Quadrotor Using Minimal Sensing For Autonomous Indoor Flight

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By

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Summary

- Introduction
- Platform
- Experiment Room
- In-Flight Experiments
- Conclusion & Outlook

Introduction

Project Start:

- January 2007

Funding:

- Future and Emerging Technologies (FET-OPEN) project funded by the European Commission

Big Picture:

- Swarmanoid Project – Heterogeneous swarm of robots
- www.swarmanoid.org

Introduction

Design Goal:

- Develop a flying robot capable of hands-off autonomous operation within indoor environments such as houses or offices

Applications Include:

- Search and Rescue
- Exploration in Hazardous Environments
- Surveillance, etc.

Strict Limitations on an MAV Include:

- Available sensing technologies
- Power consumption
- Platform size
- Embedded processing

Introduction

Design Choices (benefits):

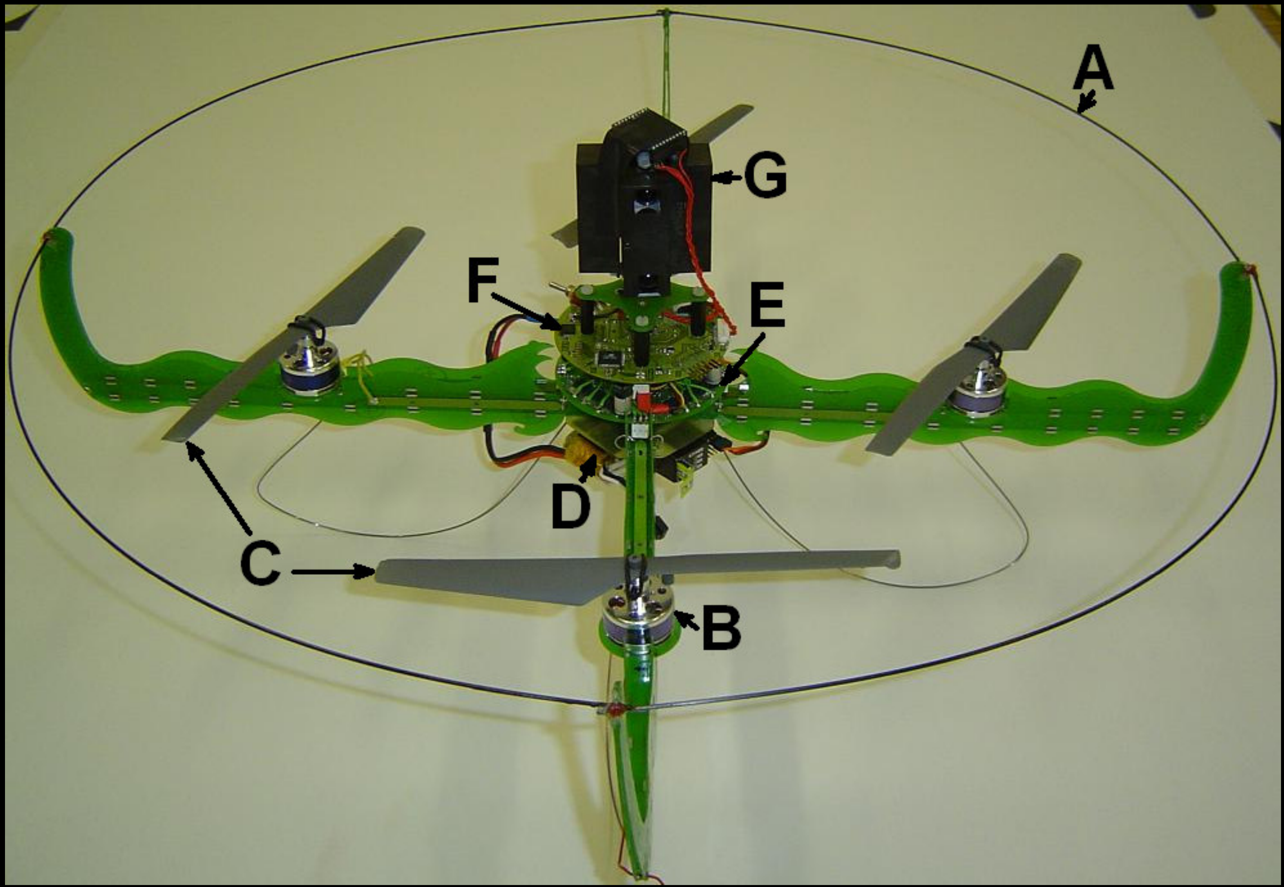
- VTOL MAV with hovering capability
- High payload capacity for high-level sensing and control boards
- Good maneuverability
- Simple platform design (robust)
- Safe to use

