Slime Mold Inspired Algorithm

Sarang Bhosle
1010

Hemang Gaur
1023

Aliasgar Lakkadghat
1037

Daksh Malhotra
1039

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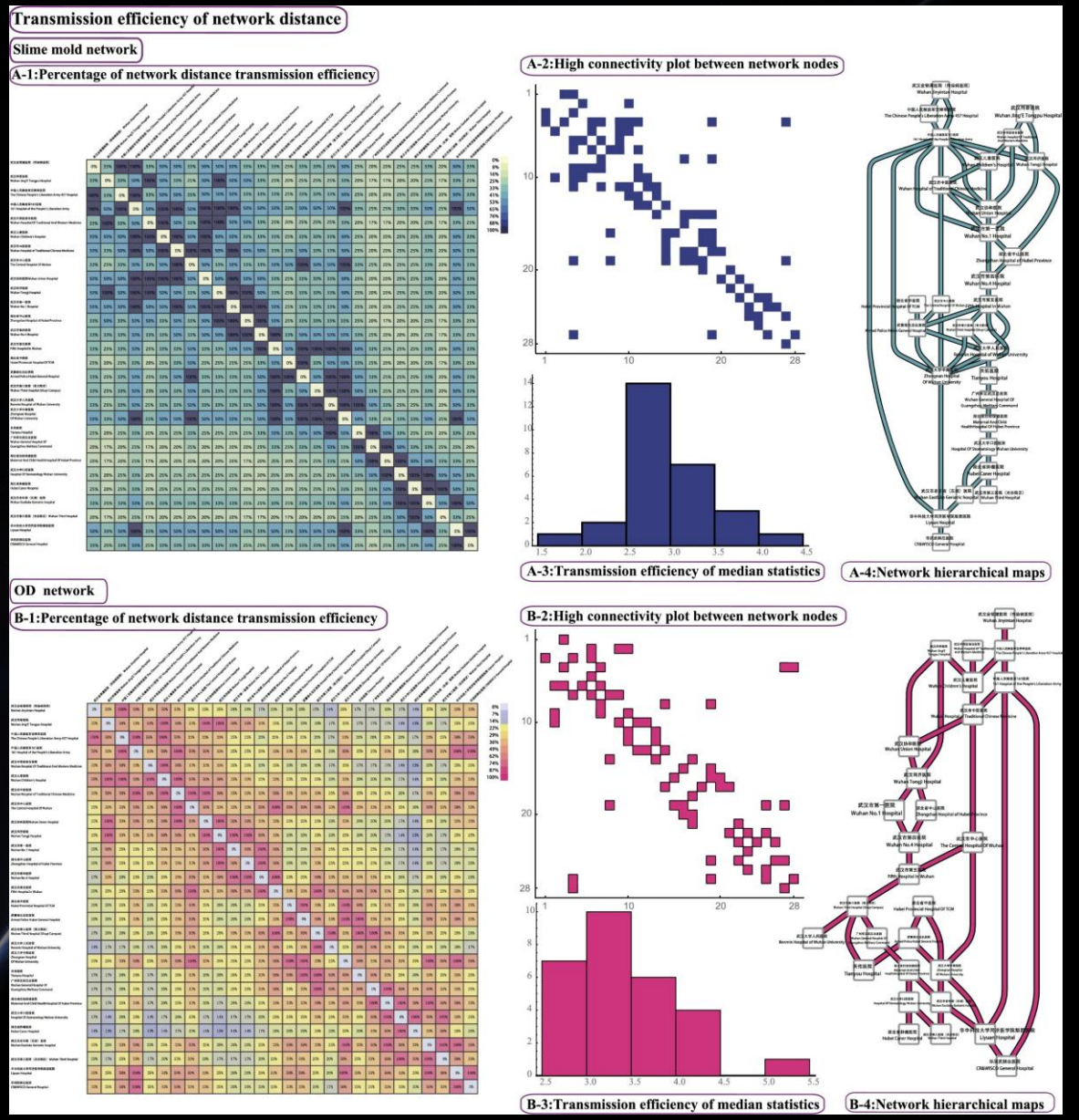
Why Slime Mould Algorithms?

Traditional optimization methods like A and A* struggle with local optima, slow convergence, or high computational costs.

The Slime Mold Algorithm (SMA) is a nature-inspired, population-based metaheuristic that mimics the foraging and oscillatory behavior of slime mold organisms in nature. Slime molds exhibit adaptive network formation, dynamically balancing exploration and exploitation through positive and negative feedback mechanisms.

