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# Traffic Flow:
# An analysis of 1D and 2D systems

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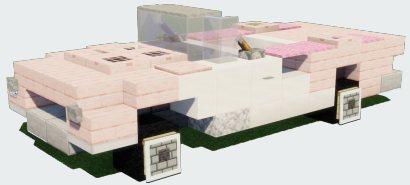
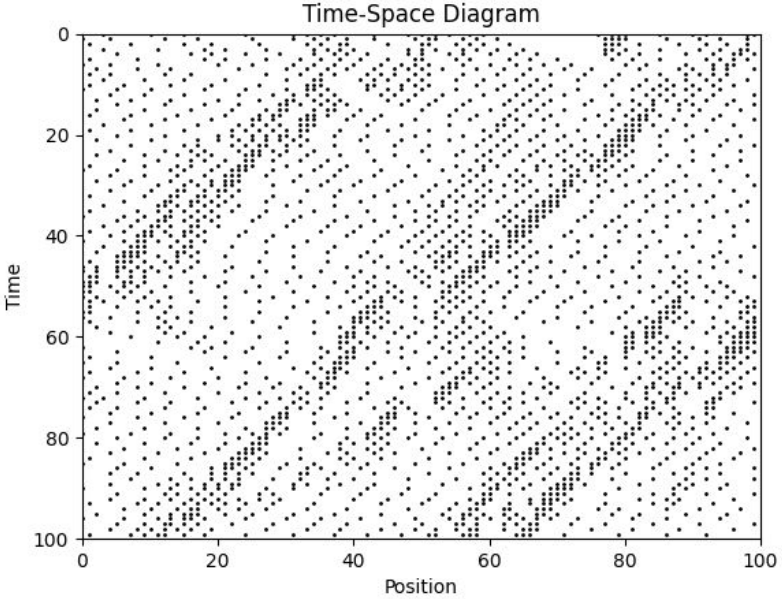
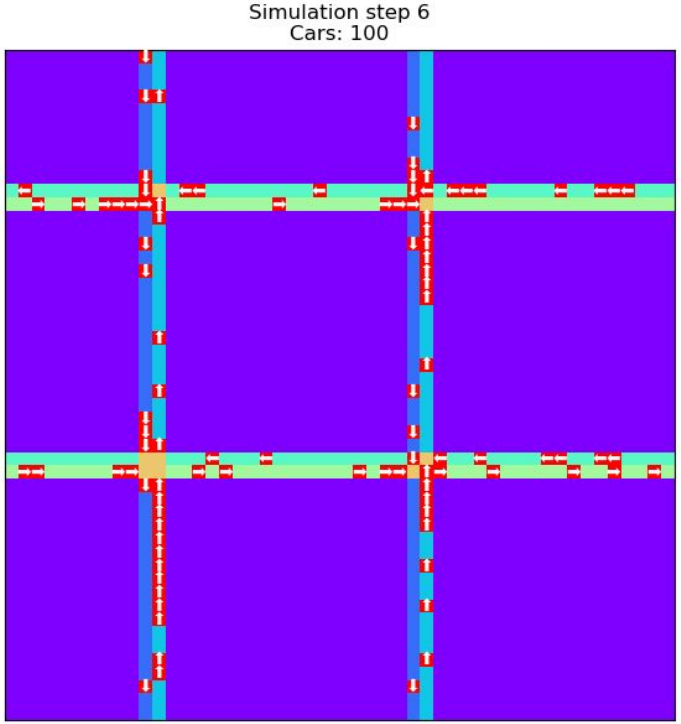


How do traffic **cluster sizes** scale with **increasing vehicle density**, and to what extent do **dimensionality** in a **cellular automata**, and **system parameters** influence the **formation of traffic jams**?


Time-Space Diagram
Time
Position
0
20
40
60
80
100


Simulation step 6
Cars: 100

# Ho:

- The size of the traffic cluster increases linearly when increasing the cars

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- No difference in emergence can be found between 1D and 2D

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- No difference in emergence can be found between 1D and 2D

- Variations in system parameters do not significantly affect the the formation of traffic jam
  - *Road Length*
  - *Max Speed*
  - *Speed Compliance*

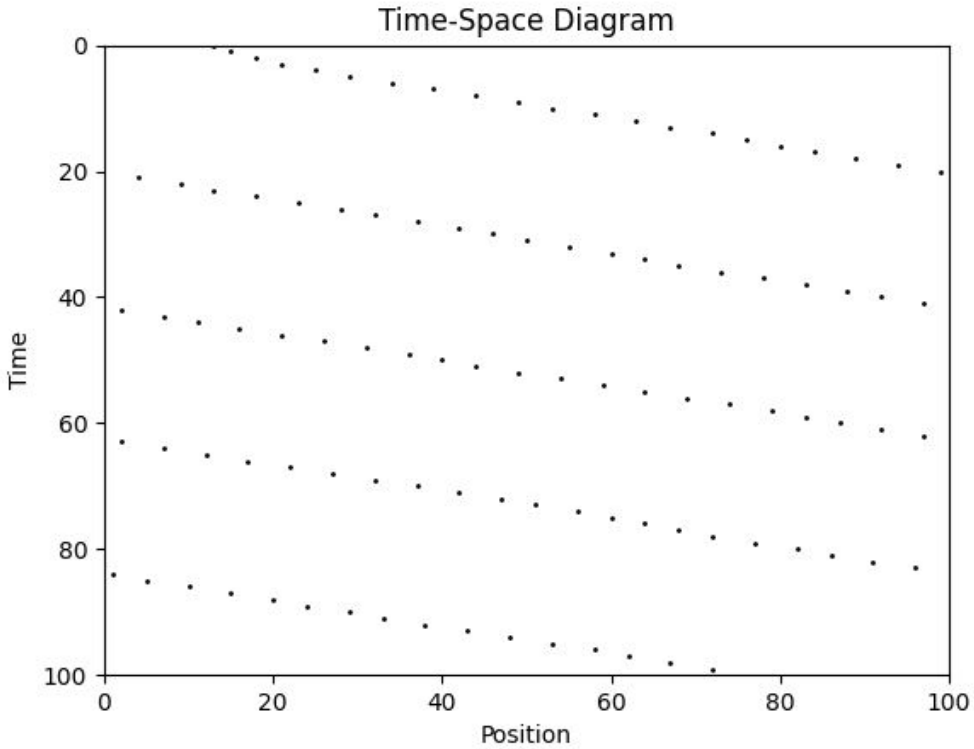
# Nagel Schreckenberg / Phantom Traffic Jams
# A 1D approach

