Simulating Traffic Flow in Dhaka City

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Abstract*—Traffic congestion in urban areas, particularly in cities like Dhaka, poses significant challenges, leading to inconvenience, delays, and environmental pollution. This research focuses on simulating traffic flow in a virtual replica of Dhaka city using the City Skyline traffic simulator using the Unity game engine. Microscopic models, specifically the Intelligent Driver Model, were employed to represent individual vehicle behavior. The simulation considered various scenarios, including different levels of vehicle occupancy, traffic law adherence, and the use of traffic police or traffic lights for control. The study aimed to understand the causes of poor traffic flow, identify bottlenecks, and propose effective solutions to alleviate traffic congestion. The experiments involved testing different traffic management policies, lane configurations, and scenarios to optimize traffic flow within the constraints of existing infrastructure. The research utilized the advanced modding capabilities of City Skyline, enabling the implementation of custom policies, lane management, and dynamic interaction with the simulation environment. Results from the simulations provided insights into the factors influencing traffic flow in Dhaka city. The analysis considered the impact of variables such as traffic police control, traffic light control, and adherence to traffic laws. Heatmaps and visualizations were produced to demonstrate the efficacy of various strategies in enhancing traffic flow. The results indicate that enforcing traffic laws and implementing traffic light-controlled systems are among the most effective methods for alleviating traffic congestion in Dhaka city. In conclusion, this research contributes to a deeper understanding of traffic dynamics in urban settings and proposes practical solutions for managing traffic flow in congested cities. While limitations exist in the accuracy of the simulation, future work could address additional real-world factors, such as parked vehicles, pedestrian behavior, and VIP movements, to further enhance the fidelity of traffic flow simulations.

***Index Terms*—Traffic simulation, Cities: Skylines, Simulation game, Intelligent Driver Model, Traffic flow, Traffic management, Microscopic models, Dhaka city, Urban planning, Traffic laws.**

I. Introduction

Traffic congestion in Dhaka city is a significant issue, leading to inconvenience, delays, and pollution. To tackle this problem, understanding traffic flow is crucial. Traffic simulation can analyze and model vehicle and pedestrian behavior, aiding in finding effective solutions. By testing different scenarios, we can enhance transportation in Dhaka and reduce congestion.

II. Literature Review

Traffic flow simulation is of paramount importance in comprehending the causes and effects of poor traffic infrastructure in Dhaka city, which leads to extensive traffic jams and millions of dollars in losses annually. Understanding the dynamics of traffic in Dhaka is crucial for effective city planning, congestion management, and infrastructure development. The traffic conditions in Dhaka city are exceptionally challenging, characterized by extreme congestion, especially during peak office hours. The diverse types of vehicles, including buses, private cars, three-wheelers, and rickshaws, contribute to the complexity of traffic flow. Rickshaws, even on highways in certain areas of Dhaka, significantly impact traffic flow.

Various traffic flow simulation techniques, such as microscopic, macroscopic, and mesoscopic models, have been employed in existing research. While there has been notable work in Dhaka, a comprehensive simulation addressing the unique challenges of the city's traffic conditions is still lacking in the literature. Despite the substantial volume of traffic-related research, our study introduces a distinctive element by exploring the potential consequences of partial or total non-compliance with traffic rules, a facet not extensively covered in previous literature. This contribution provides a deeper understanding of traffic conditions in Dhaka, offering insights that can be instrumental in finding solutions to major issues such as severe traffic jams affecting millions of people in the city.

Our simulation, while valuable, acknowledges its challenges and limitations, such as the dissimilarity of the created city to Dhaka and the inherent lack of 100% accuracy. Nevertheless, the simulation proves effective in offering insights into traffic conditions in Dhaka, especially in evaluating the potential impacts of new traffic infrastructures like bridges, flyovers, roads, overpasses, and underpasses.

In the context of implementing the "public transit priority" strategy, [Pan and Cao, 2018] emphasizes the significance of studying traffic flow in bus stop areas to address traffic problems. Using VISSIM simulation software, the study investigates the impact of bus arrival frequency and non motor vehicle traffic volume on traffic flow in bus stop areas. The research considers three representative station types and proposes a station type optimization plan for Pengyuan Ximen Bus Station in Xuzhou based on simulation results. This work contributes valuable insights into mitigating mixed traffic flow conflicts and improving bus station service levels.

