

The Physics of Fluids and Application to Traffic Flow and Patterns

Oregon NASA Space Grant SCORE Symposium

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Research Goals

Fluid Model of
Traffic

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Introduction

Research Goals
Purpose of
Research

Methods

Literature
Review
PBOT
Mathematics

Results

Intersection
Roundabout
Interpretation

Conclusion

I started by asking the following questions:

- Who has already done research on fluids and traffic?
- How have those ideas been merged into a traffic model based on fluids?
- What real-world scenarios do I want to analyze?
- What variables are important to me and how do they change?

Thus, my goals were to conduct background research on traffic and fluids and then apply my learning to an intersection and roundabout.



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Why do we care about modeling traffic?

Mathematical models give us insight into how our world works and allow us to make better-informed decisions.

A few of the reasons why traffic is harmful:

- Long commute times and unproductive use of time
- Pollution and wasted fuel
- Health damage from stress and poor air quality
- Financial impact
- Frequent road maintenance from heavy volume
- Increased accident probability



Literature Review

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I looked at...

- Early fluid dynamics, especially Bernoulli
- How traffic theory got its start
- Lighthill, Whitham, and their first fluid traffic models
- What models are currently being accepted

Important!

Math is still developing in this field, so no one model is considered superior.



Portland Bureau of Transportation Traffic Map

All traffic data was sourced from an interactive map published by the Portland Bureau of Transportation. They release data on average traffic speed and flow over a period of time.



Figure 1: PBOT Traffic Map

Mathematics

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$$\text{shockwave speed}(v_{sw}) = \frac{q_b - q_a}{\rho_b - \rho_a}$$

$$\text{flow}(q) = \frac{\text{cars}}{\text{day}} \cdot \frac{1 \text{ day}}{24 \text{ hours}}$$

$$\text{density}(\rho) = \frac{q}{v_{ave}}$$

$$\text{number of cars}(N_{cars}) = q \cdot \Delta t$$

$$\text{length of congestion}(L) = N_{cars} \cdot 8.5 \frac{\text{feet}}{\text{car}}$$

$$\text{maximum density}(\rho_{max}) = \frac{N_{cars}}{L}$$

Final equations for shockwave speed and distance

$$v_{sw} = \frac{q_b}{\rho_b - \rho_{max}}$$

$$\Delta x = v_{sw} \cdot \Delta t$$



Intersection

Results

- Time span to clear the accident is equal to time for flow to normalize
- Maximum density is constant
- Shockwave speed and distance are proportional to initial flow



Figure 2: Intersection Between NE Hancock Ave and 44th Ave

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Roundabout

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Results

- Flow and density minimally impacted by roundabout during normal conditions
- Accident has same initial impact, but takes less time to clear
- Two lanes could significantly reduce accident impact

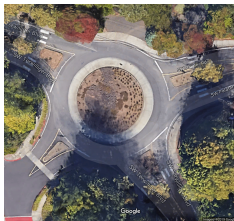


Figure 3: Roundabout at Terwilliger Blvd and Palater Rd



Interpretation

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- The longer it takes to clear accidents, the longer it takes to normalize flow.
- The higher the traffic flow, the faster and farther the shockwave will move.
- Roundabouts, especially those with two lanes, reduce the time it takes to normalize flow. Roundabouts are therefore superior to normal intersections.



Conclusion

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What do we do with this information?

- Develop methods for clearing obstructions faster. State police and transportation agencies currently aim for 90 minutes.
- Where possible, replace intersections with roundabouts.
- Widen existing roundabouts to have two lanes.
- Reduce number of shockwaves by leaving adequate space between you and the next driver as to minimize braking and prevent accidents.



Thank you for listening! Any questions?

Works Cited:

- Traffic Data: Portland Bureau of Transportation Traffic Map
- Intersection and Roundabout Images: Google Images
- Accident Clearing Time: Elliot Njus. 2016. Does it really take more time to clear traffic crashes these days? (Commuting Q& A). The Oregonian. Web page.
- University of Idaho Transportation Engineering Online Lab Manual, entry on shock waves

