National Aeronautics and Space Administration

NASA

TECHNOLOGY SOLUTION

Robotics, Automation and Control

Adaptive wind estimation for small unmanned aerial systems using motion data

A unified approach to autonomous flights of multi-rotor vehicles in urban environment

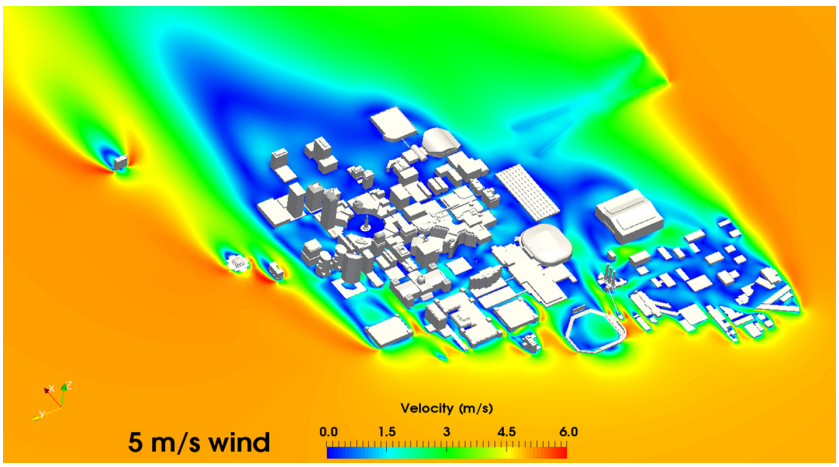
Small Unmanned Aerial Systems (sUAS) are becoming increasingly popular for research, commercial, and military usage due to their affordability resulting from their small size, low cost and simple hardware structure. Their lightweight structure and limited power make the sUAS vulnerable to wind disturbances, and hence difficult for accurate navigation and control outdoors, especially in urban environment where the wind field is more complex and has more uncertainties. NASA Ames has developed a unique and novel technology that provides fast and reliable estimation of the wind and related aerodynamic drag components for the sUAS without requiring expensive measurement components and computational power. The technology is a method to provide safe navigation and control capabilities for the multi-rotor drones in an urban wind field. It provides the critical aspects of the uses of sUAS, which is reliability while maintaining simplicity in design.

BENEFITS

- Fast and reliable estimation of drag coefficients without expensive wind tunnel testing
- The methods are computationally effective and can be implemented on conventional onboard computers
- Lightweight and low-cost adaptive wind estimation
- Low-power consumption for wind estimation/aircraft stability/trajectory control
- Increased safety for autonomous UAVs; provides safe navigation and control capabilities for UAVs in wind fields

THE TECHNOLOGY

The technology presents an on-board estimation, navigation and control architecture for multi-rotor drones flying in an urban environment. It consists of adaptive algorithms to estimate the vehicle's aerodynamic drag coefficients with respect to still air and urban wind components along the flight trajectory, with guaranteed fast and reliable convergence to the true values. Navigation algorithms generate feasible trajectories between given way-points that take into account the estimated wind. Control algorithms track the generated trajectories as long as the vehicle retains a sufficient number of functioning rotors that are capable of compensating for the estimated wind. The technology provides a method of measuring wind profiles on a drone using existing motion sensors, like the inertial measurement unit (IMU), rate gyroscope, etc., that are observably necessary for any drone to operate. The algorithms are used to estimate wind around the drone. They can be used for stability or trajectory calculations, and are adaptable for use with any UAV regardless of the knowledge of weight and inertia. They further provide real-time calculations without additional sensors. The estimation method is implemented using onboard computing power. It rapidly converges to true values, is computationally inexpensive, and does not require any specific hardware or specific vehicle maneuvers for the convergence. All components of this on-board system are computationally effective and are intended for a real time implementation. The method's software is developed in a Matlab/Simulink environment, and has executable versions, which are suitable for majority of existing onboard controllers. The algorithms were tested in simulations.



Wind profile used to test the invention

APPLICATIONS

The technology has several potential applications:

- Commercial sUAS manufacturing industry (UAVs/drones/Airtaxies)
- Aerospace industry
- Air Traffic Management

PUBLICATIONS

Patent No: 11,029,709

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More Information

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