ICDL 2006 Special Session
The role of distributed intelligence in building a social brain

Session Abstract:

The goal of the session is to take an interdisciplinary approach to improve our understanding of the role of socially-distributed intelligence in the generation of adaptive behavior. Learning mechanisms can have their components distributed across multiple individuals, so to understand mechanisms of social learning we need to look at the relationship between ecological context and the organization of behavior in tightly coupled systems (e.g. social insects such as ants and bees) and loosely coupled systems (e.g. songbirds, humans). The session will include both evolutionary and developmental approaches as well as data from multiple species.

Timeline: 20 minute talks plus 5 minutes of q&a, followed by a 30-minute roundtable discussion

8:30 – 8:55 Emma Despland, "Collective behaviour in insects: mechanisms of synchronization"

8:55 – 9:20 Jeff Schank, "Can biorobotics help us understand behavioral development?"

9:20 – 9:45 Michael Goldstein, "Prelinguistic vocal development is a product of distributed intelligence"

9:45 – 10:15 Roundtable discussion

Talk abstracts:

Collective behaviour in insects: mechanisms of synchronisation
Emma Despland, Concordia University

We use oscillator theory to explain how interactions between group-members can synchronize activity in groups of both gregarizing locusts and social caterpillars. Individual animals have activity/inactivity schedules arising from an irregular physiological oscillation based on hunger; these can become coupled when animals interact with each other.

In locusts, we show that contact with an active neighbour increases the probability of becoming active, leading to feeding, and phase-resetting of the hunger oscillation. The locusts internal physiological rhythms are thus brought into alignment and their activity becomes synchronized. When food resources are clumped, contact with active locusts increases, and this increase in the strength of coupling between individuals leads to greater synchronization of behaviour. The adaptive value of activity synchronization could be associated with inhibiting swarming when resources are dispersed and accelerating it in more favourable clumped environments.

Synchronized behaviour is common in animal groups, many of them more tightly coupled and cohesive than gregarizing locusts. In social caterpillars for instance, colonies show a cohesive synchronized alternation between foraging and resting bouts. We show how these patterns of collective behaviour can emerge from interplay between individual hunger-based activity/inactivity cycles and interactions between colony-members.

Can biorobotics help us understand behavioral development?

Jeff Schank, University of California – Davis

Infant rats are born blind, deaf, and with limited locomotor abilities, nevertheless, they can aggregate and orient to tactile, thermal, and olfactory stimuli. It would appear that sensorimotor development early in life could be fully characterized in terms of taxes (orienting responses to a stimulus) and kineses (change in behavioral patterns in response to a stimulus). One of the most basic taxes is thigmotaxis (an orienting response to contact). For example, when infant rats (7 to 10 days of age) are placed in a rectangular arena either individually or in groups, they display patterns of thigmotaxic behavior. They tend to follow walls, get stuck in corners, and aggregate into groups. Robotic-rat pups that we have built can do the same things qualitatively and quantitatively simply by moving randomly. In the case of the robots, body shape, other robots, and arena geometry constrain behavior such that it appears to be thigmotaxic. This suggests that pups early in development may not be responding thigmotaxically to every object they contact but only those with salient properties. Biorobotics and computer simulations are allowing us to disentangle the roles of intrinsic (e.g., sensorimotor rules) from extrinsic (e.g., body shape, environmental geometry) in generating behavior.

Prelinguistic vocal development is a product of distributed intelligence

Michael Goldstein, Cornell University

What are the effects of social interaction on the acquisition of complex vocal behavior, such as speech and language? Prelinguistic human infants, living in an information-rich environment, selectively attend to, interact with, and learn from caregivers. What mechanisms of social learning, in both caregivers and infants, guide the acquisition of phonology and the lexicon? Results from playback experiments show that mothers use prelinguistic vocal cues to guide their responses to infants. In addition, the findings of vocal learning studies reveal that infants use social feedback from mothers to build more developmentally advanced forms of vocalizations. Measures of prelinguistic vocal competence are predicted only by dyadic parameters and not by caregiver or infant behavior alone. Caregiver's contingent verbal responses to object-directed vocalizations predict later vocabulary development, indicating that prelinguistic learning influences the development of the lexicon.

Data from these studies demonstrate mechanisms by which the development of intelligent behavior is embedded in social processes. Infants, like many organisms, must rely on the brains and bodies of others as an alternative to evolving specific capacities for surviving in a complex environment. Socially distributed intelligence is evidenced by the foraging and nest-building activities of termites, army ants, and honeybees, and in the vocal development of male songbirds that rely on the reactions of females to shape their immature sounds into functional song. My studies demonstrate ways in which caregivers and infants constitute a system of distributed intelligence, one in which adult behavior and infant sensory capacities interact to generate the development of more advanced infant vocal behavior. Thus the experiments focus on patterns of interaction to discover sources of developmental change.