Slime Molds and Cognitive Maps

November 24st, 2026

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- World of the slime mold
  - The slime itself
  - To err is ~~human~~ slime mold
  - Mapping the world with/of the slime mold
- Models
  - Analyticaly derived
  - Monte Carlo-based models
- Results and Outcomes
  - `slimeWorld` toolbox
  - Tokyo subway map
  - Detours
  - Tolman's sun maze
- Future directions

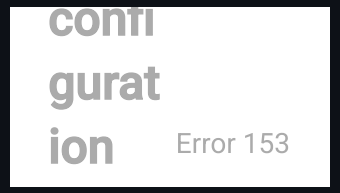
World of the Slime Mold

The slime itself

Mapping the world with/of the slime mold

as path finders

- Maze solving



- Tokyo subway map



- Tower of hanoi
- Traveling salesperson problem

Nakagaki, et al. (2000) “Maze-solving by an amoeboid organism,” https://www.nature.com/articles/35035159
Reid and Beekman (2013) “Solving the Towers of Hanoi – how an amoeboid organism efficiently constructs transport networks,” https://doi.org/10.1242/jeb.081158
Tero et al. (2010), “Rules for Biologically Inspired Adaptive Network Design,” https://www.science.org/doi/10.1126/science.1177894
Evangelidis et al. (2017) “Physarum machines imitating a Roman road network: the 3D approach,” https://www.nature.com/articles/s41598-017-06961-y

To err is ~~human~~ slime mold

Why are we interested in them? They fail in the similar ways to humans do!

Speed-accuracy trade-off

Independence of Irrelevant Alternatives

Computational Models

Analytically derived

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Monte Carlo-based

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Analyticaly derived models

Tero et al. (2007) - A mathematical model for adaptive transport network in path finding by true slime mold

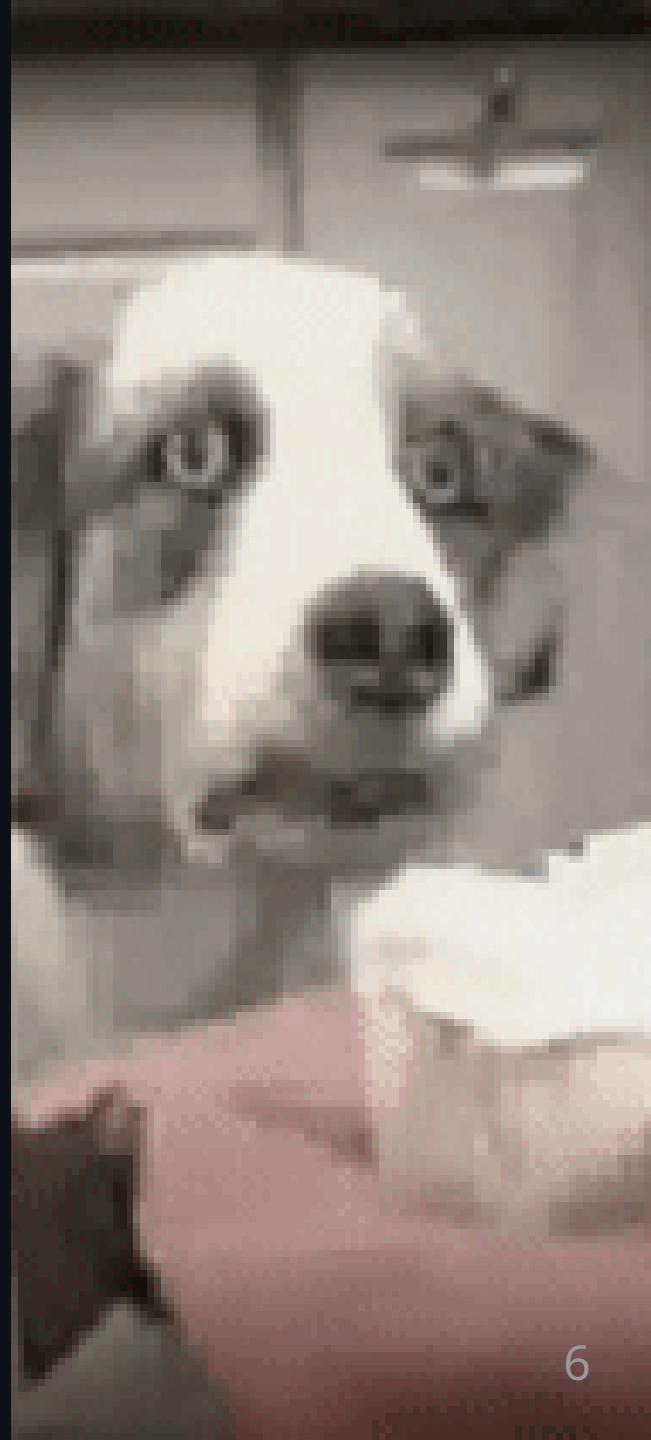
- flux from node i to j:

$$Q_{ij} = \frac{D_{ij}}{L_{ij}}(p_i - p_j)$$

- D_{ij} is the conductivity of the edge
- two nodes are special: one is source, one is sink

conserve flux at a regular node i	source node generates flux	sink node consumes flux
$\sum_j Q_{ij} = 0$	$\sum_j Q_{source,j} = I_0$	$\sum_j Q_{sink,j} = -I_0$

- **this is just a lumped circuit model!**
  - p_i is node voltages, Q_{ij} is the current $G_{ij} = \frac{1}{R_{ij}} = \frac{D_{ij}}{L_{ij}}$ is the conductance



Monte Carlo-based models

Results and Outcomes

`slimeWorld` toolbox

Tokyo subway map

Detours

Tolman's sun maze

Latent learning?

Future directions