Analysis of Traffic Congestion in North Campus using simulations and Deep Reinforcement Learning

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Introduction

With traffic congestion being a persistent problem in the North Campus of the University of Delhi, we aim to find a viable solution to this problem. We have integrated traditional traffic simulations, real-time traffic data collection, event-based scenario analysis, and advanced traffic signal control using Deep Reinforcement Learning (DRL) to develop a traffic management solution for the area. Further, we believe integrating this system with smart city infrastructure components can contribute to an efficient transport network.

Technologies Used

For the simulations, UXSim was used. UXsim is an open-source macroscopic and mesoscopic network traffic flow simulator developed in Python.

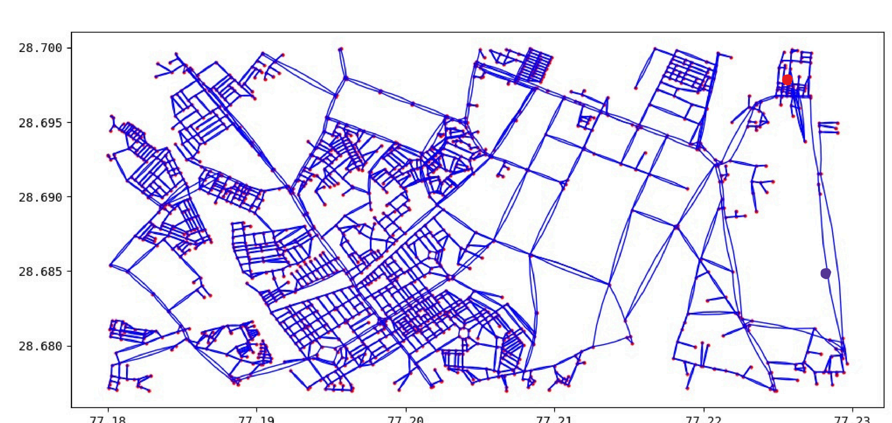
For map generation OSM was used. OpenStreetMap (OSM) is a free, open geographic database updated and maintained by a community of volunteers via open collaboration.

Continuous Time Simulation

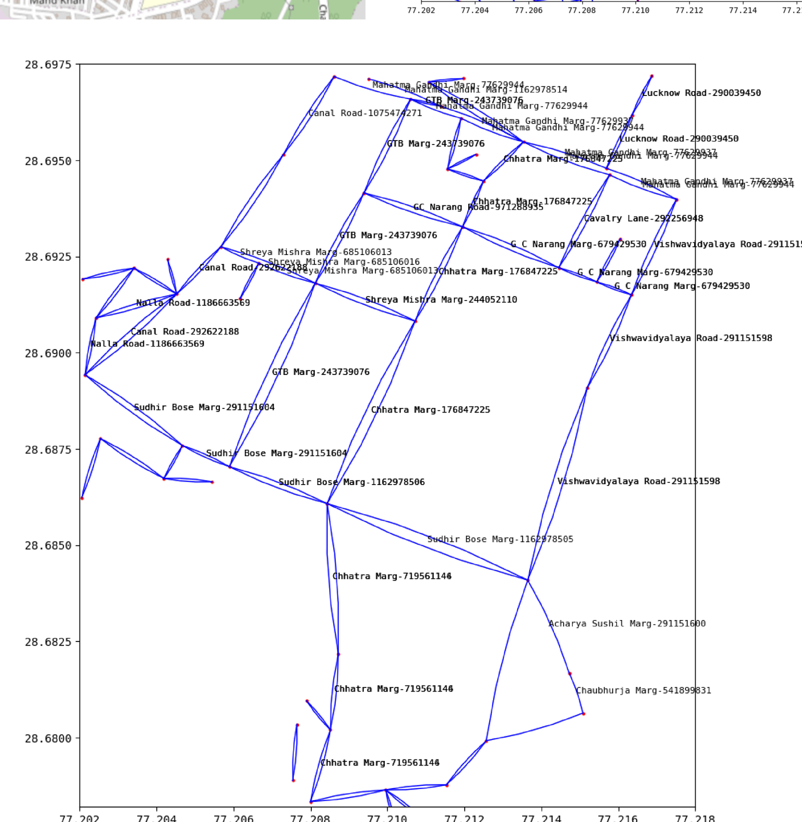
Continuous time simulations allow for the precise modeling of vehicle accelerations, decelerations, and queue formations, providing a more accurate depiction of traffic flow and congestion. Unlike discrete time simulations that update the system state at fixed intervals, continuous time simulations capture events as they occur in real-time

