2021 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

1714519: CAREER: Co-Design of Networking and Decentralized Control to Enable Aerial Networking in an Uncertain Airspace, 2015-2022

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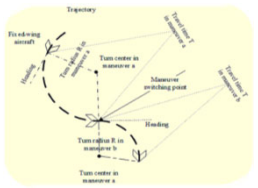
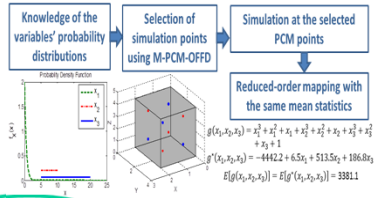
Challenge:

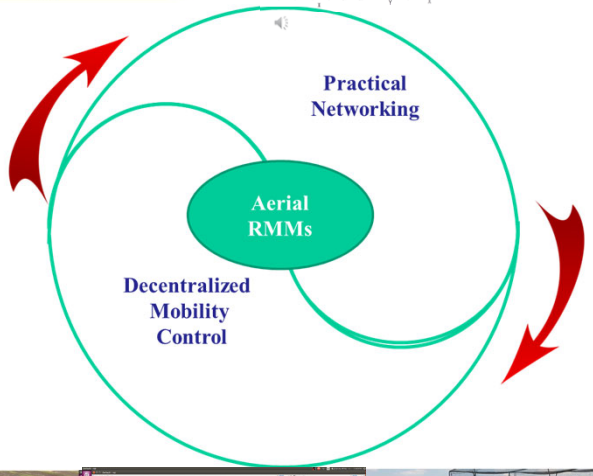
- Airborne networking utilizes direct flight-to-flight communication for flexible information sharing, safe maneuvering, and coordination of time-critical missions.
- Airborne networking, unlike the networking of fixed sensors, mobile devices, and slowly-moving vehicles, is very challenging because of the high mobility, stringent safety requirements, and uncertain airspace environment.

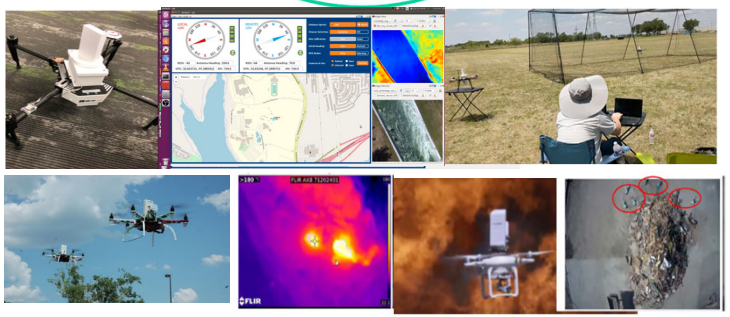
Solution:

- CPS paradigm that exploits the mutual benefits of networking and decentralized mobility control in an uncertain heterogeneous environment.
- New results include 1) random mobility models equipped with sense and avoidance protocols to analyze airspace capacity subject to flexible operations of UAVs, 2) scalable uncertainty-exploited reinforcement learning and graphical games, and 3) networked UAV testbed for beyond visual line of control.









Scientific Impact:

The project contributes to general CPS studies with

- Networking and distributed control co-design
- Scalable uncertainty evaluation
- Uncertainty-exploited optimal control
- Random mobility models that bridges communication and physical UAV dynamics
- Analysis of random switching systems
- Hieratical network control
- Autonomous agents with more intelligence to deal with uncertainties and unknowns

Broader Impact:

- Impacts to the society include on-demand emergency communication and urban aerial mobility
- The project benefits emergency agencies who need flexible on-demand communication and local governments who care about airspace safety integrated with UAVS
- Numerous education and outreach activities have been conducted, including e.g., public safety days, family fairs, E week and robotics week at the Perot Museum of Nature and Science, and national expos, and organizing student competitions
- *Quantified improvements include, e.g., reduction of computation for uncertainty evaluation from 2^m to maximally m, extension of communication distance from 200 meters to 4 kilometers, etc.*

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