# CAREER: Situational Awareness Strategies for Autonomous Systems in Dynamic Uncertain Environments

Submitted by zkassas on Fri, 04/19/2019 - 3:59pm

Project Details

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| **Lead PI:** | Zak Kassas |
| **Performance Period:** | 04/01/18 - 03/31/23 |
| **Institution(s):** | University of California-Riverside |
| **Sponsor(s):** | National Science Foundation |
| **Award Number:** | 1751205 |



**Abstract:** The potential economic and societal impacts of realizing fully autonomous cyber-physical systems (CPS) are astounding. If the Federal Aviation Administration (FAA) allows integration of unmanned aerial vehicles (UAVs) into the national civilian airspace, the private-sector drone industry is estimated to generate more than 100K high-paying technical jobs over a ten-year span and contribute $82B to the U.S. economy. Self-driving cars are predicted to annually prevent 5M accidents and 2M injuries, conserve 7B liters of fuel, and save 30K lives and $190B in healthcare costs associated with accidents in the U.S. Successful mission pursuit of such fully autonomous CPS hinges on possessing full situational awareness including precise knowledge of its own location. Current CPS are far from possessing this capability, particularly in dynamic, uncertain, poorly modeled environments where GPS coverage may be spotty, obscured, or otherwise impaired. This necessitates developing a coherent analytical foundation to deal with this emerging class of CPS, in which situational awareness and mission planning and execution are intertwined and must be considered simultaneously to address uncertainty, model mismatch, and compensate for potential GPS coverage gaps. This project is has four main objectives: (1) Analyze the observability of unknown dynamic, stochastic environments comprising multiple agents. This analysis will establish the minimum a priori knowledge needed about the environment and/or agents for stochastic observability. (2) Develop adaptation strategies to refine the agents models of the environment, on-the-fly, as the agents build spatiotemporal maps. Adaptation is crucial, since it is impractical to assume that agents have high-fidelity models describing the environment. (3) Design optimal, computationally efficient information fusion algorithms with performance guarantees. These algorithms will consider physically realistic nonlinear dynamics and observations with colored, non-Gaussian noise,

commonly encountered in CPS. (4) Synthesize optimal, real-time decision making strategies to balance the potentially conflicting objectives of information gathering and mission fulfillment. This investigation will enable autonomous CPS to navigate complex tradeoffs, leading to autonomous identification and adoption of the optimal strategy. This research has far-reaching impact- it will evolve autonomous CPS from merely sensing the environment to making sense of the environment, bringing new capabilities in environments where direct human control is not physically or economically possible. The project has a vertically-integrated education plan spanning K-12, undergraduate, and graduate students. The project will engage economically disadvantaged middle and high school students in the same UAV testbed used for research verification. Also, research outcomes will be infused into new and existing undergraduate and graduate courses.

## Related Artifacts

Presentations

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