National Aeronautics and Space Administration

NASA

TECHNOLOGY SOLUTION

Robotics, Automation and Control

Airborne Machine Learning Estimates for Local Winds and Kinematics

GPS-free Estimations using COTS Sensors for UAS and Air Taxi Operations in Complex Urban Environments

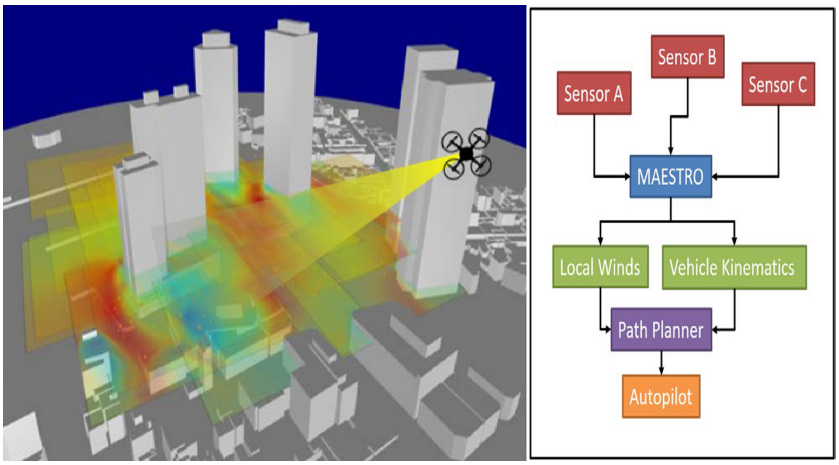
Future Unmanned Aerial Systems (UAS) and air taxis will require advanced onboard autonomy to operate safely within complex and dynamic urban environments. Urban landscapes are dynamic and constantly evolving. In addition to multi-directional, intense, and seemingly unpredictable winds often created in urban canyons, an exact knowledge of current building sizes, shapes, and positions is also often unavailable for real-time navigation. NASA Ames has developed a novel system, MAESTRO: MAchine learning ESTimations for uRban Operations, which not only improves the flight safety of UAS and air taxis in complex dynamic environments but also allows them to make smart and rapid on-board estimations of the local surrounding winds and vehicle kinematics using commercial off-the-shelf (COTS) sensors and advanced onboard computing.

BENEFITS

- Accurate and fast estimates of the local wind environment and vehicle kinematics
- Uses advanced machine learning algorithms linked with commodity sensors
- Allows for safe navigation through and around complex urban environments
- Allows UAS and air taxis to estimate winds based on geometry of surroundings
- Provides all-azimuth predictions
- Integrates well with existing airborne sensors
- Requires no external communication or network after deployment
- Provides robust and efficient predictions for dynamic (or possibly unknown) urban geometry
- Runs efficiently (less than 0.1 sec) on commodity portable computer hardware
- Produces actionable advisories that fit seamlessly into the GNC process stream
- Provides GPS-free position and attitude estimations

THE TECHNOLOGY

The MAchine learning ESTimations for uRban Operations (MAESTRO) system is a novel approach that couples commodity sensors with advanced algorithms to provide real-time onboard local wind and kinematics estimations to a vehicle's guidance and navigation system. Sensors and computations are integrated in a novel way to predict local winds and promote safe operations in dynamic urban regions where Global Positioning System/Global Navigation Satellite System (GPS/GNSS) and other network communications may be unavailable or are difficult to obtain when surrounded by tall buildings due to multi-path reflections and signal diffusion. The system can be implemented onboard an Unmanned Aerial Systems (UAS) and once airborne, the system does not require communication with an external data source or the GPS/GNSS. Estimations of the local winds (speed and direction) are created using inputs from onboard sensors that scan the local building environment. This information can then be used by the onboard guidance and navigation system to determine safe and energy-efficient trajectories for operations in urban and suburban settings. The technology is robust to dynamic environments, input noise, missing data, and other uncertainties, and has been demonstrated successfully in lab experiments and computer simulations.



Left: UAS in synthetic environment using MAESTRO for safe urban operations
Right: GPS-free Onboard Sensing and Computing Integrated with MAESTRO

APPLICATIONS

The technology has several potential applications:

- Urban air taxis / Urban Air Mobility (UAM)
- Urban UAS Package delivery
- UAS Emergency Medical Services (EMS) services (like: toxic plume/smoke/ash prediction for urban fires and pollution spills)
- UAS-based surveillance and infrastructure inspection services
- Defense and Intelligence operations
- Ship air wake predictions for safe maritime UAS operations
- Landing zone wind field predictions for precision parachute airdrops
- Detailed wind field predictions at urban airports
- Wind predictions in mountain valleys, canyons, etc.
- Improved local ballistic trajectory predictions

PUBLICATIONS

Patent No: 11,046,430

Patent-pending

"Patent Only/No Software"

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More Information

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