CAREER: Environmentally-Mediated Coordination in Natural and Robot Swarms

Award #2042411 Award Date: Apr 1st 2021 Kirstin Petersen, Cornell University

Challenge

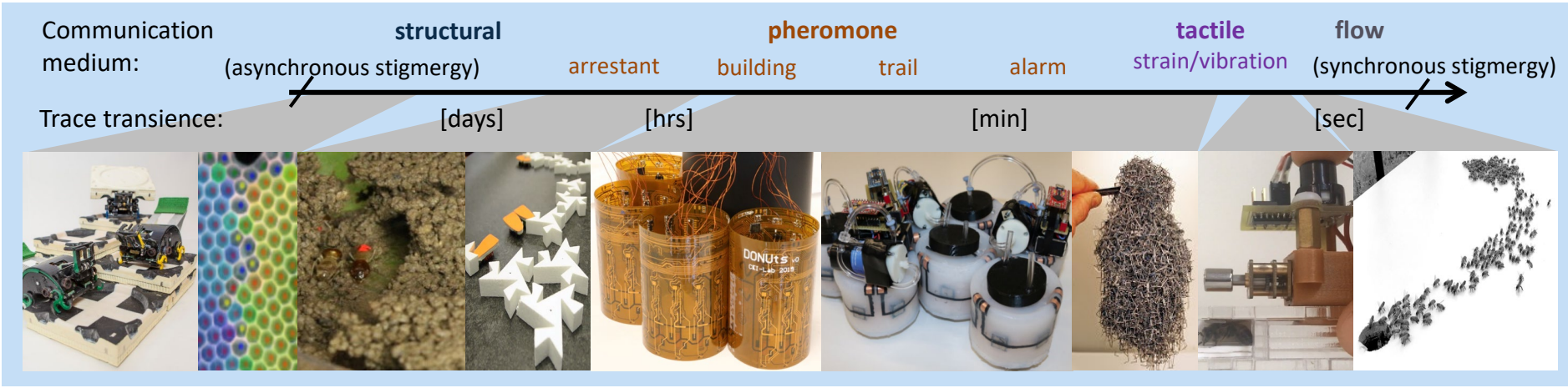
- Design methodologies for environmentally-mediated swarm coordination
  - Swarm size
  - Agent reliability
  - Agent motion and sensing
  - Agent modifications/trace
  - Environment dynamics

Solution

- *Thrust 1) Error mitigation* strategies for coordination in static environments
- *Thrust 2) Natural coordination* in highly dynamic environments
- *Thrust 3)* Coordination in *programmable matter* which actively change its dynamics.

Scientific Impact

- Environmentally-mediated swarm coordination can be useful at the macro-scale and is essential at the micro-scale
- Generic model: $\Delta E(x) = D(E(\vec{x}), \vec{x}) + \sum_{a \in A} M_a(L_a(E(\vec{x})), s_a)$



Broader Impact

- Enabling robot swarms which are faster and less expensive to deploy, are resilient to individual failures, and can adapt to changing tasks and environments.
- Educational tools to secure and increase a diverse workforce

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Results

Thrust 1) Error mitigation strategies for coordination in static environments

- Error mitigation in collective robotic construction (DARS 2021)
- Robot mechanisms for collaborative modification of granular media (RA-L 2022)
- Construction of honeycomb in constrained geometries (PNAS 2021)

Thrust 2) Natural coordination in highly dynamic environments

- Characterizing honeybee swarm aggregation through flow and pheromone entrainment

Thrust 3) Coordination of programmable matter which actively change its dynamics

- Soft robot collective that actuate, sense, and coordinate via strain (RA-L 2021, RoboSoft 2022)