The Role of Unmanned Aerial Vehicles in Future Urban Environments

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2014 Intelligent Transportation Systems Research Day
December 4, 2014

Institute for Aerospace Studies
UNIVERSITY OF TORONTO

DYNAMIC
SYSTEMS LAB

RESEARCH @the Institute for Aerospace Studies

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FOCUS: Long-term Autonomy for Robots and Automated Systems.

Associated faculty:

- Gabriele D'Eleuterio
- Tim Barfoot
- Hugh Liu
- Jonathan Kelly

TCC localization with onboard sensors only. (Barfoot)

Unmanned Aerial Vehicles for fire detection/management. (Liu)

MY RESEARCH FOCUS

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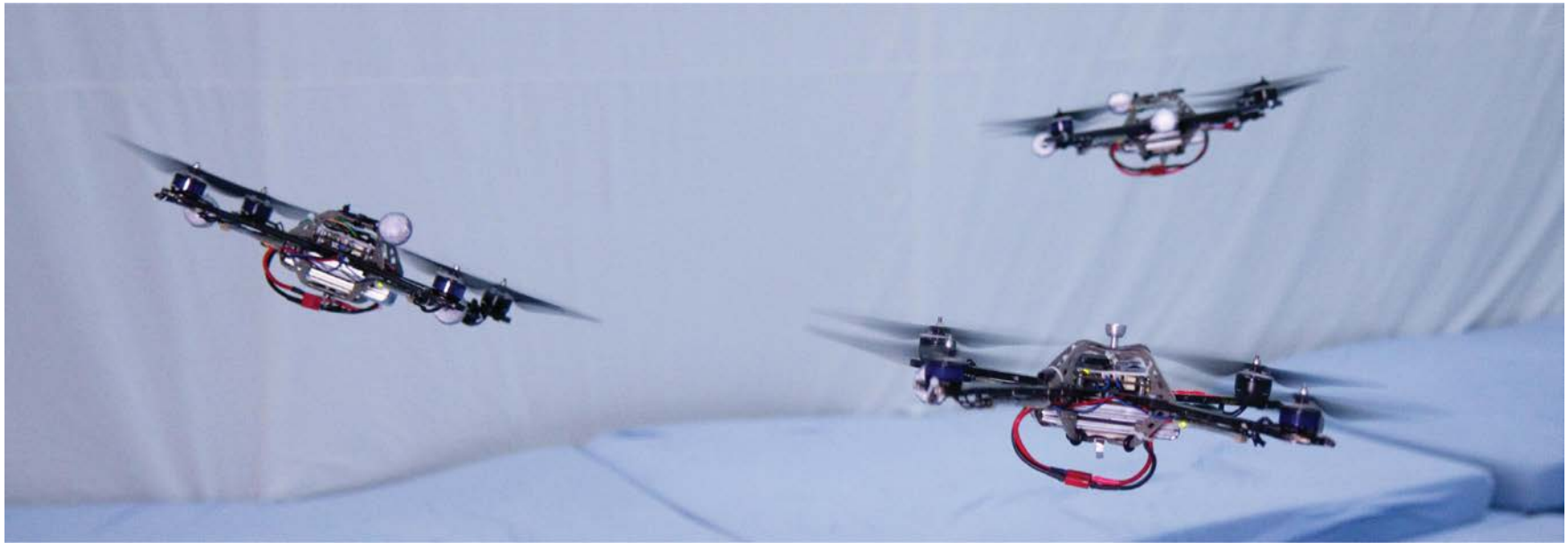
To develop algorithms that enable robots

- to perform tasks *autonomously*, and
- to improve their performance over time by *learning* from past experience.