Design Challenges:

- Stability control
- Altitude control
- Platform drift – no global positioning system available indoors
- Collision avoidance

Question: What is the most suitable platform?

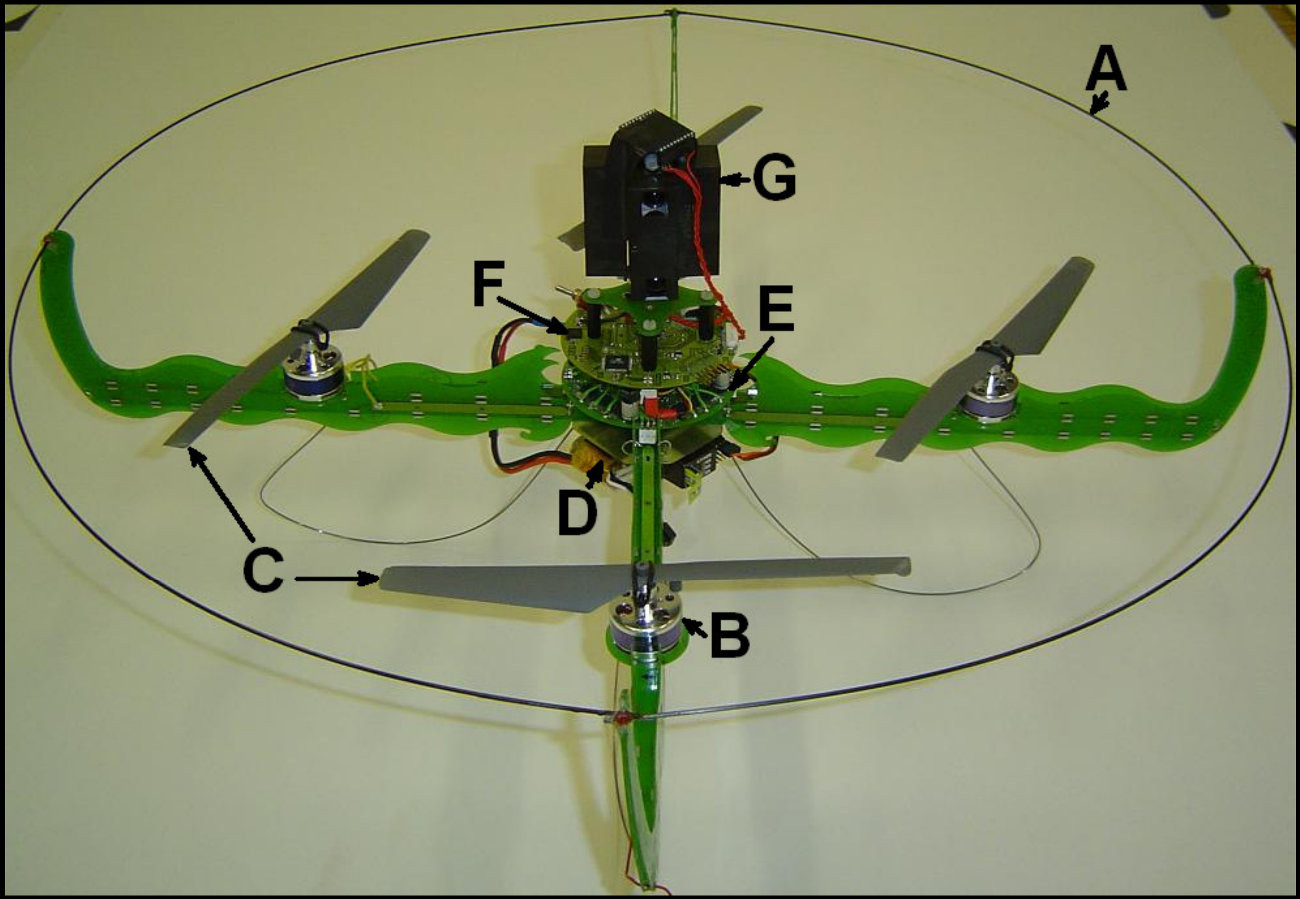
Platform



A.) protection ring
B.) brushless motor
C.) contra-rotating propellers
D.) LIPO battery

E.) high-speed motor controller
F.) flight computer
G.) infrared sensors

Platform



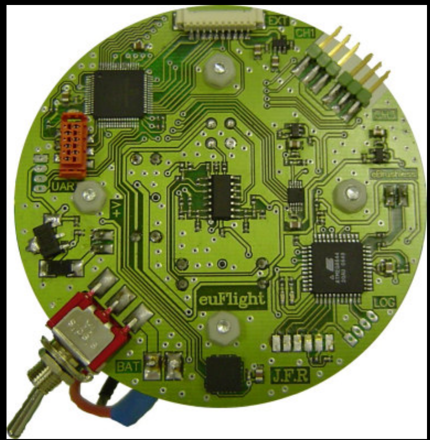
- First prototype - no optimisation performed
- PCB frame idea – tight integration between structure, electronics and sensors
- Reduce weight, minimise wiring and improve manufacturability

