Artificial Life – Ethology
CSc 355

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Lecture Overview

• What is Alife
• Brief history – timeline
• Synthetic Ethology and Food Chains
• Example: Food Chain model
  - Agent Anatomy
  - (Pseudo-) code
  - Sample iteration
  - Results
  - Observations
• Reference List

What is Alife?

• Alife [Langton] is set of mechanisms used to model and simulate evolving natural systems

  - Insect ecologies, animal behavior, negotiating entities, resource use in artificial economies

  - Studies the evolution of agents, or populations of computer simulated life forms in artificial environments

  - Complements traditional biology by trying to recreate biological phenomena

Brief history - Timeline

Synthetic Ethology & Food Chains

• Synthetic Ethology
  - Study of animal behavior in which simple, synthetic organisms are allowed to behave and evolve in a synthetic world.

  - Branch of zoology

• Food Chain
  - Describes the hierarchy of living organisms within an ecosystem.
Example: Food Chain Model (FCm)

- 3 Entities
  - Plants:
    - Fixed location, consumed by herbivores
  - Herbivores:
    - Migratory agents, eat plants, eaten by carnivores
  - Carnivores:
    - Migratory agents, eat herbivores, die from starvation

- Environment
  - Toroid grid
  - Each cell occupied by one or more agents

FCm: Agent “Life & Death issues”

- Energy ($E$) / Metabolism
  - Eat: $E = E + 1$
  - For each step: $E = E - X$, ($X=1$, $C=2$)
  - If $E = 0$ → Die

- Reproduction
  - If $E > 90\%$ → Reproduce asexually
  - Lamarckian: Offspring inherits parents’ NNet followed by random mutation of weights

- Death
  - Starvation (no food found)
  - Eaten (only for herbivores)

FCm: The (pseudo-) code

```python
SimulateOnce ( )
for all agent types
  foreach agent
    PerceiveEnvironment (agent)
    ForwardPropagateInputs (agent.Nnet)
    ComputeAction (agent)
    switch (agent.action)
      case TURN_LEFT:
      case TURN_RIGHT:
        agent.direction := UpdateOrientation (agent)
      case MOVE_FRONT:
        agent.position := UpdatePosition (agent)
      case EAT:
        Eat (agent)
```

```python
Main ( )
Init ( )
while (run < MAX_RUNS)
  SimulateOnce ( )

Init ( )
landscape := InitLandscape ( )
GrowPlants ( landscape [plants] )
while ( agents < MAX_AGENTS )
  agent := CreateAgent ( )
  if ( agent.type == herbivore )
    PositionAgent ( landscape [herbivores] )
  else
    PositionAgent ( landscape [carnivores] )
```

FCm: The (pseudo-) code

```python
... UpdateEnergy (agent, agent.action)
if agent.energy == 0
  KillAgent (agent)
else
  agent.age += 1
if agent.energy > REPRODUCTION_LEVEL
  ReproduceAgent (agent)
```
FCm: The (pseudo-) code

GrowPlants()
  location := SelectRandomLocation(landscape[plants])
  if no plant in location
    landscape[plants][location.x][location.y] := 1
CreateAgent()
  agent.energy := MAX_ENERGY / 2
  agent.age := 0
  agent.generation := 1
  agent.type := carnivore | herbivore
  foreach neuron in Nnet
    SetWeight(neuron)

PositionAgent()
  location := SelectRandomLocation(landscape[agent.type])
  if no agent in location
    landscape[agent.type][location.x][location.y] := 1
  agent.direction := SelectRandomDirection()
Eat()
  if agent.type == CARNIVORE
    UpdateLandscape(landscape[herbivores])
  else
    UpdateLandscape(landscape[plants])

KillAgent()
  UpdateLandscape(landscape[agent.type])
  if num of agent of this type < MAX_AGENTS / 4
    CreateAgent()
ReproduceAgent()
  if num of agents of type < MAX_AGENTS / 2
    // Inheritance of NNet in offspring
    new_agent := DuplicateAgent(agent)
    // Randomly mutate neuron weights
    foreach neuron in new_agent.Nnet
      if mutation_probability > 50%
        SetWeight(neuron)
    PositionAgent(landscape[agent.type])

FCm: A sample iteration

FCm: Simulation Results
FCm: Observations and Conclusions

- Competition
  - Carnivores evolve NNets, good at locating and eating herbivores
  - Herbivores evolve NNets that find plants and avoid carnivores

- Evolved Strategies
  - Herding: Herbivores follow other herbivores in front
  - Ambushing: Carnivores find plants and then wait for herbivores to wander by

- Parameters tuning
  - Number of plants $\geq$ number of herbivores
  - Number of agents must be small so as not to crowd the simulation
  - Number of carnivores $\leq 2 \times$ Number of herbivores

Reference List

- Seminal paper

- Zooland: "The Artificial Life Resource"
  - http://surf.de.uu.net/zooland/

- Book chapter on Artificial Life

Questions ...