# 1D traffic model - rules

- Looping 1D road with specified length
- Car occupies single space, moves according to current speed and speed limit
- Cars interact; speed up / slow down according to other cars
- Interaction behavior causes emergence

- Randomization parameter: 30% chance cars will slow down randomly

# 1D traffic model - logic

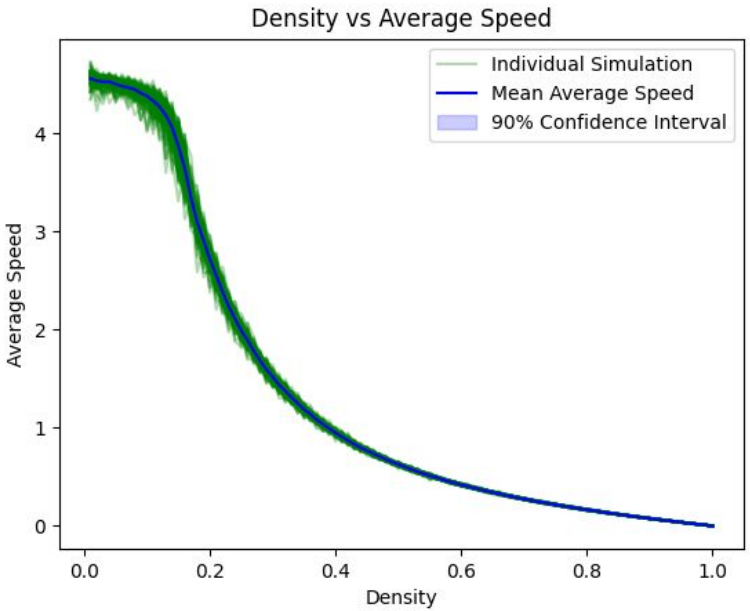



1-90 cars

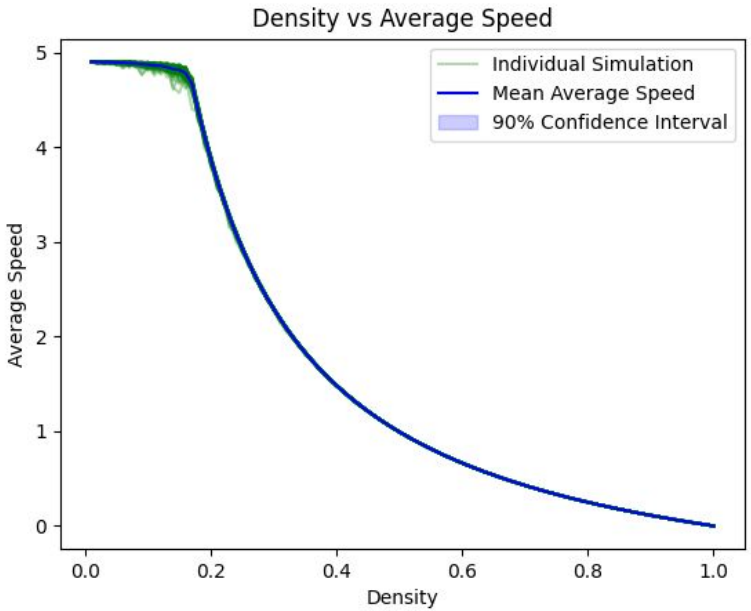
Wolfram rule 184

# 1D Results:
# Emergence after ~15% density

randomization

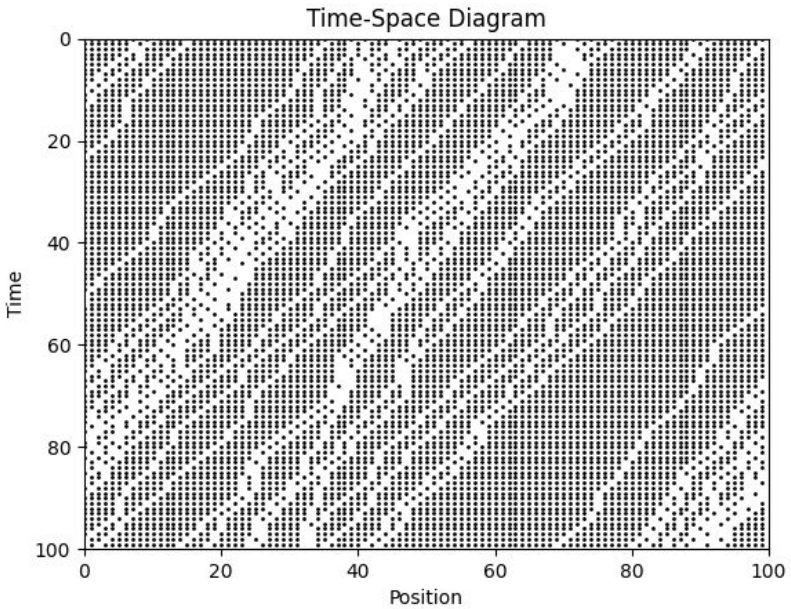



No randomization

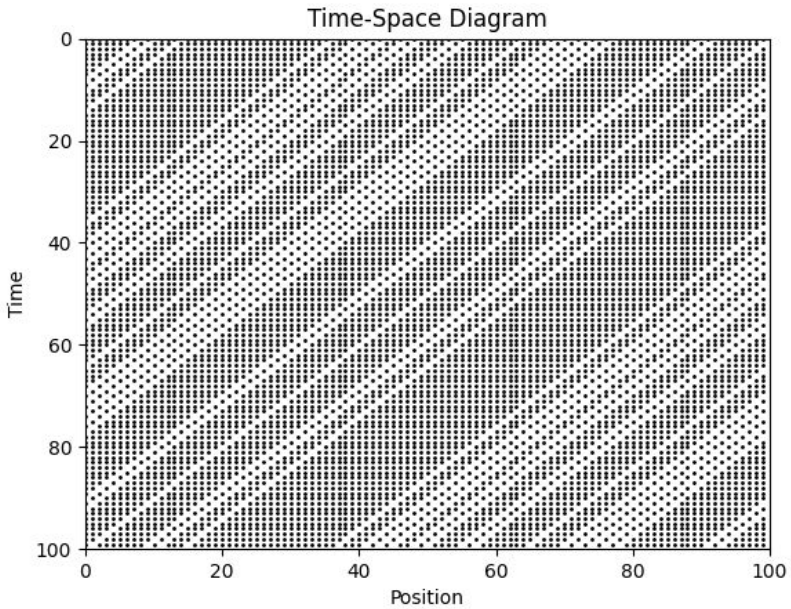


