

STAR SEMINAR

Exploring Artificial Life



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What is Life?

Discussion!

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What is *Life*?

- State of a functional activity and continual change, before death (defined complementarily as *end-of-life*).
- *Characterized* by the capability to:
 - *Reproduce* itself,
 - *Adapt* to an environment in a quest for survival, and
 - *Take Actions* independent of exterior agents.

What is *Life*?

- *Life is a pattern in space-time*, rather than a material object.
 - most of our cells are replaced many times during our lifetime. It is **the pattern and set of relationships** that are important, rather than the atoms themselves.
- *Interacts with the environment.*
 - A living organism can **respond to or anticipate changes** in its environment. Organisms create and control their own local (internal) environments.
- *Interdependence of parts.*
 - The components of living systems **depend on one another to preserve** the identity of the organism. Thus, we are not one but many acting as one.

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What is *Life*?

- *Stability under perturbations* and insensitivity to small changes,
 - allowing the organism to preserve its form and continue to function in a noisy environment, or after being subjected to minor damage.
- *The ability to evolve...*

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Nature as a special case of Life

- Biology is the study of carbon-based life forms and the entities governing their actions
 - DNA
 - RNA
 - Proteins
 - Chemicals/metabolites
- However, in theory, **nothing says that life cannot have another chemistry or governing factors**
- Also, we can be **reductionist** and study components & aspects of life, but what about the interaction of its component parts & rules governing its evolution?

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...which brings us to **A-Life**

- Lack of any available non-carbon based life-forms motivates us to create an **artificial environment** and a **set of rules** for life to evolve.
- Artificial Life, or **ALife** or **AL** is the study of *non-organic organisms*, beyond the creations of nature, that possess the *essential properties of life* as we understand it, and whose environment is artificially created in an alternative media, which very often is a logical device like the computer.

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ALife as a Synthesis approach

- Rather than being an analytical study of “natural” life, A-Life is a *Synthesis* approach to studying any form of *Life*.
- We have :
 - an artificially-created *environment* (usually) within computers,
 - A fairly universal set of *rules* and *properties* of *life*, derived from the *one* example we have of life - *Natural life*.

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Sim's Evolved Virtual Creatures!



Movie!

<http://www.genarts.com/karl/evolved-virtual-creatures.html>

But if they're not real then aren't we just playing around?

- Not really, if we can create a model that behaves like real life, then we probably understand the system relatively well
- Plus, something most difficult to study empirically are *emergent properties*



So what is the motivation?

- A-Life could have been dubbed as yet-another-approach to studying intelligent life
 - *Emergent properties* in *life* that motivates scientists to explore the possibility of artificially creating life and *expecting the unexpected*.
- An *Emergent property* is created when something becomes more than sum of its parts.
 - For example, half a human is not capable of working without the other half, but together, capable of very complex behavior (not a representative example).

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So where does *A-Life* fit in?

- The *A-Life* concept helps to:
 - **Study** existing *natural* life forms by trying to simulate **the generic rules they follow**, the environmental parameters like *entropy/chaos* , and the *seed*, i.e. **the initial set of elements** on which the rules of life apply under the given environmental condition, in order to understand *evolution in nature*.
 - **Create** new *life* within the digital world by creating new set of external parameters, seeds, and rules of evolution, and let *life* find a way.

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So is A-Life = AI ??

Both seem to approach similar problems, but...

Artificial Life	Artificial Intelligence
Concept : Late 1980s	Concept : 1960s
Grounded in Biology, Physics, Chemistry, Mathematics.	Pursued primarily in Comp. Sci, Engineering & Psychology.
Studies Intelligence as part of Life itself	Studies Intelligent behavior in isolation
Bottom-Up approach - study synthesis	Top-Down approach - focus is on results
Views life-as-it-could-be	Views life-as-it-is

• • A brief history of Artificial Life

- The first to suggest the possibility that machines could someday be considered “alive”
- Samuel Butler (1863) "Darwin Among the Machines”
- Samuel Butler (1880) “Unconscious Memory”



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A brief history of Artificial Life

