Traffic Flow Simulation Using the NaSc Model

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Conceptualization

- The Nagel-Schreckenberg model (NaSch) is a cellular automaton simulation for single-lane traffic
    - Cellular automaton simulations are grid-based systems where each cell updates its state, depending on local interaction rules (often leading to complex large-scale systems)
- The NaSch model follows a particular set of sequential rules that must be followed by vehicles in the simulation
- The model is useful for understanding simplistic phantom traffic mechanics experienced by most drivers on major freeways in real life

Rules For The Model

1. **Cars not at maximum velocity will increase their velocity by one unit**
   a. The range for velocity is between 0 and 5, inclusive

2. **Cars will slow down if a vehicle is in front of them and the number of cells for the distance between cars is smaller than their current velocity**
   a. If true, the velocity will adjust to the number of empty cells in front of the vehicle to avoid a collision

3. **Cars with a velocity of at least 1 will randomly decrease their velocity by 1 unit, in accordance to a probability parameter**
   a. The probability parameter is denoted as ‘p’ and ranges from 0 to 1, inclusive

4. **Cars will move forward the number of cells that is equal to their velocity**

Code Insight

```python
class Vroom:
    """
    Car Settings

    Parameters:
        x (int): position on the road
        v (int): velocity
        v_max (int): max velocity
    """

    def __init__(self, x, v, v_max):
        self.x = x
        self.v = v
        self.v_max = v_max
```

Code Insight (Continued)

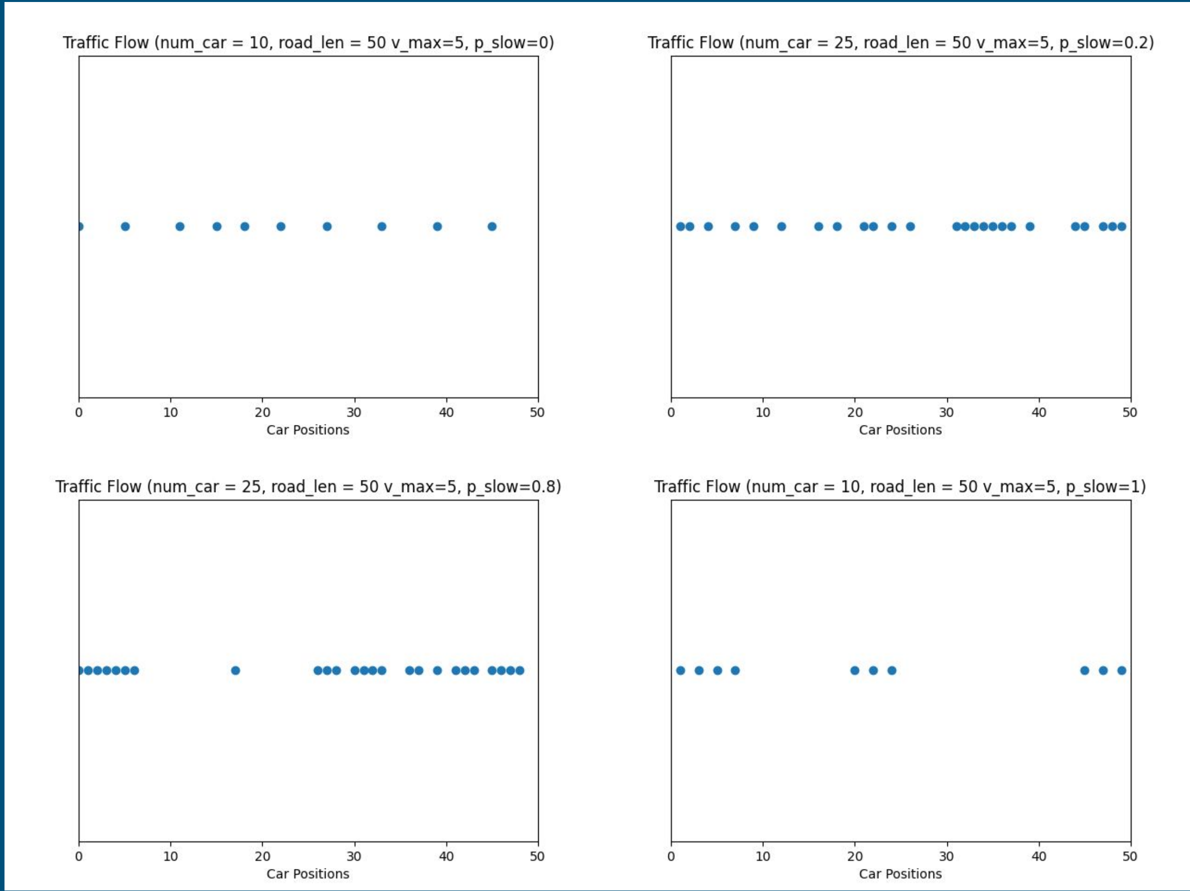
```python
class Nagschreck:
    """
    An implementation of the Nagel-Schreckenberg Model
    """

    def __init__(self, num_car, road_len, v_max, p_slow=0.3, seed=None):
        """
        Initialize Parameters
        """
        self.num_car = num_car
        self.road_len = road_len
        self.v_max = v_max
        self.p_slow = p_slow  # random slowdown probability
        if seed is not None:
            random.seed(seed)
            np.random.seed(seed)
        # list of Vroom objects
        self.cars = []
        self.spawn_cars()
```

