Flight Test of UAV Airship for System Identification

Autonomous Vehicles Laboratory

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Mission Description

• **Purpose**

  - An indoor testbed for lighter-than-air autonomous vehicle and GPS-denied navigation research
  - Advertising tool on college sport events

• **Mission Profile**

  - Fly around arena while keeping a safe altitude and course
  - Transition to hover at certain points to drop coupons/ take photo
  - Reject disturbances such as gusts due to A/C fans
  - All times avoid obstacles such as scoreboards, spectators and the players
System Requirements

• Altitude
  • Avoid no fly areas and obstacles residing both at the floor and ceiling

• Speed
  • Slower than walking speed for safety and fulfilling mission segments
System Requirements

• Size
  • Draw attention
  • Ease of handling

• Endurance
  • 5 to 30 min
  • LiPo batteries
System Requirements

• Payload
  • Banners
  • Coupons

• Camera
• LED Lighting
• Autopilot and accessories
System Requirements

- Autonomous Flight
  - Aiming autonomous navigation and flight control
System Requirements

• Ambient Conditions
  • Indoor environment: no satellite navigation
  • Very sensitive to even the air circulation due the AC system and the spectators
  • Helium is severely affected from temperature changes
Specs

Length: 17 ft (5 m)
Diameter: 8 ft (2.43 m)
Volume: 440 cu ft (12.6 m³)
E-Flite Power 15 950 KV motors in 10 inch nacelles, tilting up to 180 deg
Producing thrust up to 11 N
25 min flight time with one 12V 4000 mah lipo batteries
E-Flite Power 10 Brushless 1100 KV motor in 8 inch nacelle for tail rotor, ESC allow 100% forward and reverse control of the motor Producing up to 8N thrust.

Rudder and elevator channels are mixed to tilt angle and tail rotor
Flight Test Objectives

In our recent simulation study, waypoint navigation in changing altitude and changing speed tracking configuration was shown to be successful under forward and downward wind gusts.
Flight Test Objectives

- Flight tests aim
  - to validate an existing dynamic model used in simulations
  - to obtain a physical model of the MAV airship via system identification
- Several flight test scenarios are designed in order to reach these objectives
Flight Test Approach

- Vectored main thrust, elevator, rudder and tail thrust are excited with step doublet and 3211 inputs

- Push/Pull and Weight add/drop tests

- Operator manual flight
Resources

• UTA College Park Center Arena is used as test venue
• OverTheTop Airships Advertising provides their know-how and RC pilots
Flight Safety Considerations

- At all times manual RC pilot observes the aircraft
- During the tests, the area is cleared from human traffic and obstacles
**Instrumentation**

An Arduino based hardware with several sensors and flight logging capability is mounted at the bottom of the gondola to apply and save inputs and telemetry.
Instrumentation

- Matlab – SIMULINK compatibility
  - Toolbox and blockset support
  - Allows uploading models on hardware
Instrumentation

- MPU 6000
  - 3-axis accelerometer with a 3-axis gyroscope
  - Maximum range: accelerometer ±16g
    gyroscope ±2000 deg/s
  - 16-bit A/D converter built-in
• MEAS MS5611
  – barometric pressure sensor
  – Local static pressure 10 to 1200 mbar and temperature -40 to +85 °C
  – 24-bit A/D converter 75 Hz refresh rate
**Instrumentation**

- Honeywell HMC5843
  - 3-axis digital magnetometer
  - Field Range Full scale (FS) – total applied field -4 to +4 gauss
  - Output Rate: 50Hz (10Hz typ.)
Instrumentation

• Telemetry
  – 900 MHz Zigbee module
  – Allows two way communication
  – Used for arming the board for data recording and monitoring during flight
Instrumentation

• Dataflash
  – 4 MB micro SD card
  – Recording is armed via command
  – Downloadable by serial terminal
Data Analysis

Post processing of flight data
Data is collected at 50 Hz

– Mapping RC PWM inputs into physical units
– Digital smoothing/filtering of accelerations angular rates
Data Analysis

Stopping maneuver 1

Thrust step applied during cruise 2

Thrust step applied during cruise 1
Flight Test Results

• Several test scenarios repeated in order to
  – Make sure consistent flight data patterns achieved upon same input forms
  – Know more about general shape of dynamics and modes to design and prepare more detailed experiments
Thrust Step from hover
Thrust Step during cruise
Stopping

Graphs showing various parameters over time for a stopping maneuver.
Rudder steps

Society of Flight Test Engineers 44th Annual International Symposium

30
Conclusion and Future Work

- Initial flight tests exposed basic characteristics of dynamics and stability of MAV airship
- Detailed flight maneuvers for identification and validation purposes
- Outdoor flights for maneuvers requiring larger space
- Additional instrumentation (pitot tube, sonar, GPS)
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Questions and Feedback