Investigating the Efficiency of Slime Mold as a Maze-Solving Algorithm

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Project Motivation

- Finding the optimal path through networks has many applications.
  - Disease Transmission
  - Information Flow
- Mathematical algorithms exist, but are inefficient on a large scale.
- Developing scalable heuristics for path optimization can ease the solving of real-world problems.

 Biological Significance

- Slime mold is the common name for over 900 different species that use spores to reproduce.
- In order to find food, slime mold grows along the shortest path as a technique for survival.
- Our experiments use the species *Physarum polycephalum* in its plasmodium phase.

The Problem

- Our project seeks to utilize slime mold’s intelligent characteristics to better understand path optimization.
- We determined New York City’s street system to be an appropriate representation of a complex network with real-world applications.

Project Goals:

1. Compare slime mold to computational algorithms on a confined NYC template
2. Create a computer model that mimics the slime mold’s search process.

Lab Procedures:

1. Placed oats on template at beginning, middle, and end goals.
2. Placed slime mold on beginning oat.
3. Arranged template in cooler system.
4. Allowed slime mold to grow for 6 days, capturing pictures once every hour.

Experimental Design

Slime Mold Results

- Used ImageJ tracking software to record slime mold’s movement and gather spatio-temporal data.
- Slime mold covered a large portion of the template during its search process.
- Once all food sources had been reached, the slime mold contracted itself to the shortest or near-shortest path.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
</tr>
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<tbody>
<tr>
<td>10.84%</td>
<td>19.10%</td>
<td>39.10%</td>
<td>32.85%</td>
<td>35.91%</td>
<td>43.53%</td>
</tr>
</tbody>
</table>

Maze Solving Comparison

- Slime mold performed comparably to the simulations:
  - Search Path longer than expected
  - Final Path significantly shorter than algorithms ($p < 0.001$)

Slime Simulator

- These results led us to develop a better replica of the slime mold’s movements:
  - Randomly select paths until the end goal is reached
  - Backtrack from end goal to beginning to find shortest path

Conclusions and Future Work

- Slime mold is a viable method for traversing complex networks.
- Further experimentation will include studying:
  - Alternate food placement to gather data on slime mold’s variation
  - Slime’s ability to branch out in multiple directions at once
- Additionally, we would like to expand our experiment to test slime mold on a 3D model.

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- Rob Dunn, for providing laboratory space and equipments
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Manhattan

Physical Template

Slime Mold Comparsions

- We wanted to determine the effectiveness of the slime mold in 2 ways:
  - Total search distance
  - Final path distance
- We conducted Monte Carlo simulation experiments to which we compared the slime mold.
- We also designed a backtracking algorithm to determine the best route between the food sources.

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