⇨ 6 years of research experience in **unmanned aerial vehicles** (UAVs)



VIDEO: http://youtu.be/wwK7WvvUvlI?list=PLD6AAACCBFFE64AC5

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THE UAV MARKET IS GROWING

"**Non-military application** of Unmanned Aerial Vehicle (UAV) technology is the **fastest growing sector in the global aerospace industry** and expected to **grow by 700% between 2012 and 2018**." [1]

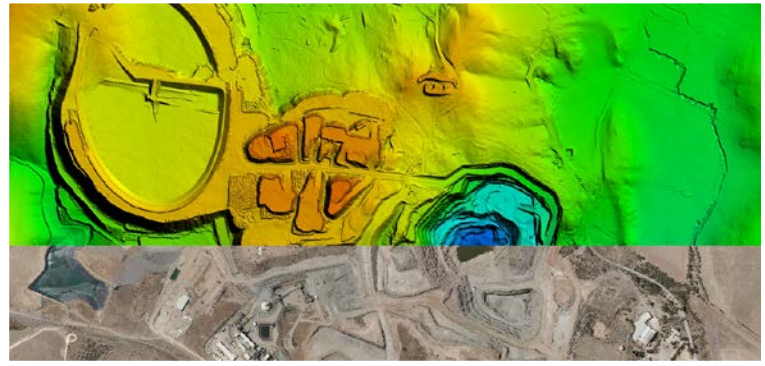
In the next 10 years:

- US$90 billion spent on vehicles globally [2]
- US$82 billion and 100,000 additional jobs in the US as UAV technology enables new approaches to a broad range of applications [3]

[1] Teal Group. "World Unmanned Aerial Vehicle Systems, Market Profile and Forecast", 2013.
[2] G J Harrison. "Unmanned Aircraft Systems (UAS): Manufacturing Trends - Report R42938", 2013.
[3] D. Jenkins and B. Vasigh. "The economic impact of unmanned aircraft systems integration in the United States." Association for Unmanned Vehicle Systems International, 2013

BROAD RANGE OF APPLICATIONS

Powerline and pipeline inspection



3D mapping

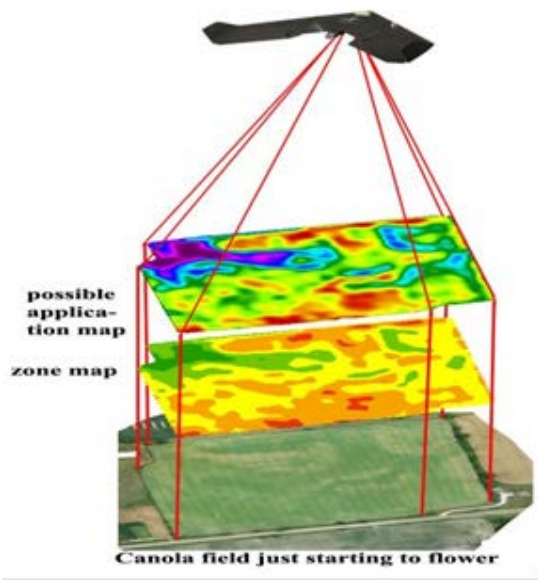
Precision Agriculture

Infrastructure inspection

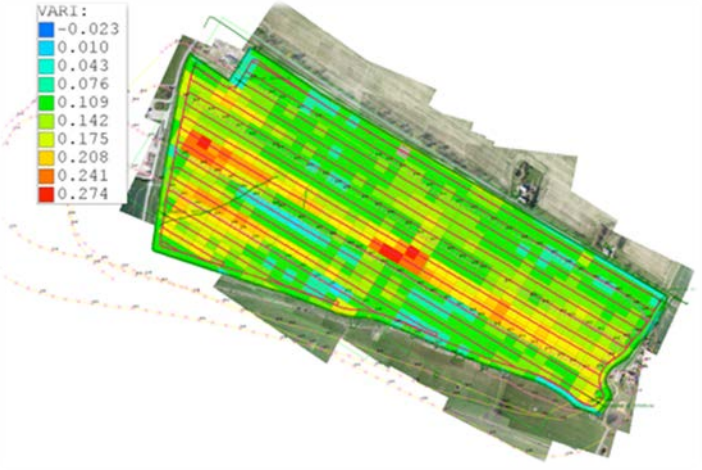
UAVs will be part of future urban environments.

