CPS: Medium: Data-Driven Adaptive Real-Time (DART) Flow-Field Estimation Using Deployable UAVs

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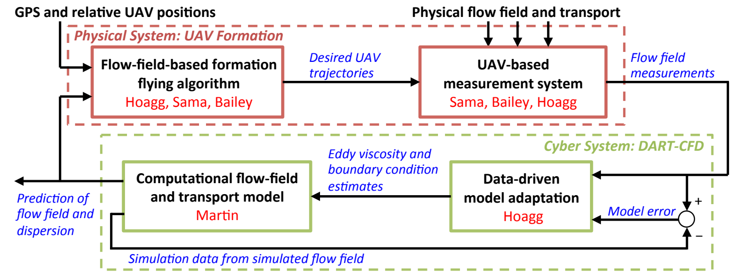
Motivation

- Fukushima Daiichi disaster and Aliso Canyon natural gas leak are examples of emergency situations that resulted from the unplanned release of an airborne contaminant
- Accurate real-time prediction of contaminant movement is invaluable for planning emergency response, protecting emergency workers, and assessing environmental impact
- However, accurate prediction is challenging because of atmospheric turbulence, ground terrain topology, and changing wind conditions

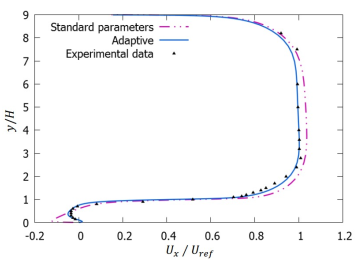
Project Objective

- **Project's aim is to develop and demonstrate a new data-driven adaptive real-time (DART) CPS that produces accurate real-time micrometeorological estimates and forecasts contaminant dispersion near its source**
- DART consists of a computational fluid dynamic (CFD) cyber system and a physical system of autonomous fixed-wing UAVs instrumented with flow sensors and contaminant-concentration sensors
- UAVs obtain sparse physical measurements of the atmospheric flow and contaminant concentrations
- Sparse physical measurements are used in real time to continually improve a computational fluid dynamic (CFD) model in order to produce an accurate real-time prediction of the contaminant dispersion

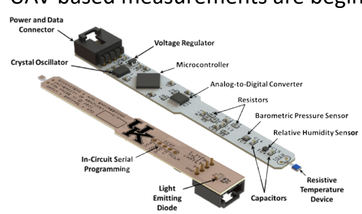


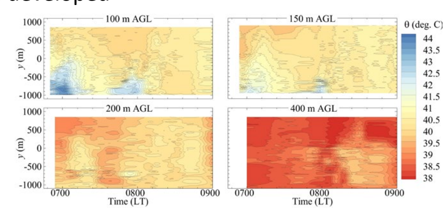
Technical Approach

DART-CFD. Data-driven model adaptation uses physical measurements to improve CFDs capability to predict airborne contaminant dispersion

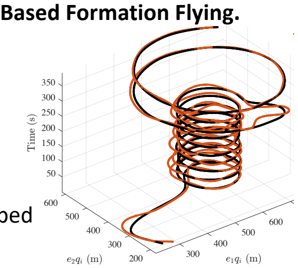


UAV-Based Sensing. New methods for taking distributed-but-coordinated UAV-based measurements are begin developed





Cyber-Feedback-Based Formation Flying. New formation flying methods, which take advantage of cyber feedback from DART-CFD, are being developed



Scientific Impact: Predicting atmospheric contaminant dispersion in real time requires advances in several areas:

1. New methods for real-time data-driven model adaption
2. Advances in CFD turbulence modeling
3. Improvements in UAV-based sensing and data processing
4. New cyber-feedback-based formation flying methods

Advances could have application to other CPS, which require either data-driven model adaptation, turbulence modeling, distributed sensing, or cyber-feedback-based control

Broader Impact: DART CPS has application to problems of societal importance

Emergency Response:

- Predicting the dispersion of airborne contaminants (e.g., chemical, biological, radiological, nuclear) in real time is critical for safety of emergency responders and response planning
- Emergency response applications could include forest fires, oil spills, fracking accidents, and train derailments

Wind Energy and Aviation Safety:

- Predicting atmospheric flow at a wind farm can help optimize operations
- Flow prediction at an airport can help improve safety and efficiency

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