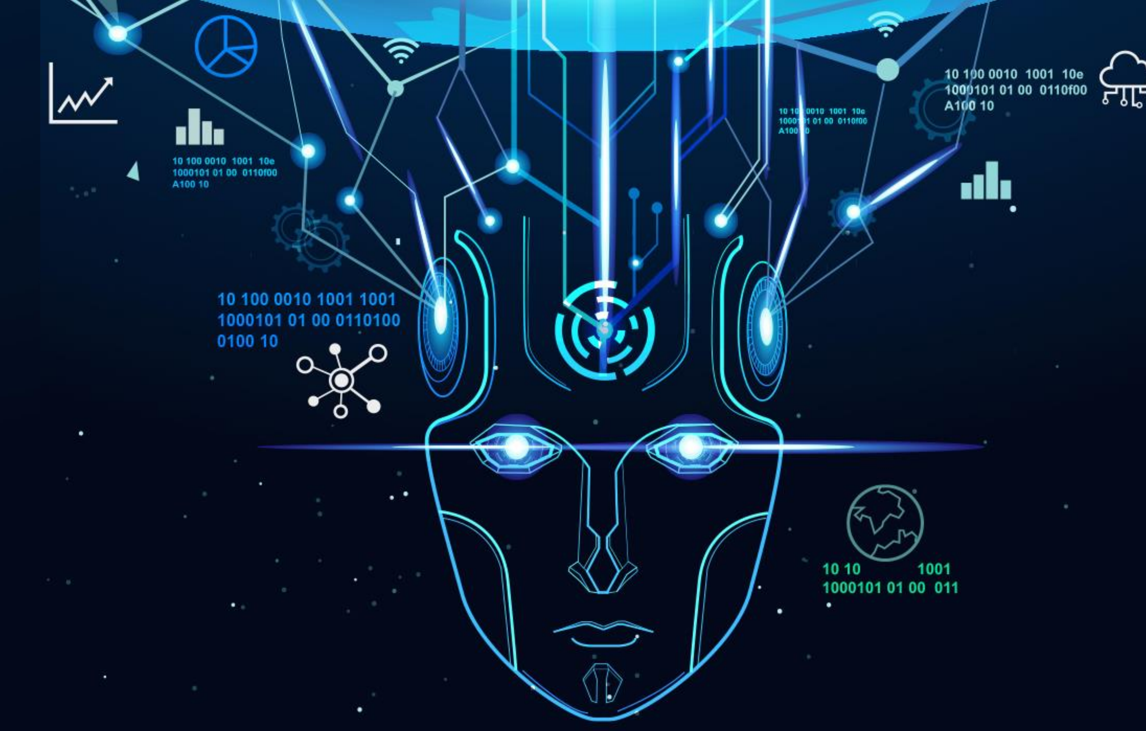
NRI: FND: COLLAB: Distributed Bayesian Learning and Safe Control for Autonomous Wildfire Detection



