UAS FOR FIRE MANAGEMENT: STATE-OF-THE-ART, EARLY WARNING AND TRENDS

Nikos I. Vitzilaios and Nikos C. Tsourveloudis
Intelligent Systems & Robotics Laboratory
Technical University of Crete
Chania, Greece
Presentation Outline

- Problem Statement
- Industrial Products
- Academic Research
- Nearhos UAS
  A UAV based automated airborne surveillance system
- Conclusions
Problem Statement

- Forest fires: constant threat to ecological systems, infrastructure and human lives
- Prognoses: half forests by the year 2030
- Annual vegetation destruction by fires
  - Europe: up to 10,000 km²
  - Russia and North America: up to 100,000 km²
- 20% of CO₂ emissions into the atmosphere are caused by fires
- Once fire fighters on the scene, the first important task is reconnaissance
  - Data collection and orientation
  - Define tasks associated with the saving of lives and the extinguishing of fire
  - Safe implementation
- Problems associated with the reconnaissance of forest fires
  - Fire covers such a large area that reconnaissance requires touring around the entire affected area
  - Perimeter monitoring hindered by natural conditions, terrain topology and vegetation
  - Circumambulating an area with a radius of 300m involves a distance of almost 2km
  - If commander of fire-fighting operations is at the scene, he is too close to be able to manage the environment. Need for many commanders to view various areas (subjective assessment)
  - The extinction of forest fires is a protracted process in time, immediate area reconnaissance needed
Air reconnaissance

- Offers an overview of several thousand hectares of forest
- Allows intervention measures to be co-ordinated
- Objectivity in ranking the individual sites in relation to the others
- Elimination of terrain topology effects that hinder visual access
- Benefits to smaller fires too
- Relatively low cost if visual inspection by staff is replaced by acquisition of image data

Unmanned aircraft vs Manned aircraft

- High altitude, above and out of the path of air-tankers and helicopters
- Almost real-time broadcasting of high quality infrared images
- Continuous operation (refueling after 10 hours of work)
- Operation at night while other firefighting aircraft are grounded
- Low cost
- Ground teleoperation or autonomous operation
- Great payload capabilities (various systems can be placed onboard)
Unmanned Aircraft Systems (UAS) for Fire Management

Development

✓ Industries (General Atomics, EADS etc)
✓ Federal Organizations (NASA, NOAA etc)
✓ Academia (Universities, Research Institutes etc)

Types

✓ High-altitude, long endurance (HALE)
  ✓ High payload
  ✓ Precision instruments, accurate detection
  ✓ Increased cost
✓ Low-altitude, short endurance (LASE)
  ✓ Low operating and manufacturing cost
  ✓ Relatively simple launch and recovery
  ✓ Limited sensor range
Current Applications

Municipal Fire Brigade Missions

- Fire-related monitoring & investigation
  - UK
  - AirRobot (Germany) operated by UK FD

Regional Fire Brigade Missions

- Forest fire detection & monitoring
  - Hungary
  - Szendro Fire Brigade

National Fire-Fighting Missions

- Forest fire detection & monitoring
  - USA
  - Ikhana (General Atomicincs) deployed by NOAA

Research Studies

- Forest fire monitoring
  - Croatia (FENIX Project)
  - Spain (COMETS, Daedalus, Horus, Sky-Eye Projects)

UVS International, November 2007
Altair UAS

- High-altitude long-endurance UAS
- Altitude up to 13-15km
- Endurance up to 20 hours with at least 300kg payload
- Parts
  - Autonomous aircraft (26m wingspan, 11m fuselage length) based on Predator B
  - Redundant control systems
  - High-speed satellite and radio communication
  - Ground based pilots and sensor operators
- Project development partners
  - US National Oceanic and Atmospheric Administration (NOAA)
  - General Atomics Aeronautical System
  - NASA
- Development: 2003-2004
- Test flights: 2005-2006
- First mission: October 2006 (Esperanza Fire)
Altair UAS on duty

- Esperanza fire (Riverside County, USA)
  - 34 homes destroyed
  - More than 40,000 acres burned
  - 5 USFS firefighters dead

- Altair Operation
  - 43,000 feet altitude
  - 16-hour flight (day and night)
  - Delivered real-time thermal infrared data to incident commanders via satellite communications link
  - Derived thermal imagery data overnight, helped to plan efforts for the next day
Aerovision Fullmar UAS

- Low cost system for civilian applications
- Fulmar aircraft
  - 3m wide
  - 20kg weight
  - 8h endurance
- Video and infrared cameras onboard
- Up to 50 km transmission
AirRobot

- Size: 1m diameter
- Weight: <1kg
- Endurance: up to 30 min
- Payload: 200g
- Distance: 500m
- Barometric altitude control
- Gyroscopic and acceleration sensors
- Autonomous landing if radio communication is missing
- Payloads:
  - Color camera
  - Night vision camera
  - Thermal camera

Intelligent Systems & Robotics Lab
www.robolab.tuc.gr
Autonomous Forest Fire Monitoring System Using Multiple UAVs (R. Beard et al.)
- Detect hotspots with detector agents and assign service agents to monitor them
- Service agents equally spaced along the perimeter of the hotspot
- Scheduling scheme for UAVs refueling
- Simulation results and experimental results using fixed wing UAVs

Cooperative Forest Fire Perception System for Multiple UAVs (Merino, Ollero et al.)
- Heterogeneous UAVs (helicopters and blimps)
- Heterogeneous sensors (infrared and visual cameras, fire sensors)
- Perception system distributed within the fleet
- Centralized system fuses data provided by different UAVs
TUC Project: Nearchos UAS

- Based on Nearchos UAV
- Medium distance reconnaissance UAV
- Main Characteristics
  - Length 3.95m
  - Wingspan 5.10m
  - Height (landing gear) 1.15m
  - Empty Weight 60kg
  - Operational altitude 7km
  - Operational speed 75km/h-220km/h
  - Flight Endurance 8h-12h
  - Payload capacity 51kg-92kg

- TUC Project: Development of an Integrated Airborne Fire Detection System
  - On-board thermal sensitive sensors (IR or NIR camera)
  - Evaluation software
    - Noise reduction
    - Feature extraction
    - Classification
    - Decision-making (alarm signal)
  - Integration with UAV-ground communication system
  - Integration with UAV autonomous navigation system
Nearchos UAS for Airborne Surveillance

IR/NIR image → Noise reduction image processing → Feature extraction (Size, mean intensity) → Feature vector classification → Alarm on/off → Persistence

Area Surveillance

Perimeter Monitoring

Detected Fire Monitoring

Satellite Communication System → Sensors → Autonomous Navigation System

Image Processing → Image compression → Intelligent System → RF link

Operations HQ → Ground station
Nearchos UAS for Airborne Surveillance

- Cooperation with developed ground surveillance system for forest monitoring
Nearchos UAS Fire Detection

**Fire Absent**

**Fire Present**


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Media Coverage
Conclusions

- Forest fires threat to environment
- Pessimistic predictions for the future
- New techniques in fire management are developing
- UAS can provide sufficient assistance
  - High altitude UAS for global monitoring
  - Team of UAVs for precision monitoring
- Both industrial and academic efforts
- Current research provides promising results
- The future is unmanned
Thank you for your attention