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Indoor Feature Detection For Micro-Aerial Vehicle Swarms

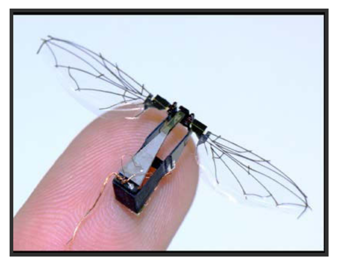
Robert DeBortoli, Javier Yu, Anand Balakrishnan, Karthik Dantu

{radebort,javieryu,anandbal,kdantu}@buffalo.edu

Department of Computer Science and Engineering

University Honors College

Micro-Aerial Swarms



RoboBee Harvard University

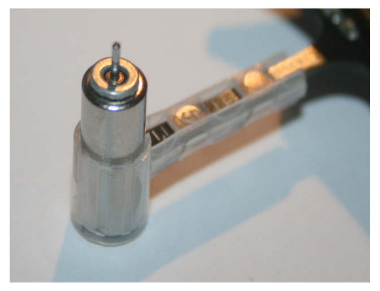
Doublehorse 9103

BitCraze Crazyflie NanoQuad

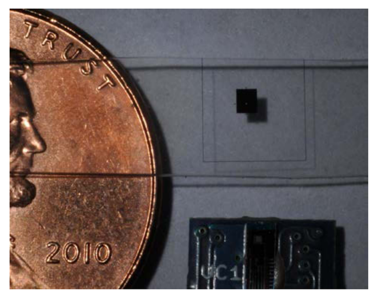
Drivers

Miniaturization in computation and actuation

Battery Technology



Understanding of control and dynamics of rotors



Quality of small-scale sensing

Applications

Micro-Manipulation

Covert Operation

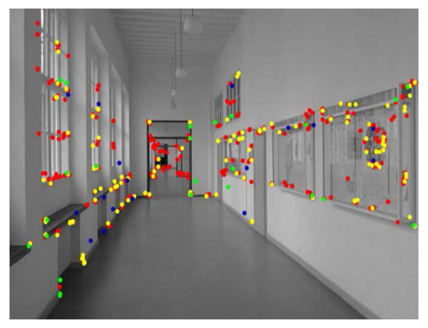
Search and Rescue

Tracking

Challenges

Size limitations

On-board sensing



Indoor navigation

Swarm coordination

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