Methodology

We used UXSim in python for the simulation and OpenStreetMap (OSM) to get a somewhat accurate map of Delhi University North Campus



We then meticulously cleaned this map to include only intersections and roads that are somewhat central in the campus and removed dead ends.

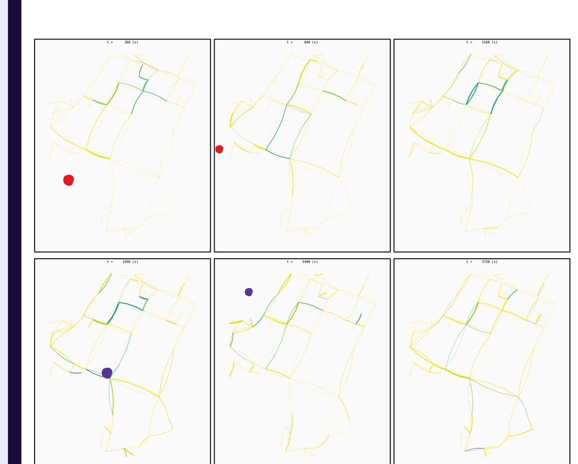


Data Collection

We went to each intersection and then counted the vehicles we saw in a 5 minute time frame. We tried to do this as many times as we could to get a better random sample that is less dependent on time, day, etc.

Intersection	Traffic Flow Rate (vehicles/second)
Vishwavidyalaya	2
GTB Bridge	5
SGTB Khalsa	5
Gate No. 3	2
Patel Chest	3
Ramjas/Stephens	5
Mall Road	2
Bonta Park	1
Malkaganj	5
Kamla Nagar	2
Roop Nagar Chowk	4

Some Simulations



Classes end at Ramjas: 0-3600s
Classes end at Miranda: 3600s - 7200s

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results:
 average speed:  7.9 m/s
 number of completed trips:      11930 / 35750
 average travel time of trips:   2462.1 s
 average delay of trips:         2332.9 s
 delay ratio:                    0.948
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Ramjas/Miranda Simulation Statistics

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results:
 average speed:  7.8 m/s
 number of completed trips:      17475 / 71500
 average travel time of trips:   1794.4 s
 average delay of trips:         1666.4 s
 delay ratio:                    0.929
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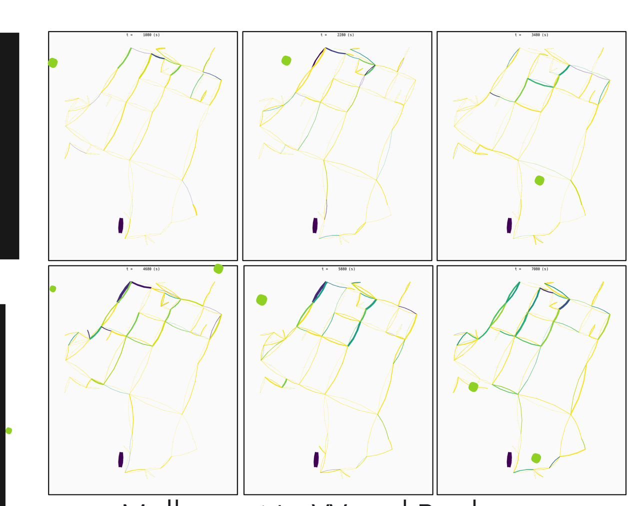
Malkaganj/Vishwavidhyalaya Simulation Statistics