# 1D Results:
# Randomization adds noise to emergent patterns

80 cars - randomization

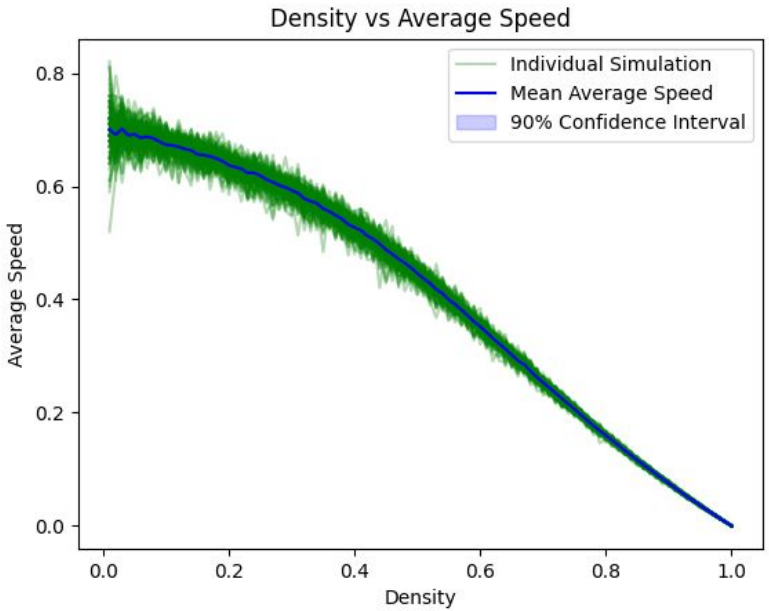



80 cars - no randomization

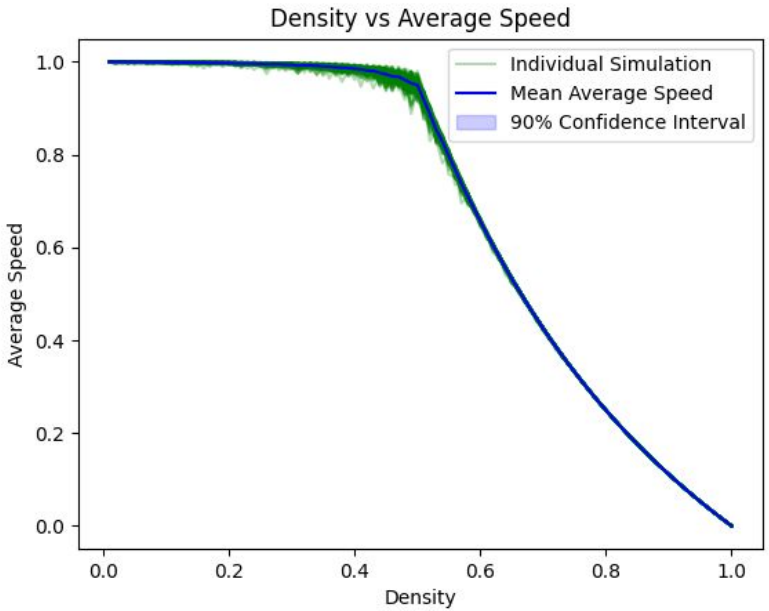


# 1D Results:
# Speed limits delay onset of, and slow transition to, emergence

randomization

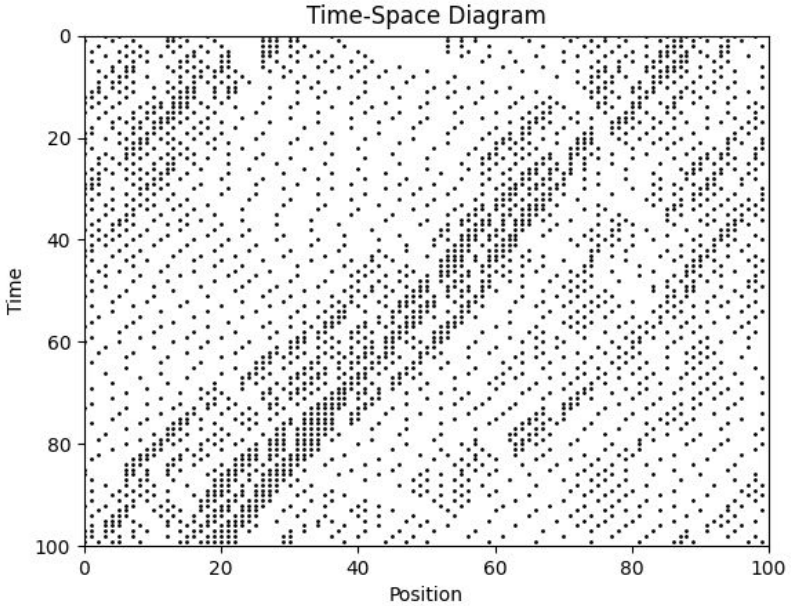



No randomization

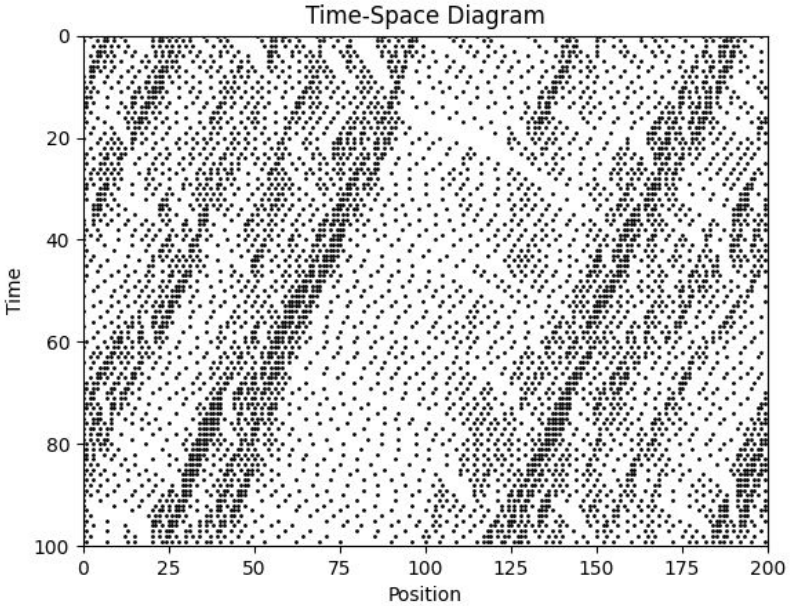


# 1D Results:
# <u>Road length</u> adjusted for density does not impact the 1D system

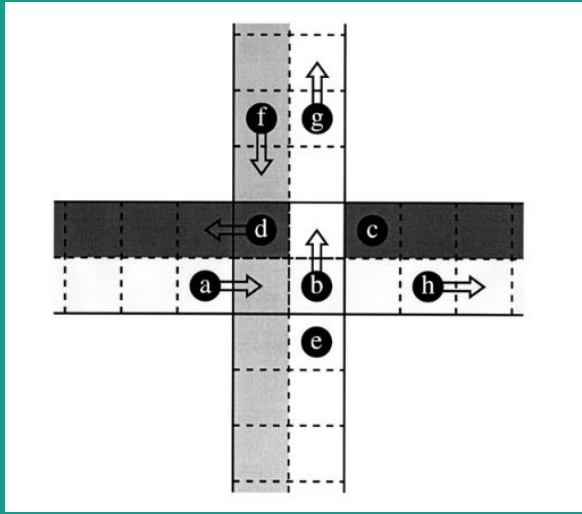
28 cars, 100 road length - 28% density




56 cars, 200 road length - 28% density



# 2D Manhattan-like city
## *Based on Chopard et al 1996*

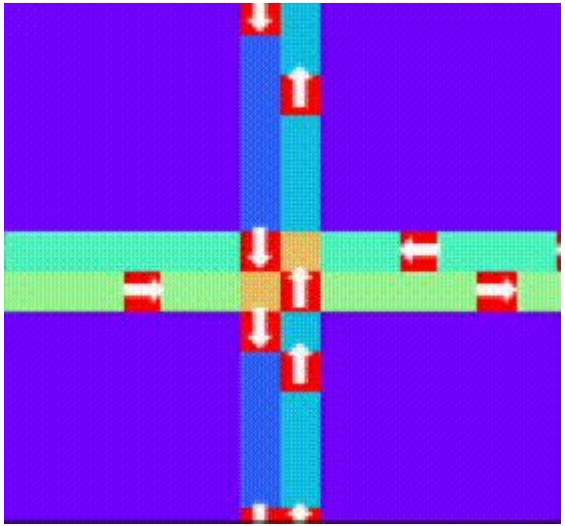


