European Clearing House
for Open Robotics Development
www.echord.info

UAVs for Close-Proximity Industrial Inspection

Overview Talk on TUAV and REMAV

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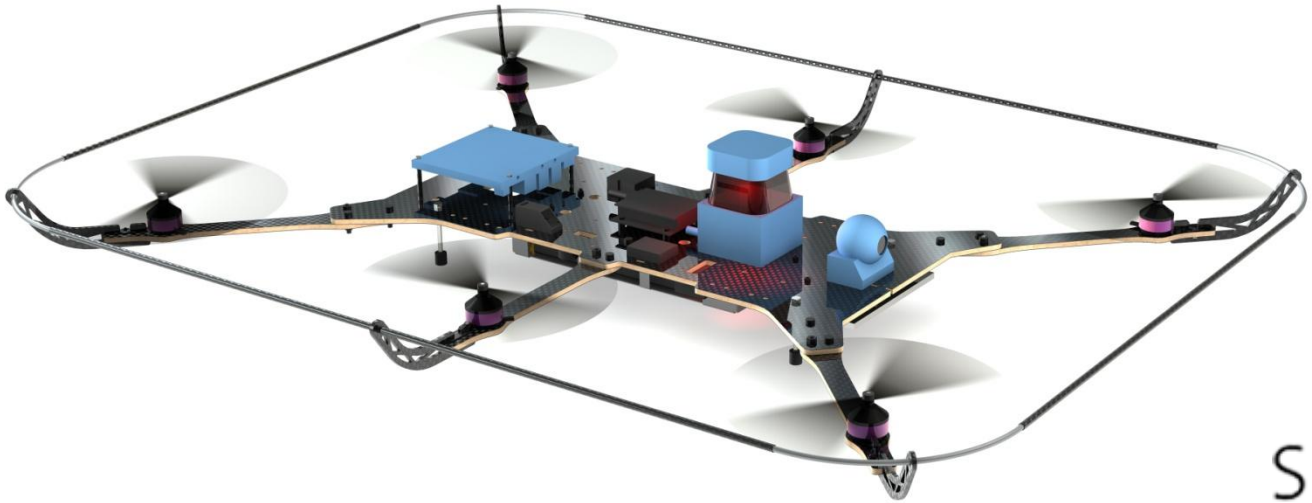
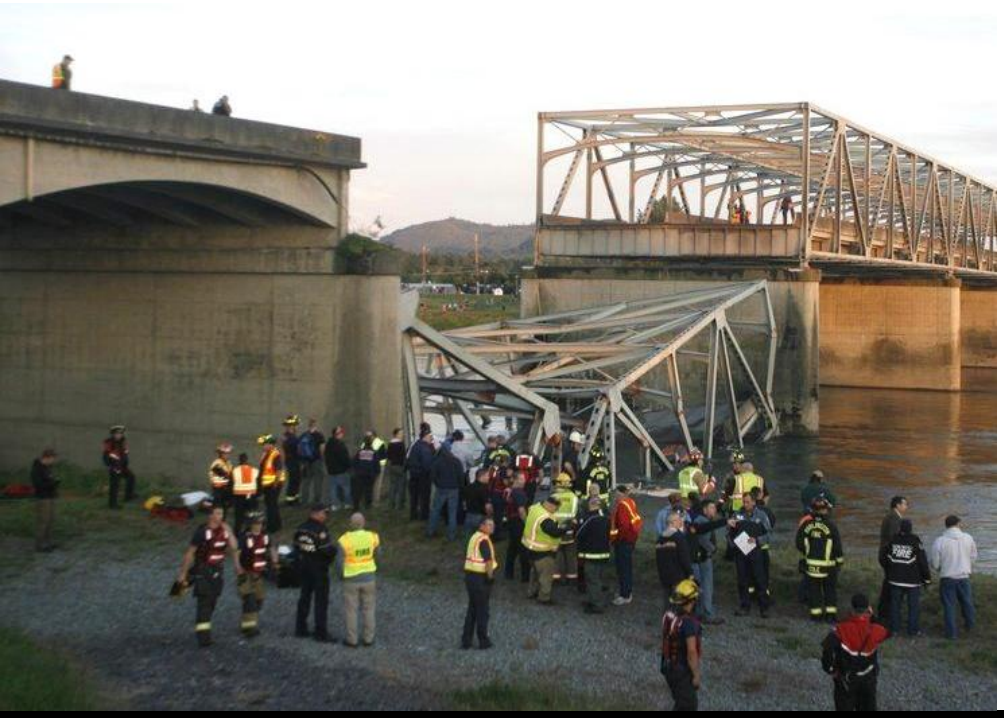
Robotics: Science and Systems 2013, Berlin, Germany