Table 2. Comparative analysis of networks.

	slime mold network	OD network
Average degree	3.571	2.786
Average path length	3.021	3.534
Average clustering coefficient	0.45	0.168
Network diameter	6	8

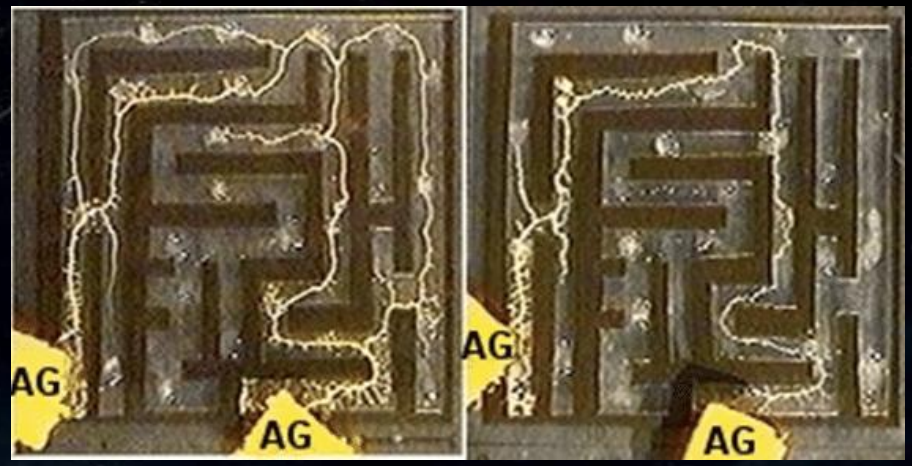


[Biomimetic method of emergency life channel urban planning in Wuhan using slime mold networks – ScienceDirect](), Section 4.2.1

WHAT IS A SLIME MOLD?

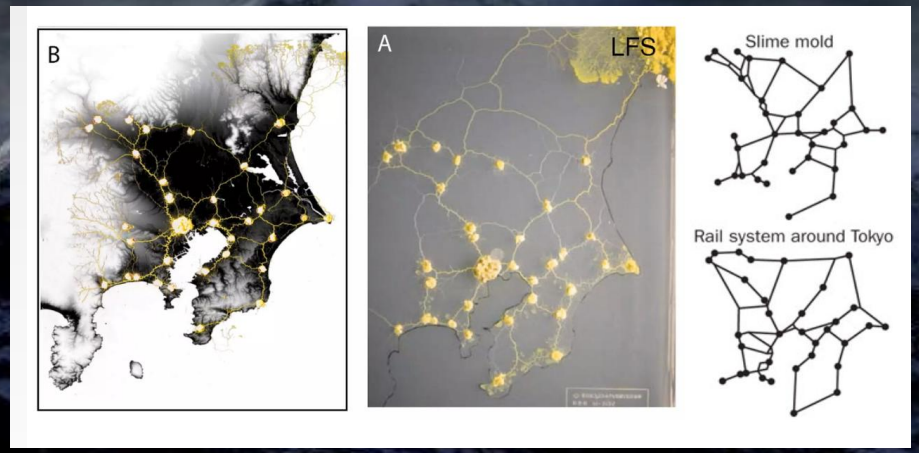
The Biological Phenomenon

Physarum moves using chemotaxis, rhythmically squeezing its own body to pump cytoplasm toward chemical attractants, reinforcing efficient paths and abandoning inefficient ones through purely physical and biochemical feedback



Physarum pathfinding

(PDF) Intelligence: Maze-Solving by an Amoeboid Organism, Page 1

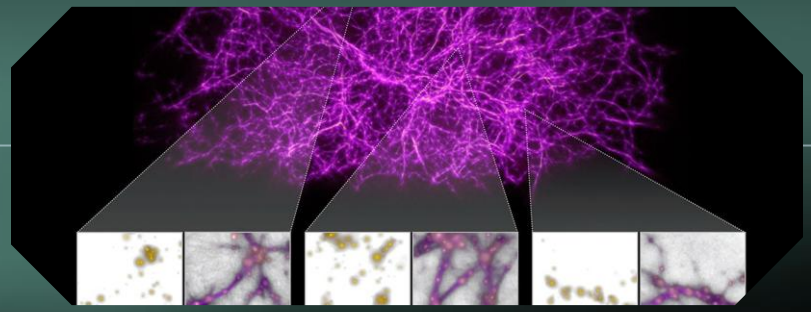


Slime Mould and the Tokyo railway system – Atsushi Tero

Engineering Application

Urban Planning

The slime mold algorithm is used in urban planning to design efficient transportation and utility networks by mimicking how slime mold finds shortest paths between food sources. It helps planners optimize road layouts, evacuation routes, and infrastructure connectivity while minimizing cost, distance, and congestion.

