Research Project Highlight

Swarm-Enabled Infrastructure-Mapping for Rapid Damage Assessment Following Earthquakes

Project # NCTRTZ

Principal Investigator
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Start-End Dates:
6/1/2016-5/30/2017

Abstract
The dramatic increase in inexpensive Unmanned Aerial Vehicle (UAV) and camera technology has made the real-time mapping of areas struck by disaster a reality. The objective of this project is to investigate the optimal deployment of multiple UAVs for rapid mapping and assessment before and after a multi-location hazard, such as an earthquake. Because of the complex multi-faceted infrastructures that need to be mapped (roads, bridges, pipelines, power-grid, and water) after a disaster, there exists the need for different mapping strategies. Such sectors need to be mapped with different technologies (infrared, RF, optical, microwave, etc.). Small UAVs are usually battery powered, thus they have limited range and their paths must be planned carefully to conserve power. Simultaneous advances in inexpensive UAVs, computational modeling techniques, and camera and sensor technologies have made rapid pre- and post-hazard mapping a potential reality. Agent-based paradigms for simulation of coupled complex systems have become powerful predictive tools. Because different infrastructures have different grids and different quantities to be mapped, the optimal path for a set of released swarms will vary over the same terrain. The proposed work develops agent-based models for a team of swarm members (UAVs) intending to map the Bay Area with various optimality conditions: minimum time, minimum energy usage, optical sensing, infrared sensing, acoustical sensing, water spillage sensing, etc. Technological advances and societal changes such as massive numbers of cost-effective drones are now game-changers in terms of the ability to 1) monitor and control events in a hazard, and 2) facilitate long-term planning. The study will develop tools to coordinate activities in heterogeneous infrastructure modeling, simulation and control. We seek optimal mapping of a) Power, b) Water, c) Transportation, d) Food distribution, e) Telecommunication, and f) Building systems.

Deliverables
A model and code to be used by emergency responders for timely information in case of damage spread over multiple geographic locations, a PEER report, and peer-refereed journal papers.

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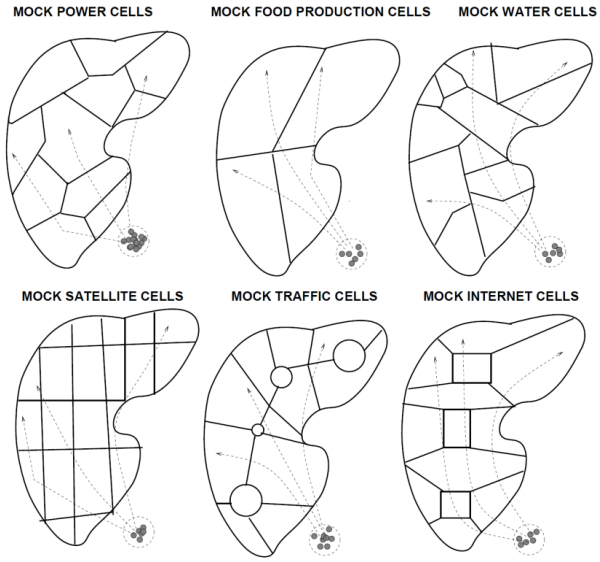
Research Impact

This study is expected to complement several ongoing PEER projects that are based on developing databases for different infrastructure systems and their earthquake performance. One of these projects is the Seismic Performance Observatory (SPO), which aims at developing a centralized, accessible, extensible and scalable database that provides pre- and post-earthquake data for buildings and various other infrastructures. The proposed swarm-based pre- and post-earthquake mapping of infrastructure will allow the intended extension objectives of the SPO project. This extension can potentially scale up the SPO database by several orders of magnitude. Currently, this SPO database consists of the information of only few (around 50) structures and the database development is not based on a systematic methodology, but on data uploads by individuals. The proposed project can provide the intended systematic methodology for the development of the SPO database. Moreover, beyond its fundamental objective of providing timely information for emergency responders after earthquakes, the project is expected to provide valuable input for several important infrastructure-related organizations, such as Caltrans for the transportation infrastructure and PG&E for the power grid.

Project Image



Different coexisting infrastructures requiring different mapping strategies and path planning

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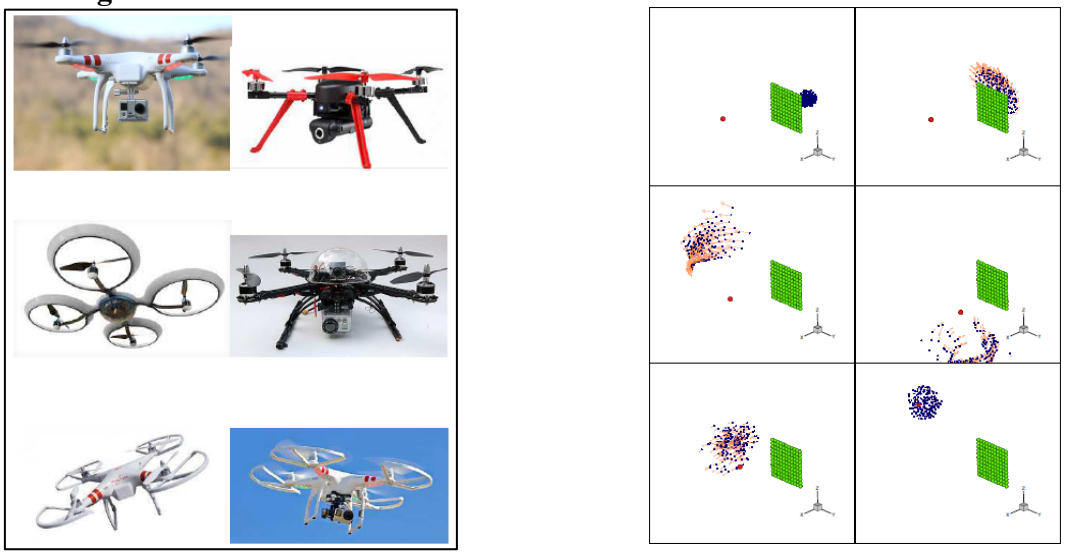
Project Image



UAVs as swarm members and simulation of swarms moving over an obstacle fence

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