Using ABM to build infrastructure networks bottom-up

Group 1

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Introduction - building infrastructure

Current

1. top-down
2. Expensive
3. Slow
4. Complex

(Pei, et al., 2022)

Modelling

1. Bottom-up
2. Low cost
3. Fast solution testing
4. Easy behavior rules

(Hu, et al., 2022)

Current metro networks are created in a top-down manner and are scale-free (Derrible & Kennedy, 2010). They are expensive and develop slowly.

What would happen if city planning is designed bottom-up?
Designed based in the needs of the consumer?

Would a network emerge that resembles existing transport networks?

Introduction - Why ABM

Space is crucial

→ network connects different destinations

Population is heterogeneous

→ agents have different destinations

Topology of interaction is heterogeneous

→ agents interact with their own local environment

Introduction - research questions

Does a network structure emerge from simple local rules?

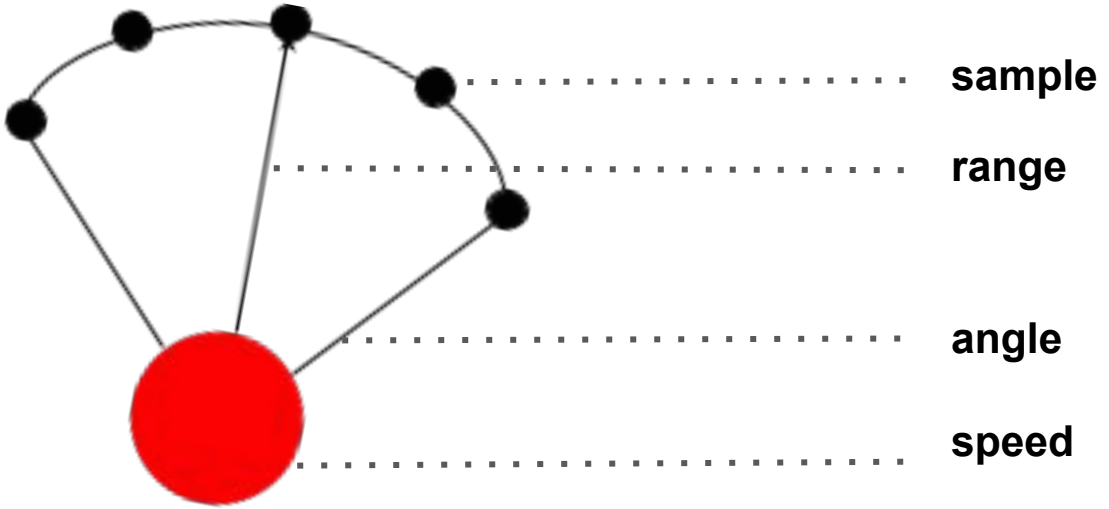
If yes, which factors contribute to this emergence?

→ Sensitivity analysis

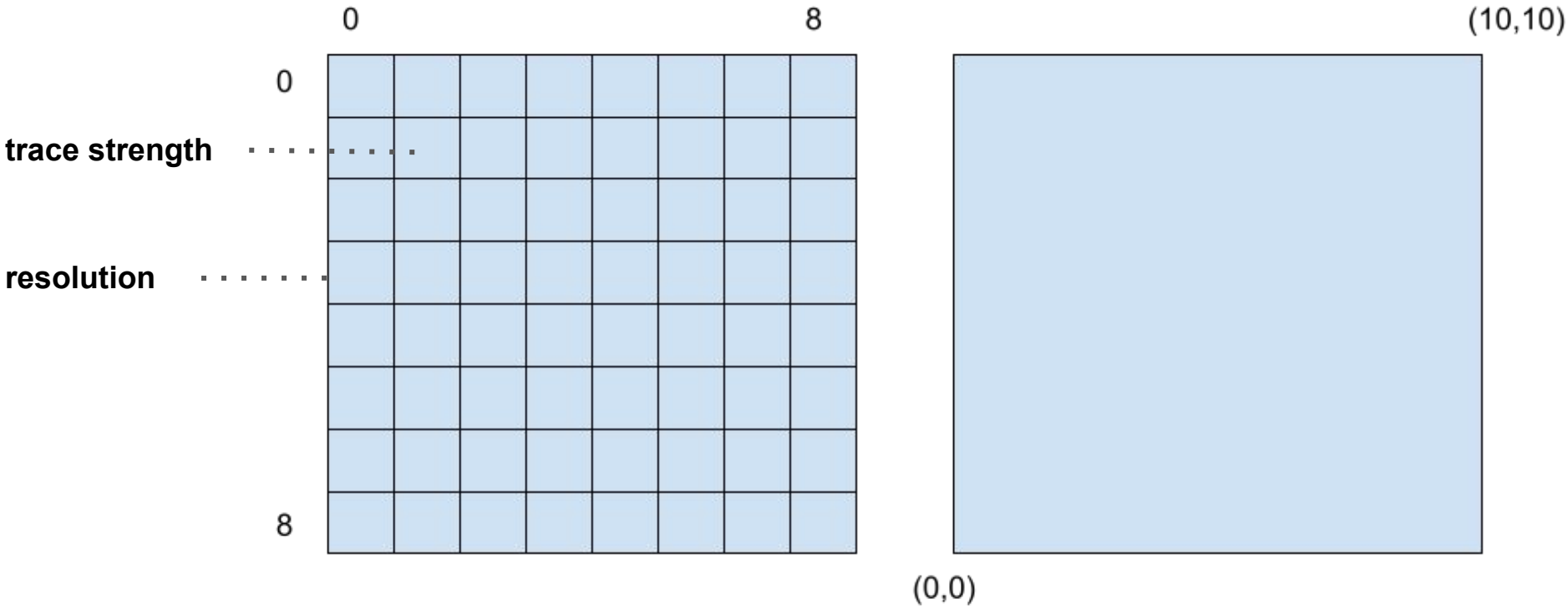
If yes, how does it compare to existing networks?