# 2D traffic model

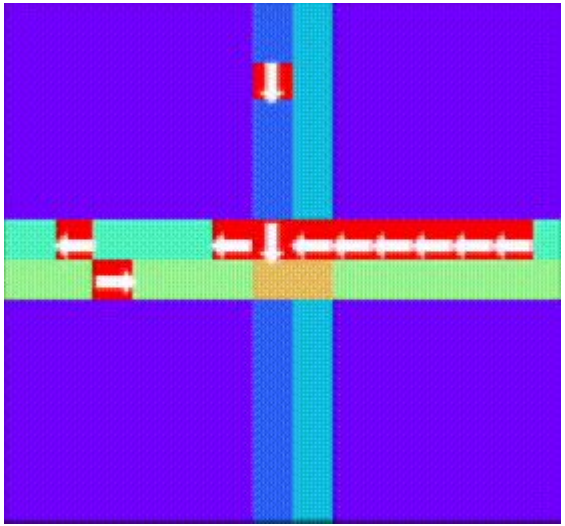
## Cars Rules:

- Cars will try to **move at maximum speed** on a straight road
- Cars will **stop** when a **car is in front** of them
- Cars will **move on the rotary** until the flag is changed to exit
  - *Free Movement*
  - *Fixed Destination*

# Rotary Methods



Free Movement



Fixed Direction

# 2D traffic model

## Cars Abstractions:

- Cars **can move instantly** to full speed and will break instantly
- Cars **don't have** a **predefined destination**
- Cars can only move as far as they can, **never overtaking another car**

