Modeling Effects of Lane Closures on Travel Times

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***Abstract*—Living in the Atlanta area comes with the curse of traffic and construction that never seems to end. Every driver quickly learns that construction, namely lane closures, mean they will be sitting in traffic for some time. Out of frustration with traffic in Atlanta, the focus of this research will be on the extent that lane closures extend travel times. This literature review delves into the current state of traffic modeling, the research done surrounding traffic and its causes, and current applications of traffic simulations.**

I. Introduction

Traffic simulations have become an important tool in urban planning and the engineering of transportation systems. The causes of traffic range from literally nothing, to massive vehicle collisions. Virtual models of traffic flows are used by engineers and city planners to better understand potential traffic flow and minimize bottlenecks in transportation networks. Modeling traffic is a very complex task, there are countless elements to consider and countless researchers have written on the subject.

II. Literature Review

Liu et al. (2023) focused on the lane changing behaviors of vehicles and the various models used to simulate such a complex process. Models discussed ranged from simple logical systems to neural networks. The work done by this team shows the range of granularity that can be used to simulate just one aspect of a traffic system. The team concluded that there is no right answer when deciding how to simulate the lane-changing behavior of vehicles, the best approach depends on the target of the simulation [1].

A. S. Mane and S. S. Pulugurtha(2018) utilized neural networks to estimate travel times on highways. The focus of their work was the use of real time data in their simulations [2]. The ability to simulate traffic in response to real time traffic data is invaluable to engineers who can use this to minimize the effects of construction delays.

Santos et al. (2021) examined the effect of construction on traffic flows, namely how infrastructure works create traffic. Their findings suggest that vehicles diverted by construction projects are a key factor in creating traffic [3].

Kukkapalli and Pulugurtha (2020) conducted a study on the effect of road construction on surrounding streets. They concluded that streets surrounding the construction projects experience the greatest increases in travel times during construction [4]. Interestingly, streets are more affected than connecting freeways, they concluded this to be the result of decreased speed limits. At the end of their paper they call for more research on what they call work zone travel times based on factors such as number of lanes closed and the speed limit.

III. Methodology

The proposed system, the lane closure traffic model(LCTM) will have several variables that govern the system behavior. These values include: number of vehicles on the road, how quickly to populate the highway with vehicles, where lane closures occur, and where vehicles will try to get off the highway. The system will revolve around a simulated highway consisting of lanes which are arrays of lane positions. Lane positions can be marked either as empty, occupied, or closed. A vehicle will be instantiated in a lane and moved through the array on a fixed time step. If the next index in a lane is closed or occupied, then the vehicle must move to a neighboring lane.

As vehicles finish their journey, they record the time step in which they were created, the time step they arrived at their destination, the number of lane positions traversed, the number of lane changes, and the number of time steps in which they waited for an opening to change lanes. This data will be the output of the simulation.

A control will be established by randomly populating the a 5-lane highway of length 300 with 100 vehicles, all vehicles will be assigned the target exit of 200. This will be run 3 times and the data averaged will serve as the control data for vehicles merging to a single exit, this will be the simplest simulation run. This test will be repeated with lane closures starting at index 25 and ending at 75. This test will be run with various depths(up to closing all but one lane) of lane closures, meaning the right lane, then the right two lanes, and so on.

For our next control 100 vehicles will be simulated on a 5-lane highway. Exits are at 50, 75, 100, and 125. These exits will be distributed sequentially as

cars are spawned, meaning the first car's exit will be 50, the second 75, and so on, repeating: the fifth car's exit will be 50. These parameters will be run 3 times and the data will be averaged and will serve as the control group with no lane closures.

This test will be repeated with lane closures from 35 to 40, 60 to 65, and 105 to 115. This will be our worst case scenario test. Data will be recorded at various depths of lane closures(up to closing all but one lane).

IV. Expected Results

It is expected that lane closures will increase vehicle travel times. The extent of which is what this project seeks to answer. Each test should yield longer travel times in comparison to each control, the first set of tests is expected to have shorter travel times due to being simpler and less lane changes are expected. I expect to see a strong relationship between lane closures and lane changes that need to be made, the more lane changes that need to be made means that vehicles will spend more time steps waiting for an opening to move lanes. The waiting period to change lanes is predicted to be the biggest contributor to increased travel times.

This system of analyzing travel times and severity will fill the gaps in research concerning work-zone traffic surrounding construction projects. Several of the research papers cited in this document have expressed the inconsistency of lane closures caused by construction, the times of day, the volume of traffic affected, etc. Despite being a simplified simulation, being able to repeatedly measure the effects of closing a specific number of lanes for a specific length of road will be able to provide some insight on the effect construction has on traffic.

References

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