ADVANTAGES OF UAVs

- On-demand ‘sensor in the sky’
- Provides high-resolution temporal and spatial data
- Able to execute tasks repetitively, fast and accurately



Example: Precision Agriculture



Question: What can UAVs do for transportation?

GOAL FOR THE REST OF MY TALK

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Introduce you to

- The components of a UAV system
- The capabilities of UAVs
- The state-of-the-art technology

To inspire you to think about how UAVs may be used in transportation applications.

UAV DESIGNS

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Fixed-Wing

Multi-Rotor

- Long range vs. limited flight time
- Constrained maneuverability vs. agility and hover capability

KEY COMPONENTS

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3|DATA ACQUISITION/ANALYSIS

1| LOCALIZATION

2|CONTROL/COORDINATION

Localization, Control, and Data Analysis have advanced a lot in recent years. Ready for applications!

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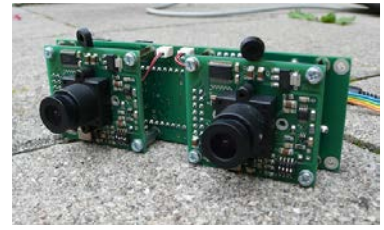
External Systems

- GPS (accuracy 2m)
- RTK GPS (1-2 cm)
- Motion capture with overhead cameras (2mm)
- Total Station (<0.5 mm)
- Other triangulation-based devices (e.g. Inmotiotec or Locata)

… external infrastructure needed.