→ Evaluate degree distribution

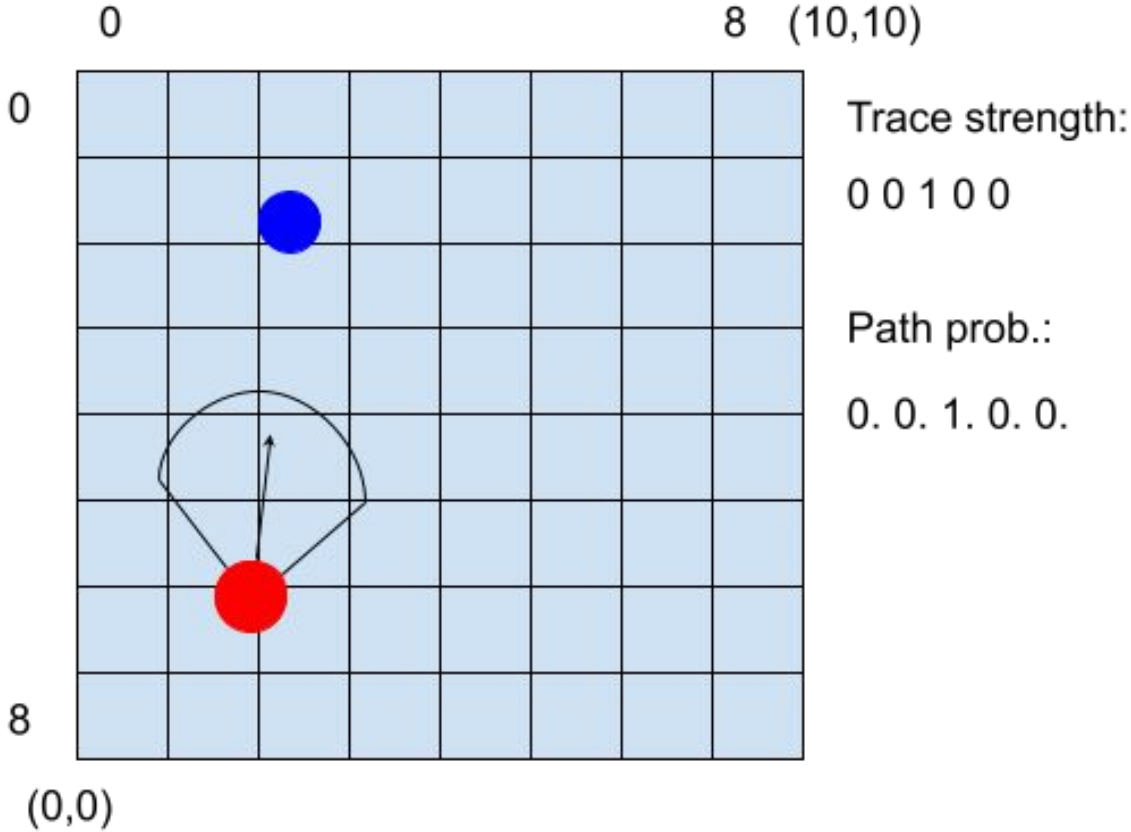
Model - Agent



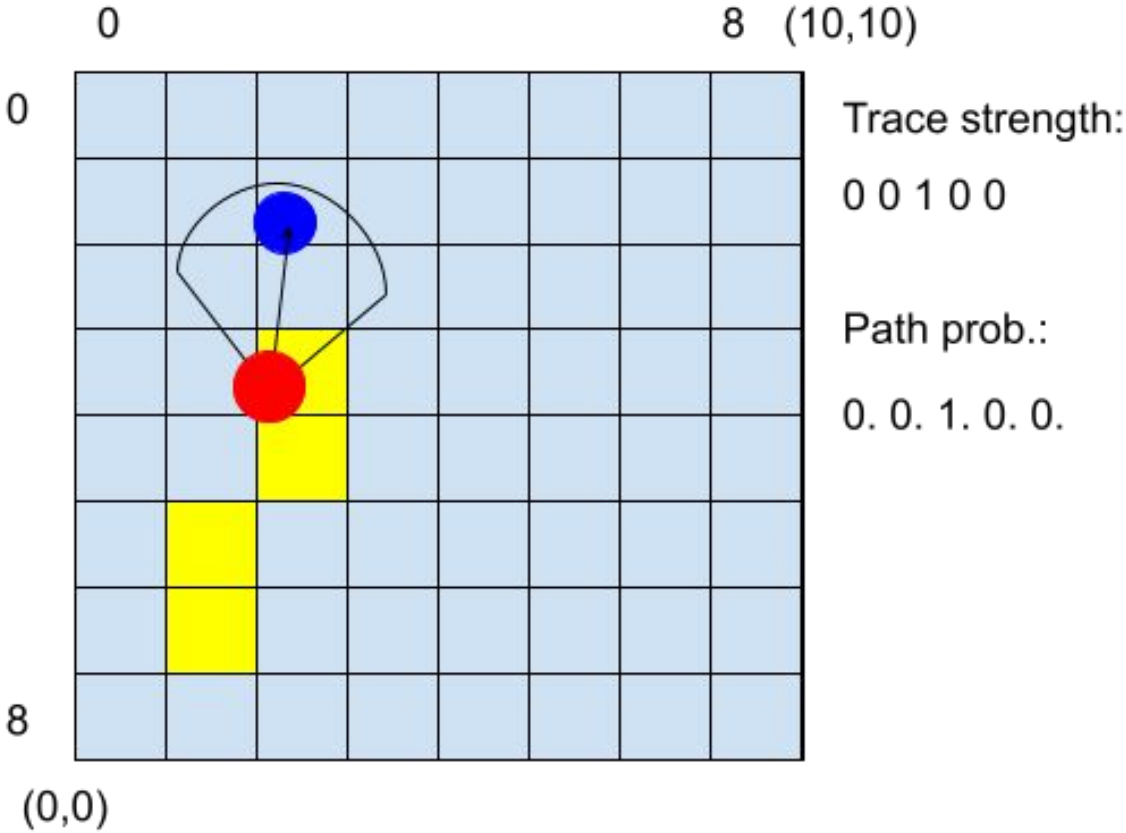
Model - Environment



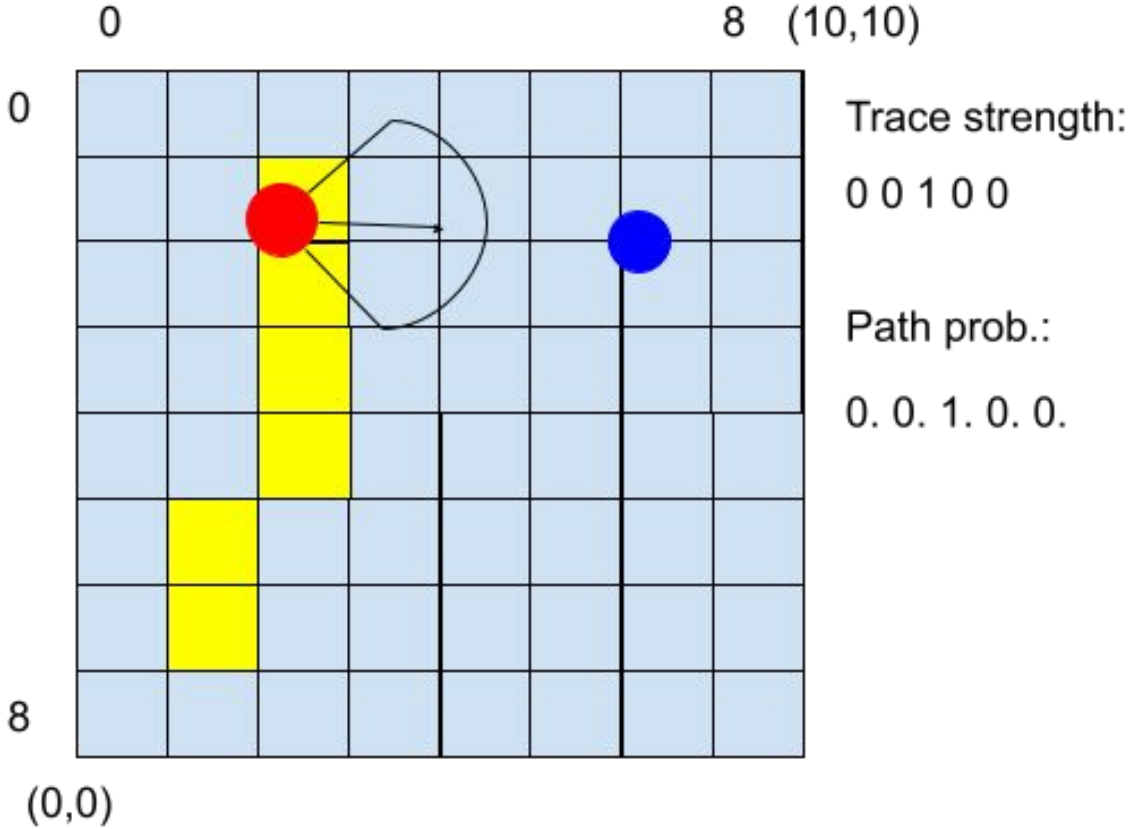
Model - movement