Skybotix
TECHNOLOGIES

A few weeks ago, Seattle, USA



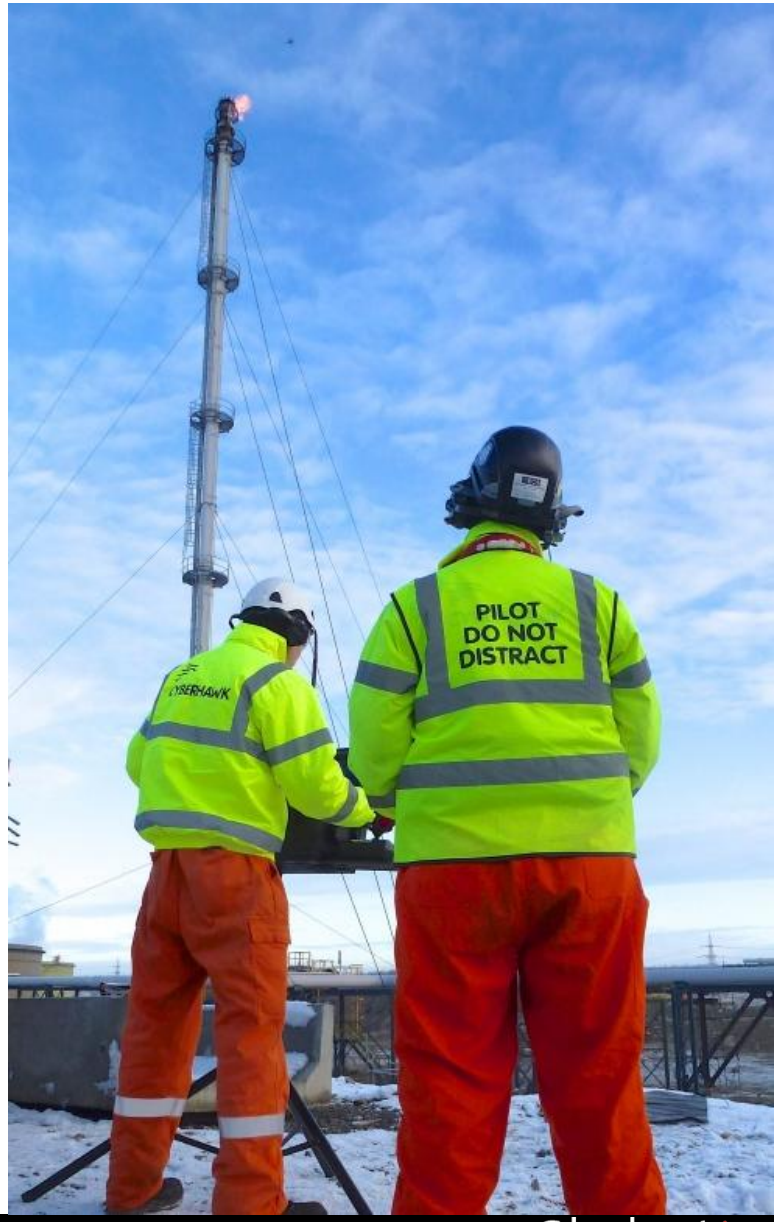
By Cranes?

By Ropes?

