TownSim: Agent-based city evolution for naturalistic road network generation

Asiiah Song, Jim Whitehead

UC Santa Cruz / Augmented Design Lab

The Sinking City (2017 YouTube video screenshot)

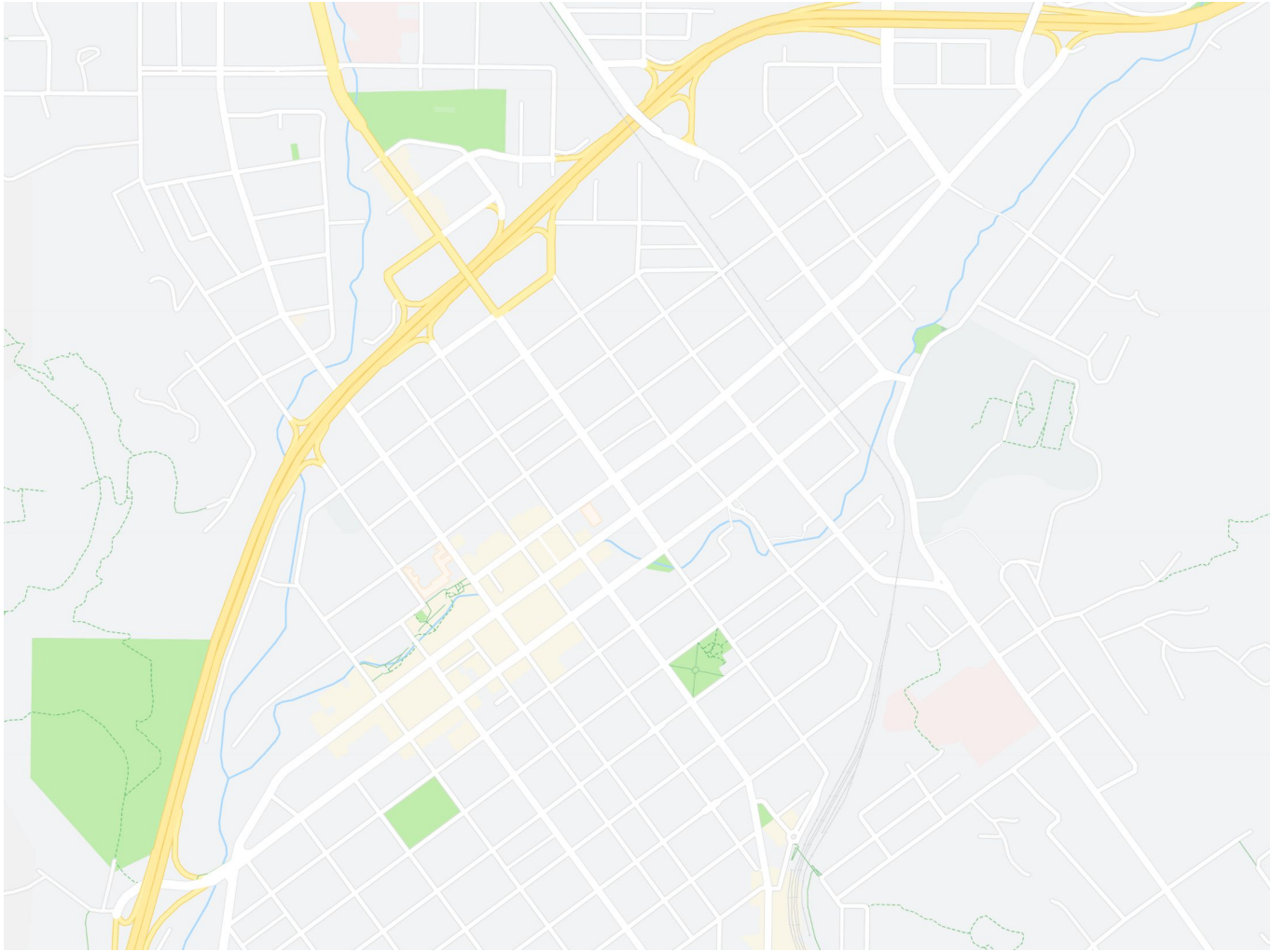
Woodridge Town Centre Master Plan

Woodridge, Illinois | August 14, 2014

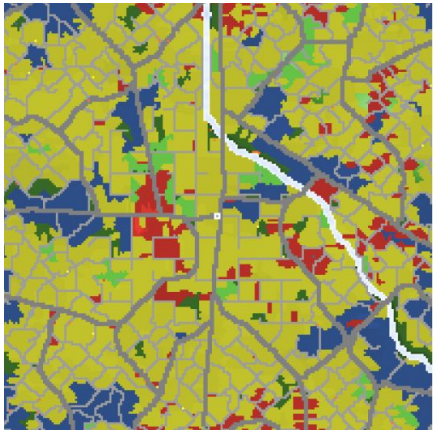
Prepared By Houseal Lavigne Associates | Gary R. Weber Associates

CARLA, a simulator for autonomous vehicle research

SUMO, a traffic simulator for autonomous vehicle research



Related Work



Parish, Yoav IH, and Pascal Müller. "Procedural modeling of cities." In *Proceedings of the 28th annual conference on Computer graphics and interactive techniques*, pp. 301-308. ACM, 2001.