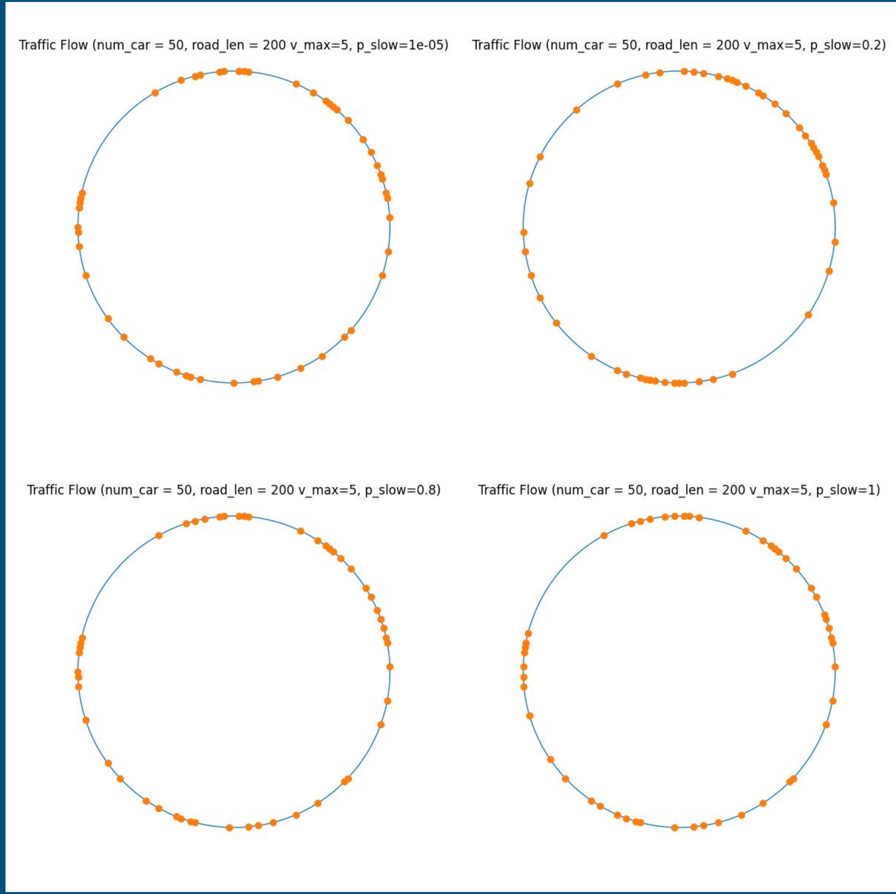
Data Analysis


```
.3302.0..52242....5..5........1...3112.430522...01
.0000.0..0000..2...1......5....1..0000.00000..2.00
1000.10..0000....2...2.......3..1.0000.00000..0.0.
0000.00..0000.......3..2......1.0.0000.0000.1.0..1
0000.00..0000.........2..2....0.0.0000.0000.0.0..0
0000.00..0000...........2..2..0.0.0000.0000..1.1.0
0000.00..0000.............1..1.0.0.0000.000.1..10.0
0000.00..0000..............20.0.0.0000.00.1.1.00.0
0000.00..000.1.............00.0.0.0000.00.0.0.0.10
0000.00..000..1............00.0.0.0000.0.10..10.00
000.100..000...1...........00..10.0000.0.00..00.00
00.1000..000....1..........00..0.1000.10.00..00.00
00.0000..000.....1.........00..0.0000.00.00..00.00
0.10000..000......1........00..0.0000.00.00..00.00
```