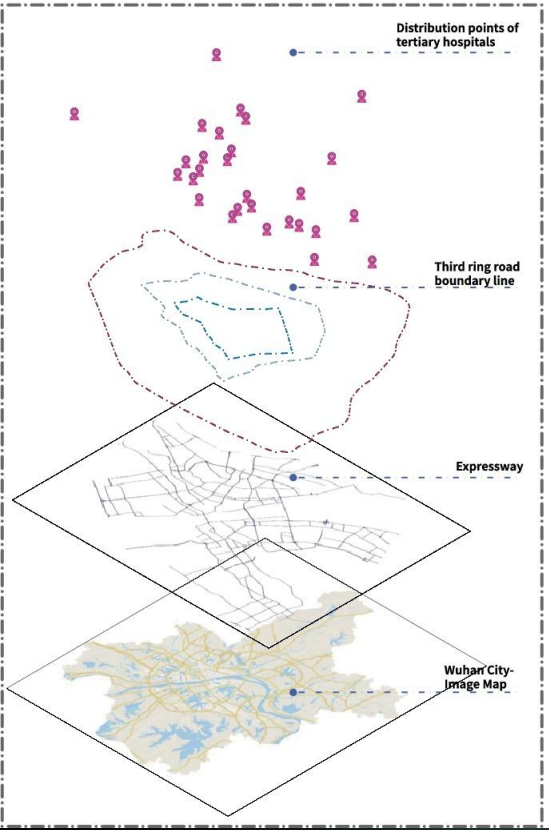


Space Exploration

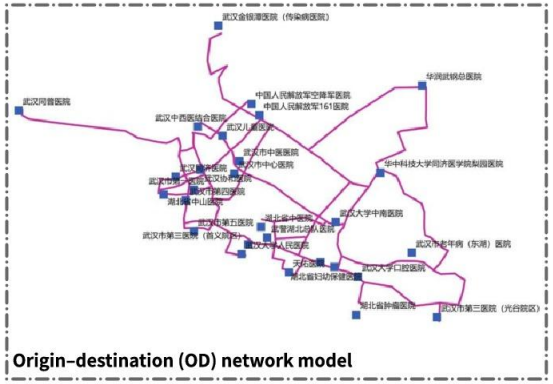
The slime mold algorithm is applied in space exploration to optimize path planning for rovers and spacecraft by finding efficient routes through complex terrains or gravitational fields. It also aids in designing resilient communication and supply networks for planetary bases while minimizing energy and resource usage

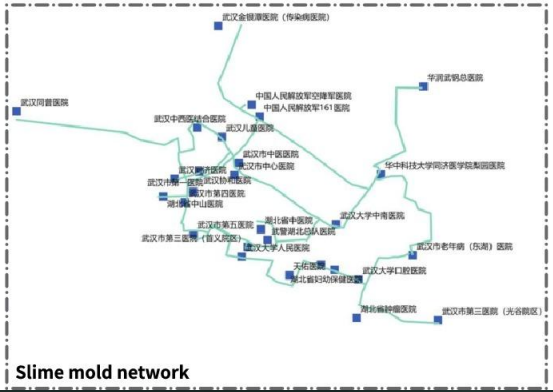
Case Study 1: SMA used in Wuhan Hospital Network