Lechner, Tom, Benjamin Watson, Uri Wilensky, Seth Tisue, Martin Felsen, Andy Moddrell, Pin Ren, and Craig Brozefsky. *Procedural modeling of urban land use*. North Carolina State University. Dept. of Computer Science, 2007.

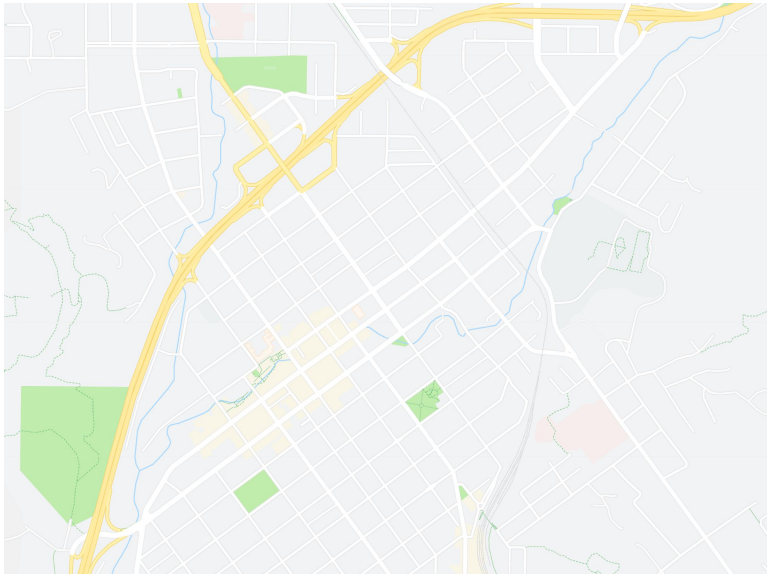
Emilien, Arnaud, Adrien Bernhardt, Adrien Peytavie, Marie-Paule Cani, and Eric Galin. "Procedural generation of villages on arbitrary terrains." *The Visual Computer* 28, no. 6-8 (2012): 809-818.

Goals

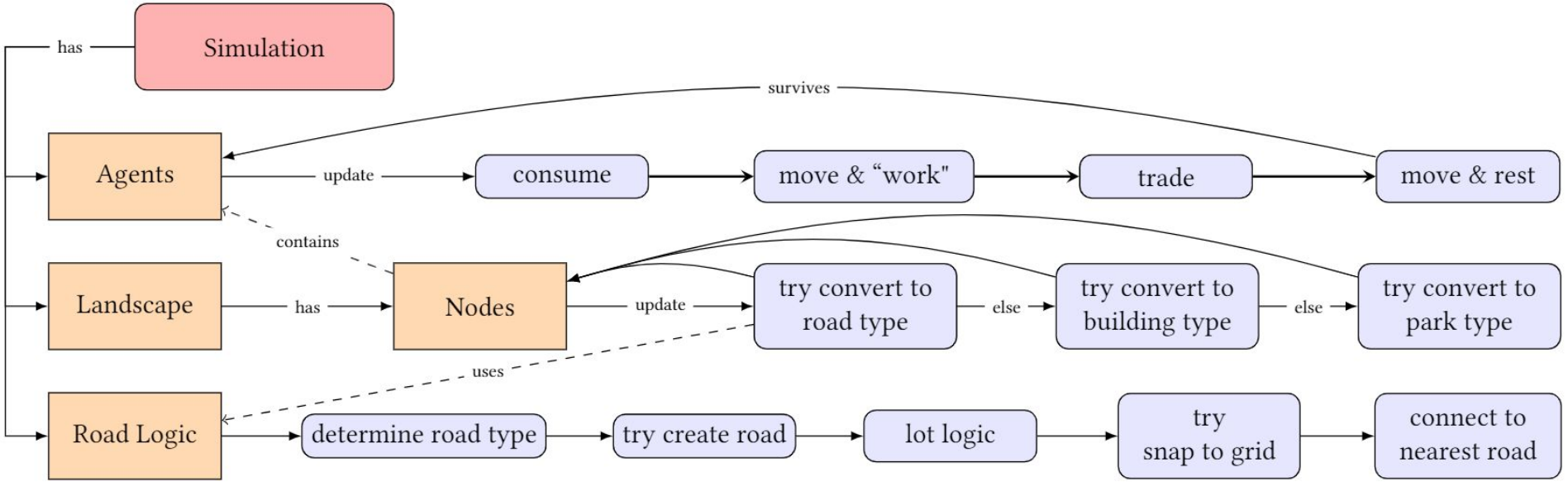
- Realistic-looking roadmaps
- Controllable by parameters
- Allow variety given same starting conditions
- Use agent-based simulation to capture emergent complexities

Goals

- Realistic-looking road maps
  - regular, grid-like neighborhoods
  - quirky, irregular intersections
  - winded, curved roads
  - “arteries” - long roads that connect different areas
  - “capillaries” - short roads that give local coverage
  - ring roads around the city center
  - etc



