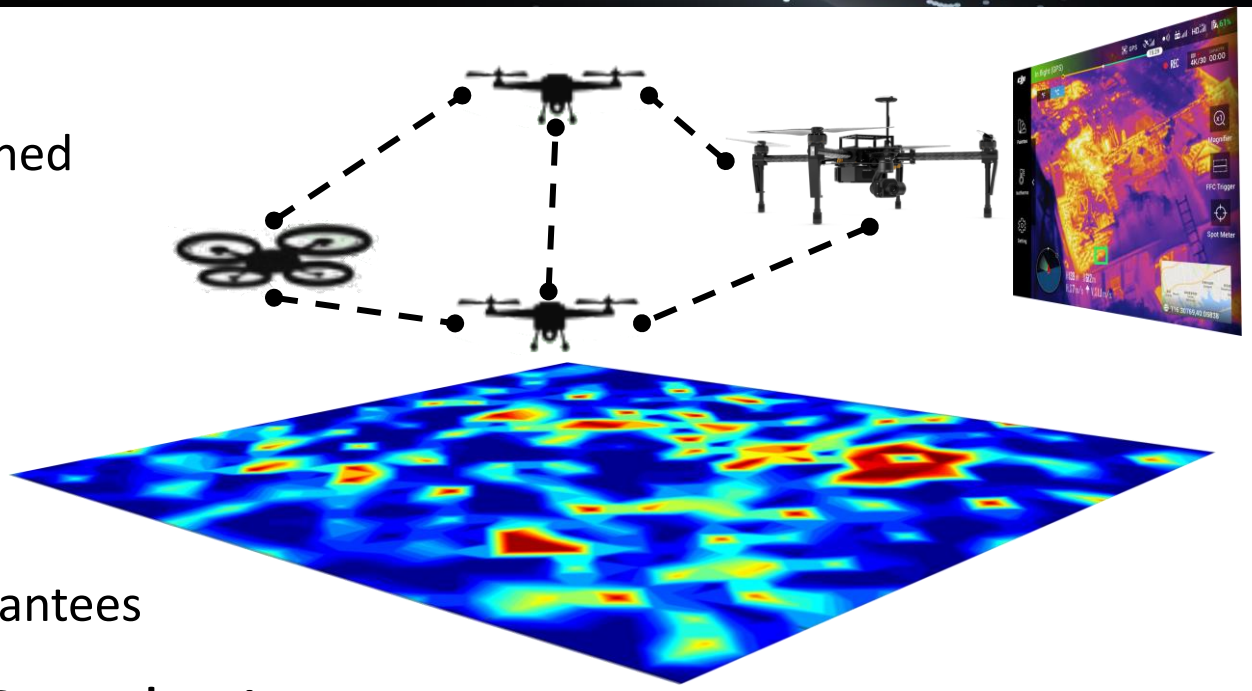
NRI: FND: COLLAB: Distributed Bayesian Learning and Safe Control for Autonomous Wildfire Detection

Nikolay Atanasov[1] Sicun Gao[2] Tajana Rosing[2] Baris Aksanli[3]

[1]ECE, [2]CSE, UCSD [3]ECE, SDSU

Challenge

- Real-time environmental monitoring using an unmanned aerial vehicle (UAV) team



Solution

- **Task A**: Online multi-modal terrain mapping
- **Task B**: Communication- and uncertainty-aware UAV trajectory planning
- **Task C**: Nonlinear control with safety and stability guarantees

Scientific Impacts

- Develop fundamental robot autonomy capabilities that generalize to other areas of CPS research
- Online terrain mapping, UAV coordination, learning Lyapunov/barrier certificates for safe UAV control

Broader Impacts

- Improve situational awareness for first responders
- Real-time data for weather and fire spread simulators
- UCSD-SDSU collaboration to increase undergraduate participation in robotics research