On-board Systems

- Monocular camera
- Stereo camera
- LiDAR
- Laser Range Finder

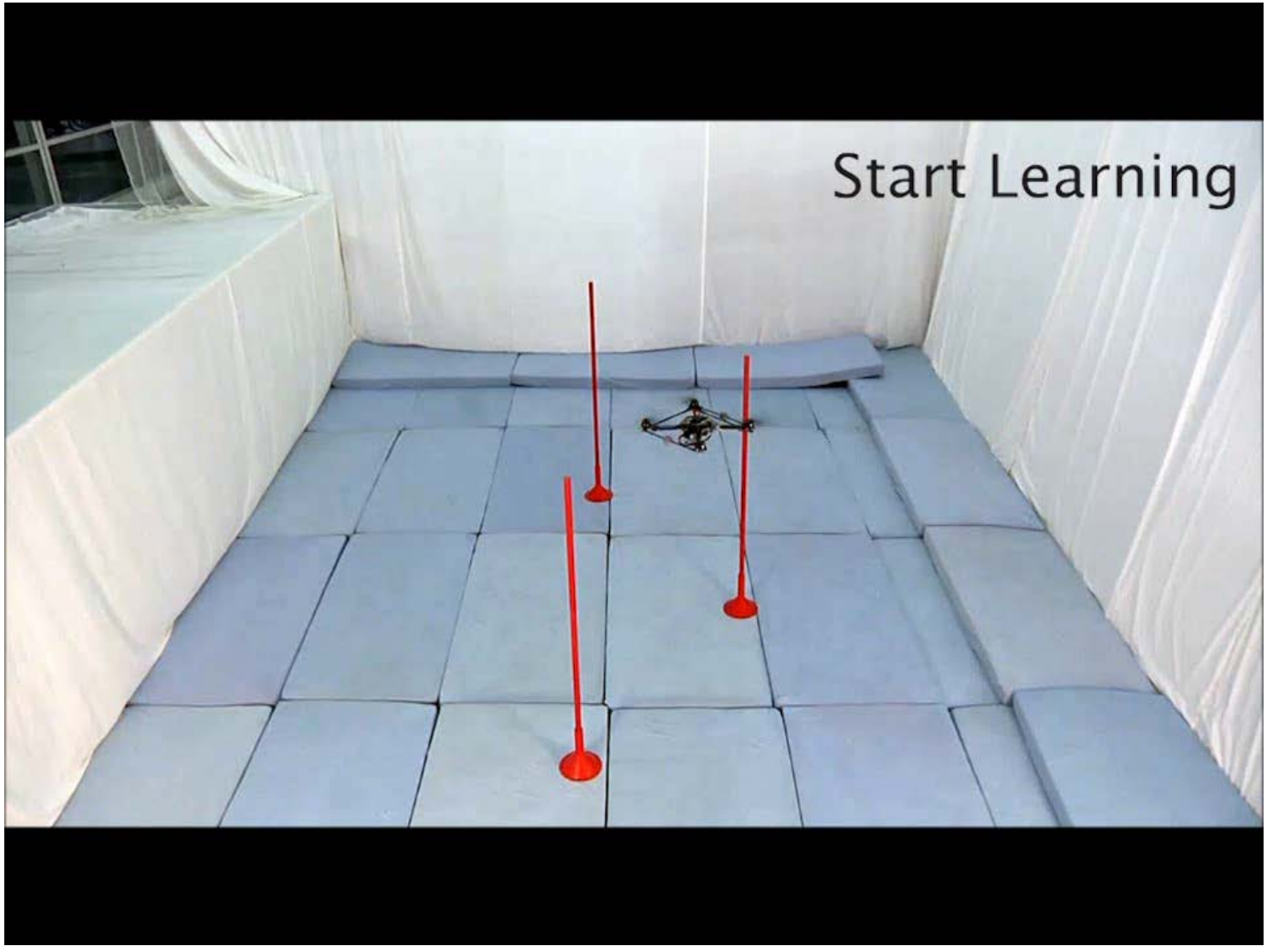


… need to be able to measure distance to the environment.

Can we re-use infrastructure of existing transportation systems?

video: http://youtu.be/nQ2ziVW6kts?list=UUYVKqp2pJFlOwyBIbs_zTxg

VIDEO: http://youtu.be/zHTCsSkmADo?list=PLC12E387419CEAFF2



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Control can only be as good as localization is in terms of accuracy and update rate.

Control performance is constrained by our knowledge about the system and environment.

⇨ *Research topics include precision flight in unknown, challenging, outdoor conditions (such as wind) using online adaptation/learning techniques.*

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3|DATA ACQUISITION/ANALYSIS

1| LOCALIZATION

2|CONTROL/COORDINATION

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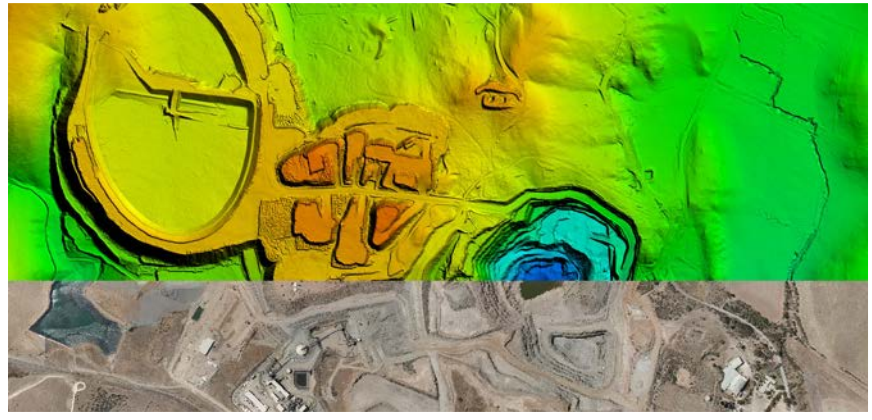
Any sensor of reasonable weight (<3kg) can be put on the vehicle.

Combination of several sensors used to get "big picture".

⇨ Research topics include fusing data from different sensors and processing it efficiently.

