Urban Traffic Simulation in the City of Nouakchott Using MATsim

Mohamed Abderahmane Mohamed Elmoctar[(1)], Cheikh Dhib[(2)], Mohamed Aly Louly[(3)],
Emmanuel Néron[(1)], Ameur Soukhal[(1)]
[(1)]LIFAT, Univertsity of Tours, France
[(2)] SupNum of Nouakchott, Mauritanie,
[(3)] Hight School Polytechnic of Nouakchott (ESP), Mauritanie
{mohamed.mohamedelmoctar, emmanuel.neron,ameur.soukhal}@univ-tours.fr
cheikh.dhib@supnum.mr, ma.louly@esp.mr

Abstract

We present a simulation-based study of urban traffic in Nouakchott using MATSim, integrating comprehensive transport data into a synthetic population via IPF. Our model simulates the real network and public transit system to identify congestion hotspots and propose targeted optimizations. Traffic outputs are visualized with VIA SIMUNTO, enabling real-time flow analysis on major arteries. This framework provides robust decision-support for sustainable urban mobility.

Introduction

Optimizing transportation networks is crucial for designing efficient and resilient systems. In this context, simulation emerges as an indispensable tool, given that the pre-validation of models before real-world deployment often requires significant time and resources. By simulating various operational scenarios within a virtual environment, we can conduct thorough tests and thereby reduce the risks associated with direct field implementation. Simulation thus serves as a vital bridge between theoretical design and practical implementation.
Recent advances in multi-agent modeling, as exemplified by platforms such as MATSim "Multi-Agent Transport Simulation" (Axhausen et al., 2016), provide innovative solutions for assessing the performance of transportation networks. By simulating the daily behavior of users and anticipating the impacts of various optimization strategies across the entire system, this approach not only optimizes transport services but also identifies congestion hotspots and adjusts network parameters dynamically in response to fluctuating demand. Consequently, multi-agent simulation offers a rigorous framework for testing and comparing different scenarios, supplying engineers and decision-makers with robust decision-support tools to tackle the challenges of modern mobility.

Methodology

To conduct this study, we adopted a simulation-based approach utilizing MATSim, an advanced multi-agent simulation tool that integrates both activity-related aspects and the co-evolution of the transportation system. Our methodology is built upon recent studies on mobility in Nouakchott and involves the collection and integration of essential transportation data, including:

- The existing transportation network,
- Public transit lines,
- Departure schedules at each stop,
- The fleet of public transit vehicles,
- Population mapping (indicating residential and work locations and schedules), and
- Mobility demand expressed as (Origin-Destination).

To ensure compatibility with MATSim, the real population is transformed into a synthetic population. Recent studies, such as those by (Hörl and Balac, 2021) and by (Ziemke et al. 2019)

have demonstrated the effectiveness of pipelines that generate structured data from census and household travel survey data. In particular, in (Ziemke et al. 2019) the authors use tools like CEMDAP (Comprehensive Econometric Micro-simulator for Daily Activity-travel Patterns) (Bhat et al., n.d.) and CaDyTS (Calibration of Dynamic Traffic Simulations) (TU Berlin et al., 2016). Similar approaches have also been applied in São Paulo (Sallard et al. 2021).In our case, we only have the results of a household travel survey. To enrich and adjust these data to generate a reliable transport demand, we employ the Iterative Proportional Fitting (IPF) method proposed by (Deming and Stephan, 1940) and (Beckman et al., 1996), which adjusts the distributions to yield a synthetic population that meets the known constraints on travel distribution.

Model and Results

Our analysis focuses on the examination of floating traffic around the city to precisely identify the network segments that require adjustments or optimization to improve traffic flow. To achieve this, it is essential to simulate the real network while accounting for current demand and the public transport system operated by the Public Transport Society (STP). This approach enables us to evaluate the operational efficiency of the network, detect inefficiencies, and propose concrete solutions to enhance overall urban mobility.

To illustrate network behavior, we exploited the output files (*output_event.xml* and *output_network.xml*) generated by MATSim, as described in *The Multi-Agent Transport Simulation MATSim*. We used the VIA SIMUNTO tool ("via-manual.pdf", n.d.) to provide a clear and detailed visualization of the network's performance. Additionally, we developed a custom script to extract, from *output_event.xml*, the number of vehicles on the city's main arteries, allowing us to visualize traffic flows in real time throughout the day.

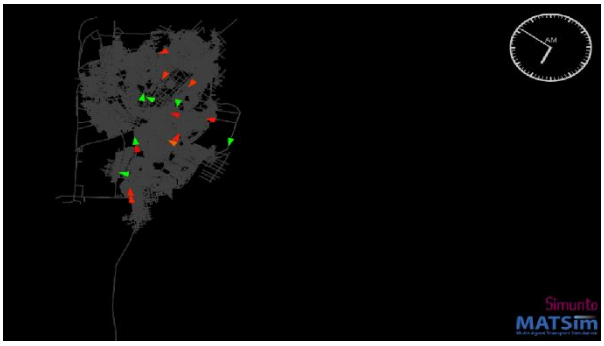

Fig.1: state of the network at 6:30am

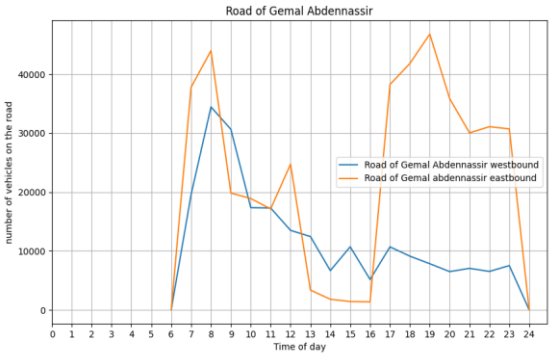

Fig2. Number of vehicles in Road

In Fig. 1, we observe the onset of mobility in the network, where the red color indicates vehicles entering the congested zone. In Fig. 2, we see the variation in the number of vehicles on certain roads throughout the day.

Discussion and Perspectives

This integrated simulation and analysis approach enhances our understanding of urban traffic dynamics and equips planners with valuable tools to design targeted interventions. For instance, by identifying the most congested segments, measures such as reorganizing transit lines or optimizing schedules can be considered. Future work will integrate environmental impact analyses (e.g., CO_2 emissions, air quality) and examine the system's robustness under scenarios of increased demand or disruptions (e.g., exceptional events, breakdowns). These additional aspects will further enrich the study and enable the formulation of more comprehensive and

sustainable solutions for urban mobility improvement. Work taken in account environmental impact is in progress.

Conclusion

The multi-agent simulation approach, combined with synthetic data generation and dynamic traffic flow analysis, serves as an effective bridge between theoretical design and practical implementation. This robust methodological framework provides decision-makers with high-performance decision-support tools capable of addressing the complex challenges of modern mobility across diverse urban contexts.

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