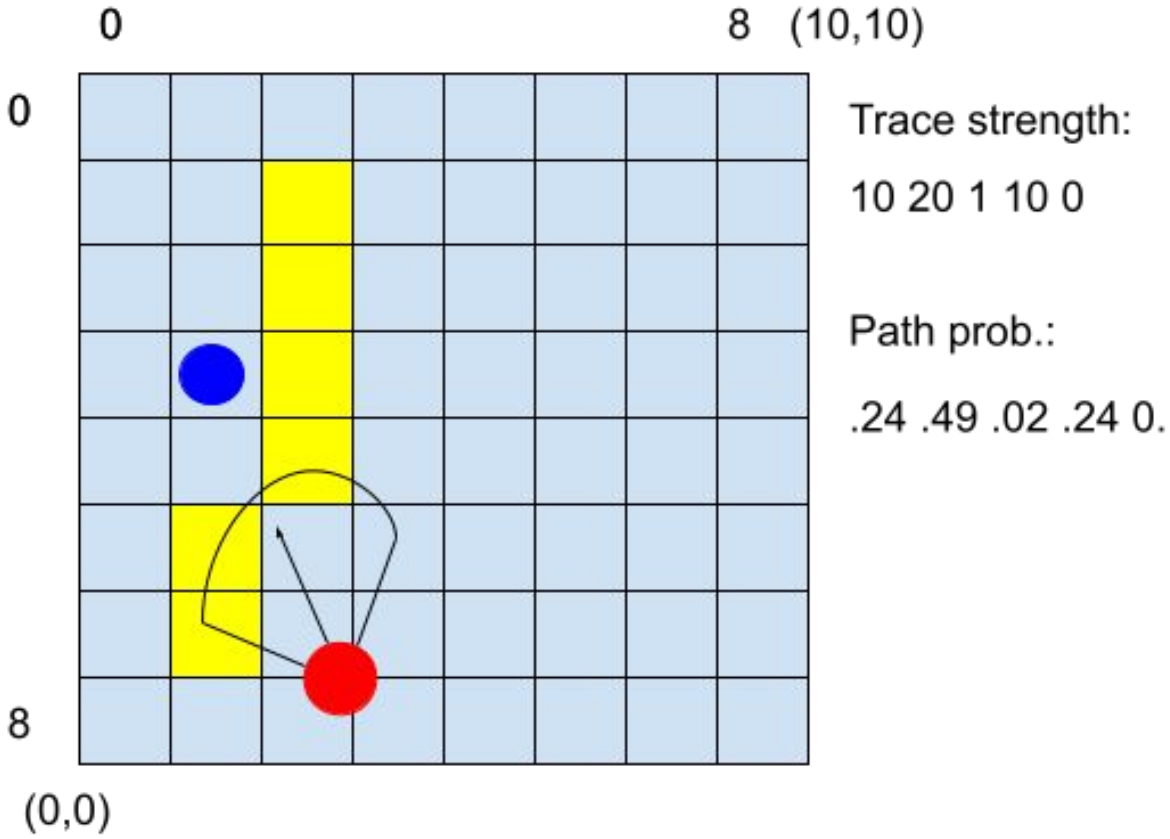
Model - movement



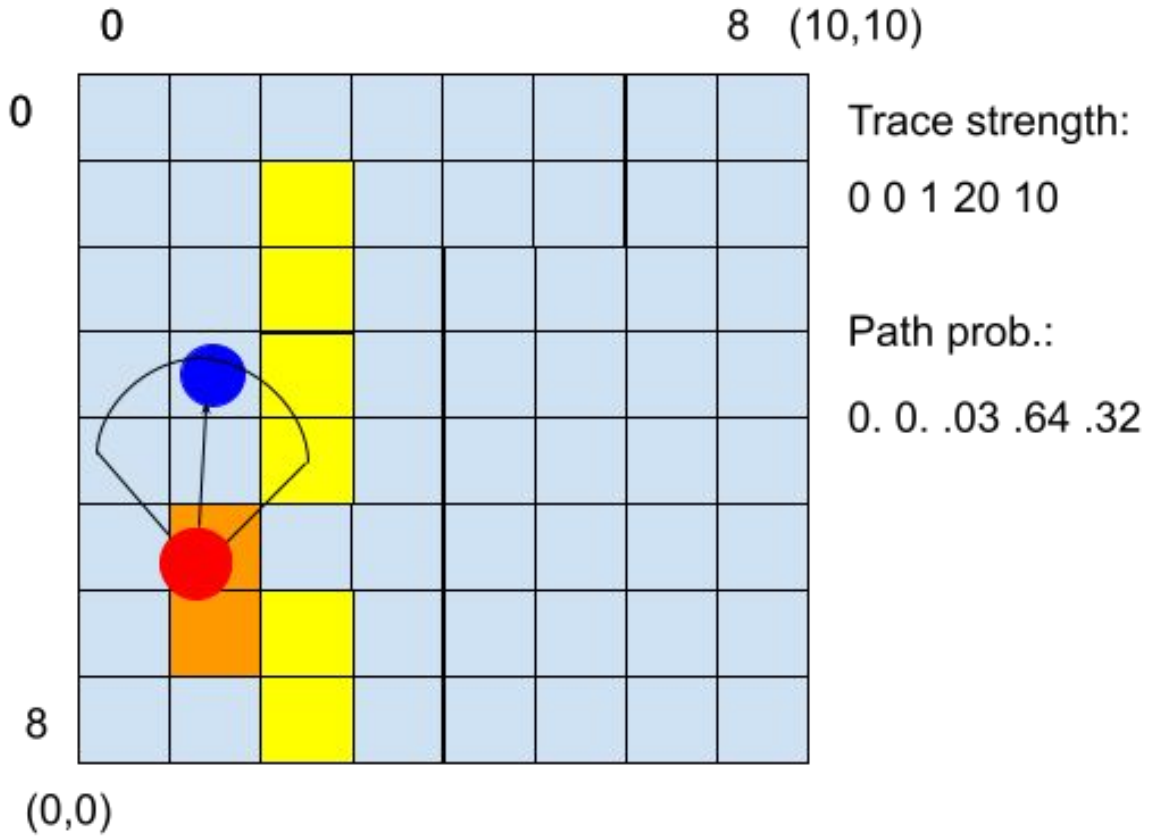
Model - movement



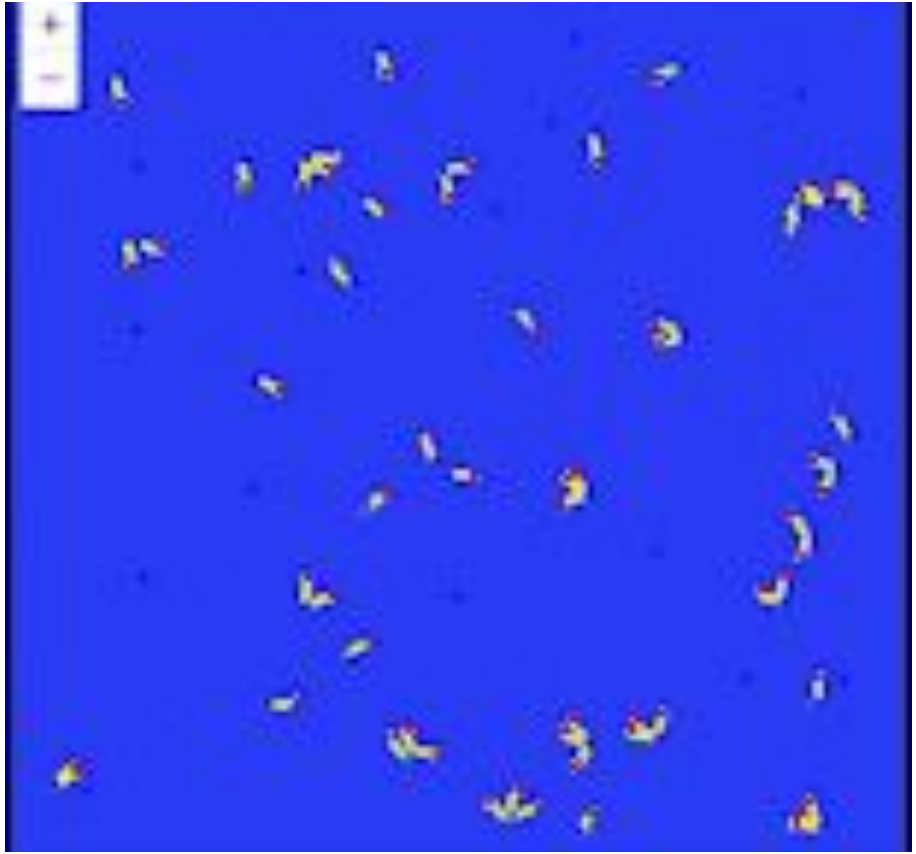
Model - movement



Model - movement