Platform

Embedded Electronics:

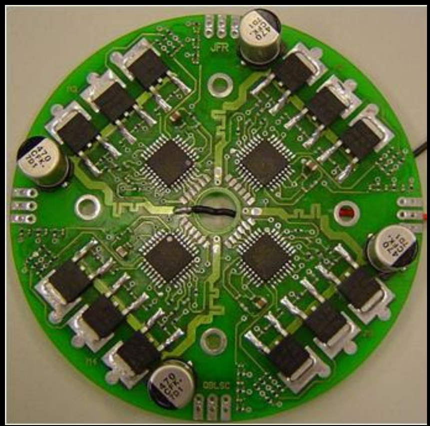
Flight Computer:

- Dedicated microcontroller for stability control (3x PID)
- Complementary filters** (roll, pitch)
- Dedicated microcontroller for autonomous control
- External connectivity (USART, SPI, I^2C)



High Speed Motor Controller (Mikrokopter Firmware):

- Dedicated microcontroller for each motor
- 500Hz update rate (10x Sensor BW)
- 11A @ 11.1V continuous
- Connectivity for the flight computer

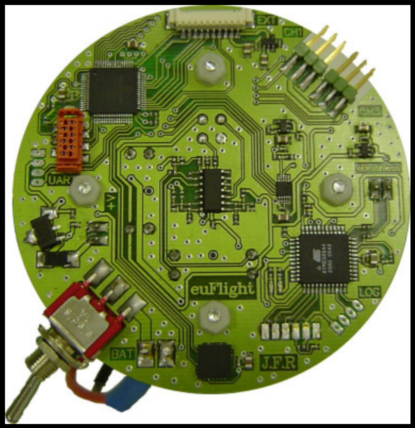


Platform

Sensors:

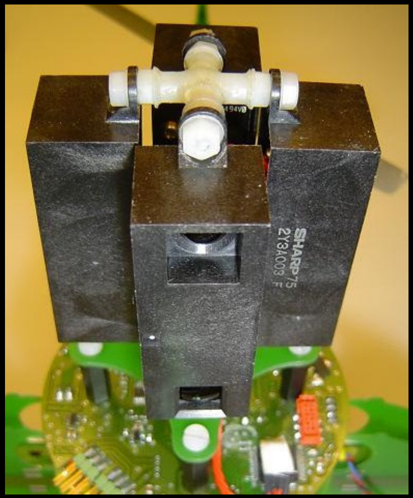
Flight Computer:

