Leveraging Honey Bees as Bio-Cyber Physical Systems

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Challenge:

SOCIAL INSECTS ARE CAPABLE OF LONG TERM OPERATION IN COMPLEX ENVIRONMENTS

ENGERNEED CYBER PHYSICAL SYSTEMS ARE TASKABLE AND HAVE PERFORMANCE GUARANTEES

Can we improve upon the ability of social insects to sense and interact with the physical world, while providing data acquisition and control on par with explicitly engineered systems?

Solution:

MICRO-SCALE FLIGHT RECORDERS TO BE MOUNTED ON HONEY BEES

1) Visual scene capture and analysis, 2) thermal and mechanical sensors, 3) clock, 4) storage, 5) processing, 6) photovoltaic chargers, and 7) short range communication

EXPLORATORY TESTS ON LARGE-SCALE BEE-MIMICKING DRONE FLIGHTS

BEE-MIMICKING SHAKER TO ELICIT MORE POLLINATION AND FASTER DATA ACQUISITIONING

A rotating magnet induces motion through glass in observation hives

16Hz, 2 sec, 20 times/min

HONEY BEE FLIGHT MODELS, TO BE USED FOR SLAM AND FEATURE RECOGNITION ON CHIP

Activity near feeder station

Activity near feeder station

“Bee-line” flights between hive and feeder station

AUTOMATED CALIBRATION RIG FOR FLIGHT RECORDERS

ANGLE SENSITIVE PIXEL STRUCTURE

Impact:

ULTRA-LOW POWER ELECTRONICS AND SENSING

- Micro-scale, power autonomous, integrated circuits for flight recording and analysis

PROBABILISTIC INFERENCE FROM LARGE-SCALE DISTRIBUTED DATA SOURCES

- Fusion of heterogeneous sensor data
- Finding trends in large incomplete bio-datasets

FEEDBACK CONTROL OF BIO-HYBRID SYSTEMS

- Towards gains for both data acquisition and improved foraging

GAINS TO APICULTURE AND ENTOMOLOGY

- Improved knowledge of how bees forage in cultivated versus natural landscapes
- Improved models of how bees advertise the location of food sources

GAINS TO PRECISION AGRICULTURE

- Instrumented hives for farmers with hourly updates on busts and blooms
- Improved output by control of colony activity level

Honey bees in numbers:

- Annual revenue world wide: $150B
- No. of U.S. commercial colonies: 2.4M
- Colony collapse disorder has increased rental fees up to 20%

Western Honey Bee (Apis Mellifera):

- Foragers in a colony: 20,000
- Flight distance: 600m
- Max flight distance: >10km
- Flight speed: 24-32km/h
- Forager payload: 55-65mg

Collective Embodied Intelligence Lab

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