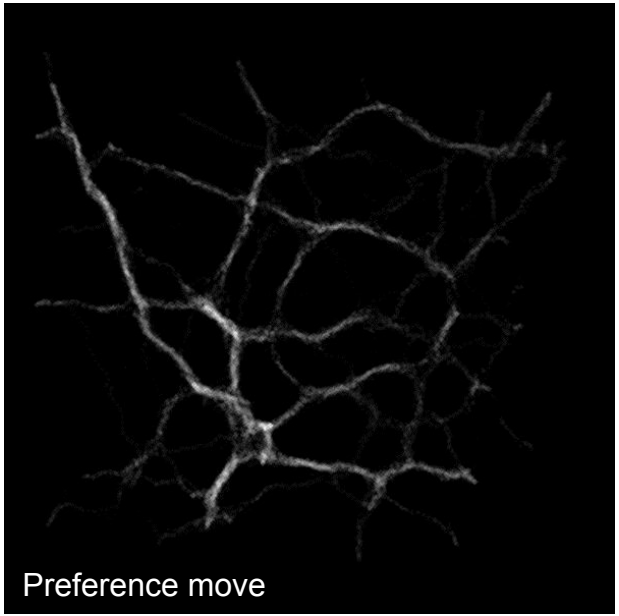
Model

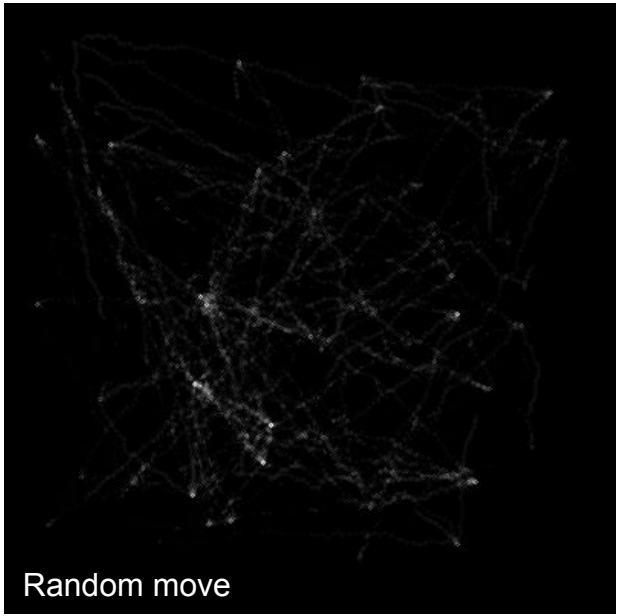


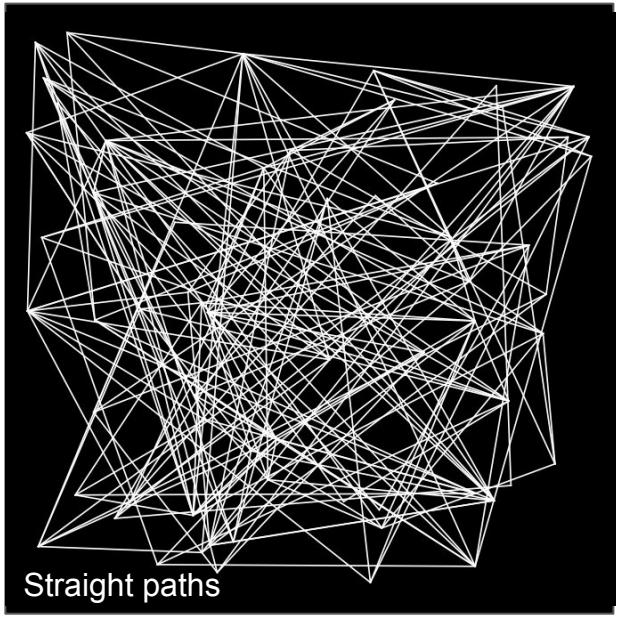
Does a network emerge?

YES!

Experiments - does a network emerge?