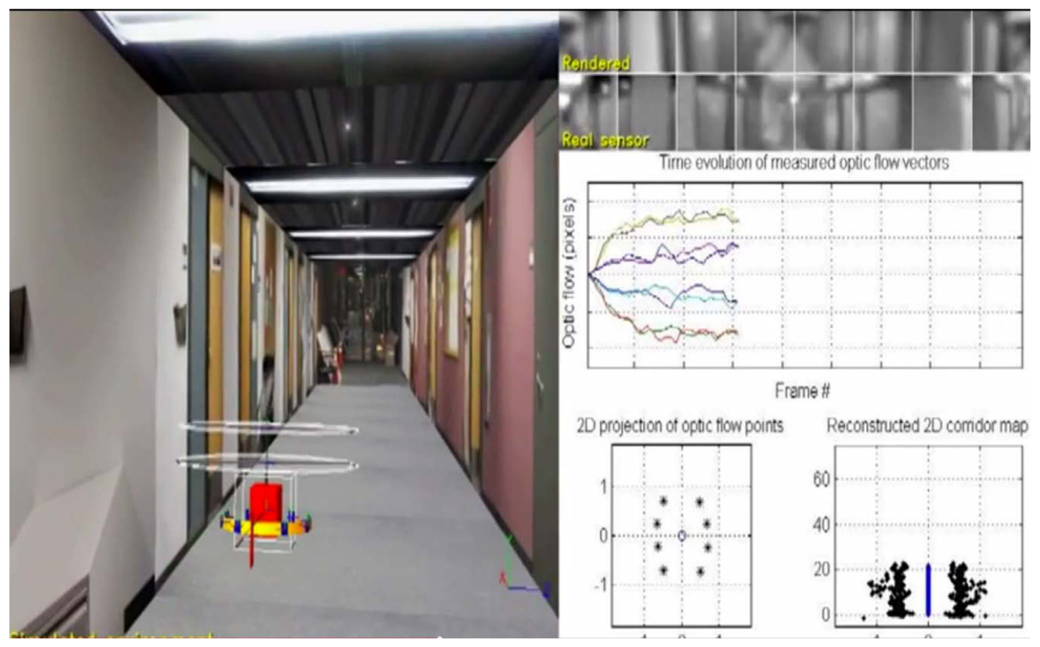
Challenges

- 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

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

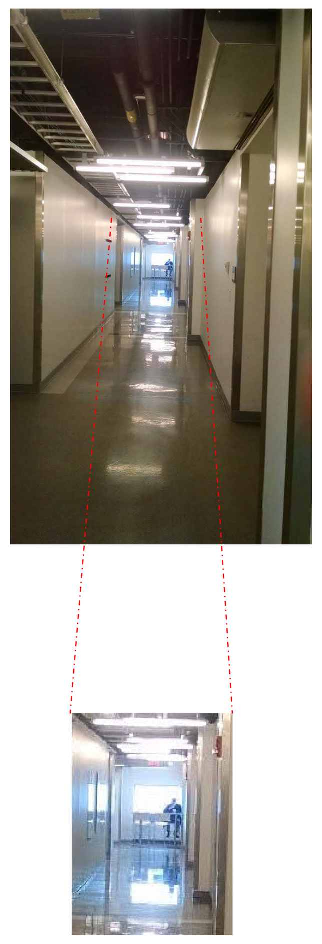


Optic Flow performed on the Crazyflie video feed

Template matching

- Scene recognition provides a basis for mapping
- Not able filter false positives

Original Image
Resolution: 563x1000



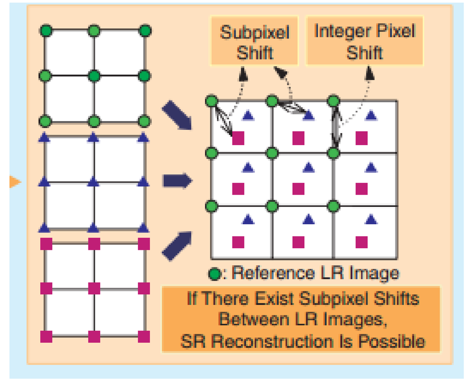
Template

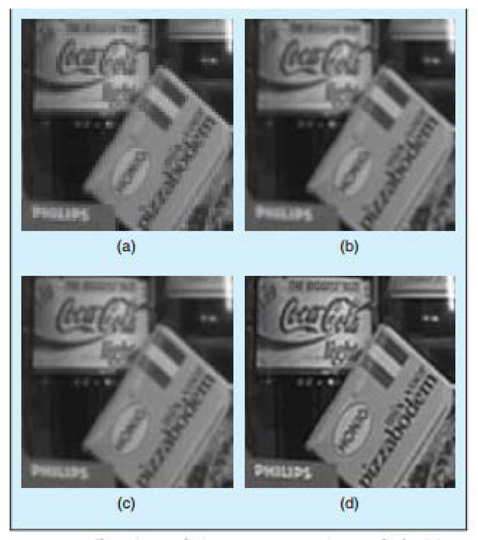
Downsampled Image
Resolution: 76x135
Match value: 0.57

Different Scene
Resolution: 76x135
Match value: 0.55

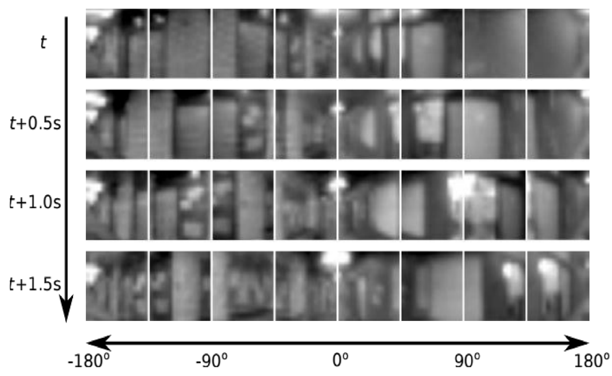
Ongoing: Super-Resolution

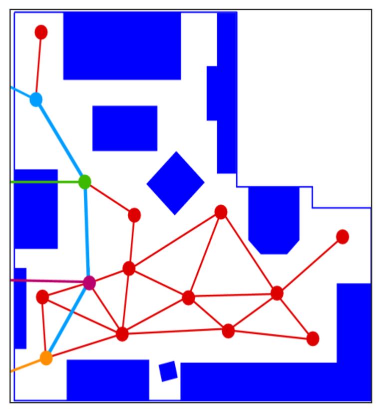
- Increasing feature definition gives more accurate scene recognition
- Frame accumulation of low resolution frames produce more defined features





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

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