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The Evolution of Complex Attributes in a Species of Simulated Agents

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Abstract

In order for evolution to populate the planet with multiple species, two processes need to be at work. One is speciation, which involves the development of a new reproductively isolated species from an ancestral one. The other is that a reproductively isolated species can evolve to be more complex and potentially more capable over time.

Objectives

- Demonstrate that populations of agents can evolve complex attributes despite detrimental intermediate mutations
  - Intermediate evolutionary steps may negatively impact survival
  - The evolutionary process should overcome local minima and reach the positive final mutation
- Confirm that complex structures can evolve gradually
  - Determine the effect of detrimental intermediate steps on the evolutionary process
  - Test viability of multi-mutation trait development with varied levels of difficulty

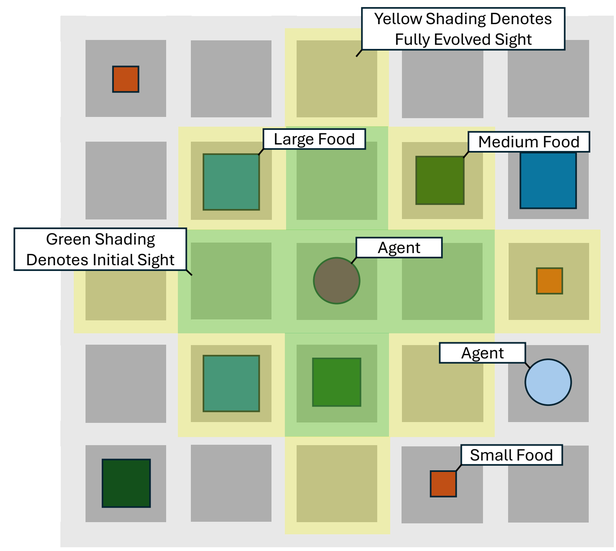
Conclusion

- Complex evolutionary traits can develop despite temporary negative effects
  - Supports the idea of "fitness tunneling"
- Questions raised and future work:
  - Investigate the evolutionary mechanisms behind traits beneficial to individuals but detrimental to populations
  - Introduce cooperative behaviors to align evolution with population-wide benefits

Methodology

- 3 scenarios designed to test evolution of enhanced sight requiring varying detrimental intermediate mutations:
- ✓ 2 mutations required (each with 10% energy penalty)
  - Strong selective pressure, few mutations required
- ✓ 5 mutations required (each with 2.5% energy penalty)
  - Moderate selective pressure, balanced approach
- ✓ 10 mutations required (each with 1% energy penalty)
  - Mild selective pressure, high complexity
- Environment simulated for a predefined time over multiple trials:
  - 500,000 turns for simpler mutation scenarios
  - 2,000,000 turns for the most challenging scenario (10 mutations)

Visualization of an Agent



Environment

- Grid-based simulation with agents performing one action per turn
  - Food resources randomly generated each turn
  - Survival depends on energy management
  - The age of an agent is defined by number of turns

Results

- Successful evolution of enhanced sight in scenarios with fewer required mutations (2 and 5 mutations).
- Agents did not achieve enhanced sight within 2 million turns when 10 mutations were required
  - Suggests increased complexity demands significantly more evolutionary time
- The number of required mutations impacts the process of evolution more than the severity of individual penalties
  - Evolution favors fewer evolutionary steps, even if individually costly