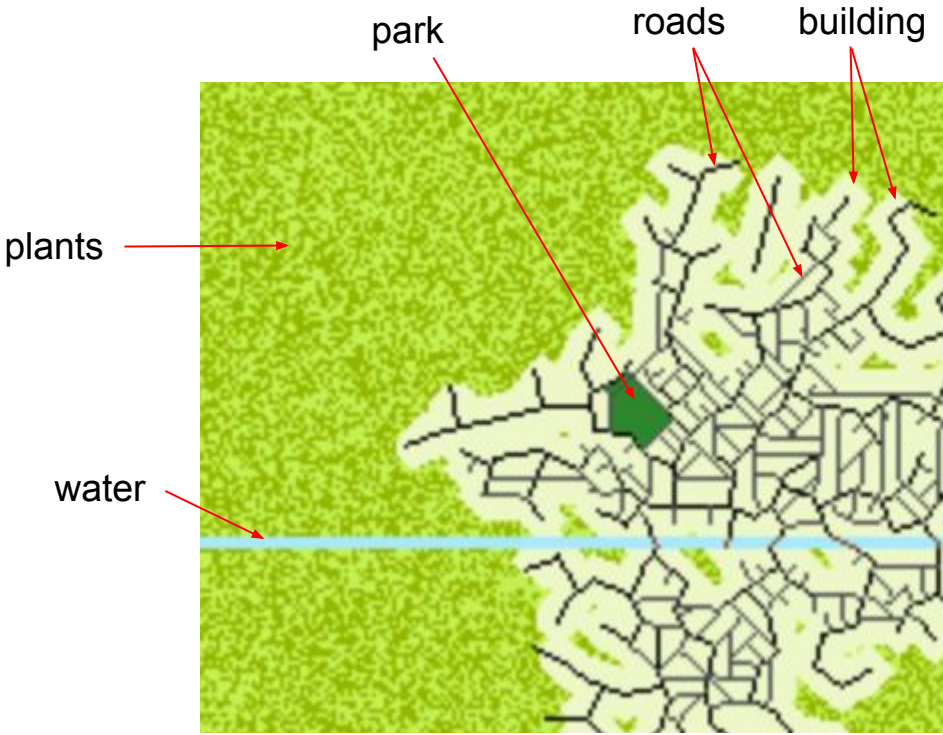
Simulation Procedure



Simulation Procedure

0- The gridworld

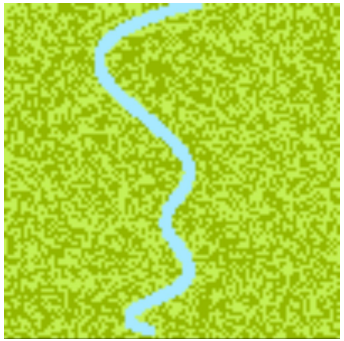
- “water” cells
- “plant” cells
- “road” cells
- “building” cells
- “park” cells



Simulation Procedure

1- Initialize the geography

- ❏ “water” cells are placed using a 4~7 degree polynomial
- ❏ the rest are “plant” cells



Simulation Procedure

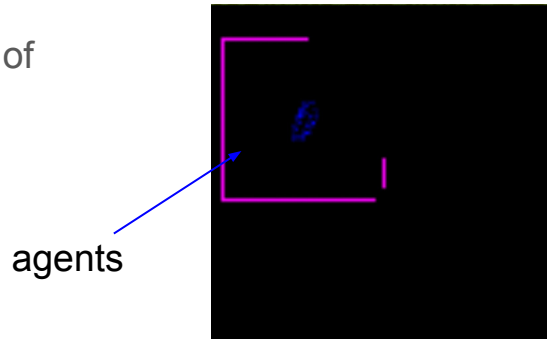
2- Seed an initial settlement

- small, continuous patch of “building” cells with a stretch of “road” cells
- small number of agents

Simulation Procedure

3- Agents go through cycles of activities

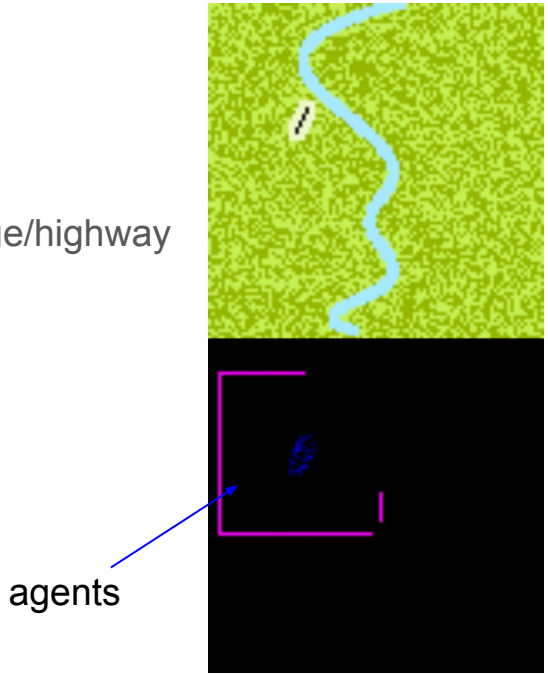
- ❏ consume resources (2 types: water and non-water)
- ❏ move to collect resources
- ❏ barter with other agents for resources
- ❏ prepare to rest in a “building” cell
- ❏ spawn a new agent if itself has an abundance of resources