2021 NRI & FRR Principal Investigators' Meeting
March 10-12, 2021

UC San Diego JACOBS SCHOOL OF ENGINEERING Electrical and Computer Engineering

San Diego State University

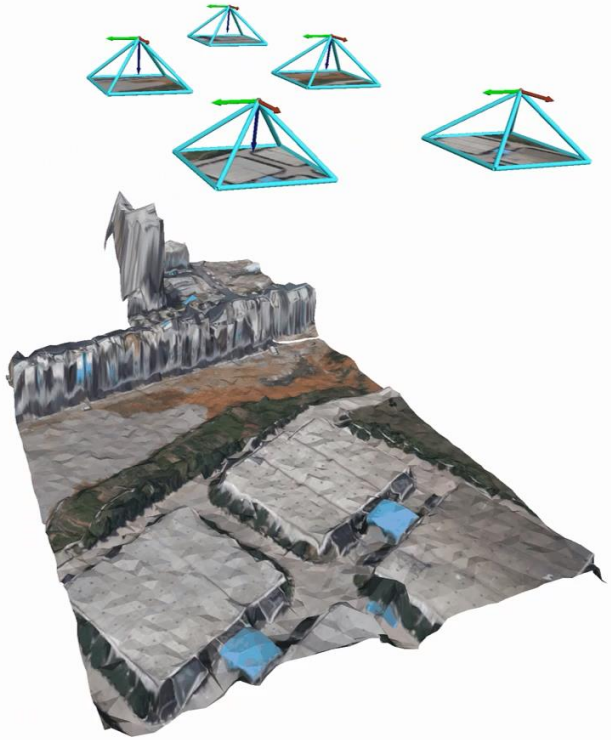
Award ID#: CNS 1830399
Award Date: October 2018

NRI: FND: COLLAB: Distributed Bayesian Learning and Safe Control for Autonomous Wildfire Detection

Nikolay Atanasov[1] Sicun Gao[2] Tajana Rosing[2] Baris Aksanli[3]

[1]ECE, [2]CSE, UCSD [3]ECE, SDSU

- **Task A**: Online multi-modal terrain mapping



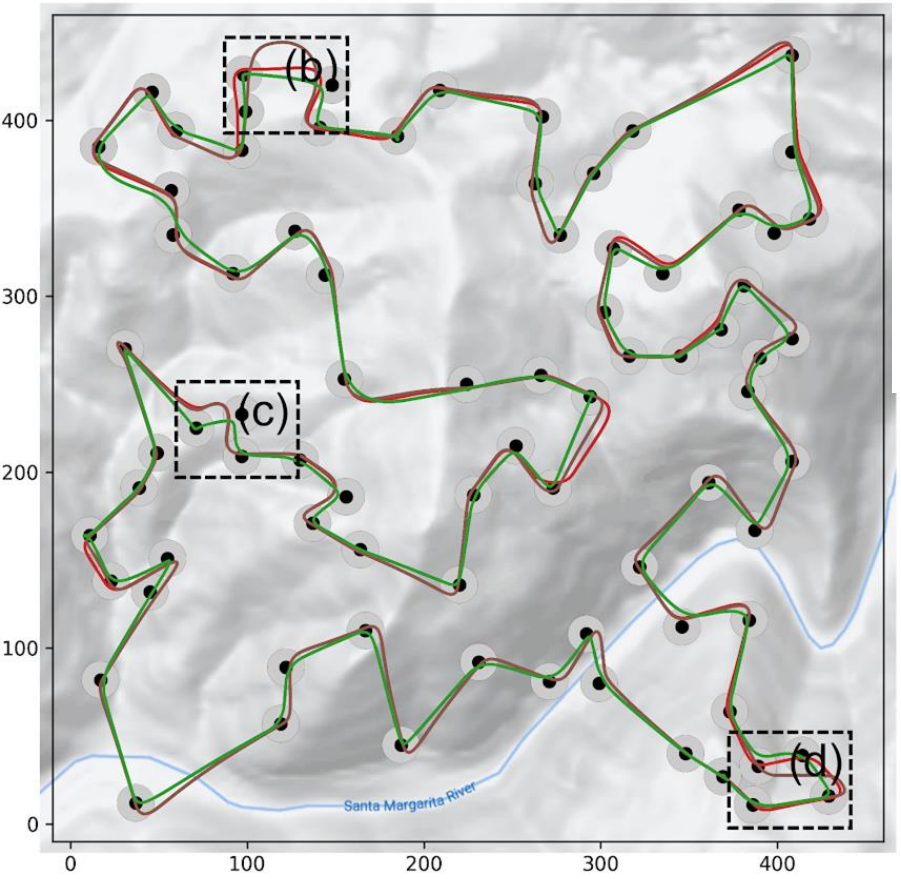
- **Input:** aerial RGB images and tracked visual keypoints
- **Output**: real-time mesh map of the 3-D terrain and semantic categories
- **Approach:** Graph convolution neural network predicts mesh vertex offsets to minimize 3-D mesh and 2-D depth errors

