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REVITALIZING TORONTO'S FUTURE

BOREALIS AI

TraffiX: Leveraging Machine Learning for Smarter Traffic Management in Toronto

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1. Introduction to the Problem

1.1 Objective

Toronto, being one of North America's busiest construction hubs, faces significant challenges in managing traffic congestion due to extensive infrastructure renewal, private construction, and transit expansion projects. It's a multifaceted issue that affects public perception and can create a negative economic impact. 86% of residents in the GTHA acknowledge that there is a significant traffic congestion issue [1] and in 2022, the average Toronto driver lost 118 hours due to a traffic and congestion crisis in a region resulting in a loss of $11 billion dollars [2].

Construction in the city leads to road space being occupied by projects such as road bridges and watermain renewals while inadequate traffic flow management results in current systems such as Google Maps being unable to adapt to dynamic conditions. Additionally, factors such as single-occupant vehicles that dominate the roads during peak hours and certain policy decisions made by the city are leading to additional complications. Competition on the road can increase accident risk due to narrowed sidewalks, blocked bike lanes, and lead to a higher risk of collision.

The limited availability of smart traffic management tools in the city has led to overall inefficiencies in the system. There is outdated infrastructure and static traffic patterns which rely on pre-programmed signal timings which don't account for dynamic changes based on construction or events. Overall, there is a lack of predictive technology incorporated into the city. Tools like Google Maps & Waze tend to be more reactive rather than predictive, offering real-time traffic forecasts. However, they lack the capability to predict future traffic conditions based on variables such as construction, weather, and recent events. Ultimately, this offers very limited foresight into future traffic patterns in a world of evolving road conditions.

2. Importance of the Issue

2.1 Personal Experience

Our team believes in leveraging the power of artificial intelligence and technology for social and economic good. As residents and frequent visitors of Toronto, we have personally experienced the frustrating and often costly impacts of traffic congestion. Whether it's missing the first pitch at a Blue Jays game, facing road closures when travelling to the Canadian National Exhibition or struggling to navigate the streets during the Toronto Jazz Festival and other concerts. Oftentimes, Google Maps's real-time traffic updates fail to forecast accurate travel conditions ahead of time, forcing us to adjust travel plans last minute [3]. For one of our team members, traffic congestion was a critical factor in determining her post-secondary education institution. When weighing the option to attend a local university in Toronto, the long commute times were a significant deterrent and she ultimately chose to pursue her education outside the city. This decision reflects the challenges faced by many Torontonians; 86% of locals agree that the city's congestion crisis prevents them from shopping, going out for entertainment or watching sports [4].

2.2 Large-Scale Impacts

As this was a prevalent issue affecting our team and community, we were committed to tackling traffic congestion head-on. Upon further research, our team discovered Toronto is ranked the 17th most congested city in the world, with the average driver facing 63 hours of traffic delays annually [5]. Traffic congestion in Toronto also impacts trade, productivity and the economy — costing the city $44.7 billion annually in economic and social costs [5]. These figures exemplify the lost time with loved ones, missed opportunities and financial burdens that weigh heavily on our communities. Driven by our passion for social change, we believe we have the creativity, determination and technical skills needed to define a new frontier for Toronto. TraffiX plans to enhance Toronto's Signal Optimization Program by utilizing data from the city's 2,487 traffic signals to optimize traffic signal operations [5]. TraffiX is a mission to build a better, more connected Toronto—a city that moves at the speed of its potential and leads the way in smart traffic technology.

3. Importance of Machine Learning

3.1 Why Machine Learning is the Solution

Machine learning is a specific branch of artificial intelligence (AI) that allows computers to process and analyze data to recognize patterns. Machine learning has the power to learn from its data and generate accurate predictions, anticipating future developments[6]. These attributes of machine learning allow it to be the perfect solution for how to approach our problem.

Our proposal addresses the problem of traffic congestion, and our goal is to optimize traffic flow in the city of Toronto. By utilizing machine learning to analyze traffic data, we can predict future traffic flow within the city. With information on traffic patterns, specifically on which regions have the most congestion, we can direct drivers to alternative routes. To ensure that new traffic congestion won't form, we can delegate different users to different routes, allowing for traffic to be evenly distributed and optimizing routes. We can use machine learning's ability to model future traffic patterns to prevent congested traffic from occurring, essentially managing traffic flow, in real-time.

4. Planned Data to Incorporate

4.1 Key Frameworks & Tools

The system will use historical and real-time data to optimize traffic flow effectively. Historical datasets, including traffic volumes, average speeds, and congestion patterns, will be sourced from publicly available archives such as OpenStreetMap and INRIX. Real-time data including current traffic conditions, vehicle flow, incident reports, and environmental factors will be gathered through APIs like Google Maps Traffic and TomTom, GPS devices, traffic cameras, and sensors at key locations. To develop predictive models, TensorFlow will be utilized to create advanced neural networks for time-series traffic predictions, while Scikit-learn will be applied to make regression models during the initial analysis. Implementation will follow four key phases: data collection and preparation, model development, system integration with APIs and user-facing applications, and pilot testing in a controlled environment before scaling. By combining diverse datasets with robust machine learning models, the system will accurately predict future congestion patterns and provide strategies to optimize traffic flow, to create an innovative solution for modern traffic management.

5. References

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