Indoor Feature Detection For Micro-Aerial Vehicle Swarms

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Micro-Aerial Swarms

RoboBee
Harvard University

Doublehorse
9103

BitCraze
Crazyflie
NanoQuad

Drivers

Miniaturization in computation, sensing, actuation

Battery Technology

Understanding of control and dynamics of rotors

Applications

Micro-Manipulation

Covert Operation

Search and Rescue

Tracking

Challenges

Size limitations

On-board sensing

Inertial Control

Inertial pose estimation and control was implemented using:
• On-board gyroscopes and accelerometers
• Off-board computation using Python
• Communication between the computer and Crazyflie using a 2.4GHz radio

Visual Inertial Estimation

• Inertial sensing drifts over time
• No sense of absolute position for global navigation
• Integrating with visual sensing greatly improves localization and mapping

Vision provides features in global space
• Can be used to restart inertial estimation and alleviate drift

Challenges

• Vision is computationally expensive
• Cameras record dense video requiring a lot of power, computation, and time
• Processing images not feasible as typical cameras produce ~25 images a second

Ongoing: Camera Integration

• Visual sensing alone must be established before incorporating on-board computation
• Transmitter allows for simple visual sensing with off-board computation

Ongoing: VICON Incorporation

• Camera needs ground level calibration
• Inertial sensors and camera alone are unable to provide this
• VICON uses many cameras to triangulate position and thus give a ground level reference point

Ongoing: Optic Flow

• Optic flow is lightweight and provides coarse odometry information
• Prior work demonstrated use of flow for proprioception and control

Simulated Optic Flow for a ring sensor on an MAV

Camera: 1.0 grams
Power Consumption: 225mW

Transmitter (left): 0.4 grams
Camera (right): 0.6 grams
Power consumption of set: 250mW

Ongoing: Inductive Charging

• Average runtime without camera is 7 minutes
• Inductive charging allows charging without wires
• The vehicle is able charge itself creating a fully autonomous system.

Future: Topo-Feature Maps

Idea: Design lightweight topo-feature maps with optic flow for topological info and image templates for features
• Flow provides odometry between features
• Feature/place recognition using template matching
• Integrate flow with inertial sensing for better and more consistent position estimate

References