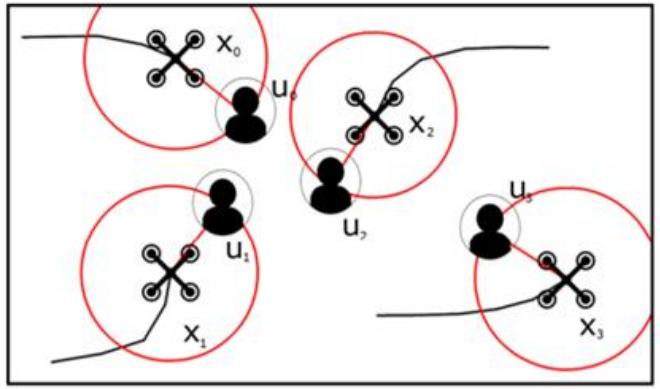
Award ID#: CNS 1830399
Award Date: October 2018

NRI: FND: COLLAB: Distributed Bayesian Learning and Safe Control for Autonomous Wildfire Detection

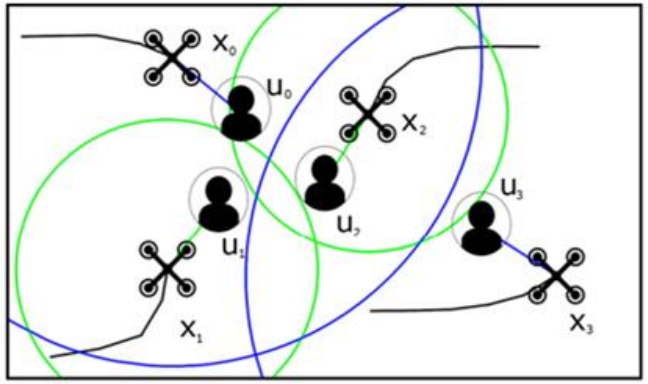
Nikolay Atanasov[1] Sicun Gao[2] Tajana Rosing[2] Baris Aksanli[3] [1]ECE, [2]CSE, UCSD [3]ECE, SDSU