- 3x gyroscopes**
- 3x accelerometers**
- 2-axis magnetometer
- Pressure altitude



Distance Sensing:

- 4x infrared triangulation sensors 3m range
  - ➢ collision avoidance
  - ➢ anti-drift control



- 1x ultrasonic sensor
  - ➢ altitude control
  - ➢ 25.4mm resolution

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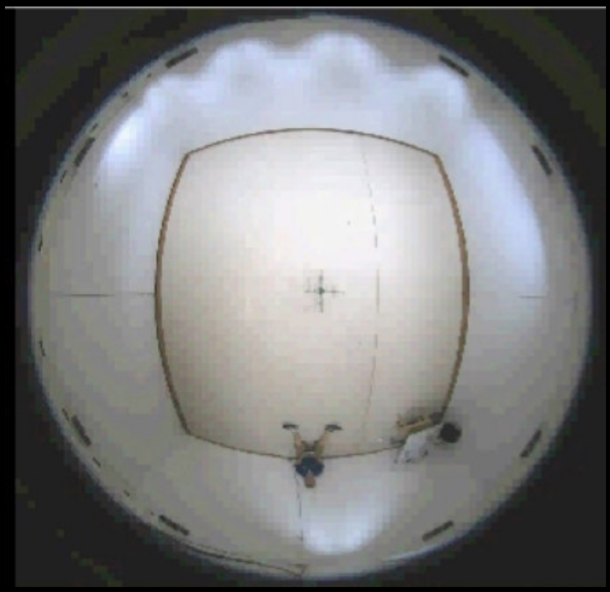
Experiment Room

Room:

- Dimensions: 6m (wide) x 7m (long) x 3m (high)
- Floor covered with white vinyl & obstacles removed
- Desk in corner to hold a laptop computer (record video & prog. gains)
- Safety pilot



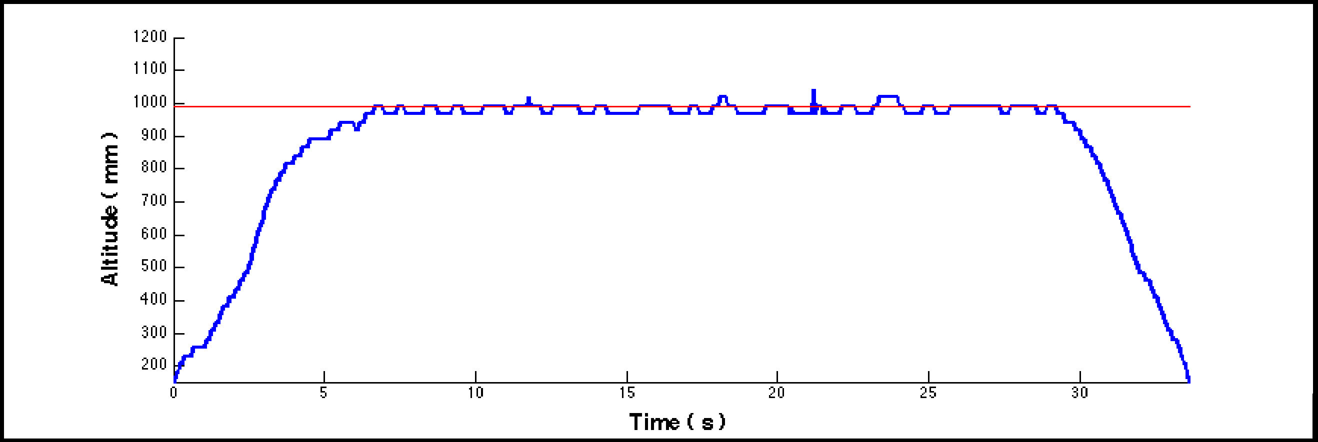
Tracking System:

- Dome camera with 180º FOV installed on roof
- Script for MATLAB extracts the trajectory from pre-recorded video