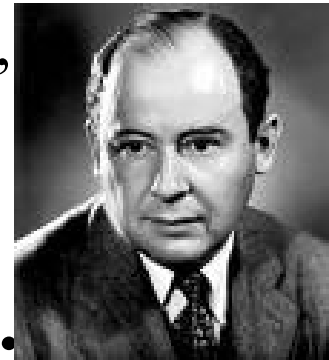
- Alan Turing

- “Intelligent machinery” (1948)
 - “Unorganized machines” — “networks” that can be “trained”
 - “Genetic or evolutionary search”
- “Computing machinery and intelligence” (1950)
 - “We may hope that machines will eventually compete with men in all purely intellectual fields.”
- Turing Test (“imitation game”)



- John von Neumann

- “Theory and Organisation of Complicated Automata” (1949)
 - Self-replicating machines



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A-Life : *Current research areas*

- **Mathematical, Philosophical, Biological foundations, Social and Ethical implications of A-Life.**
 - **Cellular Automata**
 - **Neural Networks**
 - **Genetic Algorithms**
 - **Origin, Self-organization, Repair and Replication**
 - **Evolutionary / Adaptive Dynamics**
 - **Autonomous, Adaptive and Evolving Robots**
 - **Software Agents (good/evil)**
 - **Emergent Collective Behaviors, Swarms.**
 - **Synthetic/Artificial Chemistry/Biology/Materials**
 - **Applications: Finance, Economics, Gaming, MEMS etc**
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Harvester Ants!

NetLogo Lab

- Objective
 - To understand emergent phenomenon !
- In this lab,
 - a colony of ants forages for food. Though each ant follows a set of simple rules, the colony as a whole acts in a sophisticated way.
 - Find shortest path to food
 - Prioritize food sources based on distance & ease of access

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Harvester Ants!

NetLogo Lab

- Adjust number involved in foraging based on:
 - colony size
 - amount of food stored
 - amount of food in area
 - presence of other colonies
 - etc.
- Collective decision making can be as accurate and effective as some individual vertebrate animals

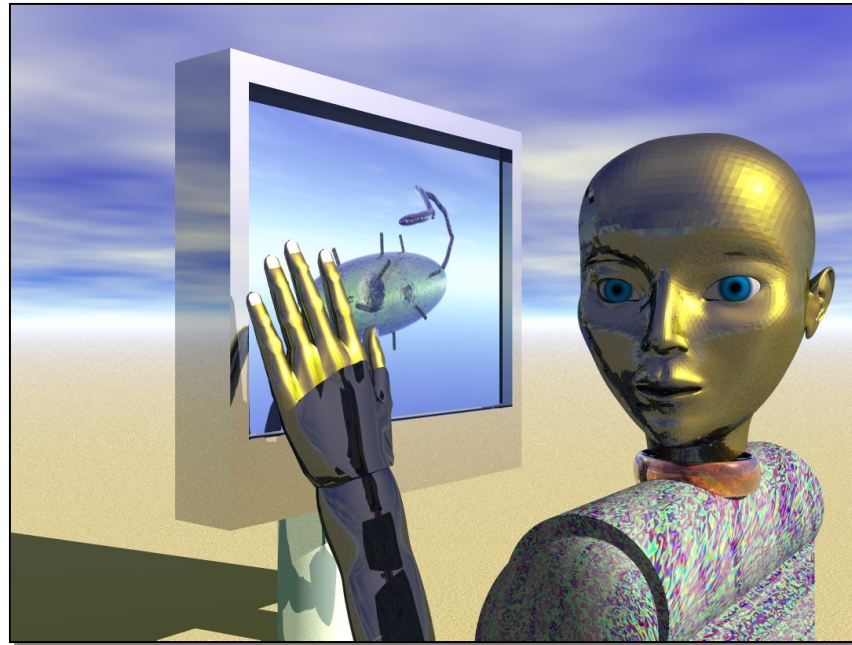
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Summary

- To better understand life, we can test our understanding *in-silico* of the basic principles regarding **rules, interactions and environment**
- Complex solutions to problems can evolve using only simple rules
- This evolutionary-based complexity is now a source of solution strategies for complex problems in real life

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Thank you!



References:

- Bruce MacLennan Trends in artificial intelligence and artificial life
- Jonathan D. Wren, Artificial Life & Cellular Automata