# Automated Life Ecosystem Simulator

## Artificial Intelligence and Adaptive Systems

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# Outline

# expert system

- Implementations
  - An engine connected to a database
  - A domain specific knwoledgebase
  - Can use probability, Neural Networks, etc.
  - Works well in medicine, online help systems
- Limitations
  - domain specificity: the less flexible the system, the more "expert"
  - knowledge discovery: expert systems typically don't make novel connections
  - flexibility: expert systems typically are not adaptive

# general concept

**Difference Engine** A mechanical calculator, no memory.

**Analytical Engine** A programmable calculator with a memory

**Turing Machine** Formal model of a Analytical Engine

**Analogical Engine** A machine capable of isomorphisms

**Warning!**

This is not a standard term!

**Isomorphism** A mapping from one domain to another

**Example**

What is the Atlanta of China?

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# understanding analogies

- Why are analogies Interesting?
  - Knowledge aquisition is difficult
  - Analogies provide context between multiple domains
- Analogies provide flexibility
  - An expert system provides an answer based on prior knowledge of the current domain
  - An analogical system could guess, based on prior knowledge of different domains

# current research

## Metacat

Metacat is a microdomain AI that attempts to build analogies. The metacat microdomain is the roman alphabet, and it uses concepts such as repetition, succession, length, and so forth to solve puzzles of the form

$$aabb \longrightarrow bbcc; eeff \longrightarrow ? \quad (1)$$

## LetterSpirit

Letter spirit attempts to create novel grid fonts.

- Very fringe area
- gave rise to very popular area: emergent behavior

# a short history

- John Holland
  - First paper on Adaptation 1962
  - Holland Classifiers 1976
  - Complex Adaptive Systems remain interesting today
- Trends
  - Originally, it was thought that a central controller was needed
  - This “model based approach” was popular until recently
  - Replaced by an agent based approach, no central control
  - To some degree, this is what we are studying

# philosophic

**Theorem**

*Clearly, if adaptive problem solving is a field of AI, ALife is a field of AI. Life practically is adaptive problem solving, at the level of agent, ecosystem, species, and even DNA molecule.*

# emergent behavior

**Emergent Behavior** A complex or unpredictable result from a simple set of rules

- Flocking or Schooling Organisms
- Stars, weather systems
- Economies

**Discrete Event Simulation** A method of simulation that attempts to model the behavior of each agent or object in a system, allows for emergent rather than averaged results.

- more accurate results for complex systems
- only approach that allows adaptive behavior

# swarms in computing

**SWARM**

SWARM is a software program built at the Santa Fe Institute, a multidisciplinary research institutio. SFI studies complexity, complex systems, and adaptation.

- A swarm intelligent system creates solutions to problems through modeled behavior
- Can be used to solve difficult problems
- TSP in polynomial time with an ANT simulator[7]
- Ad hoc network creation and maintenance[14]

# swarms in nature

- Not always homogenous
- immune system is considered intelligent swarm[8, 12, 11]
- can exist in multi-tiered relationships

## Fertile Ground for Thought

My Dog is a lot more intelligent than Deep Blue.

| Foster | Deep Blue |
|---|---|
| Many Tricks | One Trick |
| Arbitrary Commands | Delineated Commands |
| Flexible Goals | Rigid Goals |
| Self Directed | Other Directed |

But isn't he just a collection of Swarms? Aren't I?

# what is ALES

## The Automated Life Ecosystem Simulator

The ALES was a software engineering project at Georgia State University in the Fall of 2005.

**Design Team** Myself, Ed Bullwinkel, Larry Eisenstein, Michael Balaun.

**Design Goal** A self sustaining artificial ecosystem for interactive use

**Description** ALES emulates single celled life forms in a watery environment. The feedback between different creatures and the environment creates an adaptive system in its totality.

## state of ALES in December, 2005

When the ALES project terminated, we had a system that would run on exactly one laptop computer, after being compiled from netbeans. It contained three creatures, but these creatures only had a single behavior each. The user had to "prop up" the environment or the simulation would terminate quickly.

# philosophic

## Goals

- Create sourceforge project, to allow anyone access to the code
- incorporate genetic algorithms
- create feedback
- increase behaviors

At this time, the ALES creatures do not evolve. Because they were not designed too, it has proven difficult to create a set of rules by which traits would be produced.

# state of the project

- Some publicity
- code is much cleaner
- classes are being rewritten to allow for GA
- runs from the command line
- cool project logo

# simulation behavior

Game Board has oxygen and nutrients

Yellow Algae reduces nutrients, increases oxygen

Terramecium reduces oxygen, eats algae

Death increases nutrients

The theory is that the emergent behavior of these simple interactions will be a stable, self regulating system!

# recap

- Traditional AI lacks facilities for Isomorphism
- Living systems are able to create analogies
- Traditional AI lacks adaptability
- Living systems are Adapatable

Living system simulation will enhance our understanding of intelligence and expand what is possible with computers. Understanding emergent behaviors of complex systems is the next frontier for AI research.[2]

# ALES falls short

- The current ALES system is not intelligent
  - ALES is adaptable
  - ALES creatures exhibit no Swarm behaviors
  - ALES needs an inheritance model
- Future ALES systems will be more complex
  - Immune responses
  - more creature types
  - localized environment for more complex information propagation

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