Inspection required

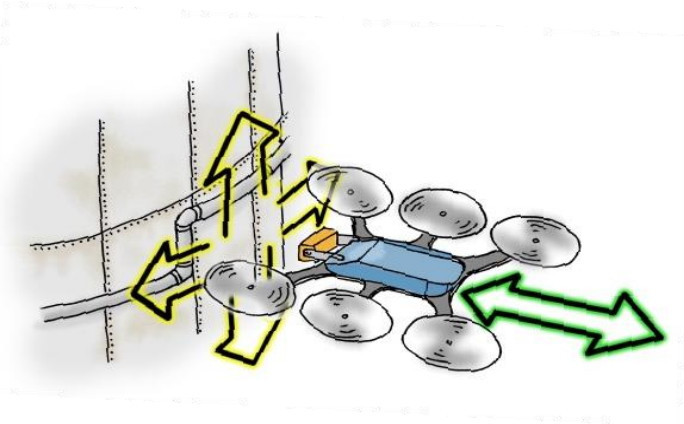
Inspection by UAV!

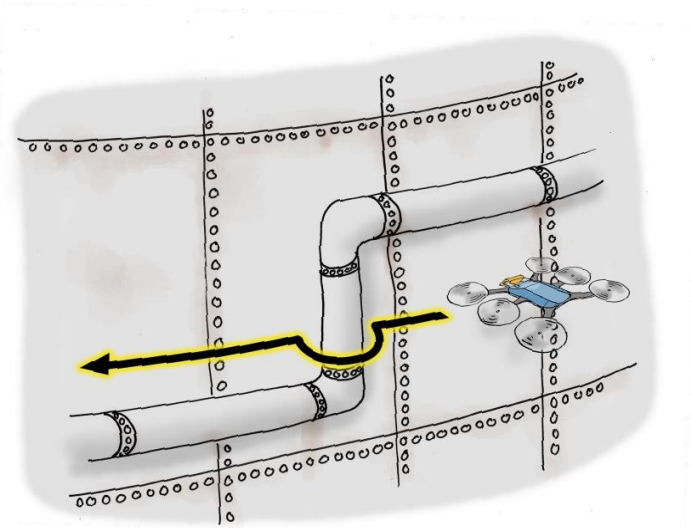
Huge Potential but not Mature yet

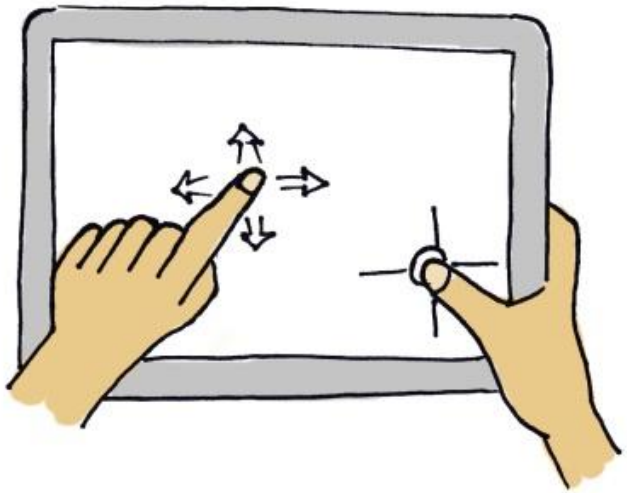


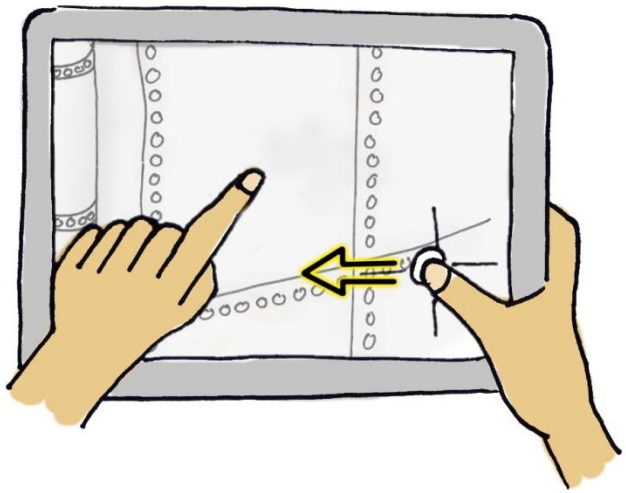
Vision

User-Friendly and Fail-Safe UAV Inspection









Flight-Stabilization Systems

Sensor Requirements

- Accurate relative localization
- Light-weight, low-power
- Indoor/Outdoor Functionality
- Metric measure of spatial surrounding

New Sensor Technologies

- Vision-based (OMNIWORKS, REMAV)
- Laser (TUAV)
- Visual-inertial (TUAV)

Courtesy of Supsi Lugano

Courtesy of ETHZ-ASL

Courtesy of Hokuyo Ltd.