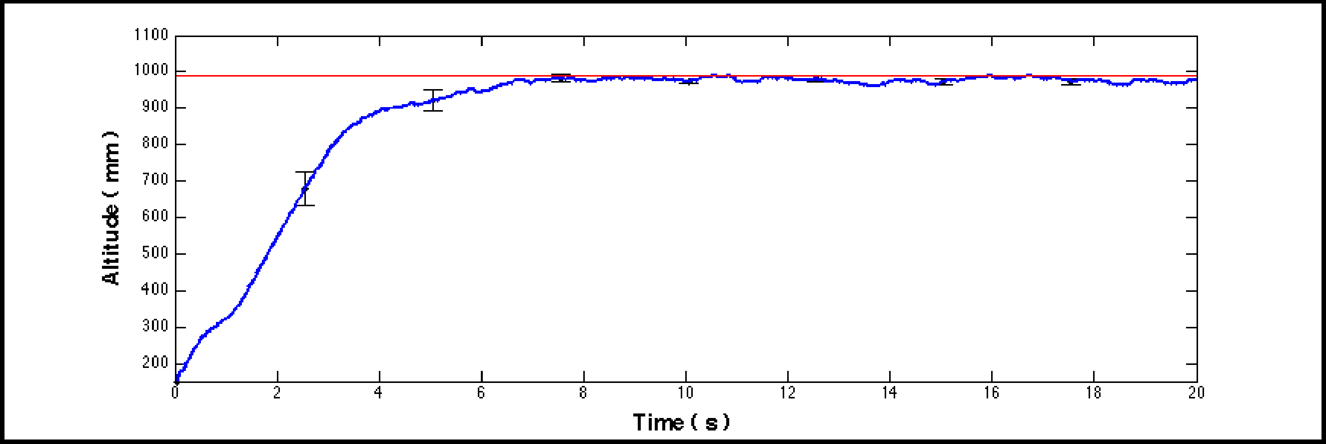
In-Flight Experiments

Altitude Control (PID): √

- Automatic take-off, altitude control and automatic landing

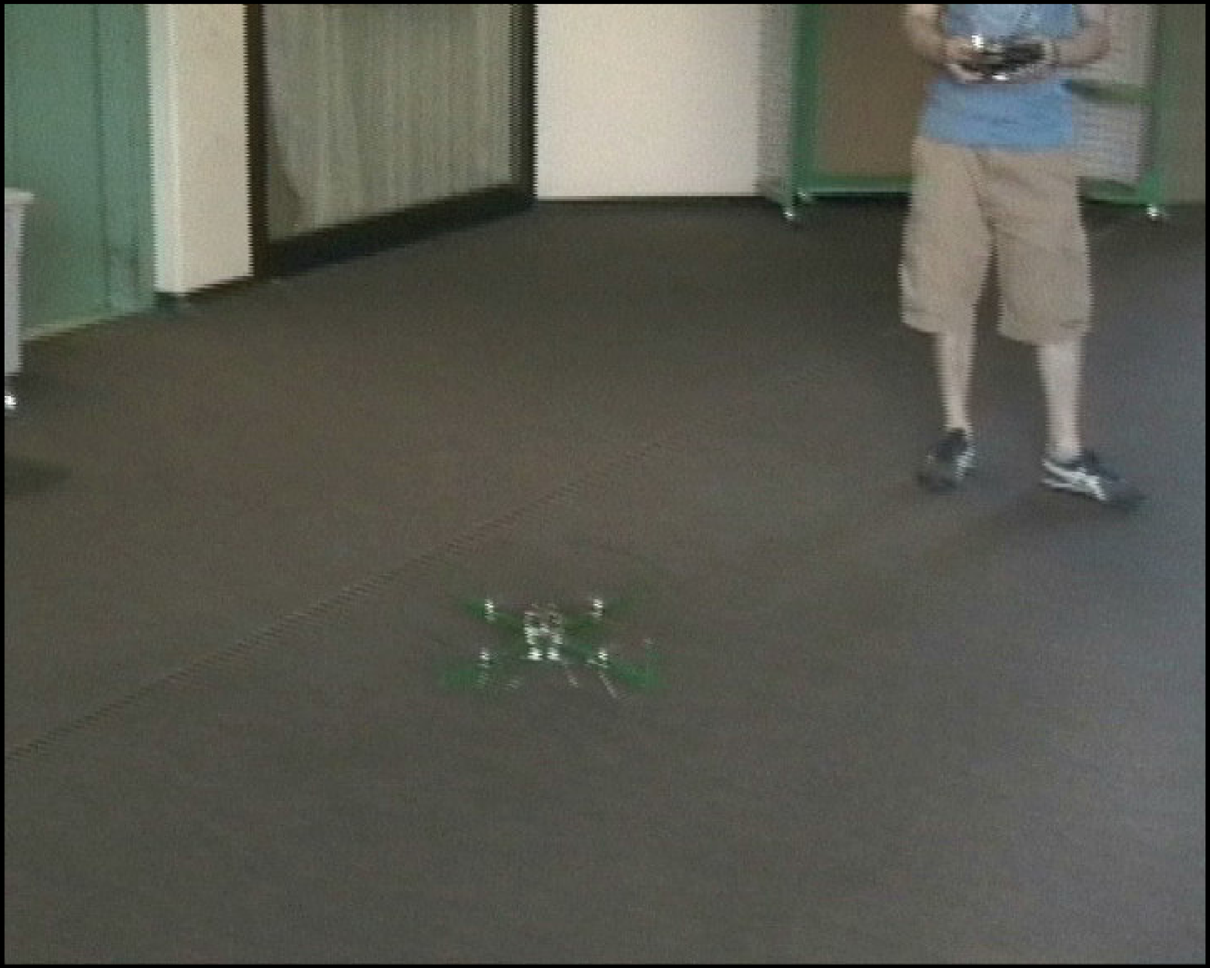


- Mean altitude (10 runs) = 974.13mm, Standard deviation = 30.46mm



In-Flight Experiments

Altitude Control (PID):