Simulation Procedure

4- Roads

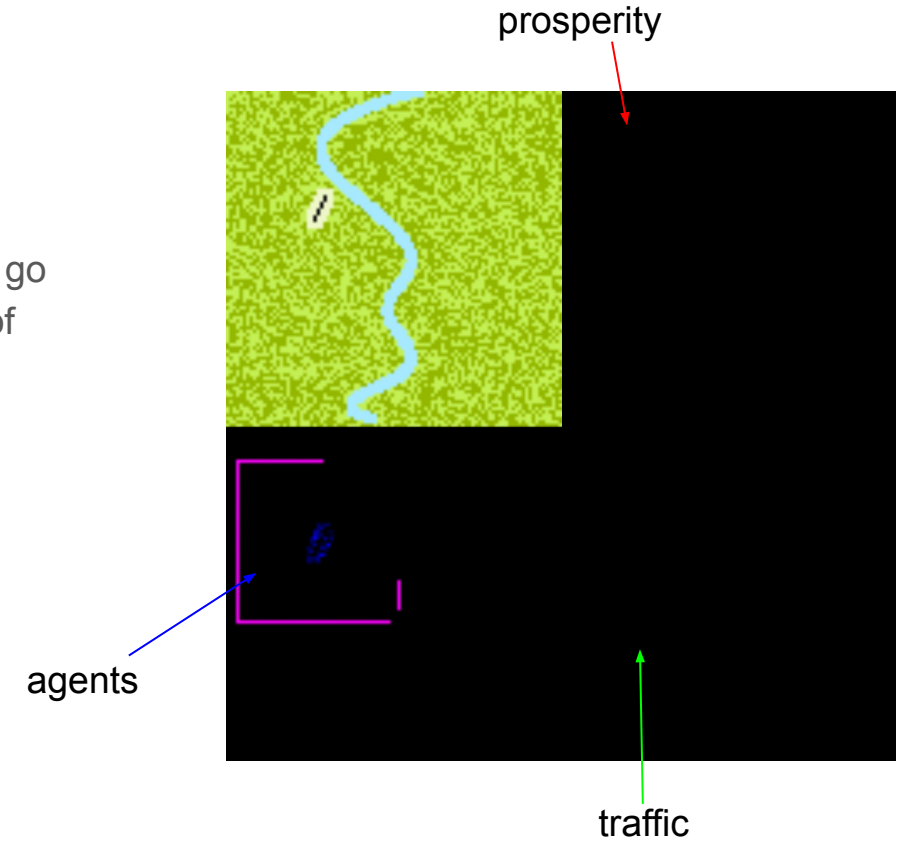
- represented by continuous “road” cells
- different kinds of road types: major/minor/bridge/highway
- allows agents to move longer distances



Simulation Procedure

5- Calculate new roads

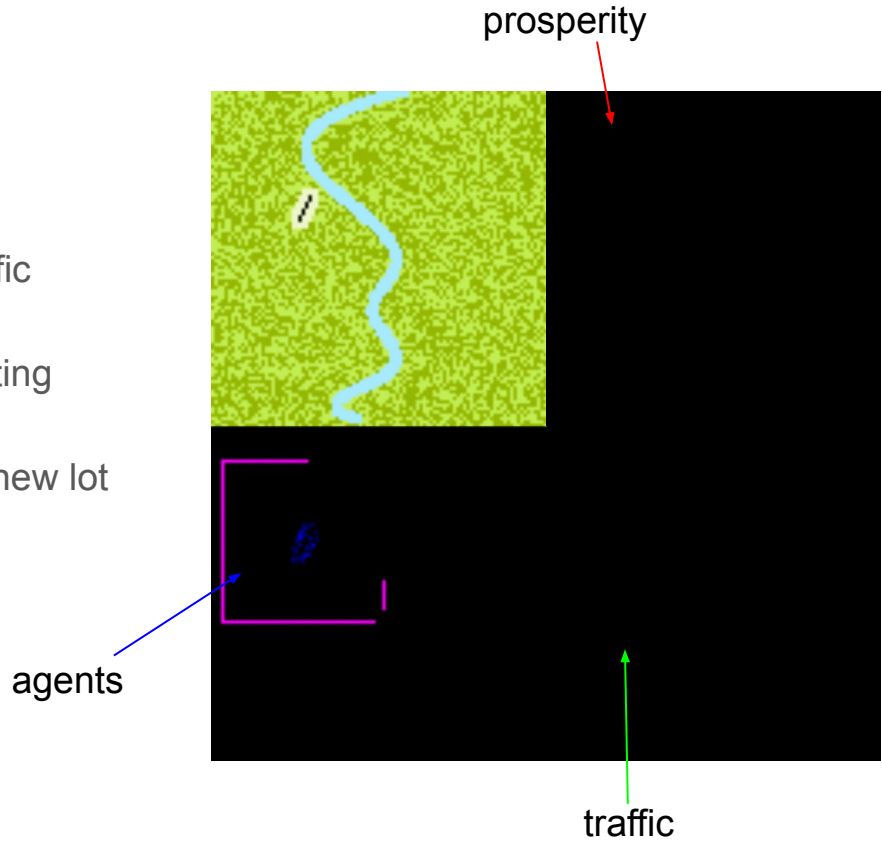
- prosperity: indicates locations agents want to go
- traffic: indicates midpoints of begin-and-end of movements (if only there was a road there!)
- increase as a result of agent movement and decays each cycle



