VISUAL SERVOING FOR MICRO AERIAL VEHICLES

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Abstract: We present a visual height controller for a micro aerial vehicle (MAV). The MAV is part of an autonomous visual inspection setup for power pylons. We demonstrate our progress in visual servoing and focus on a height controller using fuzzy logic. In preliminary results we show that the MAV can reach a desired height at a speed of 0.06m/s and a height accuracy of 0.000475m² (MSE). The generalization to full 6 DoF will allow an accurate positioning even in outdoor environments.

Motivation

Ground-based Inspection

Aerial Inspection

- Power Pylon inspection is done using a helicopter
- Imprecise, expensive and dangerous

Goal:

- Replace helicopter with a cheap MAV inspection setup

Quad-rotor

Visual Servoing

Goal:

- Accurate positioning close to rigid objects

Control using GPS:

- Local accuracy [1.5-3m]
- Drifts over long terms
- Low update rates

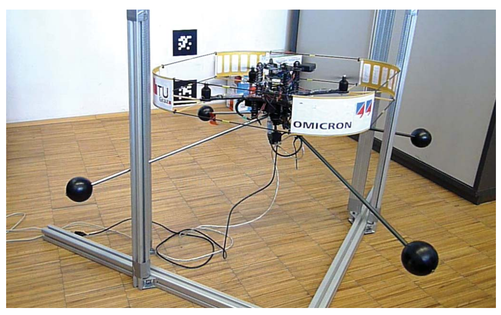
Control using IMU:

- Drifts over time
- Accumulates errors

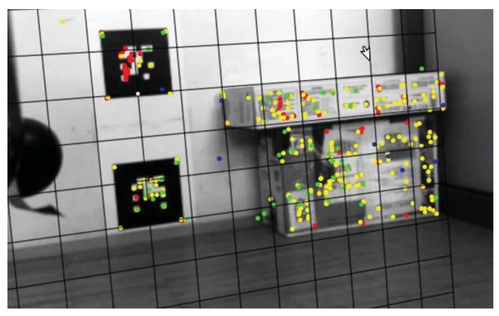
Need of improvement

Solution: Use visual servoing

Visual Localization



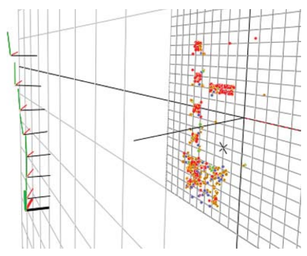
Experimental setup for height control



Detected features

3D Pose Estimation:

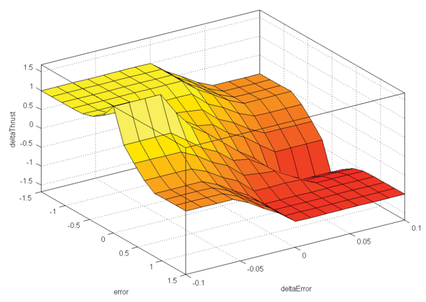
- Based on PTAM [2]
- Only visual inputs
- Estimation of 6DoF pose
- Serves as control input



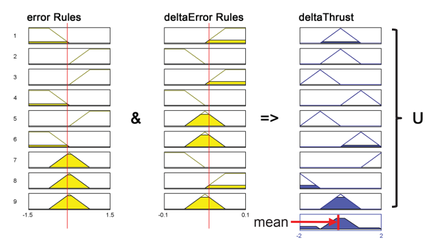
Localization map

Fuzzy Logic Controller

- Using visual inputs only
- Adjustment of 4 control parameters (yaw, pitch, roll and thrust)
- For each control parameter:
  - Calculate error between actual and desired position
  - Calculate gradient of error (deltaError)
  - Use error and deltaError for control calculation
- Obey rules to adjust control signal

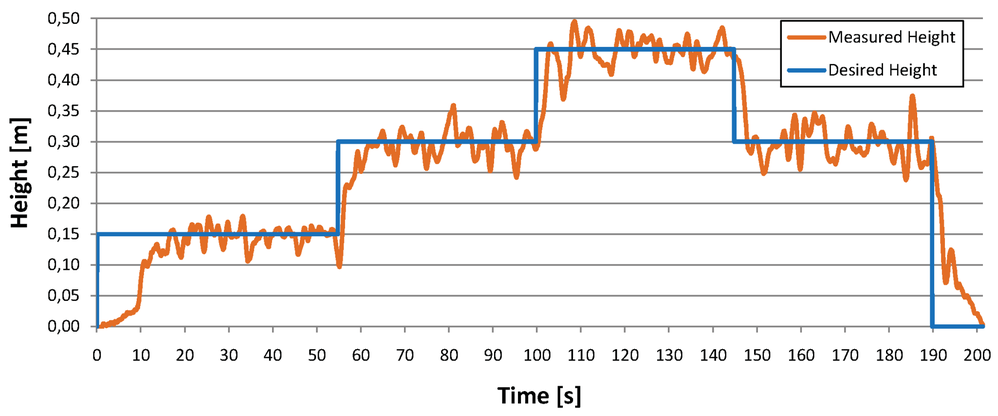


Value look-up surface



Example for control calculation

Preliminary Results



Controlling response of height controller

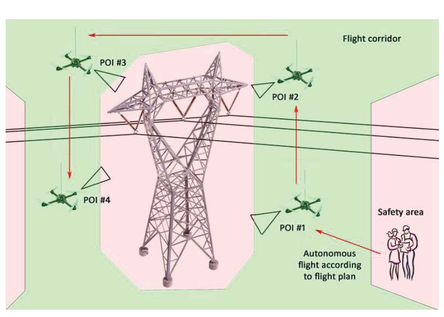
Control of height:

- Update rate: 15fps
- Mean squared error: 0.000475m²
- Transient time for Δheight = 0.15m: 2.7s

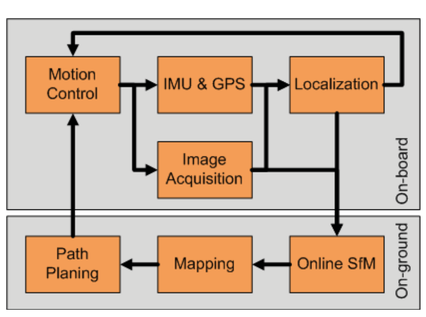
Robust to external influences

- Ground effect
- Friction on base frame

Outlook



Pylon and according flight corridor (green)



Visual Servoing Scheme

Based on height control:

- Extend to all degrees of freedom
- Control yaw, pitch, roll and thrust
- Localization based on structure from motion (SfM) results
- Fusion of sensor data (Vision, IMU and GPS)

References

[1] Robotics Operating System. http://www.ros.org.
[2] G. Klein and D.W. Murray. Parallel tracking and mapping for small AR workspaces. In Proceedings of ISMAR, 2007.

Acknowledgments

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Supplementary Material

Demo videos can be found at http://aerial.icg.tugraz.at