According to [Song and Min, 2018] focuses on urban traffic analysis and simulation technology to understand various methods for analyzing urban traffic states. It introduces a traffic demand estimation process for urban traffic simulation, utilizing a trip estimation model based on L1 regularized regression and trajectory data. The case study in Gangdong-gu, Seoul, demonstrates the effectiveness of the proposed method, with simulation results from the SALT Traffic Simulator based on SUMO reflecting real traffic patterns within approximately 10% error coverage.

[Lin, 2019] introduces DynasTIM, a real-time software system for online simulation, prediction, and optimization of dynamic traffic flows in urban and intercity networks. Developed over 15 years, DynasTIM incorporates features such as dynamic OD flows estimation, mesoscopic traffic models, and urban area signal optimization. The case study in Futian CBD, Shenzhen, China, validates its capability to reproduce real-world traffic conditions and highlights the potential for signal optimization, leading to a 13% reduction in average travel delay.

According to [Skorobogatchenko et al., 2022] discusses the introduction of automated traffic control systems as a key priority for urban street and road network development. It proposes the use of Simulation of Urban Mobility (SUMO) software for simulating the influence of adaptive traffic lights on road network capacity. The study shows that even at individual intersections, adaptive traffic control can increase overall road network capacity by 20-30%.

[Potuzak, 2022] provides a survey of existing methods for road traffic network division in the last two decades. While not a systematic review, it maps and categorizes these methods, serving as a valuable resource for researchers dealing with road traffic network division and distributed or parallel road traffic simulation.

In the broader context of traffic flow simulation and urban planning research, the understanding of traffic dynamics, optimization of bus stop areas, urban traffic analysis, real-time simulation, and the impact of adaptive traffic control systems has been collectively advanced by the papers discussed. These contributions, while valuable, underscore a notable gap in the existing literature—a lack of a comprehensive simulation addressing the specific challenges posed by traffic conditions in Dhaka city. Crucially, this gap extends to considerations of non-compliance with traffic rules, a critical factor in the chaotic traffic landscape of Dhaka. This research aims to bridge this void by presenting a detailed simulation of traffic conditions in Dhaka, offering insights into the repercussions of both partial and total non-compliance with traffic rules.

Within this landscape of traffic flow simulation, a parallel narrative emerges in the form of the utilization of simulation games, prominently Cities: Skylines, in urban planning research and education. Noteworthy studies have explored the diverse applications of Cities: Skylines, shedding light on its potential benefits and limitations in educational contexts. These studies reveal how the game serves as a powerful tool for visualizing real-world places, contributing to urban planning education, and, with thoughtful modifications, enhancing its suitability for addressing city planning problem-solving scenarios. The integration of artificial intelligence in city design optimization further expands the horizon, showcasing the game's potential as a platform for exploring advanced technologies in the urban planning domain. Thus, these studies collectively enrich the discourse on the gamification of urban-related processes, bringing attention to the multifaceted role of simulation games in advancing knowledge and understanding in the fields of traffic flow dynamics and urban planning.

A. GeoSkylines: A Geographically Accurate Visualization Tool

A significant contribution to the field is the GeoSkylines game modification, as discussed by [Pinos et al., 2020]. This modification employs automatic methods scripted in the Cities: Skylines API, allowing for the creation of geographically accurate visualizations of real-world places within the game. The methods encompass the generation of road and rail networks, tree coverage, water basins, planning zones, buildings, and services. Moreover, GeoSkylines facilitates the export of game objects into a Geographic Information System (GIS) data format, positioning Cities: Skylines as a valuable tool for data collection in redevelopment design projects.

B. Cities: Skylines in Urban Planning Education

Extending beyond its entertainment domain, Cities: Skylines has been introduced into urban planning education, as highlighted by [Commey, 2023]. The study assesses the effectiveness of the simulation in teaching urban planning principles from the perspective of students. Qualitative methods, including questionnaires, reveal that the visual elements of the game enhance students' understanding of various urban planning concepts and contribute to the development of critical thinking and problem-solving skills. The study underscores the pivotal role of instructors in optimizing the educational benefits derived from the simulation.