Simulation Procedure

5- Calculate new roads

- create roads at locations where prosperity/traffic reach certain thresholds
- lower thresholds for creating roads within existing lots
- higher thresholds for creating road as well as new lot



Simulation Procedure

5- miscellaneous tricks:

- a weak “snap to grid” effect for roads
- close small gaps between non-parallel roads
- creating “parks”

Parameters

- Minimum distance between minor roads

lower

higher

Parameters

- Range of what's considered "local"

lower

higher

Parameters

- Base movement range of agents + minimum distance between major roads

lower

higher

Parameters

- Amount of correction for snap-to-grid

lower

higher

Parameters

- Minimum prosperity for creating a new buildable zone/crossing water

lower

higher

Evaluation

- What is the directionality of the generated roads, relative to each other?

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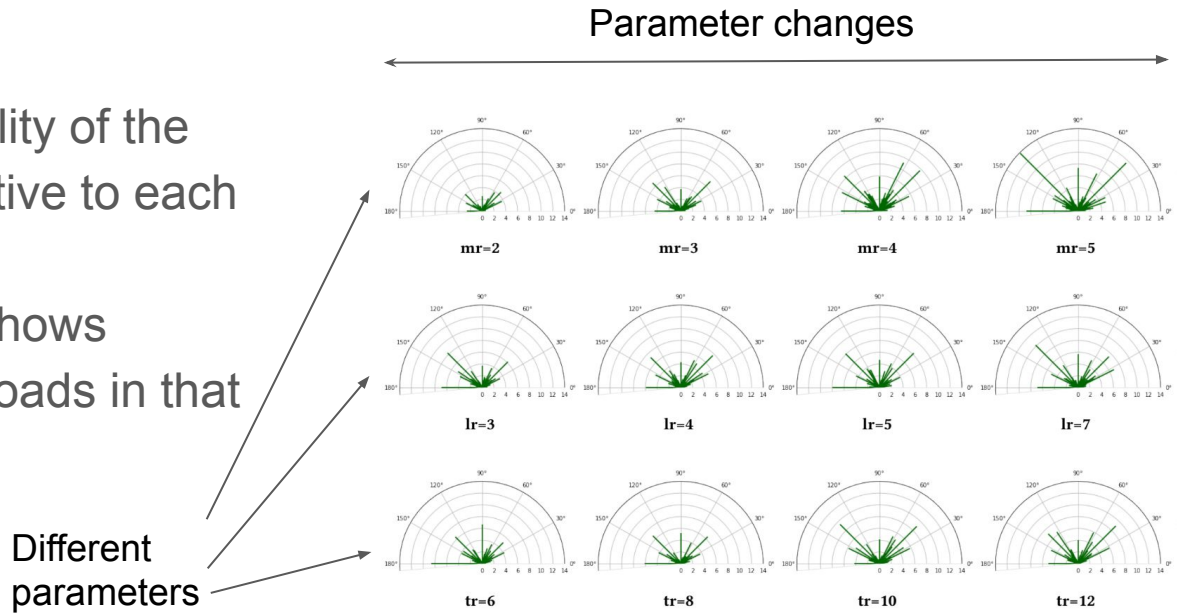
- Each spike in graph shows cumulative length of roads in that direction



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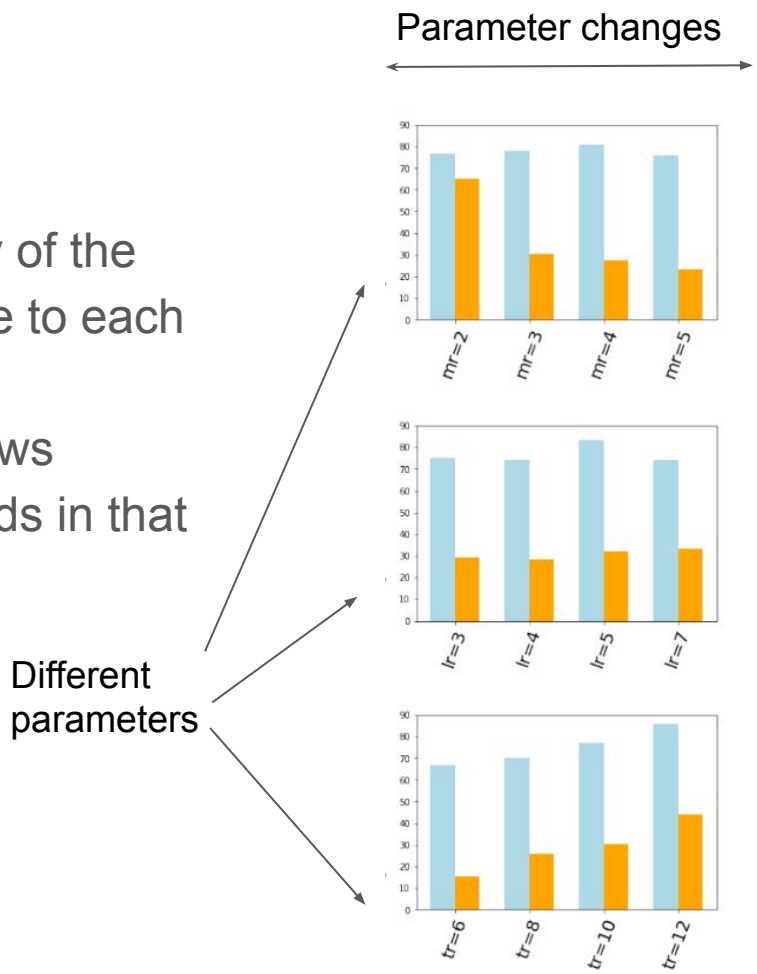