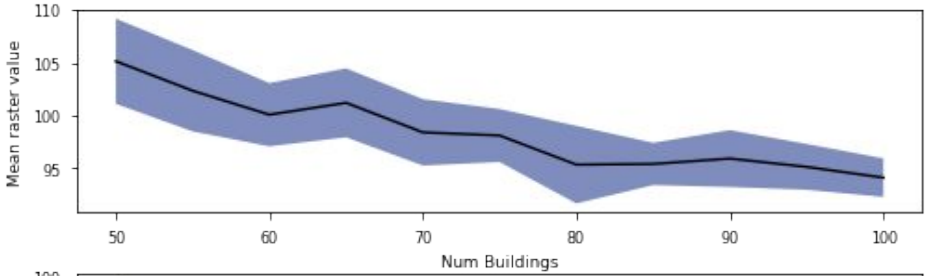


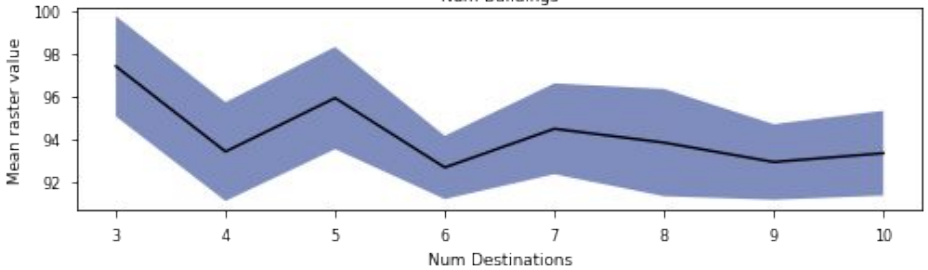


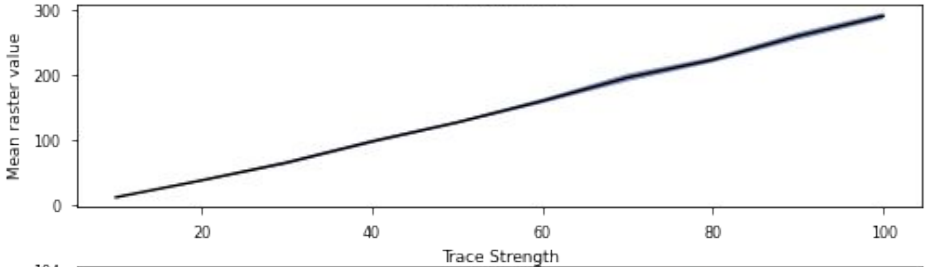


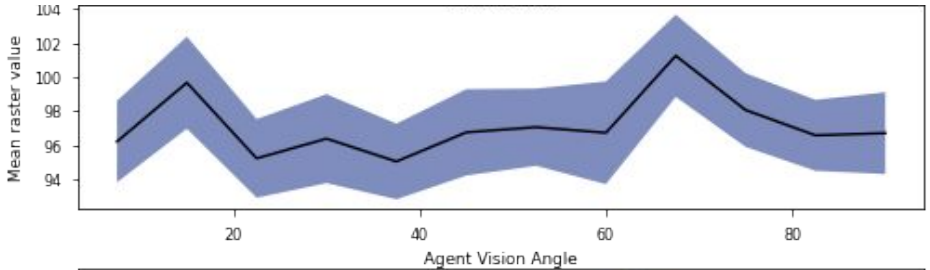
Experiments - which factors contribute to this emergence?

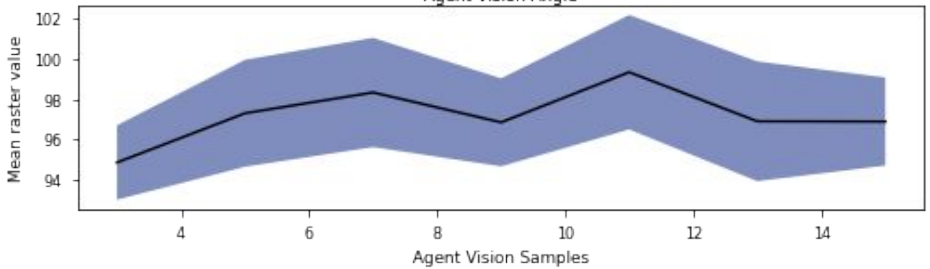
OFAT











Experiments - how does it compare to existing networks?

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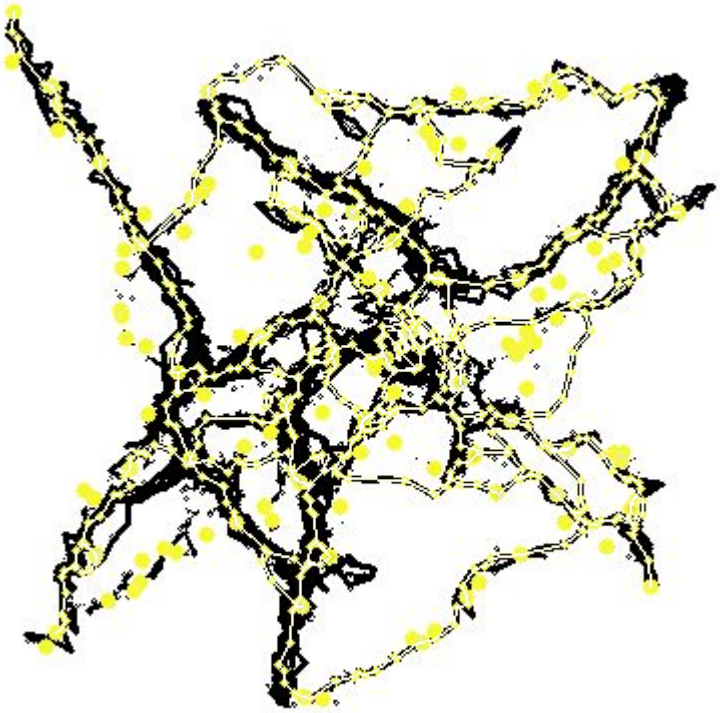
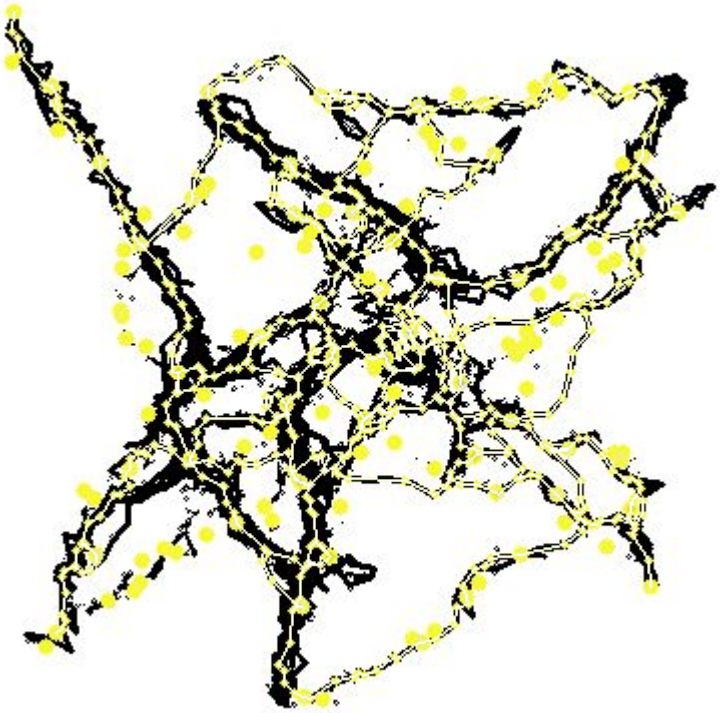
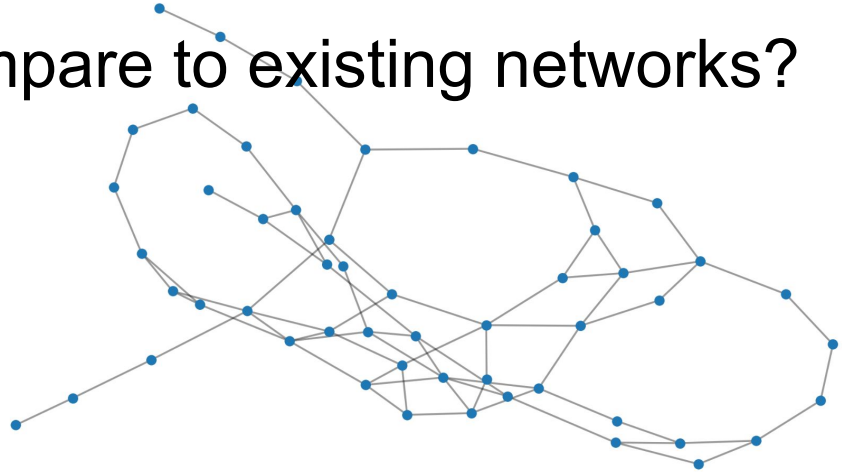
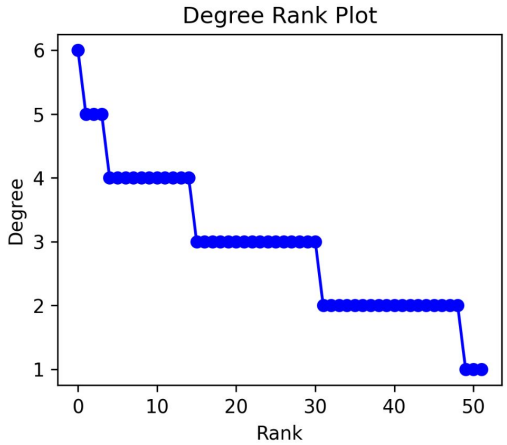


