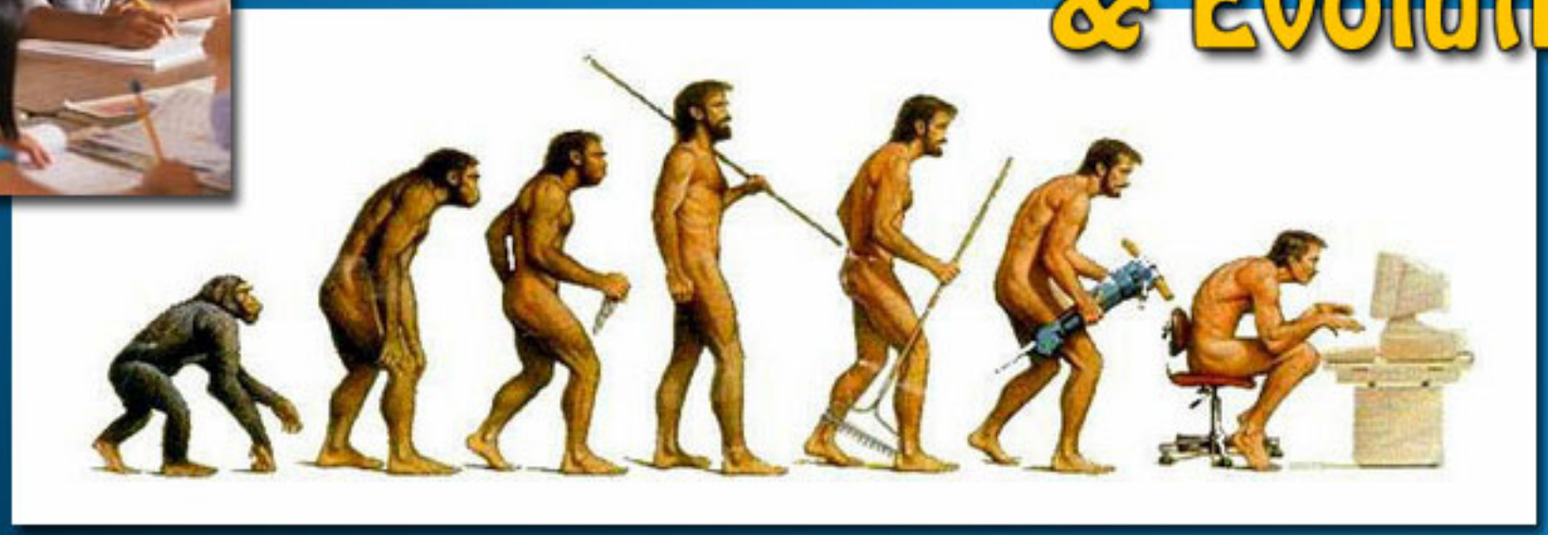
Introduction to Agent-Based Modeling

ICPSR 2009 Day 13

Adaptation, Learning, & Evolution



Distinctions and Definitions

Terminology

- Words are frequently used interchangeably
- No concise definitions and principled usage
- Distinctions are real and clear, just not the terms

Some Included and Related Terms

- Reaction
- Adaptation
- Learning
- Development
- Updating
- Evolution

Reaction

Stimulus-Response Behavior

- Behave according to a fixed update rule
- No multi-level rule feedback (maybe hierarchical)
- Memoryless: agents do not track changes

Example Models and Behaviors

- Conway's Game of Life
- 99% of Game Theory
- Wolfram-style cellular automata
- Laughing at a joke
- Moving your hand out of a fire
- Thermostats and traffic lights with sensors

Adaptation (Agents and Systems)

Multilevel Action Rule

- Behave according to update rules, but...
- Update rules may change through time
- Agents may track changes in the environment
- Must include some feedback mechanism
- Robust behavior with stickiness

Example Models and Behaviors

- Clothing choice by season
- Purchasing choices by wealth and price
- Thermostats and traffic lights
- Imitate the most successful agent
- Ant colonies and bus routes

Learning (Kinds of Agent Adaptation)

Hebbian Learning

- Reinforcement of positive feedback (bucket brigade)
- Analogous to preferential attachment w/ weights
- Model of how the brain works (neural nets)

Bayes Learning

- Updating conditional probabilities
- Statistical decision rule
- Usually updating information rather than rules

Genetic Algorithms

- Use things that work, change things that don't
- Keeps an implicit history of behavior
- Allows agents to be part of an evolving system

Evolution (System Property)

Population Dynamics

- Agents enter and leave the population
- Entry based on a fitness measure
- Ideally fitness is endogenous (system-level property)

Ellusive Structure and Dynamical Properties

- Usually fitness is defined for the model by the user
- Artificial death and replication rules
- Time scale and complication blow the human mind

Some Examples

- Existence of life and life forms on Earth
- Fashion, technology, institutions, and culture
- Future autonomous robotic systems