Urban data extraction and analysis

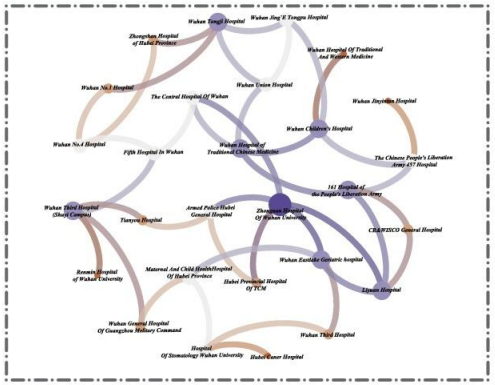


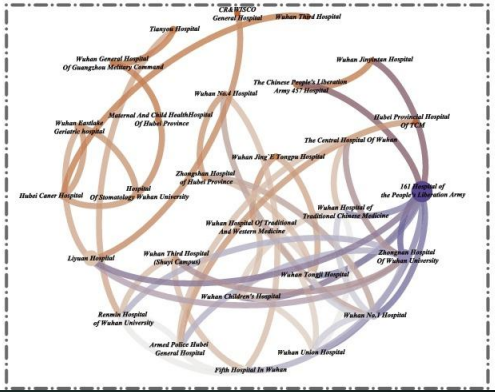
The simulation of shortest path



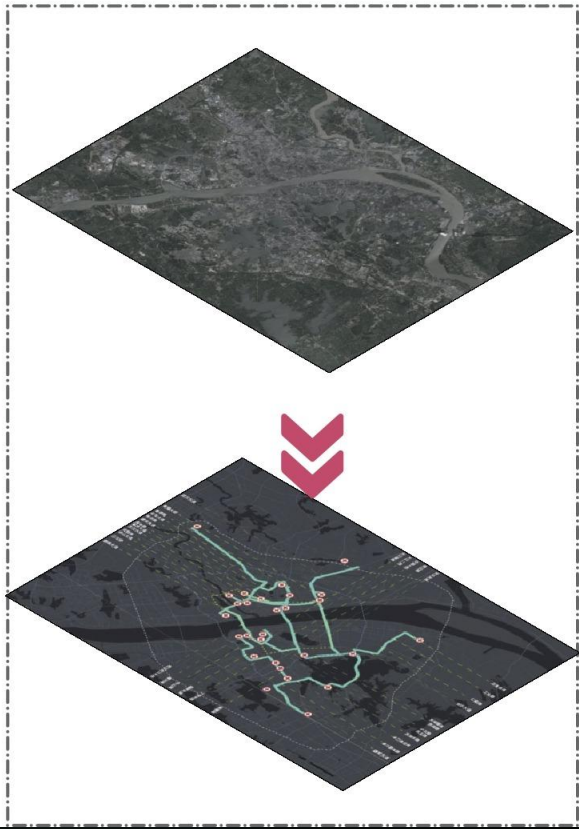


Network Analysis Comparison



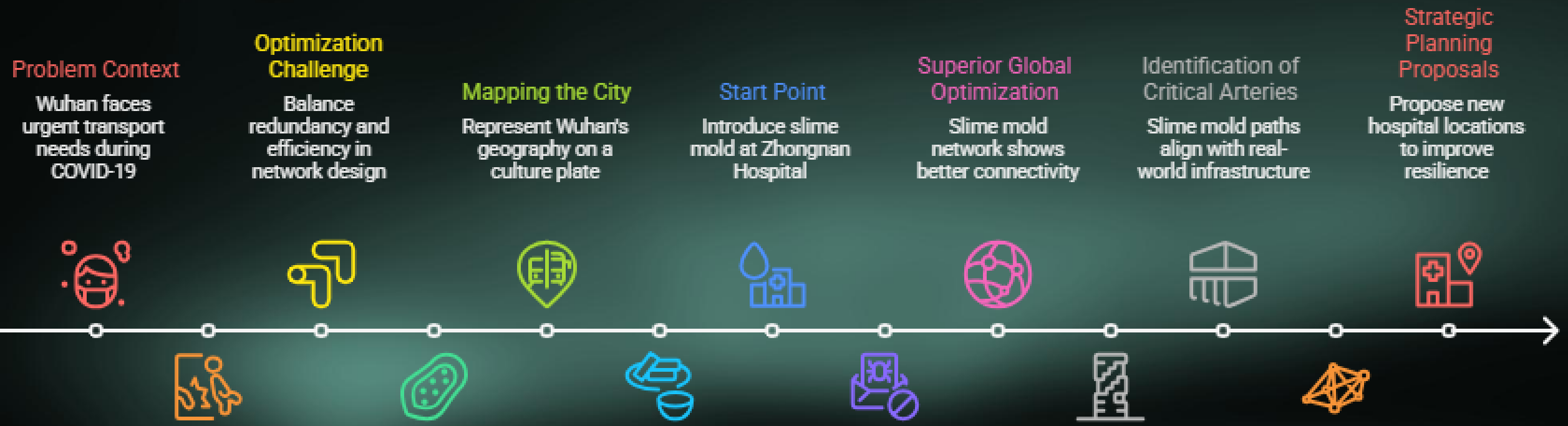


The real-world correction



[Biomimetic method of emergency life channel urban planning in Wuhan using slime mold networks – ScienceDirect](), Section 3.3.2

Slime Mold Network Design for Wuhan



Problem Context
Wuhan faces urgent transport needs during COVID-19

Optimization Challenge
Balance redundancy and efficiency in network design

Mapping the City
Represent Wuhan's geography on a culture plate

Start Point
Introduce slime mold at Zhongnan Hospital

Superior Global Optimization
Slime mold network shows better connectivity

Identification of Critical Arteries
Slime mold paths align with real-world infrastructure

Strategic Planning Proposals
Propose new hospital locations to improve resilience