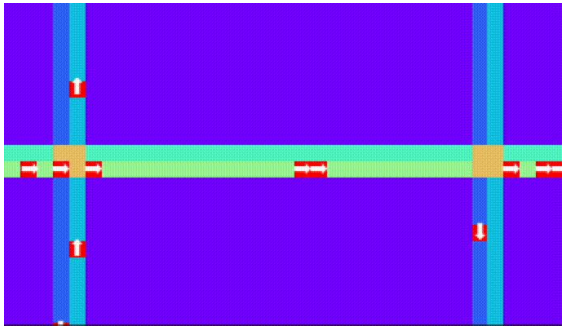
# Experimenting Parameters

**Road Length:** How long is the road between intersections

**Max Speed:** How many cells can a car move each timestep

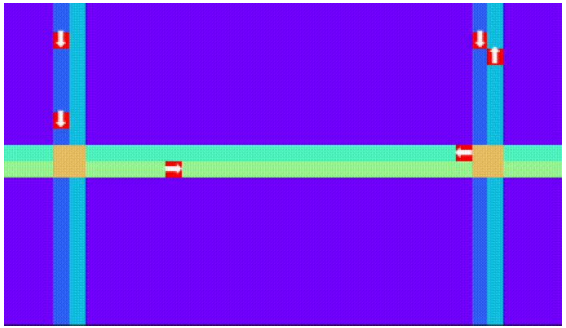
**Speed Compliance:** What percentage of cars follow the speed limit (rebels can go either faster or slower)