Data Analysis (Continued)

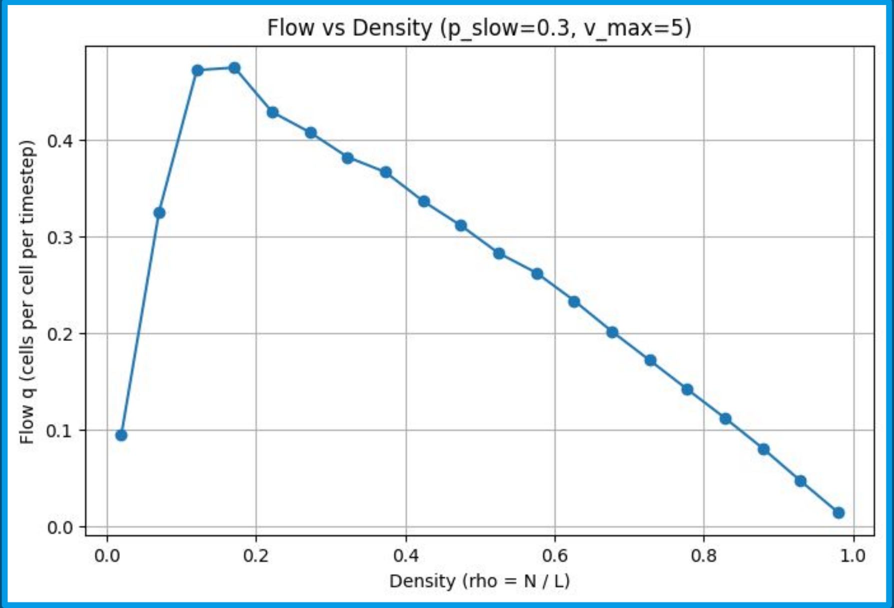


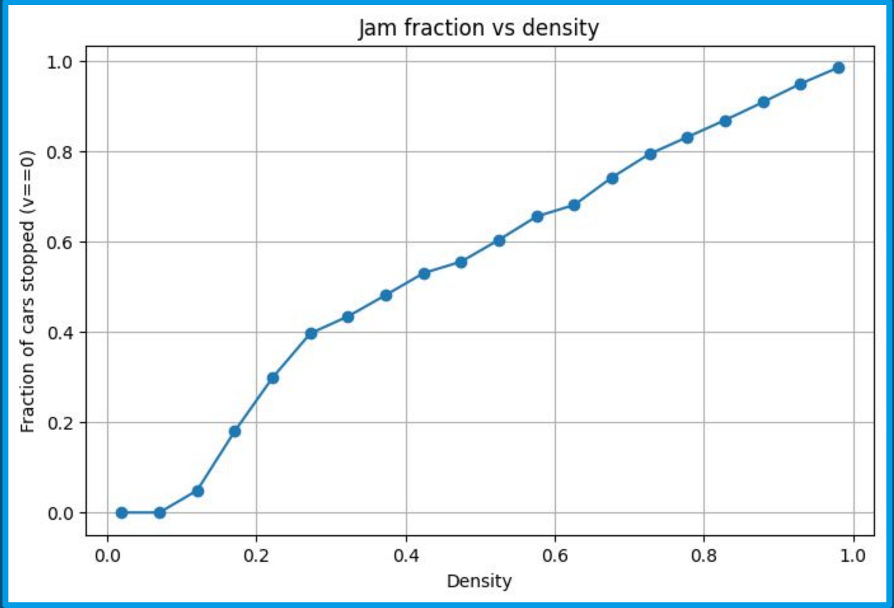
Data Analysis (Continued)