Examples:

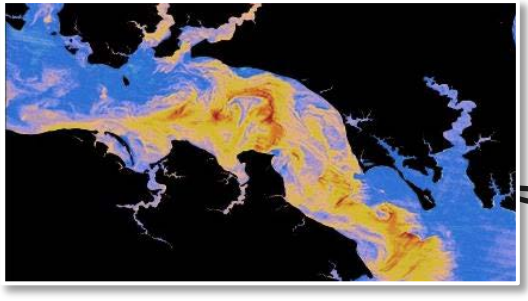
- Cameras: multi-spectral, thermal etc
- LiDAR
- Biological sensors
- Chemical sensors
- … and many more.



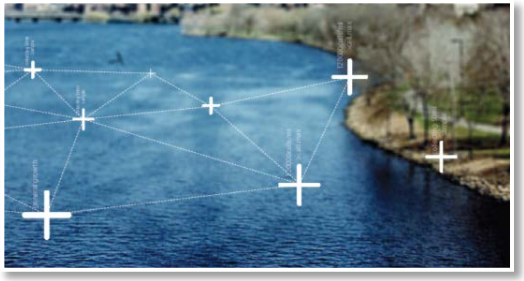
WATERfly

Algae (cyanobacteria) monitoring with UAVs.

:: aerial imaging



Understanding of algae growth.



:: probing

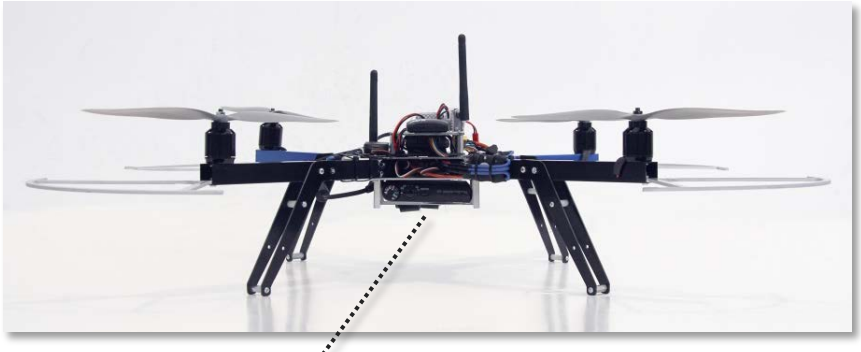
Lake Erie's algae explosion blamed on farmers

Climate change an 'aggravating factor' but runoff from agriculture seen as major culprit

By Emily Chung, CBC News Posted: Aug 07, 2014 5:00 AM ET | Last Updated: Aug 08, 2014 8:13 AM ET

WATERfly

Prototypes.



:: aerial imaging

:: probing

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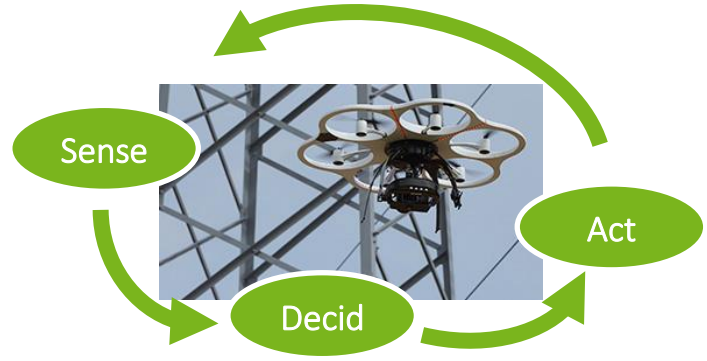
SUMMARY

- UAVs for non-military applications is a **growing and fast evolving market** with a broad range of **applications**.
- Research/development is increasingly being targeted towards applications.
- **Canada** has the potential of **being a world leader** in UAVs [1] (with Aeryon Labs Inc. and PrecisionHawk in ON).



Encourage you to think about UAV applications in transportation.

[1] Bento, Betancur, et al. “Canada: Opportunities in Canada’s Unmanned Aerial Vehicles (UAV) Market”, U.S.A. Department of Commerce, 2014.

THANK YOU

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For follow-up discussions, please contact me:

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