1



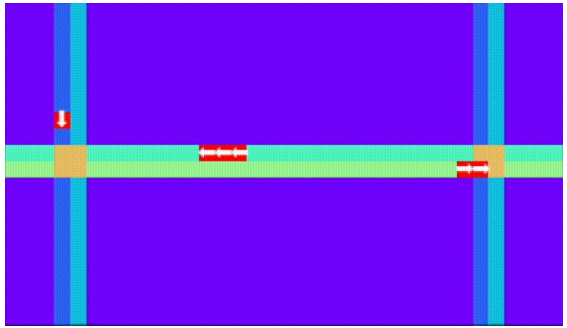
Speed: 1, Compliance 100%

2



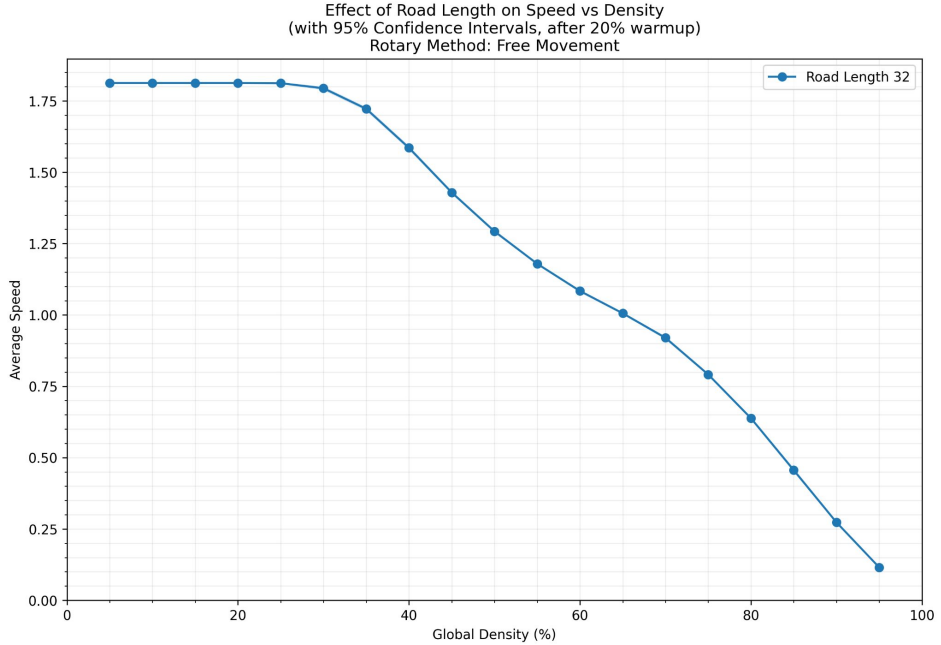
Speed: 5, Compliance 100%

3

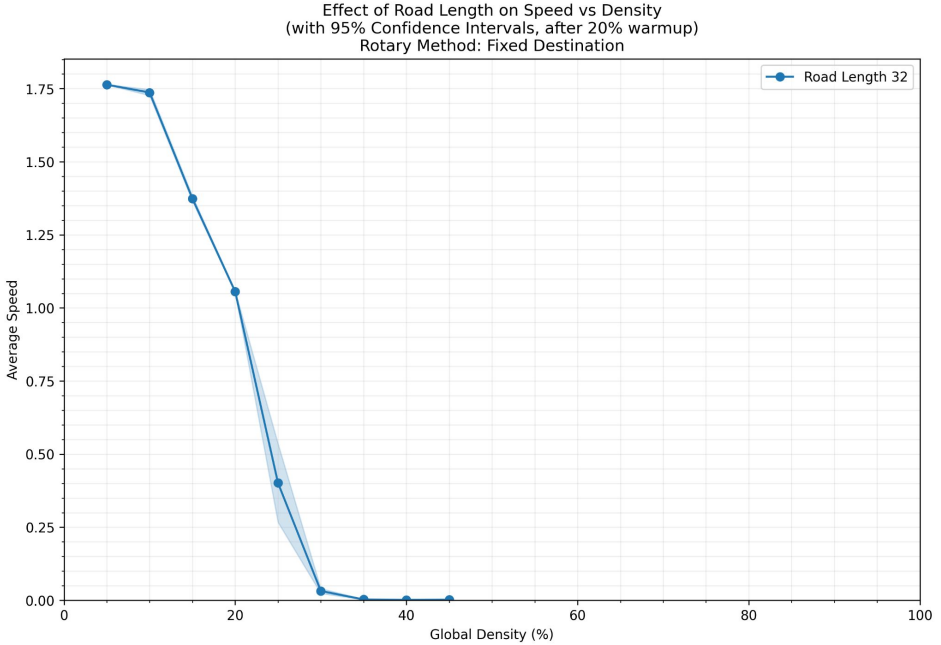


Speed: 2, Compliance 50%

# Effect Rotary Method

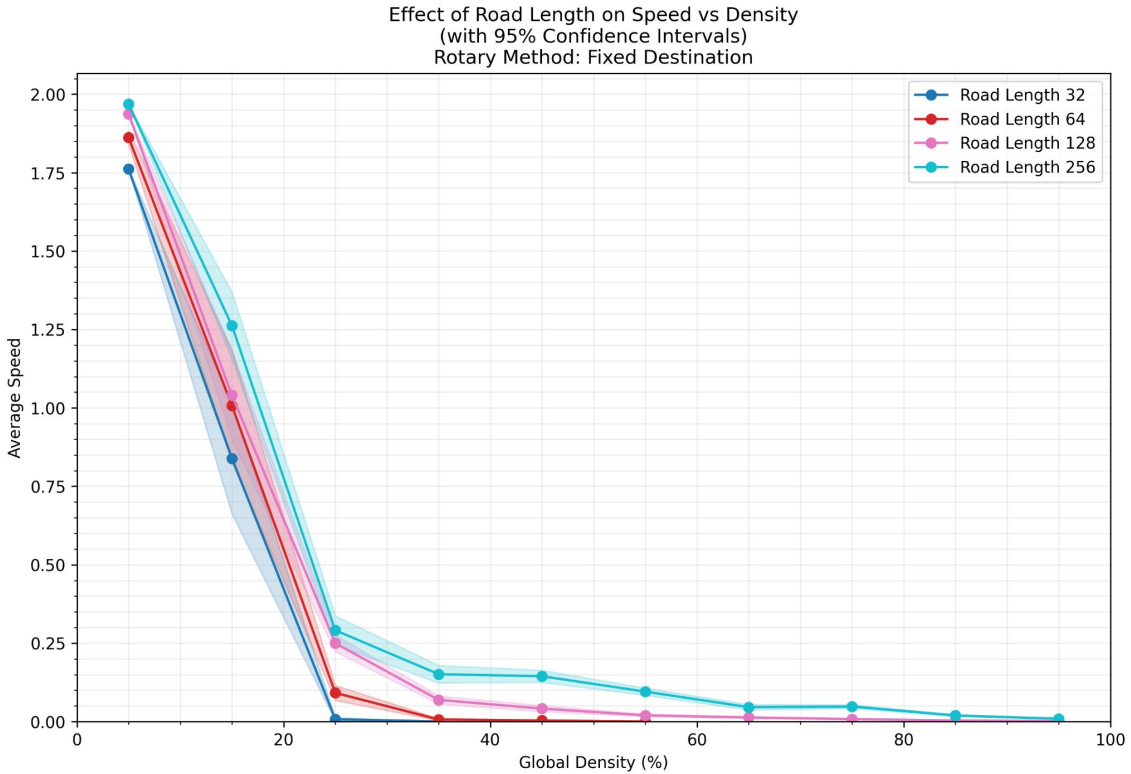



Free Movement

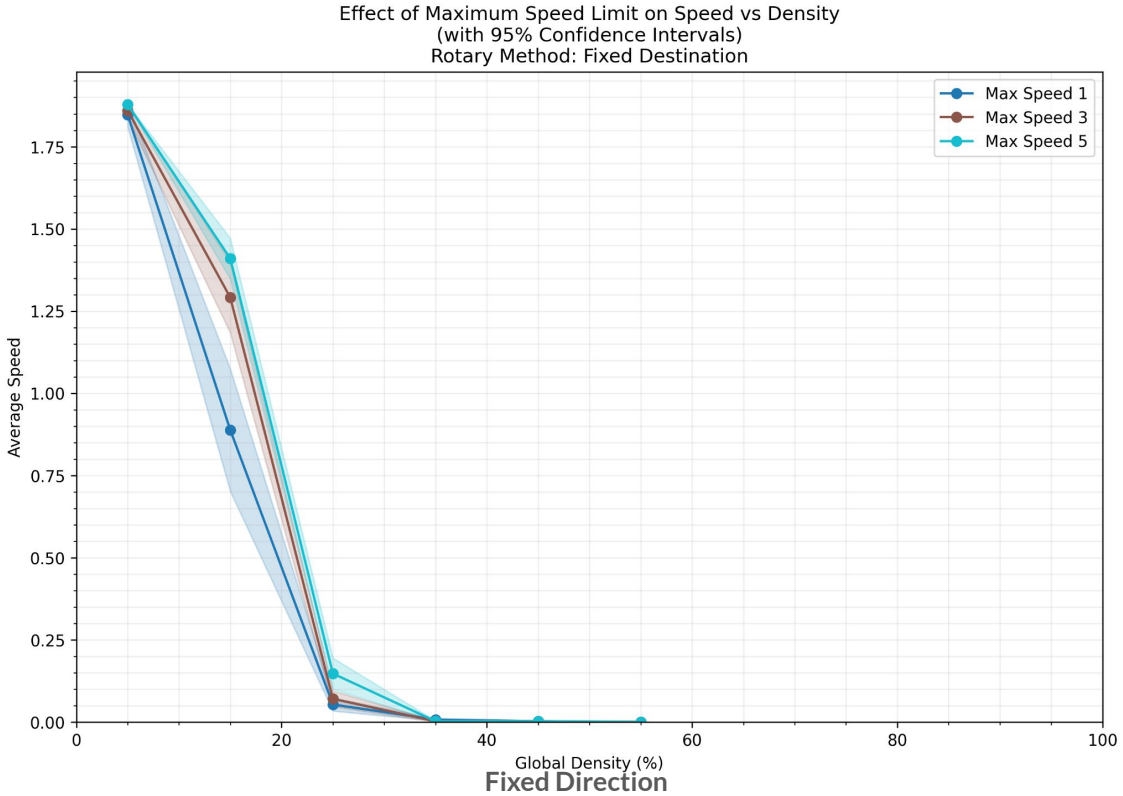



Fixed Direction

# Effect Road Length

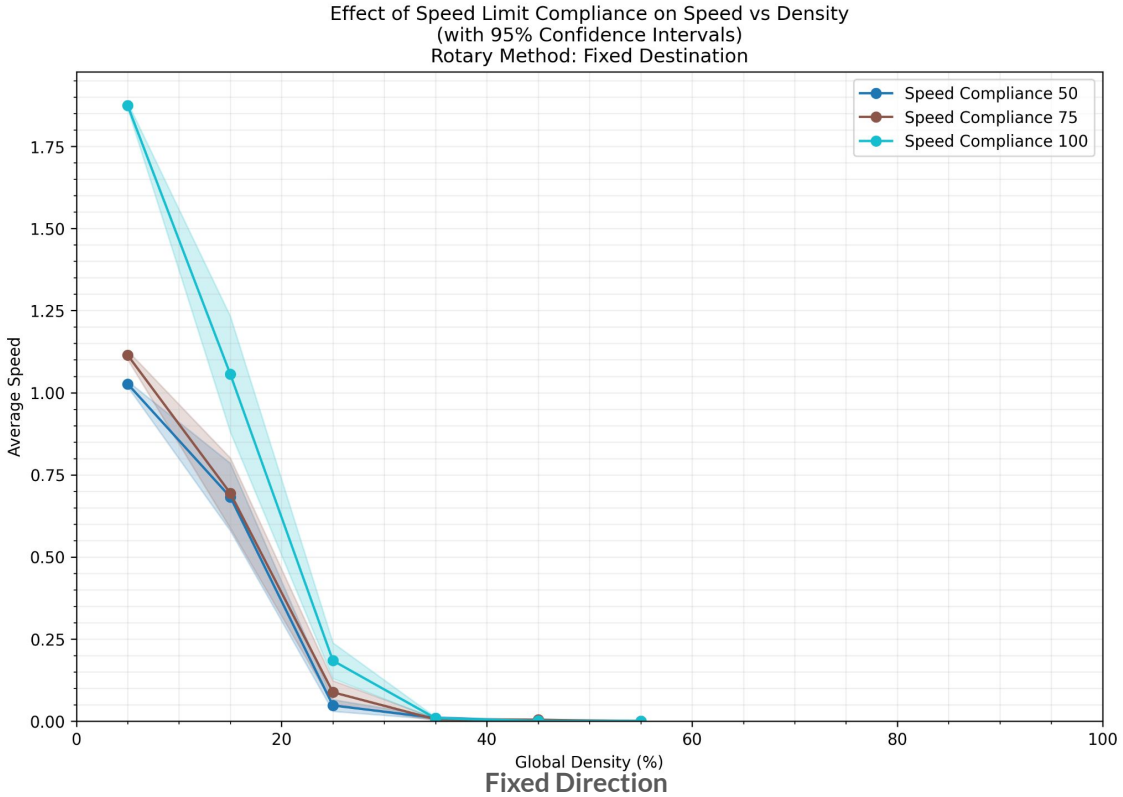


# Effect Max Speed



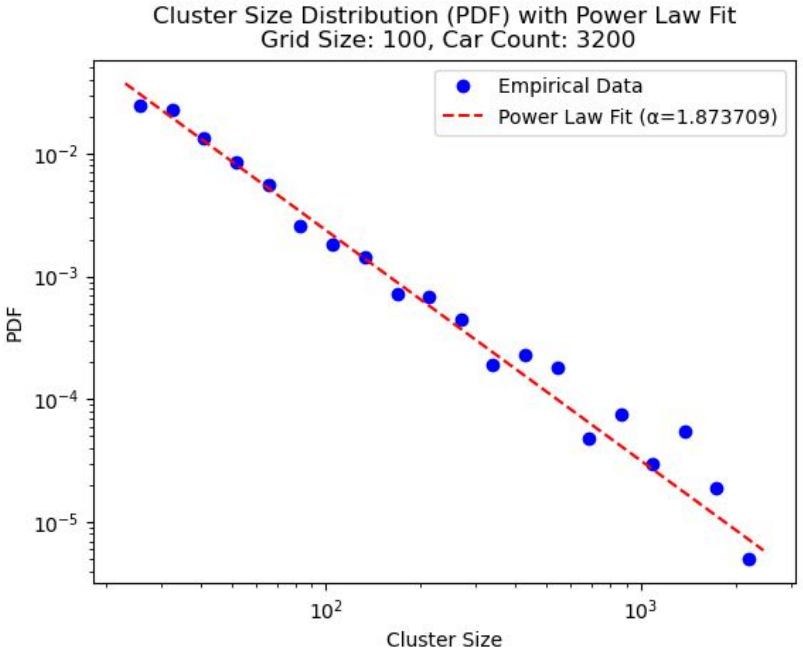

Fixed Direction

# Effect Speed Compliance



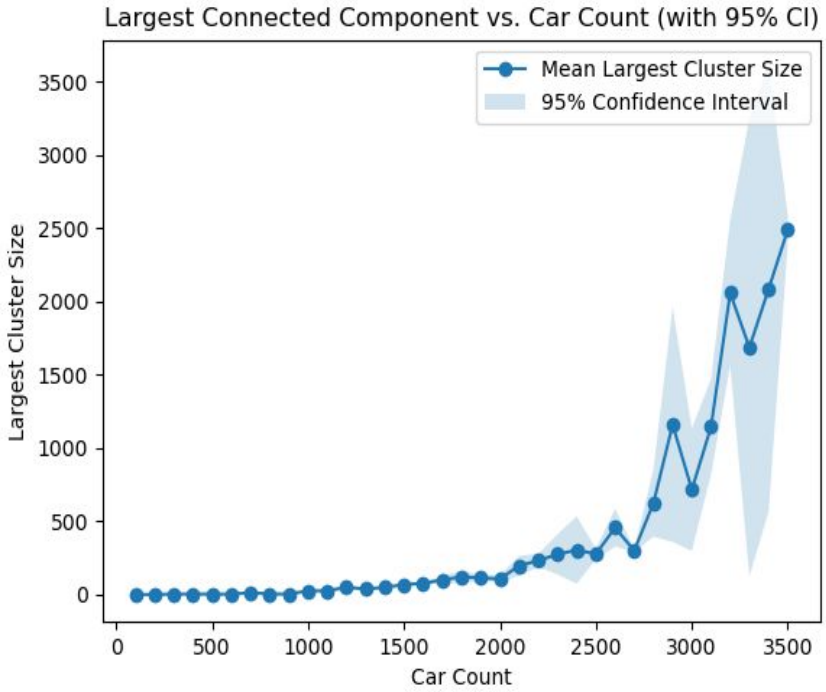
# Emergent Behaviour?

# Distribution of jammed cars




- Power law distribution preferred over exponential distribution ($p << 0.05$) for 20 simulations.

