Autonomous UAV Landing Using Monocular Vision

A Half-time Report

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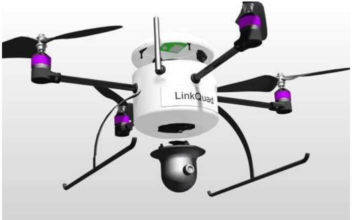
What should be done?

- Develop a platform for real-time control of a UAV,
- Integrate the PTAM library as a component in the state estimation,
- Implement a simple landing procedure using the pose estimate.



What has been accomplished so far?

- Internal/serial communication,
- Visualization and evaluation tools,
- Physical modelling,
- Pose/state estimation (some problems still),
- Control,
- PTAM.

CRAP

- A framework for internal communication.
  - Minimal overhead using C++ function pointers and minimizing copies
- Serial communication library;
  - Some connections to previoius implementation,
  - C++ templates moves calculations to compile-time,
  - Simplistic API.
- Integrated Matlab-style real-time plotting (enabled compile-time),
- Easily configurable, modular design.

Physical Modelling

Detailed physical model of forces and moments acting on the quadrotor.

- Gravity,
- Wind
  - Stochastic model - estimated by the filter,
  - Models forces and moments on the quadrotor.
- Thrust;
  - Propeller flapping,
  - Ground Effect.
- Additional forces,
  - Gyroscopic effects, hub forces etc.

State Estimation

Estimates the full set of 23 states.

- UKF,
- EKF.

Control

Basic idea: Linearize the physical model and use linear control theory.

$$\dot{x} = f(x,u) \approx f(x_0,u_0) + \underbrace{\left.\frac{\partial f}{\partial x}\right|_{\substack{x = x_0 \\ u = u_0}}}_{A} \underbrace{(x - x_0)}_{\Delta x} + \underbrace{\left.\frac{\partial f}{\partial u}\right|_{\substack{x = x_0 \\ u = u_0}}}_{B} \underbrace{(u - u_0)}_{\Delta u} \tag{1}$$

$$\dot{X} = \begin{bmatrix} \dot{x} \\ 0 \end{bmatrix} = \underbrace{\begin{bmatrix} A & f(x_0,u_0) - Ax_0 \\ 0 & 0 \end{bmatrix}}_{\bar{A}} \underbrace{\begin{bmatrix} x \\ 1 \end{bmatrix}}_{\bar{X}} + \underbrace{\begin{bmatrix} B \\ 0 \end{bmatrix}}_{\bar{B}} \Delta u. \tag{2}$$

- SDRE

PTAM

- Parallell Tracking And Mapping,
- Developed at the University of Oxford,
- `http://www.youtube.com/watch?v=Y9HMn6bd-v8&feature=player`
- Compiled for the Gumstix but not yet tested,
- Camera settings needs adjustment for good tracking.

Personal Goals

- Create a general lightweight platform for robot automation.
- Learn about flight dynamics.
- Use quaternions.
- Evaluate the UKF and the EKF non-linear filters.
- Use and evaluate SDRE for non-linear control.
- Take the time to write really good and re-usable code.

Time Schedule

- Approx. two weeks behind schedule,
- Expected hover by now,
+ About two weeks of buffer left,
+ Ketchup effect expected as soon as the observer is working.

Next Steps

- Get the #!#?! observer working,
- Compile for gumstix and evaluate speed,
- Update the report;
  - Results from the evaluation of the UKF,
  - Further describe the model,
  - Chapter about PTAM and video tracking.
- Verify the model against flight data and put in real parameter values,
- Perform test flight.