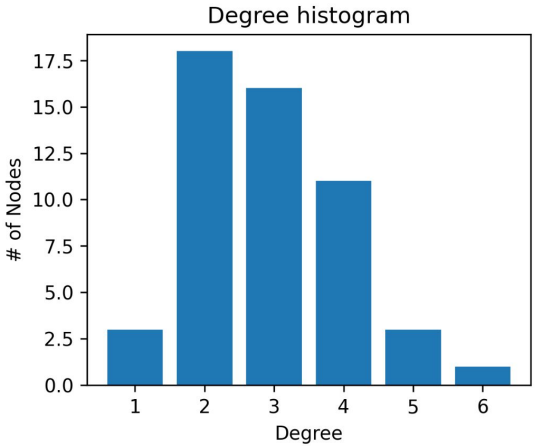
github.com/danvk/extract-raster-network

Experiments - how does it compare to existing networks?









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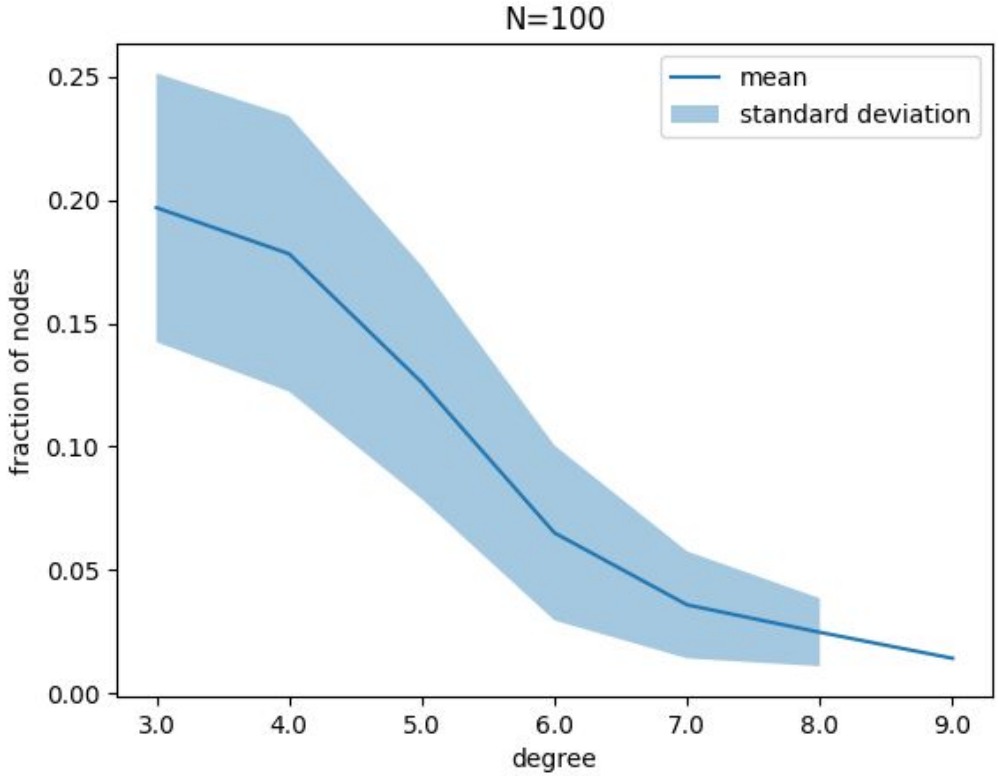
Experiments - how does it compare to existing networks?



Key findings

Does a network structure emerge from simple local rules?

→ Yes!

If yes, which factors contribute to this emergence?

→ Trace strength and number of buildings are important

→ Emergent behaviour is not sensitive to input parameters

→ Did we use the right measure?

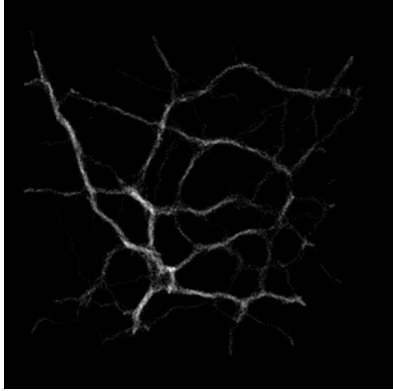
If yes, how does it compare to existing networks?

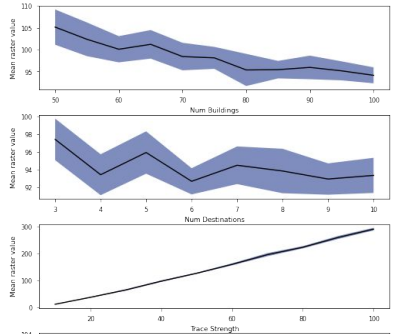
→ TBD

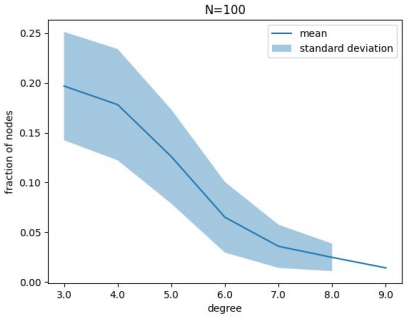
→ Power law, shortest path length, clustering coefficient

(Derrible & Kennedy, 2010)

→ Is network structure sensitive to input parameters?







Lessons learned & future research

Keep it simple!

Many different approaches

Use and compare to real data


Any
Question

References

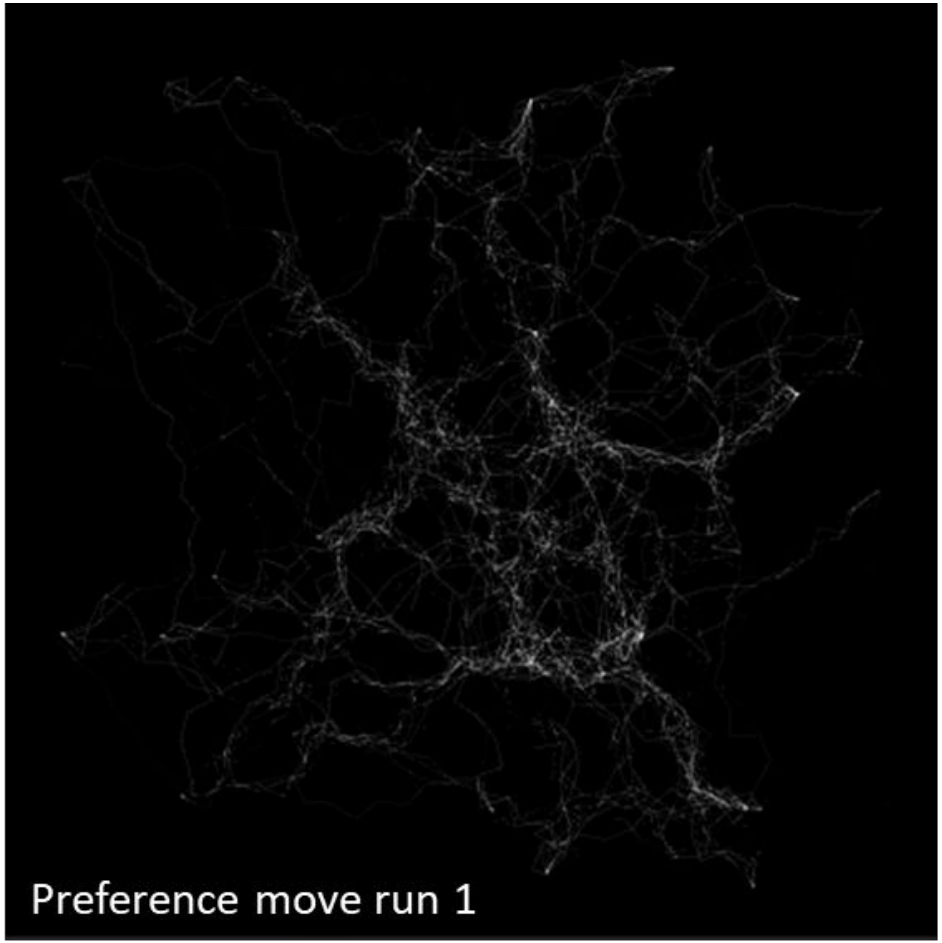
Derrible S (2012) Network Centrality of Metro Systems. PLOS ONE 7(7): e40575.

