How AI and robotics will accelerate research in social animal behavior

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Challenges for AI

- What does it mean to understand the behavior of physical multi-agent systems?
- How can AI and robotics help?
Thanks

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Example 1: Ant colony migration

Stephen Pratt, Princeton University
Nest exploration/evaluation
Methods & results ca. 1990
Methods & results ca. 2005

Pratt and Sumpter, 2005
Methods & results ca. near future...
Example 2:
Task allocation in honey bees
How they do it: The waggle dance

Von Frisch (1940s), Seeley et al (1980s-90s)
Methods & results ca. 1995

Seeley, et al
Revisiting our questions...

- What does it mean to *understand* the behavior of physical multi-agent systems?
  - Track
  - Label
  - Quantify
  - Model
- Why is this research important?
- Why is this research difficult?
Tracking: Problem statement

- **Given:**
  - Examples of the appearance of animals to track.

- **Compute:**
  - Positions of the animals over time, including association with a unique ID.

- **Assumptions:**
  - Animals appear identical,
  - Lighting is stable,
  - Background is stable.
Tracking:
Appearance-based particle filter
Score
Resample
Position estimate
Target Movement
Apply motion model
Refinements

Khan, Balch, Dellaert, CVPR-04, CVPR-05, PAMI
Tracking results
Other appearance-based techniques

Eigenbees: Khan & Dellaert; Parts: Schindler & Dellaert
Detection-based tracking

Khan, Balch & Dellaert
Labeling: Problem statement

- **Given:**
  - Animal trajectories over time
  - Quantitative features over trajectories
  - Example labeled data

- **Compute:**
  - Correct labeling (segmentation) of trajectories

- **Assume:**
  - Features are relevant
  - Example labels are correct
Detecting interactions
Interaction features
Automatically labeled interactions

result
Model-based techniques

- HMMs: Feldman & Balch, *Adaptive Behavior*
- SLDSs: Oh, Balch, Rehg & Dellaert, *AAAI-05*
Others doing similar work

- Couzin, Oxford
- Parrish, Viscido & Grunbaum, Washington
- Belongie, UCSD
- Ratnieks, UK
- Franks, UK
- Theraulaz, France
Belongie: Smart vivarium

Basic Posture Recognition

sit  sit  walk
Parish & Grunbaum: Fish schools
Labeling is not enough

- Labeling provides/supports:
  - Classification of movements, motions, activities
  - Role identification
  - Opponent strategy identification

- Labeling does not provide:
  - Explanation of how or why an animal chooses a motion
  - Testable models of behavior

- We need executable models!
Executable models
Learning executable models: Problem statement

- **Given:**
  - Low-level controllers *(or labeled trajectories)*
  - Animal trajectories over time
  - Perceptual features that cause transitions

- **Find:**
  - Most likely switched controller

- **Assume:**
  - Animal uses a switched controller
Approach: Treat as I/O HMM learning problem

Guillory, Balch & Isbell, submitted
Idea: Sample from controllers as motion models
Learned controller
Qualitative comparison
What if you don’t have the controllers?

- Learn them from labeled data

Egerstedt, Delmotte, Balch, Khan, Dellaert, ICRA 05
Summary and next steps

- Track, label, quantify, model
- Learn executable models from live animal data
  - Ants
  - Humans
  - Monkeys
- Test models experimentally
  - Do they correctly predict the performance of the real thing?