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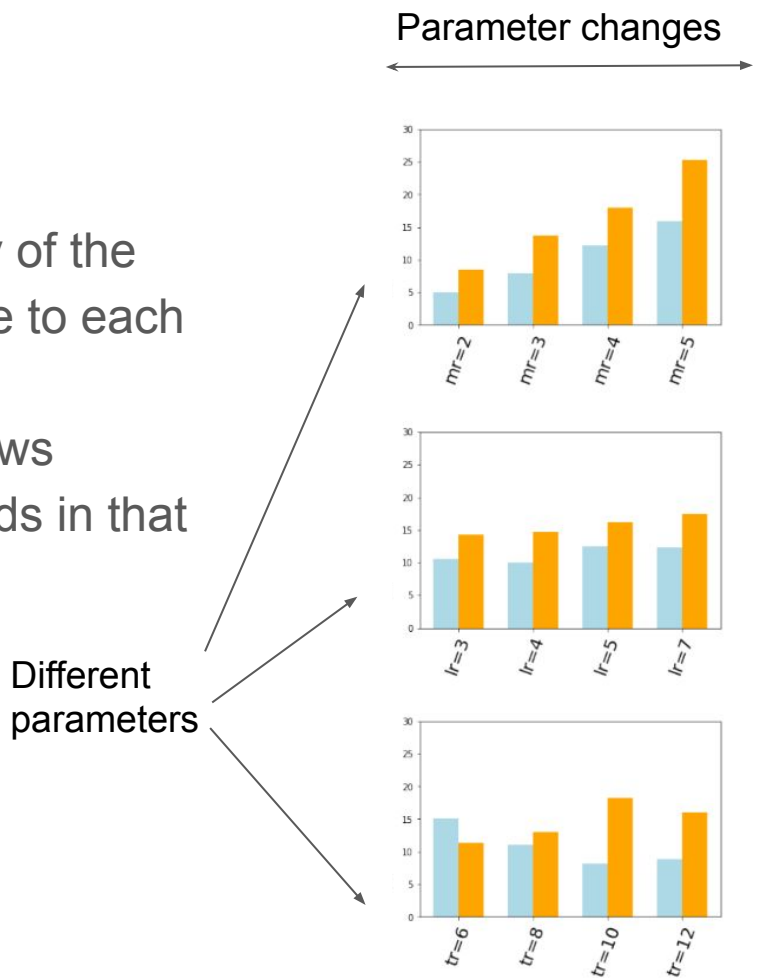

Evaluation

- How connected is the road network?
- Is it quick to get from one point to another?

$$\sum_{s=1}^{m} s \times N_s = \begin{cases} simple\ connectivity & \text{if } m = 1 \\ local\ depth & \text{if } m = k \\ global\ depth & \text{if } m = l \end{cases}$$

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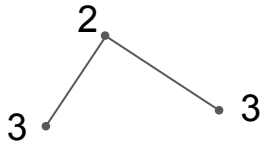
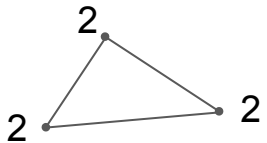


Total: 8



Total: 6

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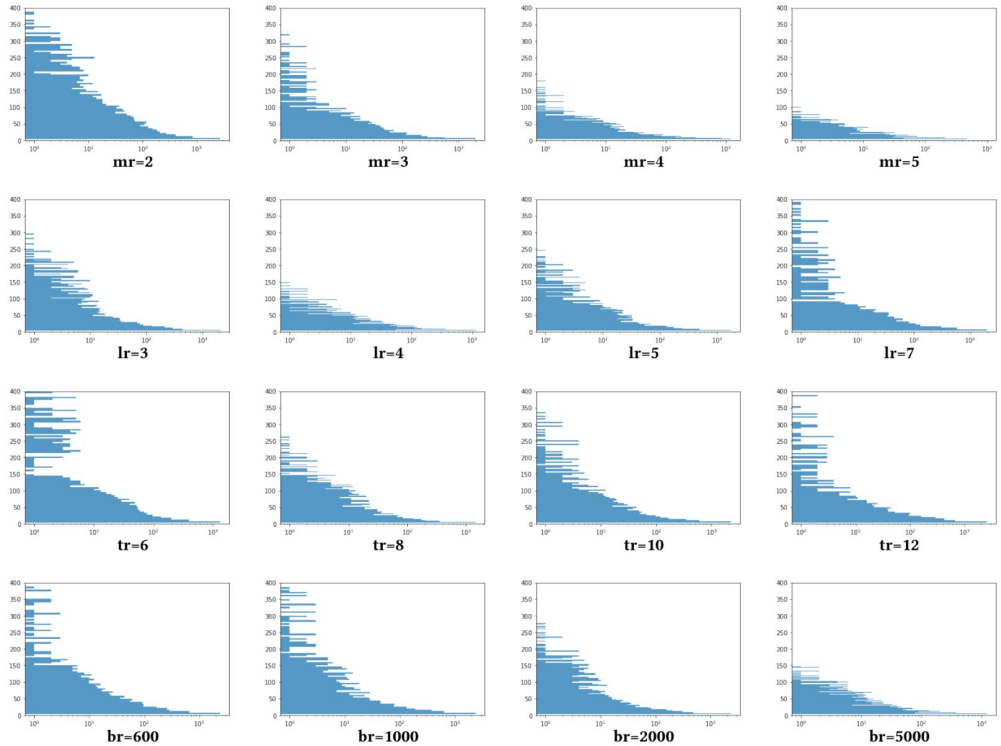
Parameter changes