Objective
Design emergency life channels connecting hospitals

Biological Simulation
Use slime mold to simulate network growth

Nutrient Sources
Place rice cake pieces at hospital locations

Comparative Algorithm
Compare biological results with computer algorithms

Enhanced Robustness
Slime mold network is more fault-tolerant

Node Centrality and Polarization
Identify core nodes and isolated regions

-Biomimetic method of emergency life channel urban planning in Wuhan using slime mold networks, 2023

Slime Mold Network Design for Wuhan

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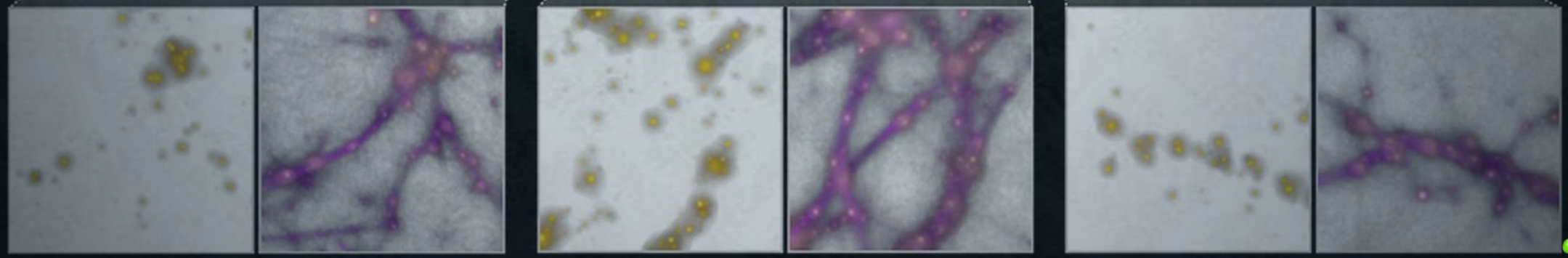
Comparative Network Topology Analysis of Slime Mold and OD Transportation Networks

Fig. 10. Comparative analysis of networks, A: The degree distribution of networks, B: The average clustering coefficient of networks, C: The average path length of networks.

Case Study 2: SMA used in Space Exploration



https://science.nasa.gov/asset/hubble/cosmic-web-and-slime-mold/

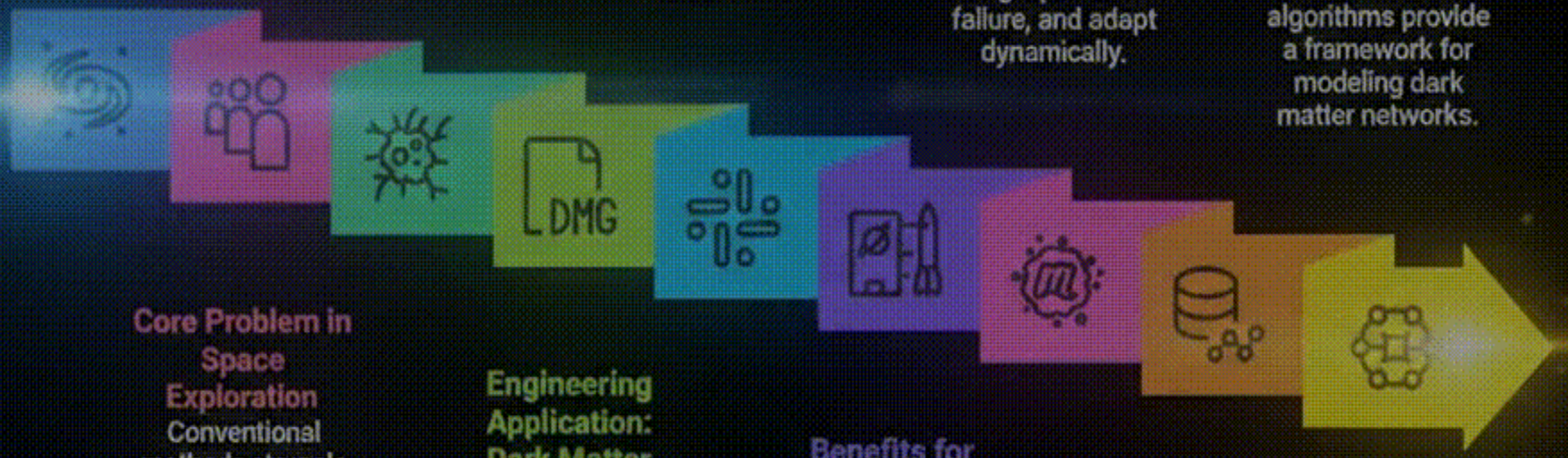
Background: Dark Matter in the Universe
Dark matter constitutes 85% of the universe's matter and is detected indirectly.

Biological Inspiration: Slime Mold
Slime mold forms efficient transport networks with self-organizing properties.

