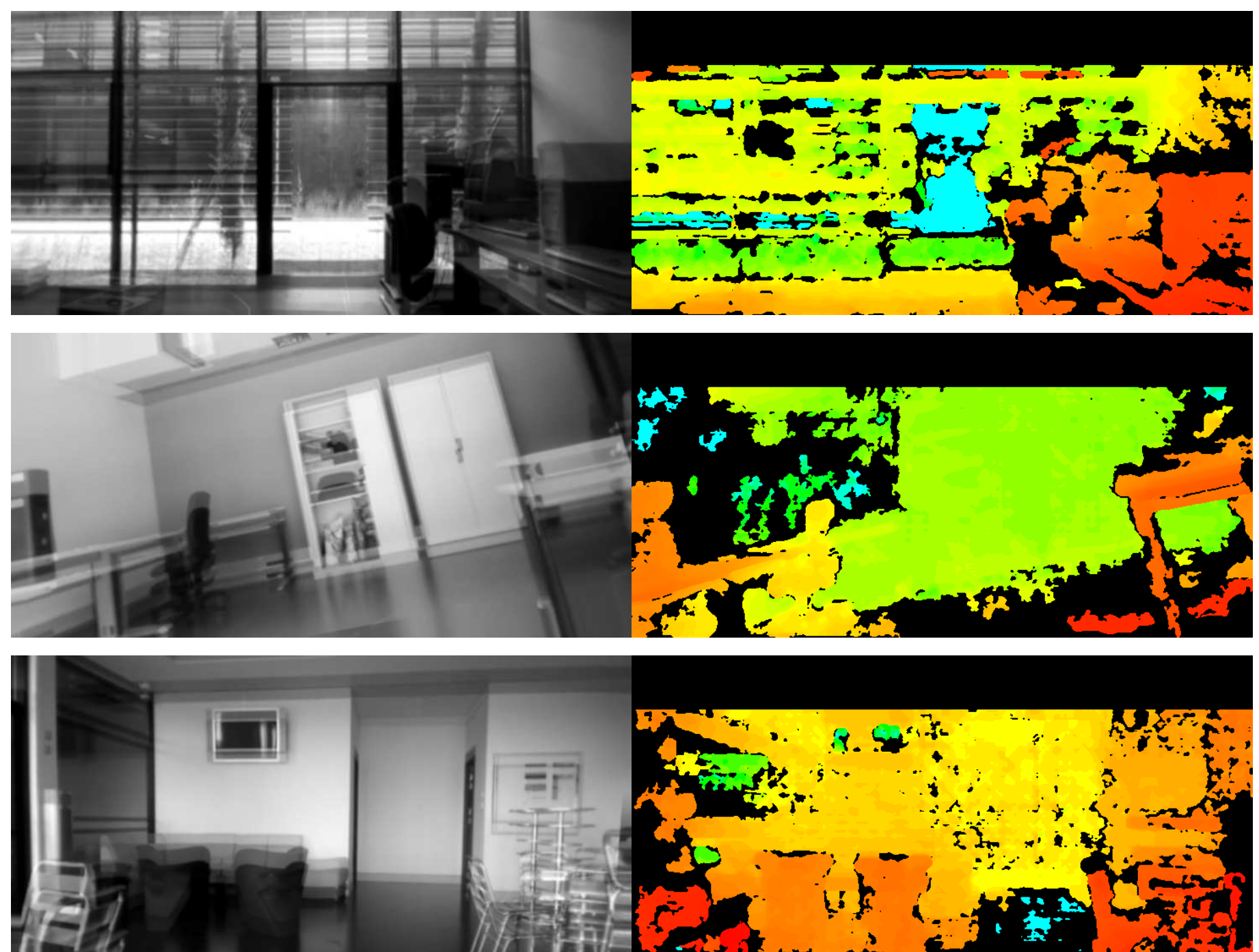
- *Parrot AR.Drone 2.0* quadcopter
→ remote PC required
- anti-windup PID pose control
- perception modules parallel on multi-core CPU



Dense 3D Reconstruction using a Virtual Stereo Camera

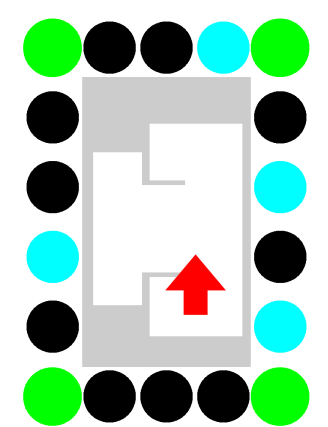
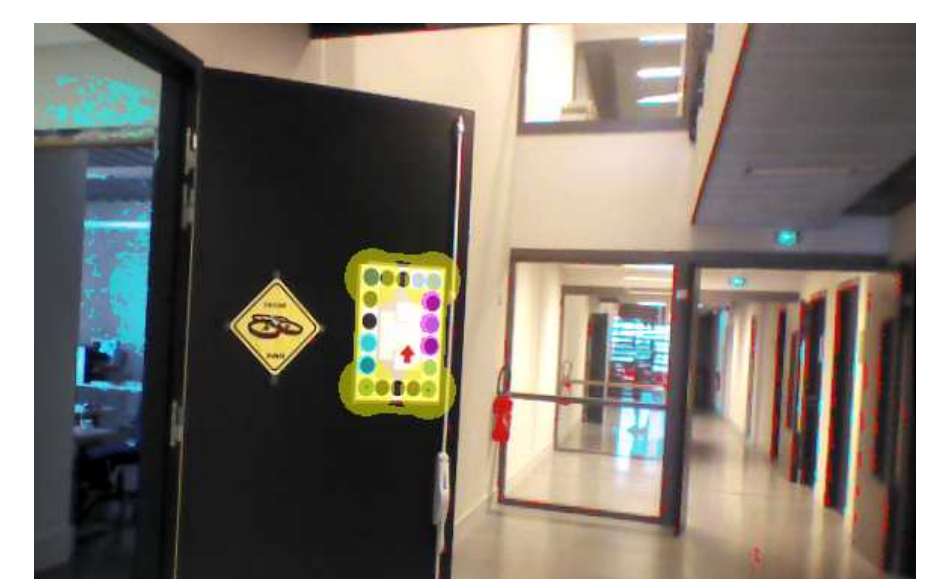
Perception: evaluate images before/after an altitude change as a stereo pair

- hover in place, stabilize video
→ detect moving objects to be masked in results
- perform altitude change, rectify images based on estimated camera motion
→ use existing matching implementation (*OpenCV SGBM* shown)



Landmark-based Navigation

- Landmarks contain human-readable floor plan and machine-readable pattern.
→ encodes crossing ID, inbound direction and checksum
- After detection, quadcopter assumes defined position w. r. t. landmark.
- At recognition, mission description maps info to outbound flight direction.



CONTACT PERSONS

FZI Research Center for Information Technology
Benjamin Ranft
ranft@fzi.de
www.fzi.de

Institut Eurécom
Jean-Luc Dugelay
jean-luc.dugelay@eurecom.fr
www.eurecom.fr

Télécom ParisTech
Ludovic Apvrille
ludovic.apvrille@telecom-paristech.fr
www.telecom-paristech.fr