- **Task B**: Communication- and uncertainty-aware UAV trajectory planning





single channel, uniform power



multiple channel, varied power

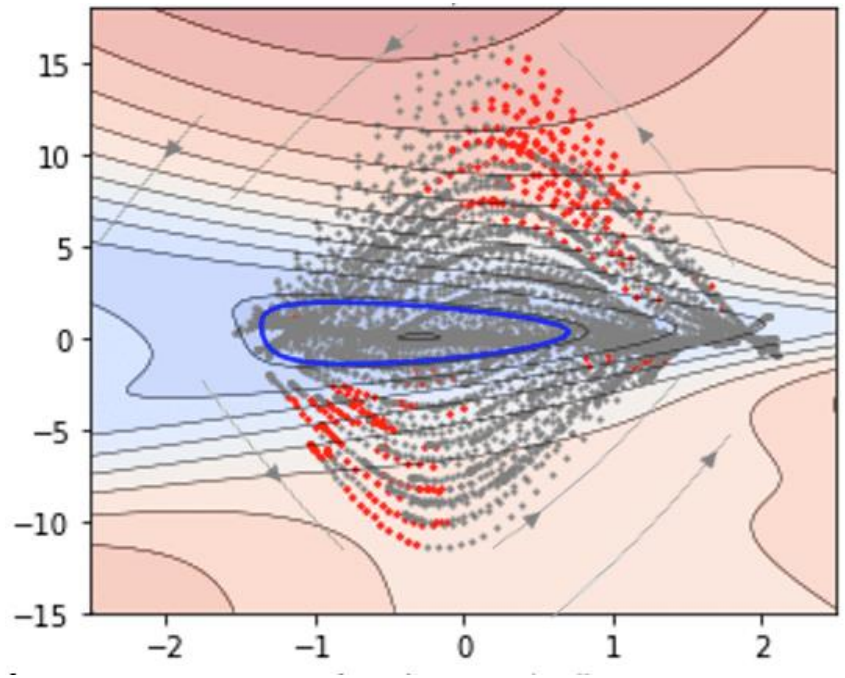
- **Uncertainty-aware Planning**
  - Minimize max uncertainty for estimating points of interest
  - Generate continuous min-jerk dynamically feasible trajectories
  - Bi-level optimization of number of observations and B-spline trajectory
- **Communication-aware Planning**
  - Max network capacity for multiple UAVs assigned to human users
  - Joint alternating optimization of trajectories, RF channel, RF power

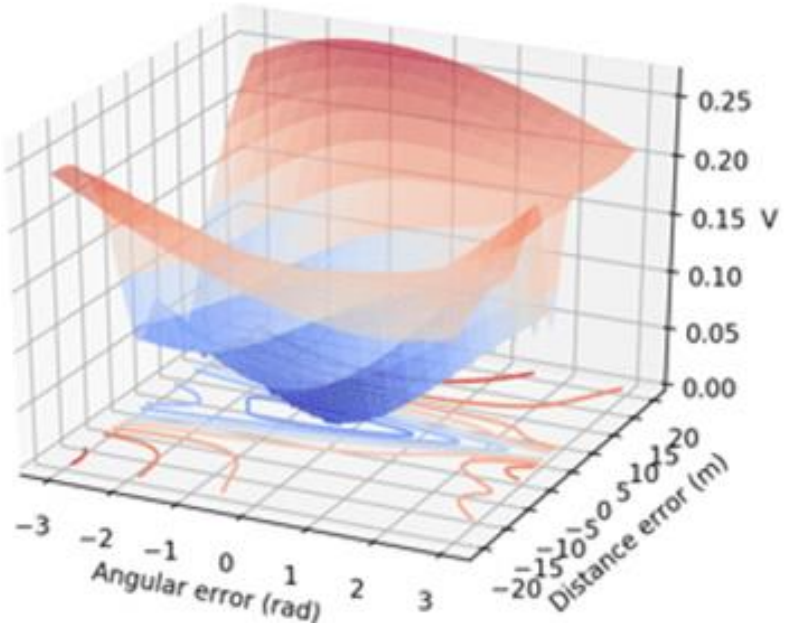
UC San Diego JACOBS SCHOOL OF ENGINEERING Electrical and Computer Engineering
San Diego State University
Award ID#: CNS 1830399
Award Date: October 2018

NRI: FND: COLLAB: Distributed Bayesian Learning and Safe Control for Autonomous Wildfire Detection

Nikolay Atanasov[1] Sicun Gao[2] Tajana Rosing[2] Baris Aksanli[3] [1]ECE, [2]CSE, UCSD [3]ECE, SDSU

- **Task C**: Nonlinear control with joint stability and safety guarantees





- Learn Lyapunov/Barrier functions with unknown system dynamics
- Sampling-based certification
- **Critic**: aims to obtain a neural Lyapunov function
- **Actor**: aims to minimize the Lie derivative