Development and Implementation of Multi-lane Configuration Concept in SUMO

Master‘s Thesis of Shrutik Vilas Pundkar

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Introduction and aim:

Infrastructure planning and transportation engineering have long faced the challenge of efficiently utilizing the capacity of the motorways. The fixed-lane configuration of motorways cannot accommodate the dynamic behavior of traffic demand, which often results in congestion during peak periods. Dynamic lane configuration (DLC) is a novel concept proposed by Rostami-Shahrbabaki et al. (2024) that aims to mitigate congestion through adaptive traffic management. DLC focuses on the underutilized lateral capacity of a motorway by reducing vehicle speeds in peak hours to reduce the lateral gap between vehicles complying with the safety regulations at given speeds. Consequently, a fixed-lane configuration of a motorway can be transformed into a multi-lane configuration, dynamically adjusting the number of lanes at different sections in response to traffic demand. This research aimed to develop and implement a multi-lane configuration in the microscopic traffic simulation package Simulation of Urban MObility (SUMO) using its sublane model and Traffic Control Interface (TraCI) to control the simulation dynamically.

Research questions and scope:

This study addresses the following research questions:

1. How can dynamic lane configuration be effectively implemented and simulated in SUMO?
2. What will the effect of dynamic lane configurations be on different traffic scenarios?
3. What will be the impacts of these lane changes on traffic flow and vehicle behavior?

This research primarily focuses on implementing and evaluating the DLC concept, particularly emphasizing passenger cars on urban motorways in compliance with German traffic regulations.

Methodological approach:

The methodology incorporates the following three phases:
Phase 1: Developing a framework for implementing DLC in SUMO
Phase 2: Evaluating the feasibility of DLC
Phase 3: Analyzing the impacts of DLC on traffic dynamics

The framework to implement DLC consists of two parts: a traffic simulation and a Python-based script to control it via TraCI. The first part requires SUMO and its sublane model, and the second part requires knowledge of functions provided by TraCI, especially those related to vehicles and edges. After DLC was successfully implemented, it was tested on a multi-lane network resembling a real-world motorway, thus evaluating the feasibility of DLC on other networks. Finally, the impacts of DLC on traffic dynamics were analyzed at the microscopic level based on the network and demand profile consistent with the macroscopic evaluation framework of Rostami-Shahrbabaki et al. (2024).

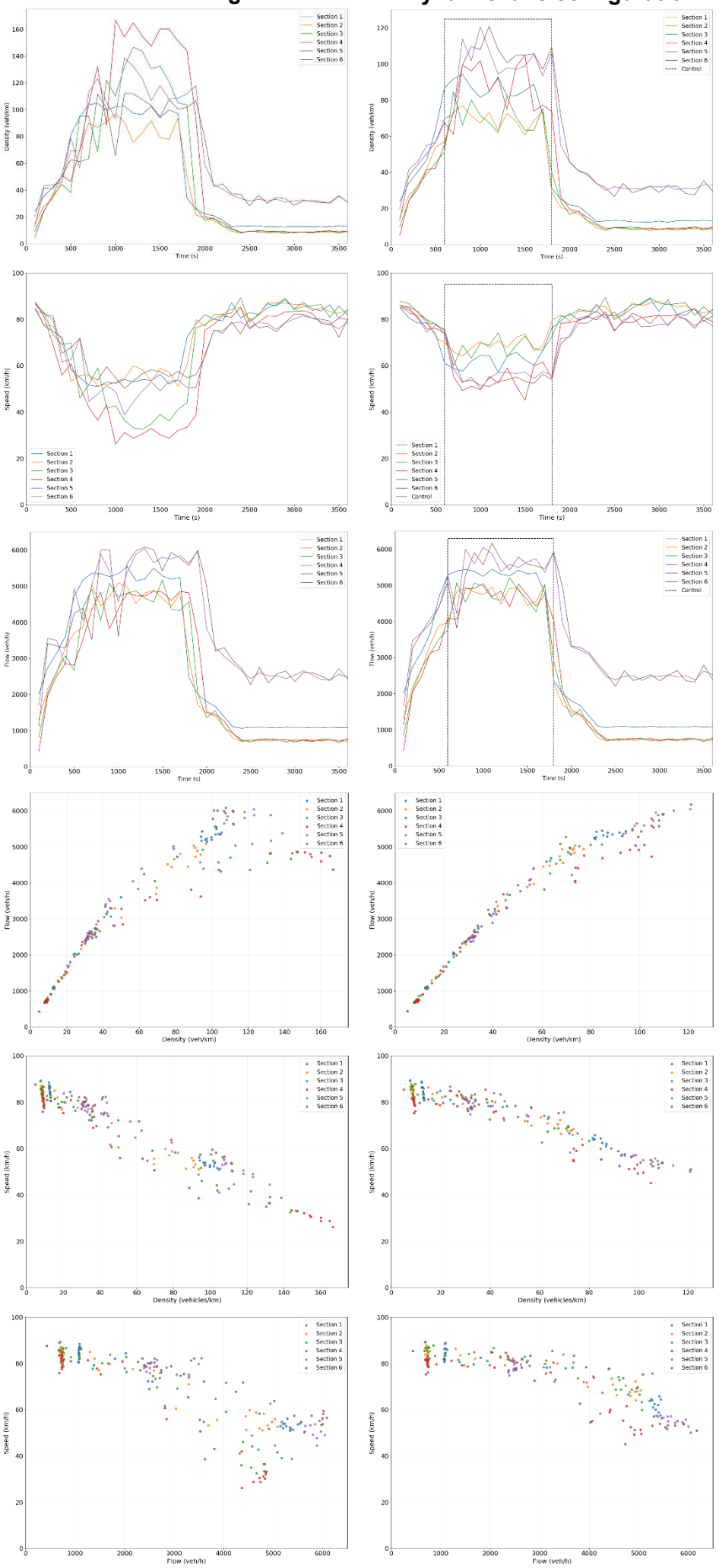
Conclusion:

The analysis demonstrates that dynamic lane configuration can be effectively implemented and simulated in SUMO. The findings suggest that implementing this strategy before congestion occurs significantly increases road capacity and mitigates congestion.

References:

Rostami-Shahrbabaki, M., Keyvan-Ekbatani, M., Bogenberger, K., & Papageorgiou, M. (2024). Dynamic Lane Configuration for Improved Traffic Efficiency on Motorways. *Authorea Preprints.*

Fixed-lane configuration | **Dynamic lane configuration**



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