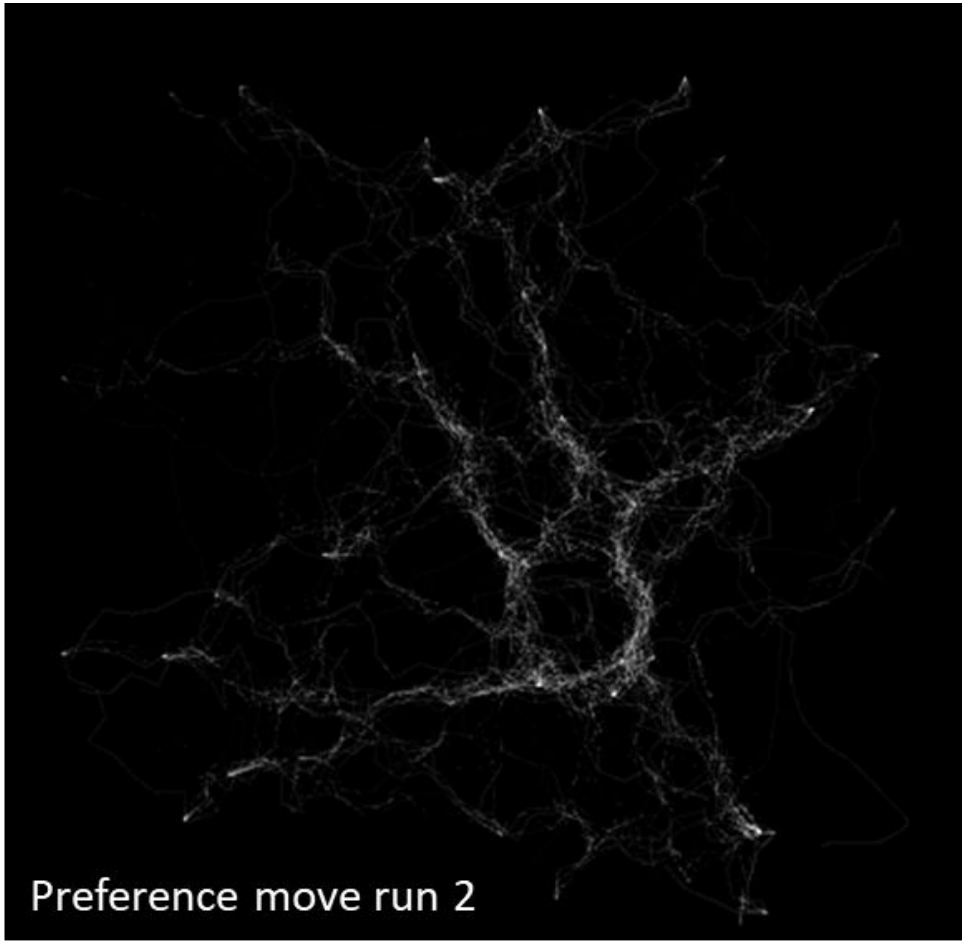
Derrible, S., & Kennedy, C. (2010). The complexity and robustness of metro networks. *Physica A: Statistical Mechanics and its Applications*, *389*(17), 3678-3691.

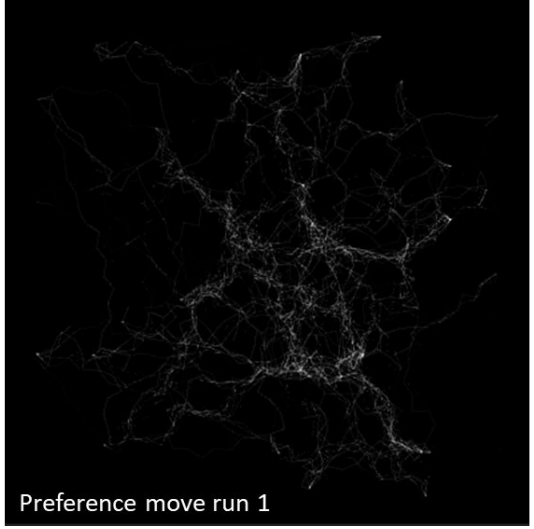
Hu, W., Dong, J., Yuan, J., Ren, R., Chen, Z., & Cheng, H. (2022). Agent-based modeling approach for evaluating underground logistics system benefits and long-term development in megacities. *Journal of Management Science and Engineering*, *7*(2), 266-286.

Pei, A., Xiao, F., Yu, S., & Li, L. (2022). Efficiency in the evolution of metro networks. *Scientific Reports*, *12*(1), 8326.

Parameter	Value
num_buildings	70
num_commuters	60
num_destinations	3
agent_speed	0.1
agent_vision_range	0.1
agent_vision_angle	20
agent_vision_samples	7
trace_strength	40
resolution	400
model_steps	170


