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UAVs for Emergency Responders
University of Cincinnati-Aug. 10, 2016
UC has a very strong research program in the areas of UAVs that focuses on the following research areas:

- Navigation and path planning
- Multi-sensor fusion for situational awareness and tracking
- Novel UAV design, system ID, and control
- Large scale optimization for tasking and resource allocation

UAV Research @ UC

- Novel quad-rotor design and control
- Tracking of ground objects
- System identification and control of multi-copters

UAV path planning in National Air-Space
UAV Operations @ UC

UAVs for wildfire monitoring

UAVs for package delivery with Workhorse

Winner of Indoor Navigation Challenge, AAVC 2014-15

Prof. Franck Cazaurang flying a quad-copter in the UAV Master Lab

Dr. Wei in West Virginia
## Main Features of the Technology

- A small-UAV gathers real-time data that includes vision/infrared videos, and flight data from GPS and Inertial Measurement Unit.
- Data processed to obtain current locations of wildfires and geo-referenced to mapping services such as google maps.
- Real-time data combined with environmental and topographic information fed to fire prediction model to provide predicted growth of fire fronts to aid resource allocation/decision-making.
Introduction to SIERRA

Technological Innovations
Control and autonomous navigation

- Autonomous search of ground events
- Autonomous hot-spot visit for persistent monitoring
- Auto-pilot Design
- Tracking of Maneuvering Ground Targets

Data processing and information portrayal

- Video processing for smoke removal, hot-spot and human identification

User interface development
Save lives and property by enhanced real-time information and decision making: The proposed UAV based platform provides an unprecedented opportunity to gather real-time information and deliver emergency supplies. Such capability, currently unavailable, will allow the firefighters to make decisions to save lives and suppress fire in most efficient manner.

Ease of use by first responders: As opposed to other UAV platforms available in the market, this platform will provide push-button facility to operate the UAV and visualize the information. Such a capability is invaluable for non-pilots working in heavy stress situations.
# SIERRA - Timeline

## Intro to SIERRA
- NSF BECS Project (EFRI-1024608)
- NASA/OSGC funding of $25K
- Fire-fighting training for UC graduate student

## Value Proposition
- UAV flight training in Georgia
- Demo #1 & #2 with West Virginia Forestry
- Extensive media coverage of SIERRA on Discovery Channel, BBC radio, local TV

## Timeline
- Fall 2010
  - Demo #3 with West Virginia Forestry
  - NSF I-Corps Project (IIP-1343498)
- Spring 2011 - Fall 2011
  - UAV Package delivery system gets extensive media coverage
  - UC receives COAs for flight operations
- 2010-2012
  - NSF PFI Project: (IIP-1414346)
- July 2013 - Feb 2014
  - Demo #4 with West Virginia Forestry
- June 2014 – Nov 2015
  - Seeking support from UC business accelerator program
  - Prep of 3 invention disclosures
  - NSF CHSI Project: (1526677)
- Winter 2016
  - Team wins 2 consecutive Autonomous Aerial Vehicle Competitions: 2014-15

## Publications and Media
- Extensive media coverage of SIERRA on Discovery Channel, BBC radio, local TV
- Demo #3 with West Virginia Forestry
- NSF PFI Project: (IIP-1414346)
- Demo #4 with West Virginia Forestry
- Seeking support from UC business accelerator program
- Prep of 3 invention disclosures
- NSF CHSI Project: (1526677)
People Impacted

Graduate Students
- Bryan Brown, Current M.S. Student
- Mohammad Sarim, Current Ph.D. Student
- Balaji Sharma, Ph.D. 2013, Now at Mathworks
- Sushil Garg, M.S. 2013, Now at Google

Undergraduate Students
- Alireza Nemati, Current Ph.D. Student
- Anoop Sathyam, Current Ph.D. Student
- M. Radmanesh, Current Undergrad Student
- Ruoyu Tan, MS. 2013, Now at PSU
- Sarthak Kukreti, Current Ph.D. Student

Collaborators
- Mr. Rodger Osborne, West Virginia, Dept. of Forestry
- Ch. Thomas Lakamp, District Fire Chief, Cincinnati Fire Department
- Steve Burns, Workhorse Group
- Connor Kress and Kyle Lentz, Founders, Hephaestus LLC

Intro to SIERRA  Value Proposition  Timeline  People Impacted  Publications and Media
## Publications and Media

### Publications: 11 Journal papers, 2 book chapters, 1 invention disclosure, 20+ conference papers


### Invention disclosure/provisional patent

Earth-Fixed Inertial Frame Based Radio Controller (RC) for Multi-copter UAVs, Disclosure filed on 02/09/15, Approved for provisional patent application on 9/10/15

### Media coverage: 4 Local and national TV, 1 Radio (BBC), and 20+ print media

- SIERRA, Daily Planet, Discovery Channel Canada, Feb. 9, 2012

### Print

Octo-Copter Package Delivery

- UC is partnering with AMP Electric Vehicles on package delivery using Octo-rotor UAVs.
- Rather than a UAV traveling straight from warehouse to delivery site, this duo will be able to more efficiently deliver a large amount of packages.
- The UAV can recharge wirelessly using the truck’s battery, and safety redundancies are in place such as the octorotor design.
- Other ease-of-use features are planned, such as the ability for the HorseFly to scan a package’s barcode and then autonomously navigate to the destination.


Package Delivery – with Workhorse Group
Fault Tolerant Flight Control

• Fault tolerance means
  – The UAV should be able to complete its mission in case of individual component failure
  – The UAV should gracefully abort its mission in a safe manner

• Failures could be
  – Motor/rotor failures
  – Sensor/communication failure

• Working with Prof. Franck Cazaurang of UB
  – Using flatness property to design fault tolerance
  – Using novel UAV design

Novel quad-rotor design and control
Unmanned Aerial Vehicles: Tracking of Ground Maneuvering Targets

\[ \phi = \sin^{-1} \left( \frac{v_T \sin \beta}{v_P} \right) \]
Tilted-Rotor Quad copter

- Better maneuverability
- Allows achieving any desired configurations
- Extra DOFs can be used for fault tolerance and robustness to disturbances
Integration of UAVs in the National Airspace

- Developing algorithms for management of UAV traffic
- ADS-B provides flight data to neighboring aircrafts
- Objectives: maintain separation to avoid collisions while fulfilling UAV’s mission
Smart Unmanned Aerial Vehicle for Exploration (SUAVE)

Aug. 26, 2014

April 28, 2015
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