Slime Mold-Inspired Algorithm
The algorithm reinforces high-density paths and suppresses weak connections.

Why Slime Mold Algorithms Work
They produce filamentary networks, avoid single points of failure, and adapt dynamically.

Key Takeaway
Slime mold algorithms provide a framework for modeling dark matter networks.

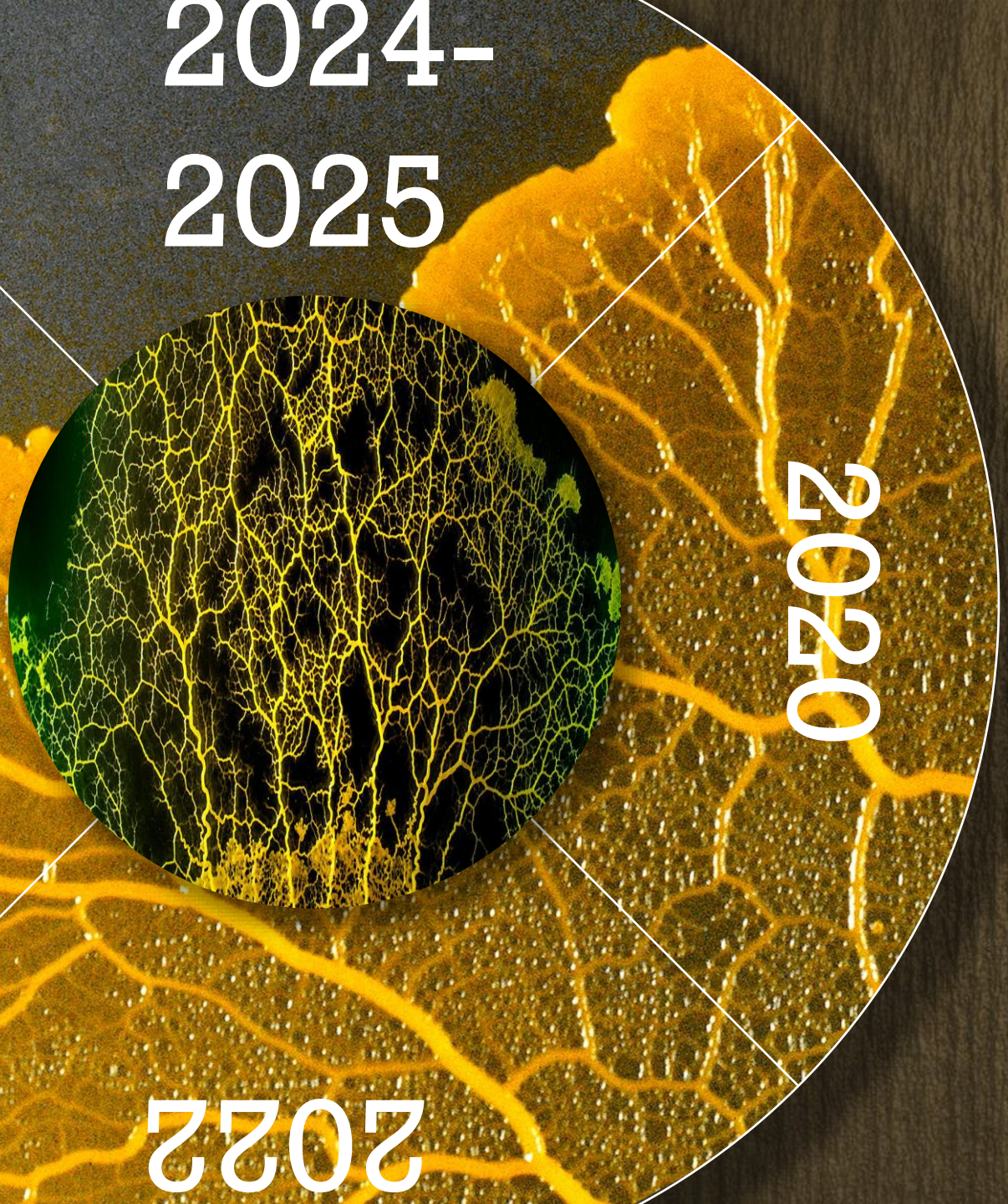


Core Problem in Space Exploration
Conventional methods struggle to map dark matter filaments and handle noisy data.

Engineering Application: Dark Matter Filament Reconstruction
Galexy clusters are treated as nodes, and gravitational influence as edges.

Benefits for Space Exploration
The algorithm improves mapping of cosmic structures and planning for missions.

Future Scope
Integration with apace telescope data and enhanced navigation models.