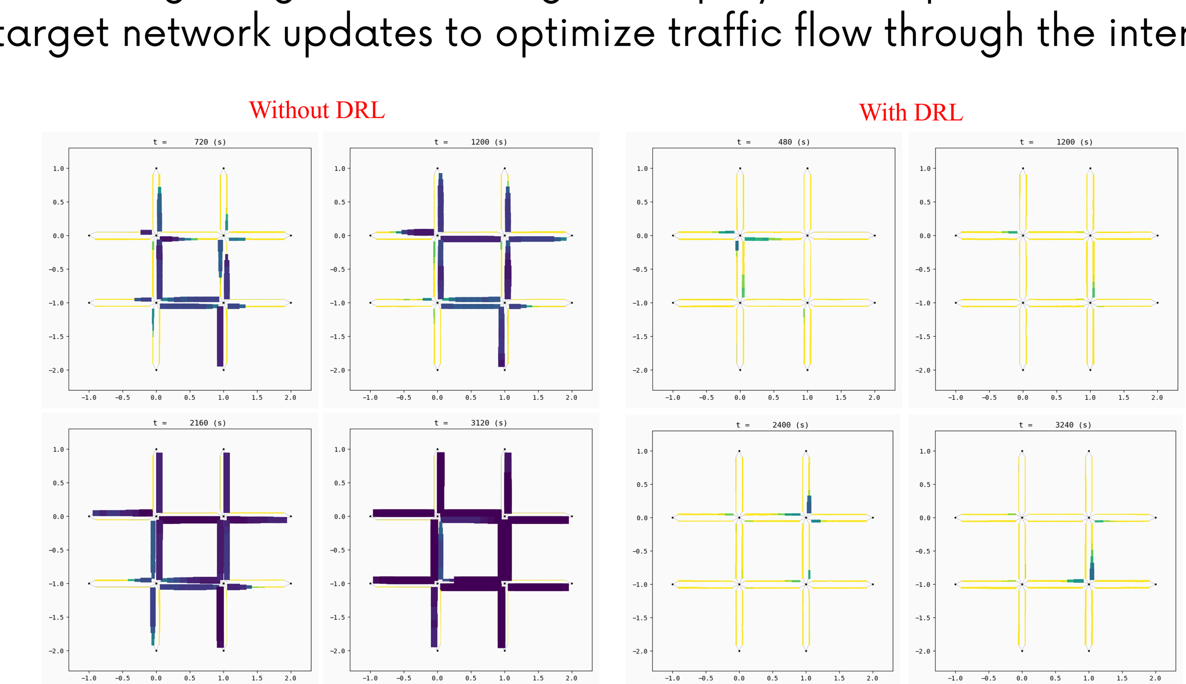
Malkaganj to VV and Back

These simulations help us better understand the congestion points. The one found were: e G.T.B. Road Bridge, the Ramjas-St. Stephen's intersection, the Patel Chest Institute Intersection, Gate No. 3 Intersection, and the GTB Khalsa Intersection.

Deep Reinforcement Learning

To enhance traffic flow efficiency we implemented a Deep Reinforcement Learning (DRL) based traffic signal control system. We first implemented it on a 9 block set, then the intersection near Ramjas College and St. Stephen's College, which frequently experiences significant congestion was chosen.

Deep Reinforcement Learning (DRL) uses a trial-and-error approach where an agent learns to control traffic lights (actions) by observing traffic conditions (state) and receiving rewards for minimizing congestion. The agent employs a Deep Q-Network (DQN) with experience replay and target network updates to optimize traffic flow through the intersection.



By dynamically adjusting signal timings based on real-time traffic conditions, the DRL algorithm improved traffic flow efficiency and significantly decreased vehicle wait times. This adaptive approach to traffic management proved effective in mitigating congestion at critical intersections, highlighting the potential of DRL in enhancing urban traffic systems.