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

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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.

Base System

Parrot AR.Drone 2.0 quadcopter and remote PC for off-board processing

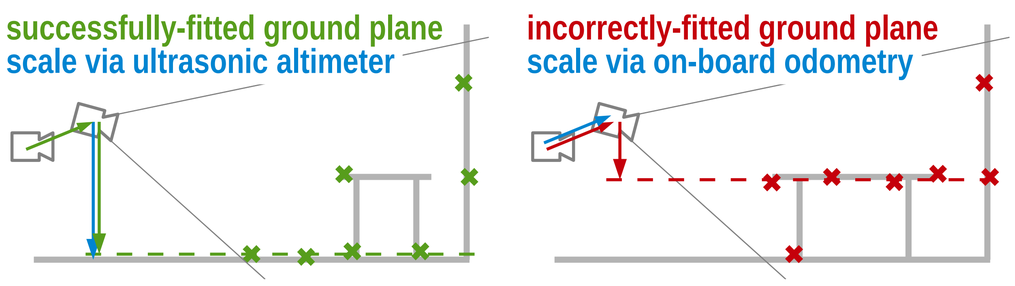
- perception modules parallel on multi-core CPU
- anti-windup PID pose control

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 on-board odometry

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



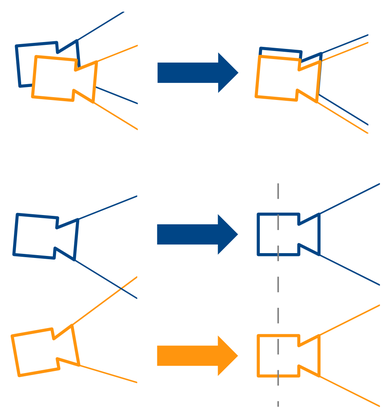
Flight strategy

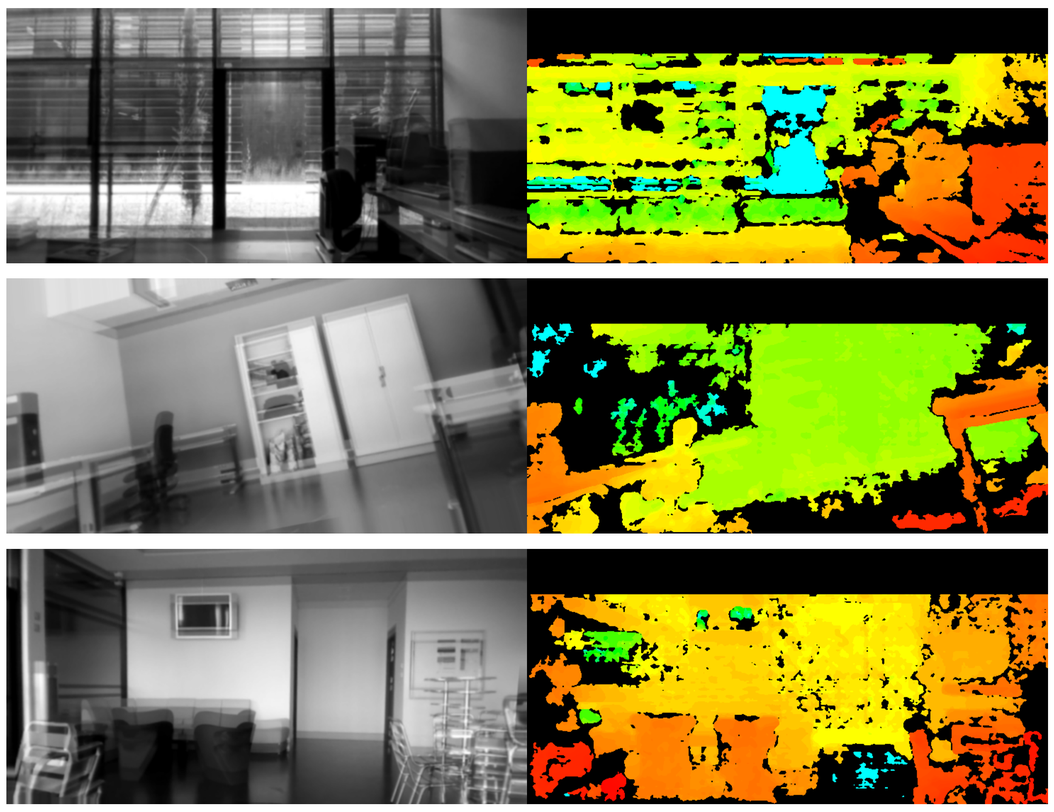
- vertical and lateral oscillation (0.3m, 0.33Hz) for sufficient camera motion → „corkscrew“-shaped trajectory
- closed-loop heading control towards farthest 3D points
- forward speed heuristic based on heading error

Dense 3D Reconstruction using a Virtual Stereo Camera

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

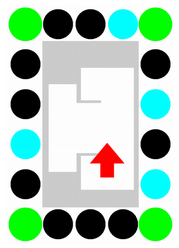
- hover in place, stabilize video
  → detect moving objects to be masked in results
- perform altitude change, rectify images based on estimated camera motion
  → use existing stereo matching implementation (*OpenCV SGBM* shown)





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 definition maps landmark to outbound direction.



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