Different parameters

Evaluation

- How windy are the roads?
- What’s the distribution of windy roads vs. straight roads?

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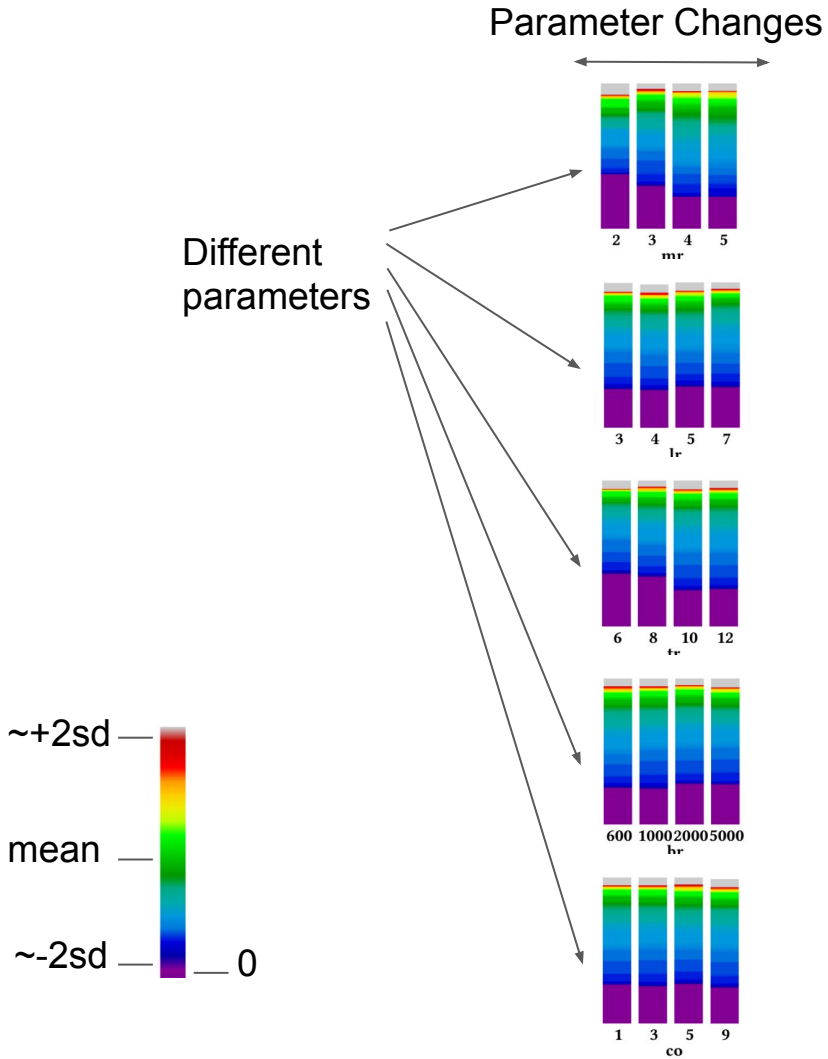
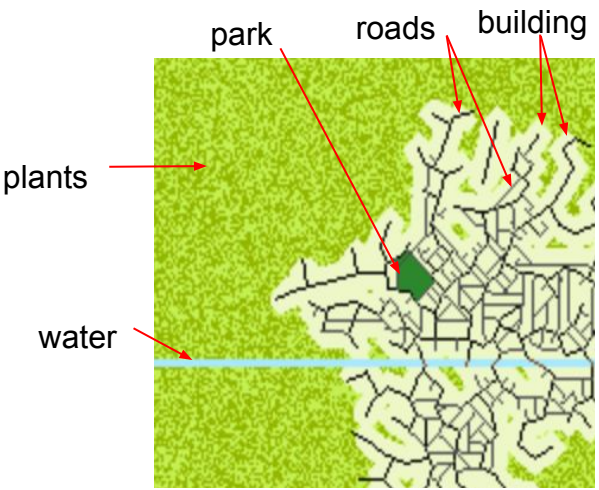
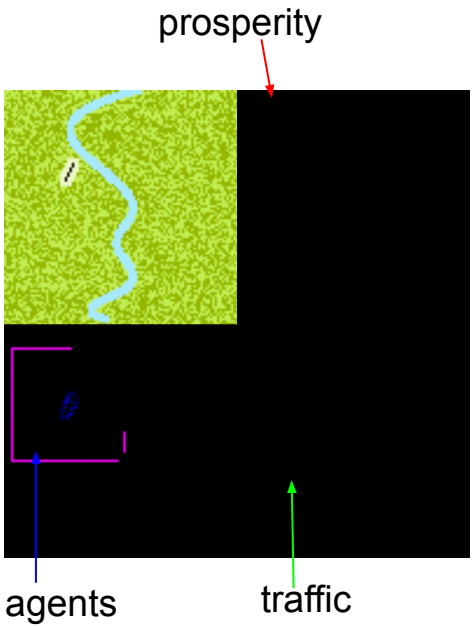
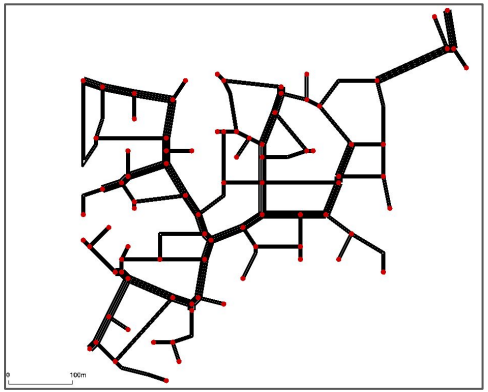
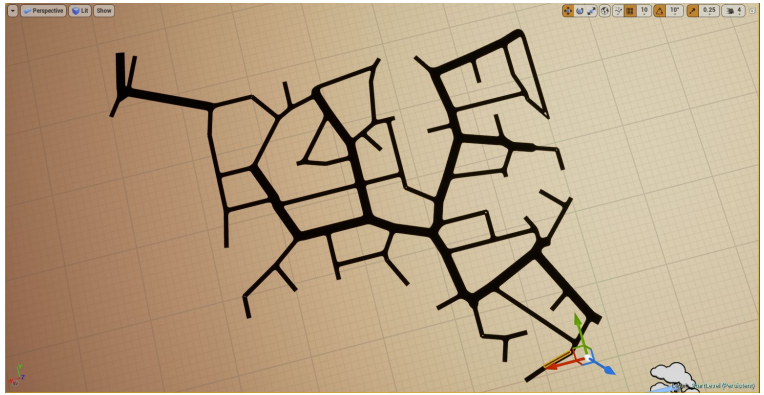


