# cis32-ai — lecture # 27 — mon-15-may-2006

today's topics:

- artificial life

# brief overview

- Artificial Life as a Tool for Biological Inquiry, by Charles Taylor and David Jefferson (1995)
- what is artificial life?
- four levels (according to Taylor and Jefferson):
  1. molecular level — "wetware"
  2. cellular level — "software"
  3. organism level — "hardware"
  4. population level — "multiagent systems"

# resnick and wilensky

- Learning about Life, by Mitchel Resnick (1995)
- Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds, by Mitchel Resnick (1994)
- Modeling Nature's Emergent Patterns with Multi-agent Languages, by Uri Wilensky (2002)
- centralized versus decentralized models, ways of thinking
- the old way: *centralized* — "by lead or by seed"
- the new way: *decentralized*
- decentralized computational models:
  - neural networks
  - subsumption architecture
  - cellular automata
- *emergence*, *evolution*
- what is *emergent behavior*?

# resnick and wilensky, continued

- decentralized tools for learning: *constructionism*
  - hands-on exploration
  - no recipe to follow
- StarLogo, NetLogo
  - "creatures" (agents)
  - "patches" (environment)
- lessons for understanding decentralized thinking
  1. positive feedback isn't always negative
  2. randomness can help create order
  3. a flock isn't a big bird
  4. a traffic jam isn't just a collection of cars
  5. the hills are alive

# sims

- Evolving Virtual Creatures, by Karl Sims (1994)
- classic trade-off: complexity vs control, e.g., dynamic simulation vs kinematic control
- evolve "body" and "brain" together: *hyperspace* of possibilities to explore
- genetic algorithms
  - *representation*
    - genotype (coded representation)
    - phenotype (the real thing)
  - *reproduction*
    - mutation
    - crossover
  - *selection*
    - performance
    - fitness metric

# sims, continued

- morphology ("body")
  - dimensions
  - joint type (e.g., rigid, revolute, twist, ...)
  - recursive-limit
  - neurons (see below)
  - connections (to other nodes)
- control ("brain")
  - sensors (joint, contact, photo)
  - neurons (functions, e.g., sum, product, divide, ...): map sensor input to effector output
  - effectors (amount of force on a joint)
- morphology and control are combined

# sims, continued again

- physical simulation (body dynamics, collision detection, collision response, friction, ...)
- evolution
  - selection for specific behaviors: swimming, walking, jumping, following
  - reproduction using: random mutation (40%), crossover (30%), grafting (30%) (see fig 5)
- results — see the movie!!

# lipson

- Automatic design and manufacture of robotic lifeforms, by Hod Lipson and Jordan Pollack (2000)
- response to Sims' work
- uses REAL physics and REAL creatures
- results — see the movie