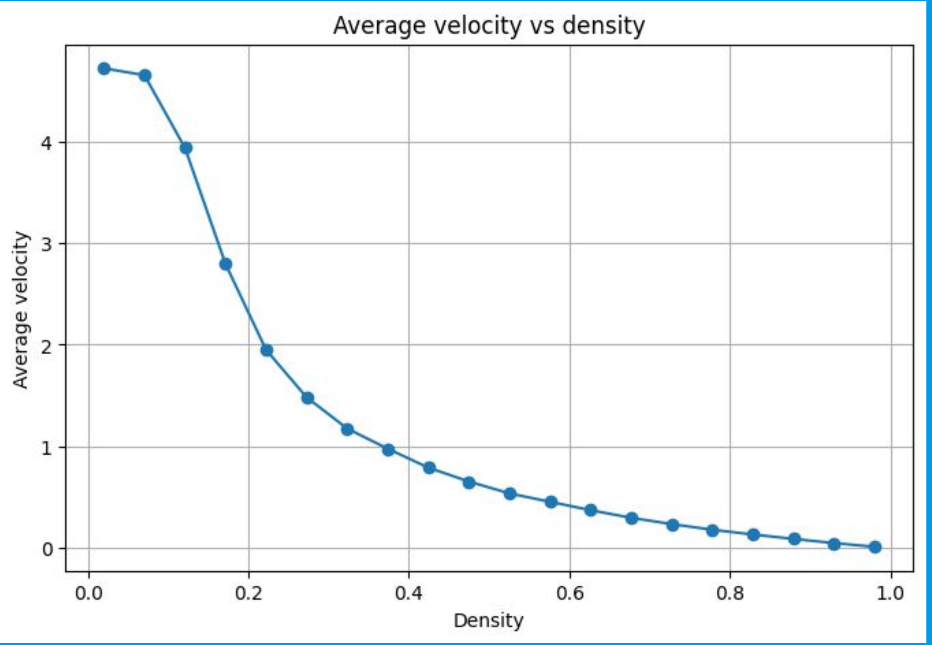
Comparable to Experimentation

Graphical Analysis

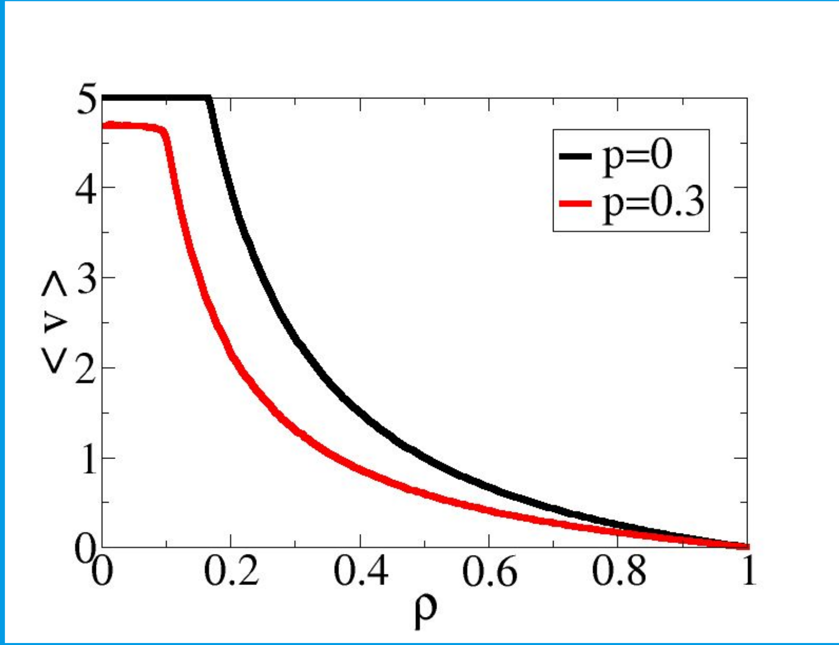




Comparison to the Predicted Model



Calculated Model



Predicted Model

Potential Solutions

- **Variable Speed Limit**
  - Gradual decrease in the speed limit before congested or higher-density areas
- **Jam-breaking Car Insertion**
  - Providing a car with a reduced ‘p’ can dampen smaller oscillations (thereby reducing the probability of congestion)
- **Adaptive Cruise Control**
  - Autonomy of speeds reduces the chances of oscillations (traffic jams), effectively lowering ‘p’
- **Light Metering System**
  - For complicated systems with on-ramp and off-ramp locations, a metering system is used to maximize flow (critical roadway density) and provide mitigation for congestion

Conclusion

- The Nagel-Schreckenberg model provides a deeper understanding of the phantom traffic phenomenon

- The model can be used for large scale representations, assisting urban planners and civil engineers with simplistic, foundational city development

References

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