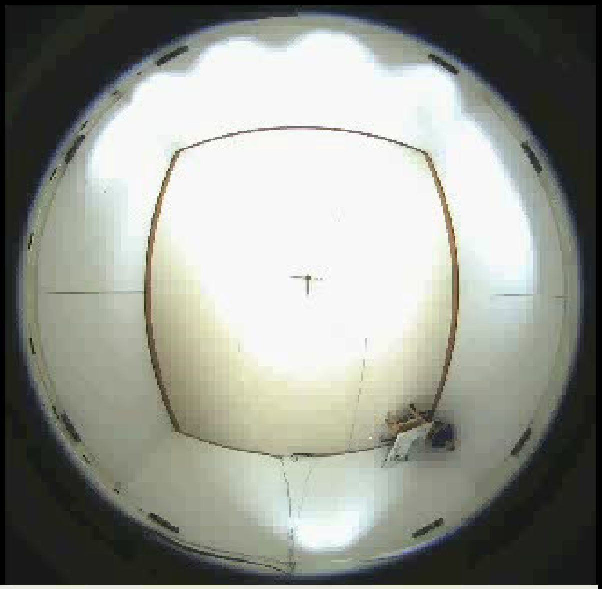


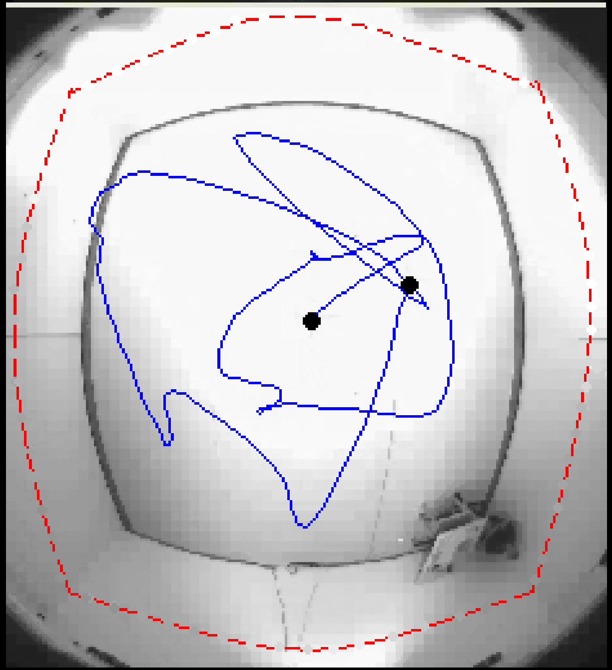
In-Flight Experiments

Autonomous Collision Avoidance: √

- Experiment setup
  - ➢ Initial position in centre of room
  - ➢ Distance balancing algorithm
  - ➢ PD controller
  - ➢ Infrared range limited to 1.5m

- Experiment results
  - ➢ Automatic take-off
  - ➢ Avoids colliding with walls
  - ➢ Automatic landing



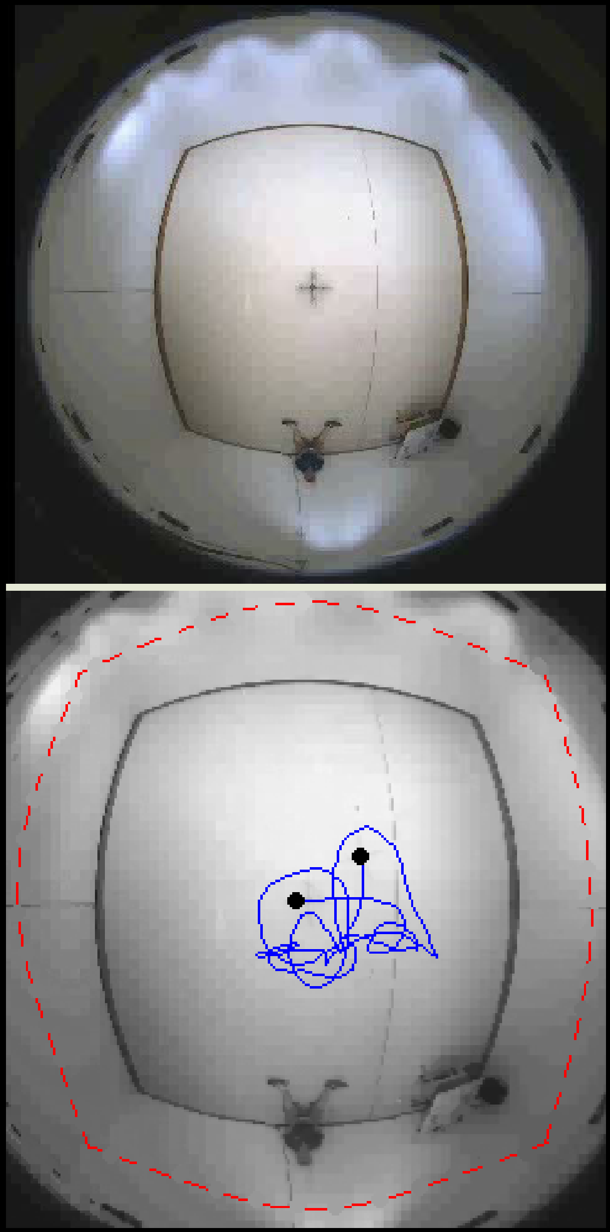


In-Flight Experiments

Autonomous Anti-Drift: √

- Experiment setup
  - Same as previous
  - No range limits – 3m

- Experiment results
  - Automatic take-off
  - Hovers approximately in the middle
  - Automatic landing



Conclusion & Outlook

Design Achievements:

- A flying robot capable of hands-off autonomous operation within an obstacle free indoor environment has been developed
- Capable of automatic take-off, constant altitude control and automatic landing
- Collision avoidance ability
- Anti-drift ability
- Using simple sensing and control strategies

Future Work:

- Only useful to sense walls or large objects – develop a 3D distance scanning system for better environment scanning
- Perform more advanced experiments including corridor following and autonomous flight in populated rooms

Conclusion & Outlook

Thank you!