TUAV: Teleoperation of UAVs

Goals

- Teleoperation of UAVs with haptic feedback
- Reactive obstacle avoidance

Sensor Technologies

- 2D laser-ranger scanner
- Visual-inertial stereo sensor

Partners

- I3S UNS-CNRS, Sophia-Antipolis, France

Courtesy of Novint

Courtesy of ETHZ-ASL

Courtesy of Hokuyo Ltd.

TUAV: Teleoperation of UAVs

Results

- 2.5 D Laser-based teleoperation scheme implemented
  - Laser-based stabilization of UAV
  - Generation of obstacle map using laser-scanner
  - Reactive obstacle avoidance
  - Rendering of obstacle map on haptic joystick

Current Work

- Extend current scheme to visual-inertial sensor to fully unstructured environments

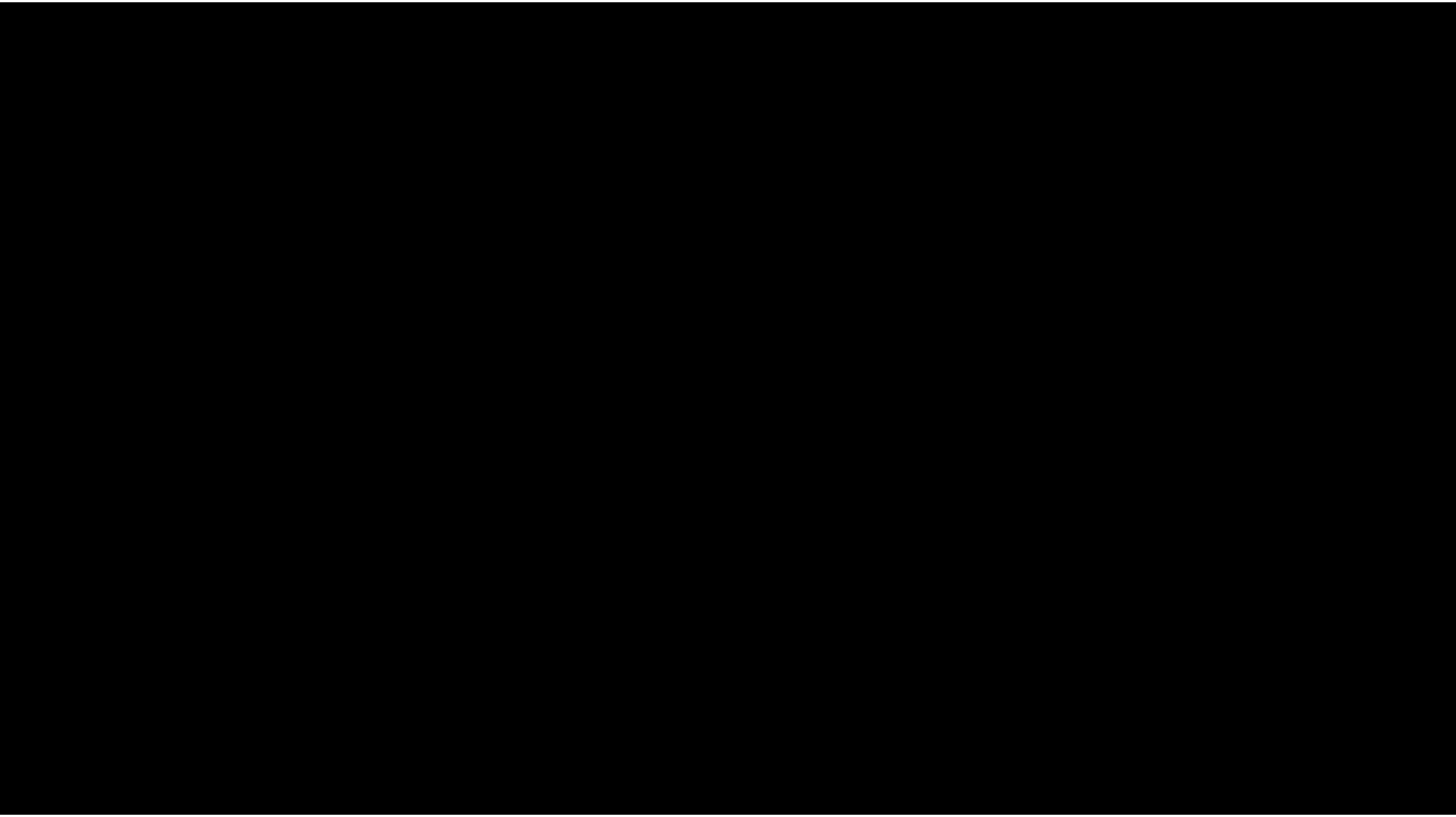
Courtesy of Novint

Courtesy of ETHZ-ASL

Courtesy of Hokuyo Ltd.

TUAV: Teleoperation of UAVs

Experimental Results: Laser-based Unilateral Teleoperation



TUAV: Teleoperation of UAVs

Experimental Results: Laser-based Bilateral Teleoperation

Bilateral Haptic Teleoperation of VTOL UAVs

Video Recording of Experiments

Sammy Omari, Minh-Duc Hua, Guillaume Ducard, Tarek Hamel

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Skybotix TECHNOLOGIES

i3S sophia antipolis

REMAV: Remote Eye for MAVs

Goals

- Velocity-control and obstacle avoidance of UAV using FPGA-based vision sensor

Sensor Technology

- Monocular Optical-Flow FPGA-based Speed Sensor
- Now: Vision-based Line-Detector

Partners

- Vissee, Zurich, CH
- Supsi, Lugano, CH

Courtesy of Supsi Lugano

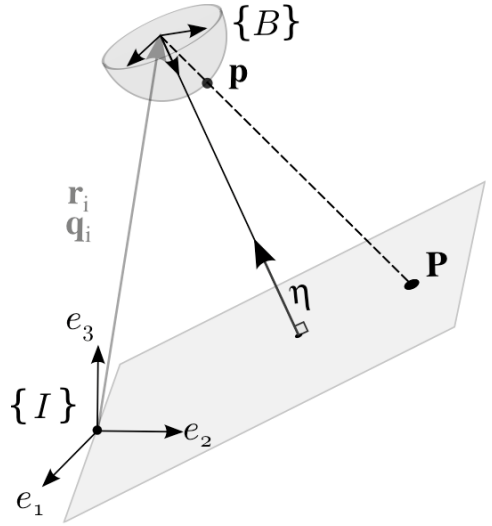
Courtesy of Apple Inc.