Beginnings

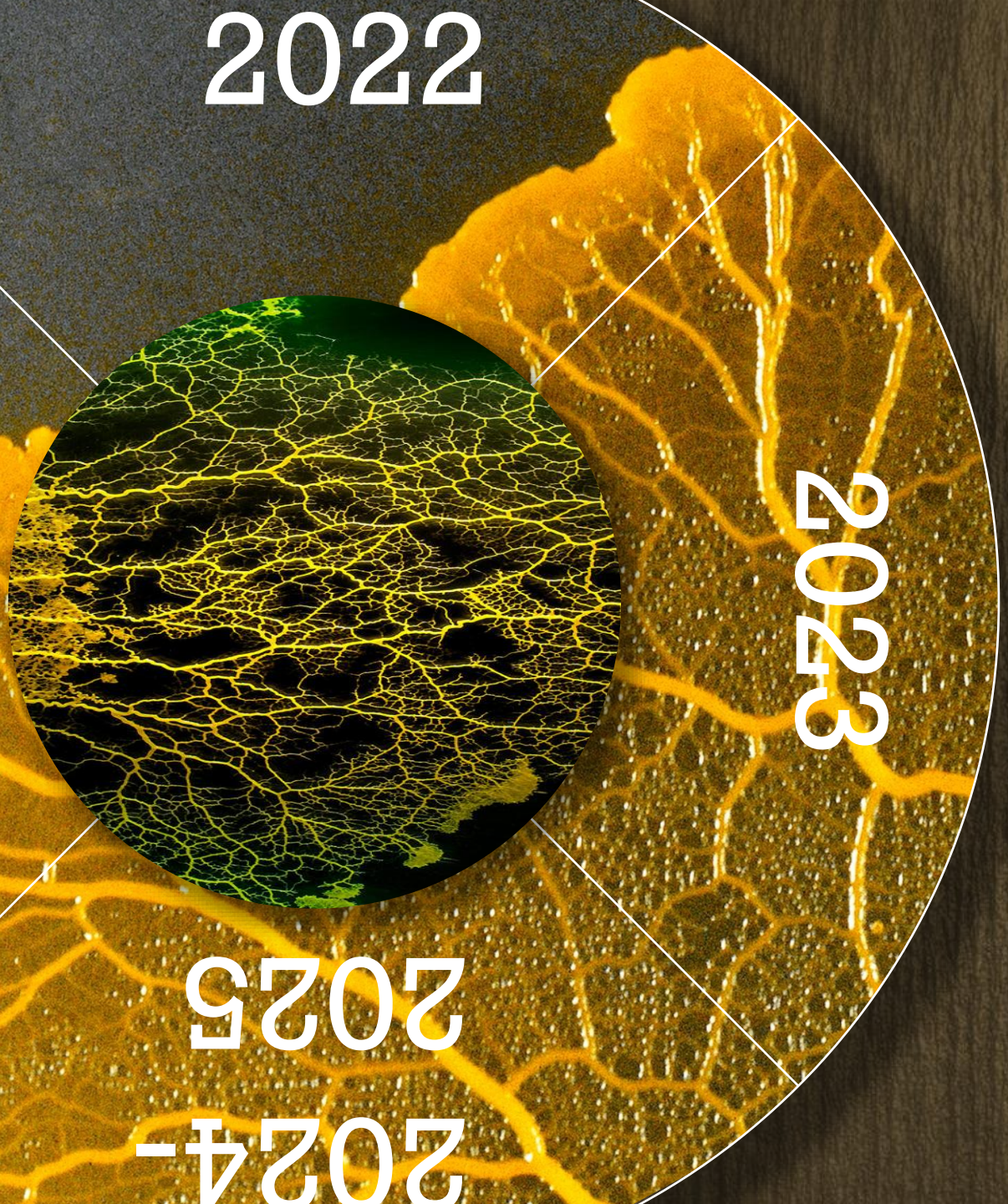
The Slime Mold Algorithm is proposed by Li at al, inspired by the slime mold's foraging behaviour

- Slime mould algorithm: A new method for stochastic optimization - ScienceDirect

Early Variants

SMA applied to engineering optimization,, and hybridization with chaos theory and reverse learning. Variants introduced to improve convergence and avoid local optima.

- Implementation of Chaotic Reverse Slime Mould Algorithm Based on the Dandelion Optimizer



Chaotic Enhancement

Integration with other models Applied to Extreme Learning Machine (ELM) and forecasting problems.

- Maximum Lyapunov exponent-based multiple chaotic slime mold algorithm for real-world optimization | Scientific Reports

Real World Applications

SMA-GM introduced to tackle constrained optimization problemsSMA applied to distributed generation placement in power systems, showing improved voltage profiles and reduced losses.