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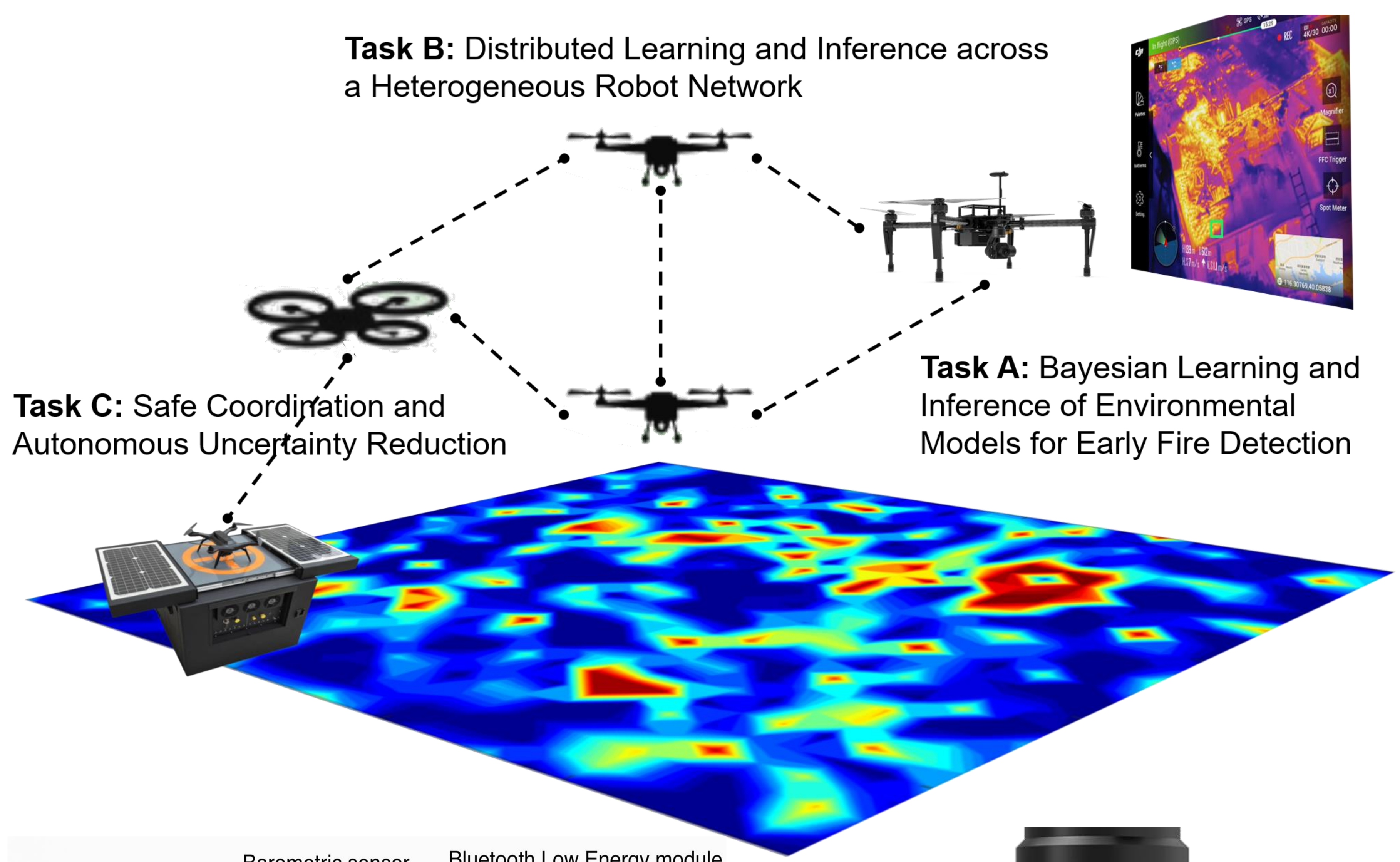
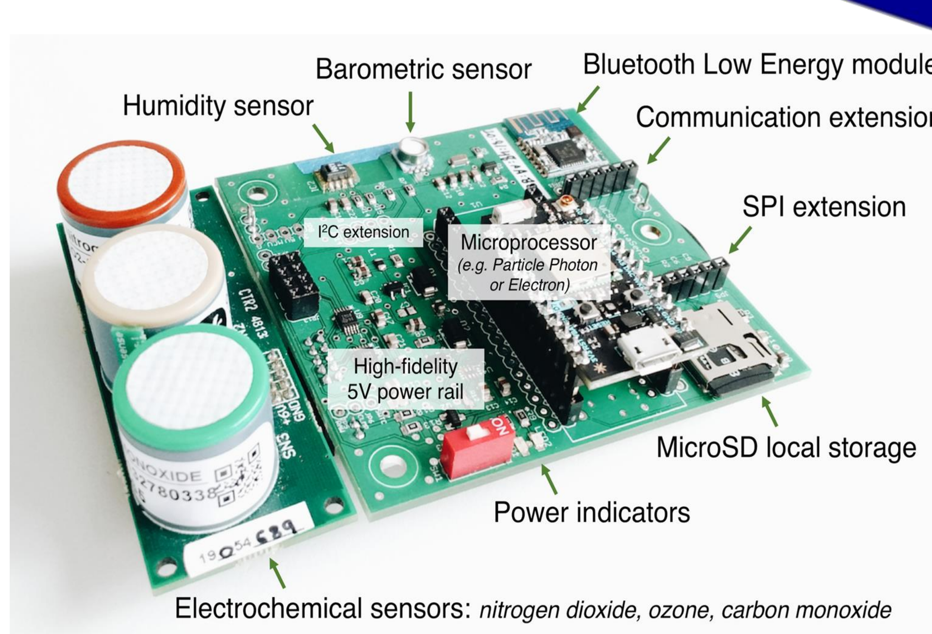


Objectives and Motivation

- Wildfires destroy millions of hectares of forest, sensitive ecological systems, and human infrastructure
- A critical aspect of mitigating damages is *early detection*, well before initiating fires grow to disastrous proportions.
- Current practices are based on expensive assets, satellites, watchtowers, remote-piloted aircraft, that require constant human supervision, limiting them to high-risk/high-value areas.
- Aid wildfire prevention through continuous surveillance and early detection of ensuing wildfires using advancements in small UAVs, low-powered chemical and thermal sensors and long-range adaptive wireless comms.



Technical Approach

- **Task A**: Bayesian learning and inference for multi-modal (thermal, semantic, geometric, chemical) mapping with adaptive accuracy and uncertainty quantification. Approach based on Gaussian Process regression, exploiting radial decomposable kernels and Bayesian neural networks exploiting probabilistic backprop.
- **Task B**: Hierarchical architecture for cooperative mapping across a heterogeneous team of UAVs and static sensors fuse uncertainty-weighted models rather than raw measurements. Approach based on neural network compression and distributed geometric averaging of probability densities.
- **Task C**: Satisfiability Modulo Optimal Control framework to handle mixed continuous flight dynamics and discrete constraints and ensure collision avoidance, persistent communication, and autonomous recharging for UAVs. Approach based on concolic reinforcement learning, allows the learning process to interact with nonlinear constraint solvers that generate critical traces enforcing the hard constraints.

Evaluation

- Experiments at UCSD Aerodrome and HPWREN sites
- Leverage data, models from **HPWREN** & **WIFIRE** projects

Scientific Impact

- Develop fundamental autonomy capabilities, including multi-modal environmental understanding, collaborative inference over heterogeneous networks, and multi-objective navigation with safety, communication, and energy constraints
- Impact on environmental monitoring, search and rescue, and transportation applications

Broader Impact

- Supply critical real-time data to large-scale weather and fire spread simulators such as WIFIRE and early fire warning and improved situational awareness to first responder
- Outreach to underrepresented minorities leveraging programs at SDSU and UCSD to establish a path from K-12 to graduate degree programs in STEM
- Incorporate the results into the curriculum of undergrad and grad courses at UCSD and SDSU.
- Develop new talent in robot autonomy which will be critical for the future of the U.S. economy.