VISSEE SUPSI

REMAV: Remote Eye for MAVs

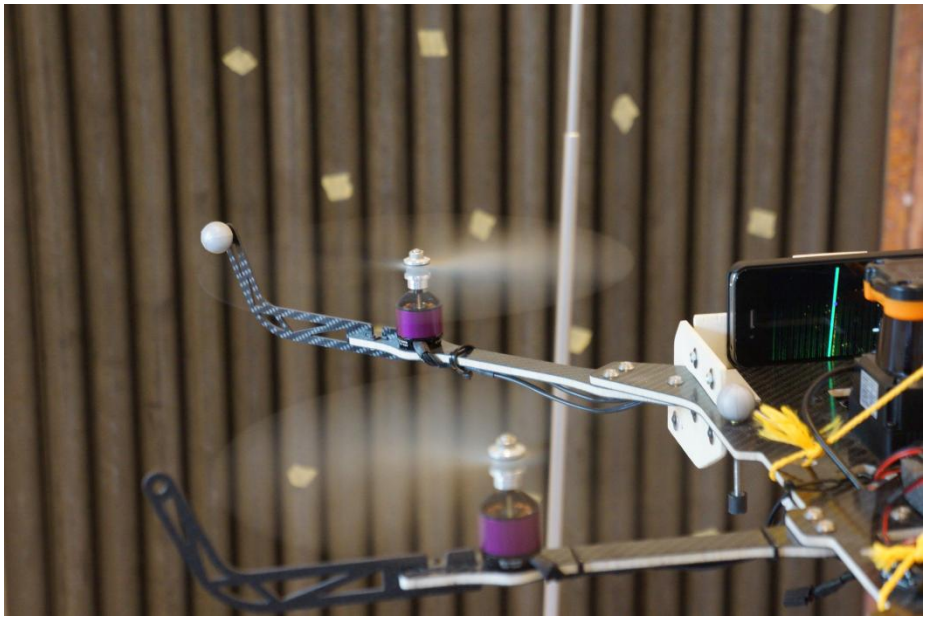
Results

- Optical-Flow based pose estimation (with visual-inertial sensor...)
- Integration of line-detector on UAV