# Evolution of the Giant Component




Grid size = 100

# Conclusion:

# Ho:

- Variations in system parameters do not significantly affect the the formation of traffic jams
  - *Road Length*
  - *Max Speed*
  - *Speed Compliance*

1D:

- Density and speed limits make a big difference
- Road length less of an impact because of the infinite lattice

2D:

- Density and road length make a big difference
- Speed limits and speed compliance less so

# Ho:

- The size of the traffic cluster increases linearly when increasing the cars

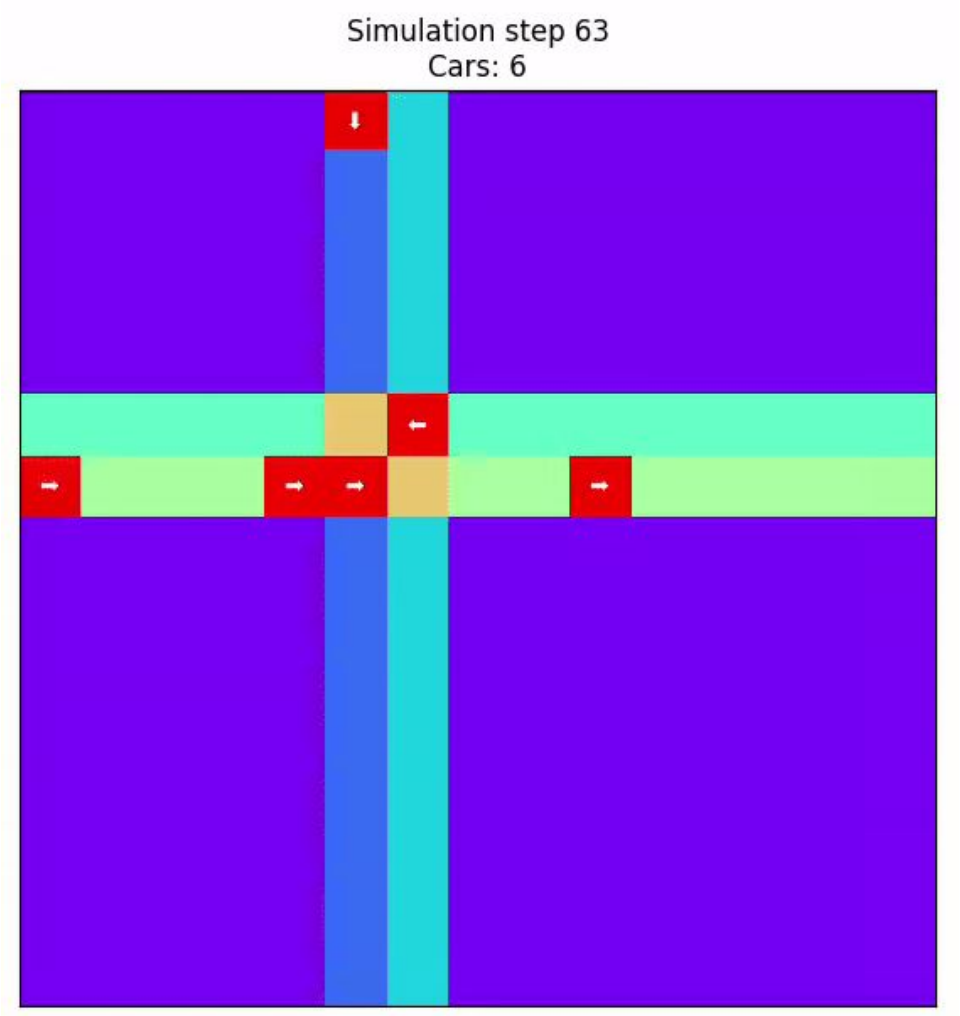
- Given the log-log plot an almost linear distribution can be observed
- Suggests a Power-law
- More clusters of a lower size
- Phase transition after x > 2000 for Giant component

# Ho:

- No difference in emergence can be found between 1D and 2D

- 2D has the possibility of system wide locks even in lower density

- Cars have a more familiar logic in 2D


Simulation step 63
Cars: 6

# Summary

- Use of a Cellular Automata (CA) in 1D and 2D
- The impact of speed limit and road length on the 1D CA

- Implementation of basic car logics, with some necessary assumptions
- The impact of the 2D parameters on the traffic jam
- Cluster frequency follows a power law
- Emergence of a Giant Component