seminar in artificial life
csc 84200

today's topics:

- steels (1994)
- kim and cho (2006)

Luc Steels (1994)

- *the artificial life roots of artificial intelligence*
- also called: "bottom-up AI", the "animat" approach, "behavior-based AI", "animal robotics"
- "behavior is intelligent if it maximizes preservation of the system in its environment"
- "the term *behavior-oriented*...distinguish[es] the field...from the more knowledge-oriented approach of classical AI"

- primary methodologies:
  - (1) *computational models*—process-oriented; descriptions of algorithms, data structures;
    ⇒ *simulations* if they correspond to natural phenomena
  - (2) *artificial models*—physical device whose behavior corresponds to natural phenomena;
    ⇒ *robotics*
  - the second is harder to do; has stronger requirements
    e.g., building a simulation of a bird flying is easier than building a mechanical bird that flies

- ingredients:
  - study of intelligent behavior
  - methodology of constructing artificial systems
  - strong biological orientation

- key features:
  - intelligence—

    The behavior of a system is intelligent to the extent that it maximizes the chances for self-preservation of that system in a particular environment.
  - adaptivity—

    A system is capable of adapting and learning if it changes its behavior so as to continue maximizing its intelligence, even if the environment changes.
  - emergence—

    A behavior is emergent if it can only be defined using descriptive categories which are not necessary to describe the behavior of the constituent components. An emergent behavior leads to emergent functionality if the behavior contributes to the system's self-preservation and if the system can build further upon it.

- EMERGENCE!
  - ingredients criticial:
    * cooperation
    * competition
    * selection
    * hierarchy
    * reinforcement
  - KEY FOCUS OF THE PAPER

- behavior systems
  - functionality—something the agent needs to achieve
  - behavior—regularity in the interaction/dynamics in the system
  - mechanism—principle/technique for establishing a particular behavior
  - component—physical structure for implementing a mechanism
  - *example*: "honing in" functionality → "zig zag" behavior → "phototaxis" mechanism → "light sensor" component

- guidelines
  1. make behavior systems as specific as possible
  2. exploit the physics
  3. do not think of sensing and acting in terms of symbol processing
  4. simple mechanisms may give rise to comlex behavior

- approaches
  - neural network
  - algorithmic (e.g., subsumption)
  - circuit
  - dynamics

- more on emergence
  - controlled vs uncontrolled variables
  - visible vs invisible variables

    For a behavior to be emergent, we expect at least that the regularity involves an uncontrolled variable. A stricter requirement...involves only invisible variables.
  - wall following example
- forms
  - side effects (e.g., wall following)
  - temporal structures (e.g., ants, potential fields)

- functionality
  - supervised learning methods
    difficulties:
    * require adequate computation of error
    * weight adaption uses lots of resources
    * not all networks will learn
  - reinforcement learning methods
    difficulties:
    * determining reinforcement signal
    * trial-and-error to find policies
    * credit assignment
  - evolutionary methods
    difficulties:
    * requires lots of computational resources
    * on-line vs off-line learning
    * correct/appropriate fitness function

- "In general, it takes about 10 years before a technology becomes sufficiently accepted for serious real-world applications."

kim and cho (2006)

- "a comprehensive overview of the applications of artificial life"
- two modeling approaches:
  - top-down (traditional AI)
  - bottom-up (ALife)
- THREE LEVELS:
  1. soft
  2. hard
  3. wet
- CONTRAST TO FOUR LEVELS [Taylor and Jefferson, 1995 (ch1)] FROM LAST CLASS:
  1. molecular level — "wetware" (biology labs)
  2. cellular level — "software" (cellular automata)
  3. organism level — "hardware" (robotics)
  4. population level — "multiagent systems" (swarms, social networks)

- emergence is important! key!
- application areas
  - robot control
  - robot manufacturing
  - computer graphics
  - natural phenomenon modeling
  - entertainment and games
  - music
  - economics
  - internet and information processing
  - industrial design
  - simulation software
  - electronics
  - security
  - data mining
  - telecommunication

- common properties
  1. achieving similar behavior to biological creatures
  2. details of the final results have not been described before experimentation
  3. designing without expert knowledge
  4. interdisciplinary cooperation
  5. huge computational requirements
  6. evolution based on simple primitive shapes such as box and pipe
  7. computer simulation