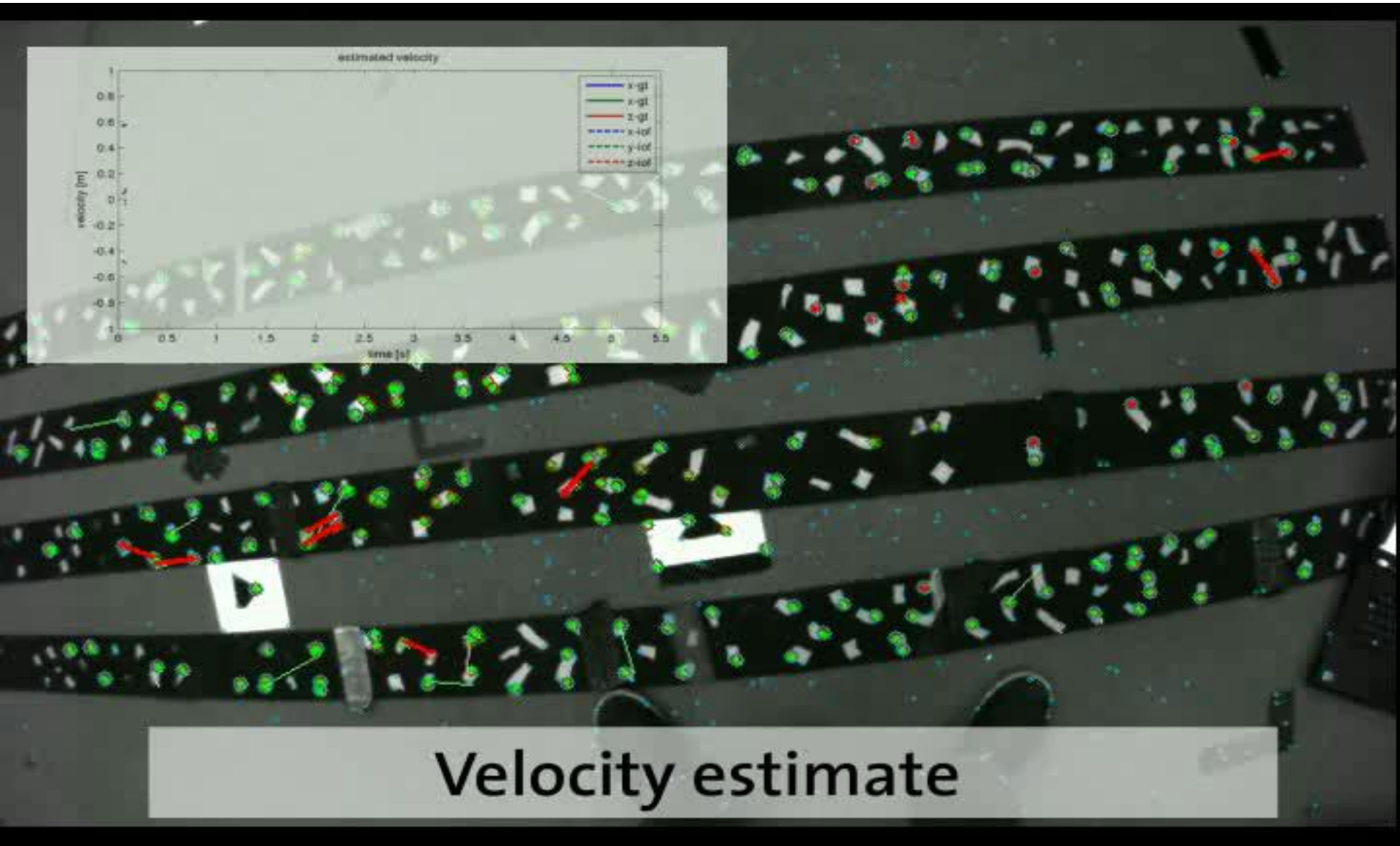
Current Work

- Evaluationof sensors in-flight



REMAV: Remote Eye for MAVs

Experimental Results: Optical-Flow based pose estimation



REMAV: Remote Eye for MAVs

Experimental Results: Line Detector

Scientific Output

Book Chapters

- ***Bilateral Haptic Teleoperation of an Industrial Multirotor UAV***,
  S. Omari, M.D. Hua, G. Ducard, and T. Hamel
  Springer Tracts of Advanced Robotics (STAR), Technology transfer experiments from the ECHORD project, 2013 (to appear)

Journal Articles

- ***Hardware and Software Architecture for Nonlinear Control of Multirotor Helicopters***,
  S. Omari, MD. Hua, G. Ducard and T. Hamel,
  IEEE/ASME Transactions on Mechatronics, Special Issue on Aerospace, 2013 (to appear)

Conference Papers

- ***Haptic Teleoperation of a VTOL UAV***,