- Slime Mould Algorithm Based on a Gaussian Mutation for Solving Constrained Optimization Problems

STATISTICAL DATA

🏹 *Interpretation:*
•Lower path length & diameter → faster emergency transport
•Higher degree & clustering → better redundancy and robustness

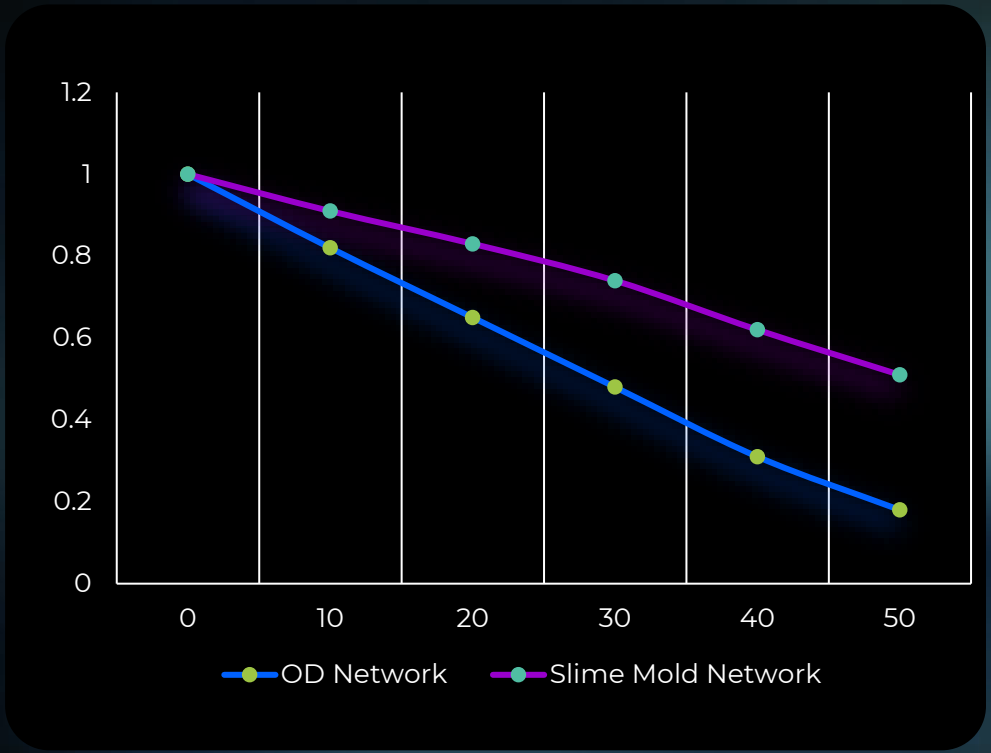
Metric	OD Network	Slime Mold Network	% Improvement
Average Shortest Path Length	3.58	3.02	↓ 15.6%
Network Diameter (Max Shortest Path)	9.0	7.2	↓ 20.0%
Average Degree (connections per node)	2.31	2.89	↑ 25.1%
Average Clustering Coefficient	0.41	0.63	↑ 53.7%
Global Transmission Efficiency	0.112	0.148	↑ 32.1%

Node Removal (%)	OD Network	Slime Mold Network	Meaning
0%	1.00	1.00	Full network, no failure
10%	0.82	0.91	Minor failures, slime mold reroutes better
20%	0.65	0.83	OD starts fragmenting
30%	0.48	0.74	Slime mold still functional
40%	0.31	0.62	OD nearly collapsed
50%	0.18	0.51	Slime mold retains alternate paths

- Biomimetic method of emergency life channel urban planning in Wuhan using slime mold networks – ScienceDirect, Section 4.2.2

Statistical Data

CHARTS



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PROS

Global Optimization Ability

High Robustness & Fault Tolerance

Adaptive & Self-Organizing

Efficient Resource Distribution

CONS

PROS

CONS

Higher Computational Cost

Parameter Sensitivity

No Guaranteed Optimal Solution

Implementation Complexity

Future scope for SMAs

Hybrid and Ensemble Methods
Combining SMA with other search strategies.

Multi-Objective & Real-World Integration
Extending SMA for multi objective optimization, dynamic environments, or large-scale engineering systems.

Constraint & Diversity Enhancements
Enhancing search mechanisms (like Gaussian mutation in SMA-GM) to manage diversity and avoid early convergence.

Cross-Disciplinary Applications
Finance, feature selection, predictive modeling, robotics, and network design. The biological inspiration also enables contributions bio inspired hardware.

Theoretical Analysis
Formal analysis of convergence behaviors and theoretical bounds similar to particle swarm and genetic algorithms.