**Motivation**

- Future missions will rely on large, networked groups of vehicles and sensors operating in dynamic, resource-constrained environments
- Large groups will need to operate with little direct supervision
- Biology provides many models and paradigms for group behaviors

**Objectives**

- Create a research community of biologists, computer scientists, control theorists, and roboticists
- Systems-theoretic framework for swarming
- Modeling and analysis of group behaviors observed in nature
- Analysis of swarm formation, stability and robustness
- Synthesis: Formation and navigation of artificial Swarms
- Sensing and communication for large, networked groups of vehicles
- Testbeds, demonstrations, and technology transition

**Impact**

- Technology for deploying resilient, secure teams of inexpensive, unmanned vehicles
- Adaptive communication networks
- Search, reconnaissance, surveillance missions

**Research Thrusts**

System-Theoretic Framework (T)
- Formal language of swarming behaviors with a grammar for composition;
- New formalisms and mathematical constructs for describing swarms of agents derived from the unification of methods drawn from graph theory, switched dynamical systems theory and geometry.

Modeling (M)
- Model-based catalog of biological behaviors and groups with decompositions into simple behaviors and sub groups;
- Techniques for producing abstractions of high-dimensional systems and software tools for developing low-dimensional abstractions of observed biological group behaviors.

Analysis (A)
- Stability and robustness analysis tools necessary for the analysis of swarm formation;
- Analysis of asynchronous functioning systems and abstractions to a single synchronous process; and
- Theory for computability and complexity for swarming facilitating the design of scalable algorithms.

Synthesis (S)
- Design paradigms for the specification of cost functions and coordination algorithms for high-level behaviors for navigation, clustering, splitting, merging, diffusing, covering, tracking, and evasion;
- Distributed control algorithms with constraints on sensing, actuations and communication; and
- Software toolkit for composition of cataloged behaviors and decomposition of synthesized behaviors with the ability to automatically infer properties of resulting behaviors.

Sensing and communication (V)
- Estimators for vehicle and sensor platforms to localize individual agents and groups of agents;
- Algorithms for coordinated control in support of localization and information diffusion; and
- Bio-inspired, sensor-based (communication-less) strategies for coordination of a swarm of vehicles.

Testbeds, Demonstrations and Technology Transition (E)
- Adaptive network of micro-air vehicles for aerial surveillance of an urban environment;
- Self-healing swarm of ground vehicles (and sensor platforms) for threat and intrusion detection; and
- Swarms of UAVs, micro-air vehicles, and small ground vehicles for operation in urban environments.

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