Improved Macroscopic Traffic Flow Modelling with Cellular Automata

Noah Gardner*
ngardn10@students.kennesaw.edu
College of Computing and Software Engineering
Marietta, Georgia, USA

Andy Vu*
College of Computing and Software Engineering
Marietta, Georgia, USA

Olivier Tran*
College of Computing and Software Engineering
Marietta, Georgia, USA

Sanjeev Khemani*
College of Computing and Software Engineering
Marietta, Georgia, USA

Abstract

This paper is based on another research paper in cellular automata in which city traffic and its affection by factors like distributed occurrence, evanescence, and time variation is observed on a two-dimensional grid. The variables used in this new experiment include diagonal paths, one-way streets, pre-generated flows, varying speeds, varying destination priority, and different types of roads. With these additional factors in the experiment, the results of the new simulation will yield results that more accurately reflect the environment of real-world traffic.

Keywords: traffic flow, cellular automata

1 Research Statement

There are a few interesting changes we could make to the original algorithm in order to explore the impact of different traffic environments and flows. For example, the original paper randomly generates *traffic flows* which are an abstracted representation of the traffic that really represents a group of vehicles as a random amount of traffic. Additionally, when each traffic flow is generated, the destination of the flow is also generated randomly. After the traffic flow is generated and the destination is chosen, the traffic flow chooses it's

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*All authors contributed equally to this research.

path automatically as the shortest distance from the starting cell to the current cell. Finally, the original paper uses one traffic environment with simple two-way roads that are placed on the grid laterally and vertically.

One idea we would like to explore is to add different priorities for cells as destinations. If a cell is a high priority destination, then it is more likely to be chosen as a destination for a traffic flow when it is generated. Another improvement could also allow for modelling of different types of roads. For example, rather than the flow taking the shortest path from the source to the destination, each cell could have a parameter for the weight of adding that cell to the path of the traffic flow. If the weight of adding the cell to the path is low, that cell may be modeled as part of a road that can handle more traffic such as a highway. The original experiment also did not test diagonal or one-way streets, so that may be valuable for a traffic flow model as well.

2 Literature Review

- Simulation of urban macro-traffic flow based on cellular automata [4]

  This paper uses a cellular automata model to simulate traffic flow on a two-dimensional grid. Traffic flows are randomly generated that have a certain amount of traffic (low or heavy) and also have a random destination. There exists a grid with cells filled in which are meant to model the roads for the traffic flow to move on. On each timestep, the traffic flows move towards their destination using a minimum distance method. The cells can hold a certain amount of traffic capacity. When the traffic capacity for a cell is reached, the cell will not allow new traffic flows to enter the cell. The cell also have a traffic volume, which helps the programmer to see at a glance which cells have high and low volumes of traffic.

- A cellular automaton model for freeway traffic [3]

  Nagel and Schreckenberg have gone away from the typical fluid dynamical approaches to traffic flow studies during this time to the use of a more revolutionary technique. The need for this was to introduce

a factor of laminar start-stop waves with increasing vehicle density with an emphasis on human behavior a traffic environment. In their model, it is represented as a single dimensional array where each cell may be a vehicle with functions to accelearte, slow down, as well as randomized velocities. These functions are to represent the randomness in human behavior and varying conditions that are expected during traffic. The authors concluded that a computational way to simulate traffic flow, was more advantagous to a fluid dynamical approach that incorporated real world behavior ofa driver but also retained the key aspects of fluid dynamic studies.

- Self-organization and phase transition in traffic-flow model of a two-lane roadway [2]
  Tasdf

- Multi-value cellular automata model for mixed bicycle flow [1]
  Tasdf

- Cellular automaton model for bidirectional traffic [5]
  Simon and Gutowitz have built upon the paper referenced above by Nagel and Schreckenberg. Here they are implementing a bidrectional traffic using a two lane road with traffic moving in opposite direction in comparison to Nagel and Schreckenberg's one lane cellular automaton. They have incorporated inteteractions to simulate passing, as well as a distribution of varying vehicle speeds. Once again, Simon and gutowitz, like their reference model, had an emphasis on approximating the behavior of real traffic and human behavior. They wanted to address the issue of a one lane cellular atomaton where all vehicles have a maximum velocity and thus the model unrealistically follows a lead slow car, hence the need and emphasis on passing. The bidirectional model varried in types where there was varrying rules regarding passing. The researchers have found that passing greatly increases fluidity in traffic not seen in single dimensional cellular automaton and greatly resembles real world traffic dynamics and flow.

3 Methods

For this project, we plan to use Python to implement our cellular automata traffic flow model. We may also include a GUI to visualize the traffic flow on each time step. This section will be expanded as the project progresses.

4 Milestones

Date	Milestone
9/24/2021	**Project Deliverable 1**
	Implement the original algorithm
	Add weights to the cells
	Add destination priorities
	Model different traffic environments (one-way, etc.)
10/29/2021	**Project Deliverable 2**
	Create different environments
	Collect experimental results and present findings
	Optional Add GUI to visualize the traffic flow

5 Project Management

Our project has already set up weekly meetings in order to share progress and updates, and we schedule ad-hoc meetings when necessary. Additionally, we have our project inside of a github repository, where we can easily share our updated code. We plan to make use of pair-programming sessions, where we can collaborate while also sharing the load of programming.

Members' Roles

- **Andy Vu:** Programming, Writing
- **Olivier Tran:** Programming, Writing, Submitting Documents
- **Sanjeev Khemani:** Programming, Writing
- **Noah Gardner:** Programming, Writing, Source Control

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