Conclusion

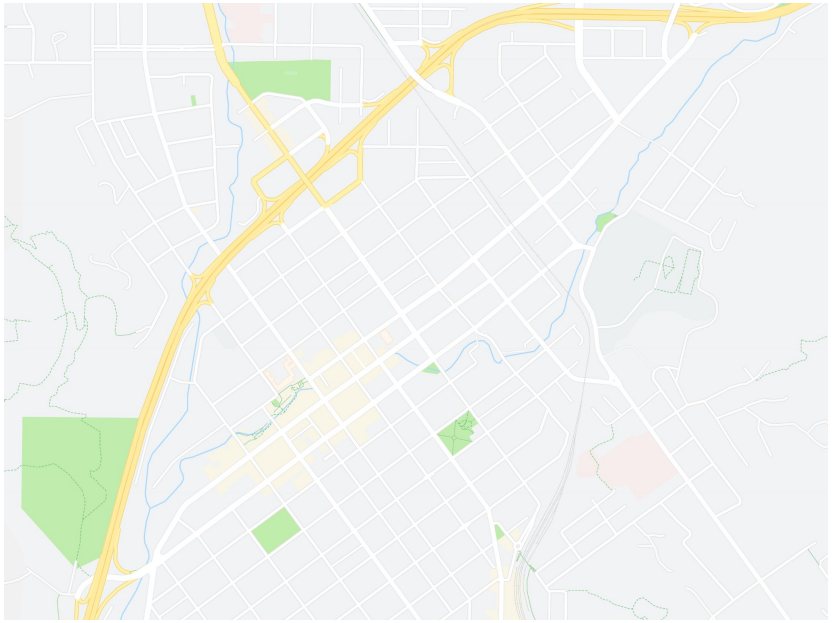

park
roads
building
plants
water

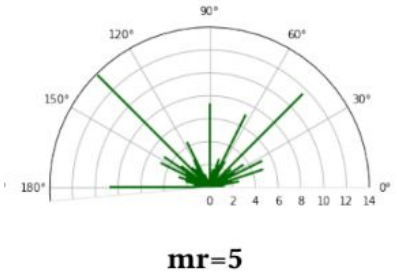

prosperity
agents
traffic





Conclusion

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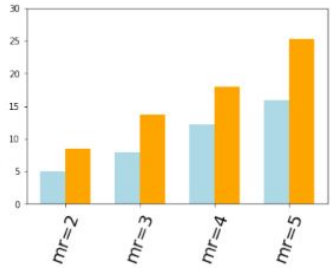
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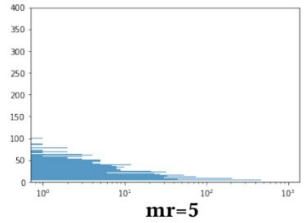
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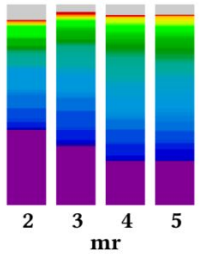
mr=5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Thanks!

Questions?

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