Preference move run 1


Preference move run 2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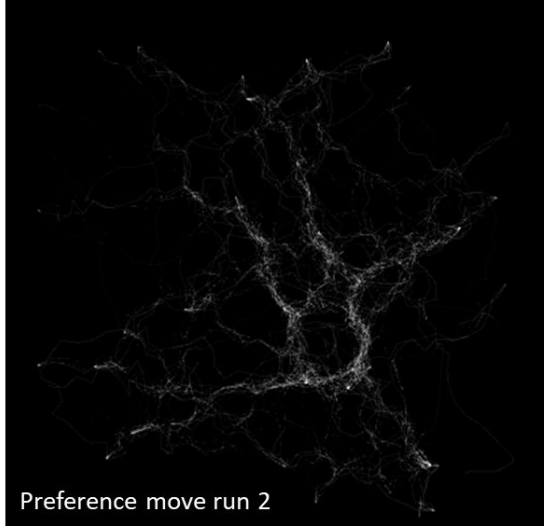
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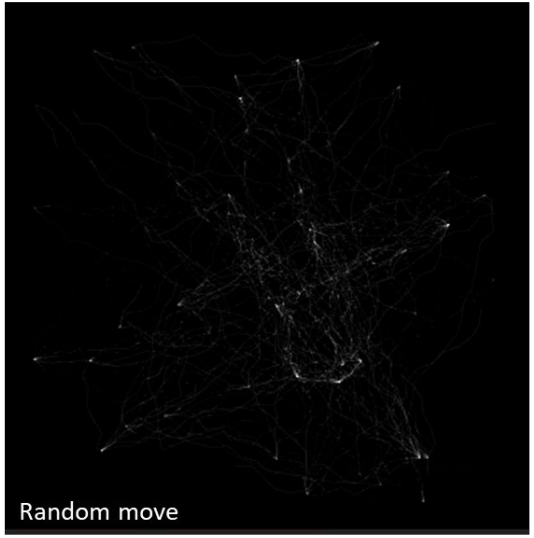
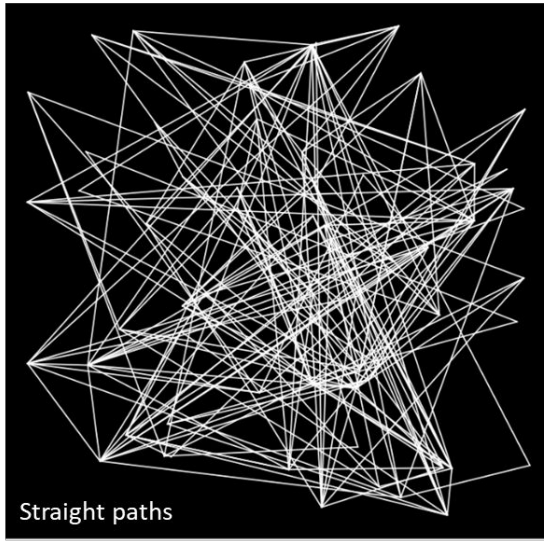
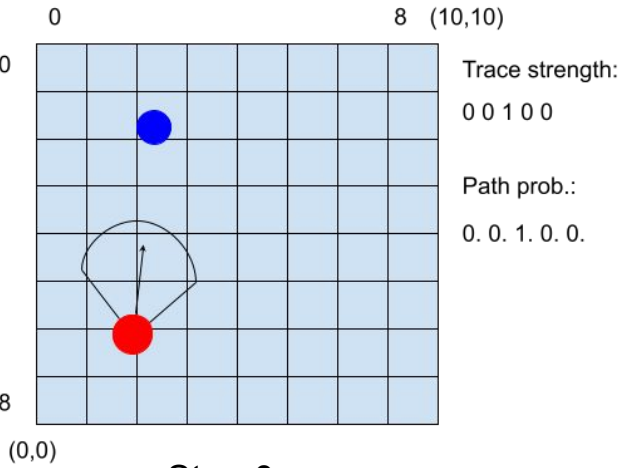
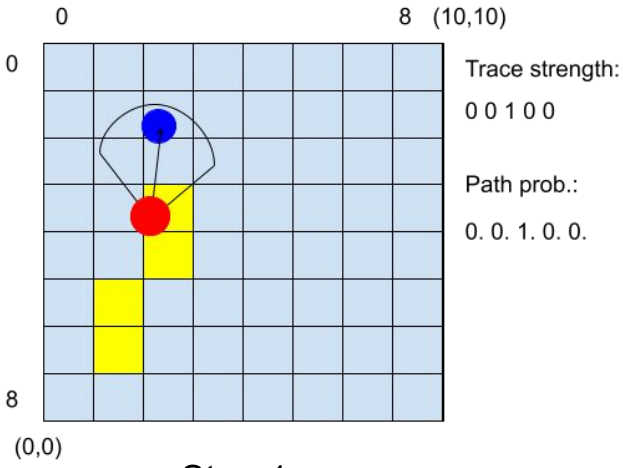

Random move

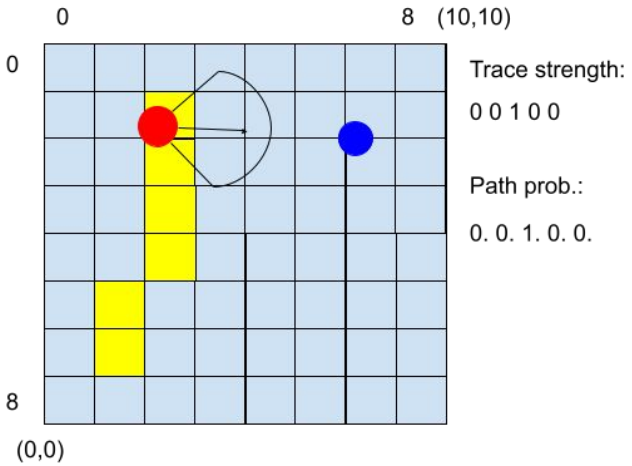

Straight paths



Step 0



Step 1



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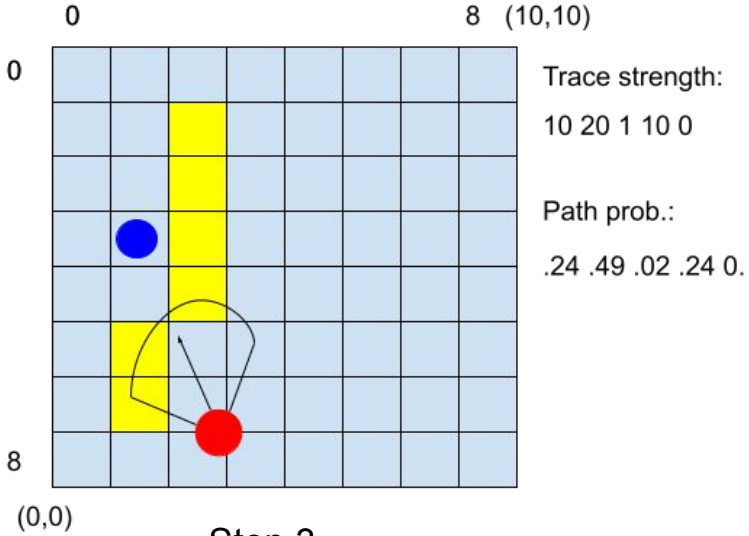
0
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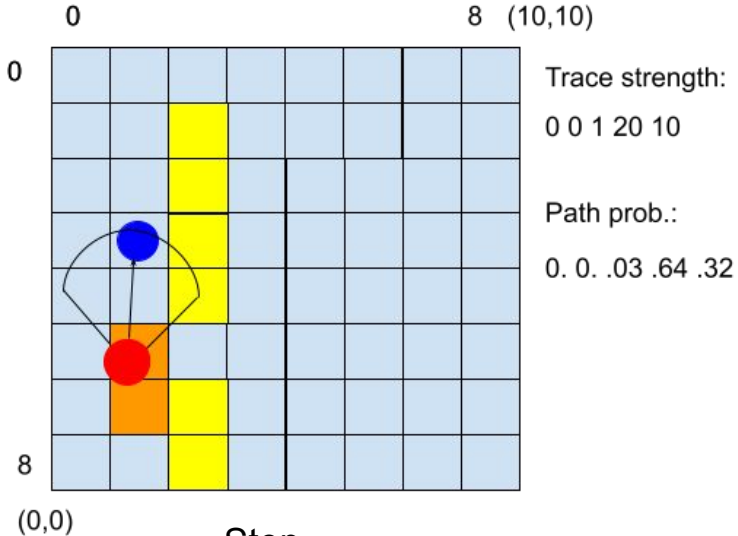
0
8
(0,0)
Trace strength:
10 20 1 10 0
Path prob.:
.24 .49 .02 .24 0.

Step 3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8
(0,0)
Trace strength:
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Path prob.:
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Step