C. Computer Games in Education: Potential and Modifications

[Haahtela et al., 2015] delves into the broader landscape of using computer games, including Cities: Skylines, as a teaching method. It emphasizes the comprehensive yet simplified view of reality that games offer, fostering inner motivation

among students. While acknowledging Cities: Skylines' potential for educational purposes, the paper suggests that well-thought modifications could enhance its suitability for city planning problem-solving scenarios.

D. Gamification of Urban Planning: Student Perspectives

[Khan and Zhao, 2021] evaluates the effectiveness of Cities: Skylines for teaching urban planning through gamification. In-depth semi-structured interviews provide insights into students' perspectives, indicating that the game fosters conceptual understanding, critical thinking, and problem-solving skills. However, internal limitations hinder the confident application of knowledge in real-world scenarios, emphasizing the importance of the instructor's role.

E. AI in City Design Optimization

Venturing into artificial intelligence and machine learning, [Duncan et al., 2021] presents a project involving the creation of an artificial intelligence agent to design optimized city layouts in Cities: Skylines. This initiative illustrates the viability of using AI as a tool in urban planning for real cities, leveraging the customization and control offered by the game environment.

Incorporating insights from these studies into the literature review enriches the discussion, showcasing the multifaceted role of Cities: Skylines in education, urban planning, and the potential integration of artificial intelligence for city design optimization. These findings collectively contribute to the broader understanding of the gamification of urban-related processes and its implications for educational and planning contexts.

III. Methodology

We will simulate traffic in urban areas to identify the bottlenecks. After analyzing the data we will try out various policies, lane management order, traffic obedience of people. We will be testing our changes and we will find the best possible solution for a particular scenario. Furthermore, adapting the changes for each scenario and combining them. After adapting all the changes we will compare the model with the pre-existing model and show the changes of traffic flow, congestion level. In recent times most of the urban area is preoccupied with infrastructure. As a result we can not construct any new road or lane. We have limited space and unchangeable roads. We have to work with the existing infrastructure. Various traffic policies can be tweaked in this stage. A good traffic laws, policies and law abidance of the citizen plays a massive role in modern day traffic flow. It is really important to simulate new policies and laws before implementing them in the real world. The room of error in the real world is hazardous. As city infrastructure is connected more than ever, a tiny error possesses a massive threat to the overall city traffic. We will try to find the optimal policies for any given Urban city. For this paper we will be using the model of Dhaka city. Simulating new policies, analyzing the change and comparison will be done in this paper.

We will be using a correlational design model. Identifying the policies and their impact on the overall traffic will be done. In this experimental design using Unity engine to simulate the traffic flow in a city. We would like to observe the effect of various variables such as: Traffic congestion, policies, traffic flow, lane management etc on our city.

To simulate the traffic flow in Dhaka city, a model has to be chosen which can represent the traffic system of Dhaka city in mathematical representation. This kind of model can be used to simulate

the traffic flow in Dhaka city using some input parameters such as road network geometry, vehicles per minute, speed of the vehicles etc. There are mainly 3 types of traffic simulation models such as -

- **Macroscopic models:** Such models depict both the overall flow and density of traffic as it relates to vehicle mobility.
- **Microscopic models:** These models are used to distinguish between various vehicles, which makes it easier to replicate the distinct driving styles of each individual.
- **Mesoscopic models:** These models are hybrid meaning they are a combination of microscopic and macroscopic models.

We used Unity Engine where traffic flow simulation has been implemented using Microscopic models.

A. Microscopic models

Microscopic model is one kind of model that simulates the movements of a vehicle which is called a tiny model. Therefore, the system must be multiple agent based, with every vehicle operating independently and utilizing distinct environmental input data. Each vehicle in this model has a label that reads "i." The i-1 - th vehicle comes before the i-th vehicle. Let's denote x1 as the position of it, l1 as its length and v1 to be its speed.

$$\text{IV. } s_i = x_i - x_{i-1} - l_i$$

$$\text{V. } \Delta v_i = v_i - v_{i-1}$$

Here s_i is the distance between two vehicles and Δv_i is the relative velocity between i-th vehicle and i-1 - th vehicle.

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