  S. Omari, MD. Hua, G. Ducard and T. Hamel,
  IEEE/RSJ International Conference on Robotics and Automation, Karlsruhe, 2013
- ***Metric Visual-Inertial Navigation System Using Single Optical Flow Feature***,
  S. Omari and G. Ducard,
  European Control Conference, Zurich, 2013 (to appear)

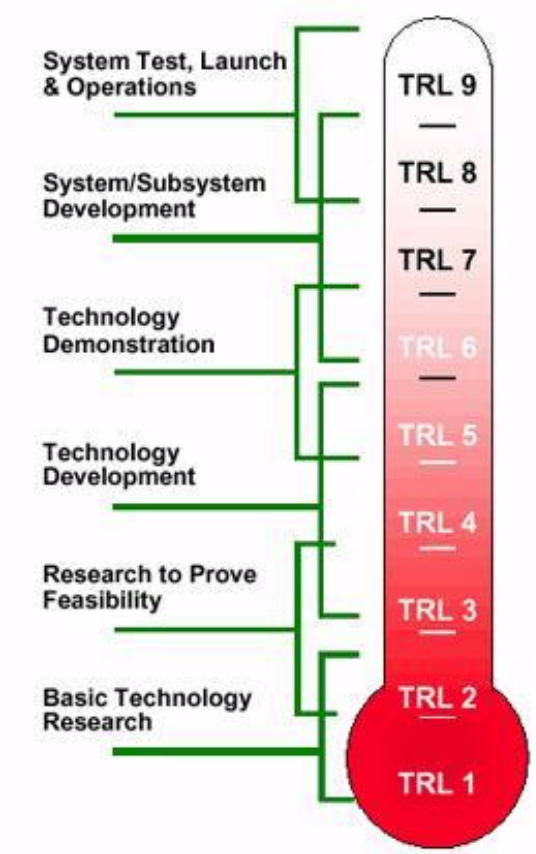
Technological Readiness Level

TUAV

- Laser-based: **TRL 7**
  Demo in operational environment
  (with limitations...)
- Stereo-sensor: **TRL 5**
  System validated in mock-up

REMAV

- Optical-Flow Sensor **TRL 3**
  Active R&D with first lab tests
- Line Sensor **TRL 4**
  Sensor Validation in lab environment



Conclusions

- **ECHORD Projects Successful for Skybotix**
- Acquired significant knowhow in several sensor technologies
- Pros/Cons of sensors evaluated

- Follow-up project with stereo sensor?