SynCity: Synchronized Urban Traffic via AV-Infrastructure Synergy

by
Ch. Karthikeya (22761A5477)
Ch. Sai Jyothi (22761A5481)
O. Vinay Venkatesh (22761A54A8)

Department of AI & DS, LBRCE, Mylavaram

Under the supervision of
Mrs. K. Lakshmi Padmavathi
Asst. Professor

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Outline

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Introduction

- Rapid urbanization has led to unprecedented traffic congestion, posing significant challenges to urban mobility and sustainability.
- This project proposes a novel platform for seamless integration of Autonomous Vehicles (AVs) with smart city infrastructure to create an intelligent traffic management system.
- At the core is Vehicle-to-Infrastructure (V2I) communication, enabling real-time dialogue between AVs and central traffic control networks.
- This bidirectional data flow enables dynamic signal control, cooperative intersection management, and predictive traffic routing.
- Primary objectives: optimize traffic flow, reduce congestion, minimize travel times, enhance road safety, and decrease emissions.

Literature Review (1/2)

S.No	Author(s)	Year	Title	Methodology / Dataset
1	Lopez, P. A., et al.	2018	Microscopic Traffic Simulation using SUMO	SUMO architecture, network importation, TraCI interface
2	Alvarez Lopez, F. M., et al.	2018	The SUMO-RL framework	SUMO + OpenAI Gym for Reinforcement Learning traffic control
3	Krajzewicz, D., et al.	2012	Recent Development and Applications of SUMO	SUMO applications overview, TraCI for online interaction
4	Walraven, E., et al.	2016	Multi-Agent Deep RL for Traffic Signal Control	Deep RL for traffic lights, custom Python with SUMO
5	Gatfor, V., et al.	2021	Review on traffic datasets for ML applications	Survey of real-world vs synthetic datasets
6	Every, A., et al.	2020	T-Intersection: RL Environment for Traffic Control	SUMO environment for T-intersection benchmarking

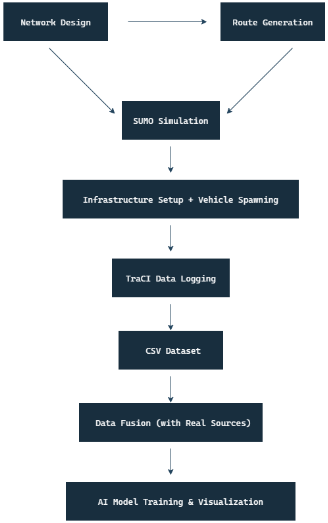
Literature Review (2/2)

S.No	Author(s)	Year	Title	Methodology / Dataset
7	Hayat, A., et al.	2023	SUMO-based dataset for traffic signal control	Public dataset generation using SUMO for traffic control
8	Codeca, L., et al.	2017	Simulating Autonomous and Connected Vehicles	SUMO with network simulators for V2X communication
9	Mo, Y., et al.	2022	Review of traffic data collection methods	Traffic data methods review, simulation data context
10	Polyak, B. T.	1964	Speeding up convergence of iteration methods	Foundational optimization methods for ML training

Problem Statement

- Traditional traffic management systems cannot adapt dynamically to real-time traffic conditions
- Lack of synchronization between autonomous vehicles and urban infrastructure
- Inefficient traffic signal timing leads to unnecessary congestion and delays
- Limited data integration between vehicle movements and infrastructure control
- High emissions and fuel consumption due to stop-and-go traffic patterns
- Need for scalable solutions that can handle increasing urban vehicle density

Proposed Methodology – Diagram



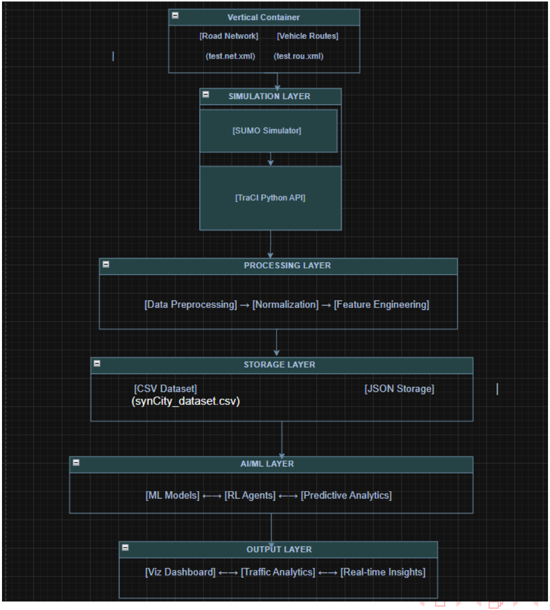
Proposed Methodology – Explanation

- **Simulation Setup**: Network Design → Route Generation → SUMO Simulation
- **Simulation Execution**: Infrastructure Setup and Vehicle Spawning within simulation
- **Data Collection**: TraCI Data Logging → CSV Dataset generation
- **Enhancement & Utilization**: Data Fusion with real sources → AI Model Training & Visualization
- Creates ML-ready datasets with synchronized vehicle-infrastructure data
- Enables training of predictive models and reinforcement learning agents

System Architecture – Explanation

- **Simulation Environment**: SUMO (Simulation of Urban Mobility) as core traffic simulator
- **Control & Data Interface**: TraCI API in Python for real-time simulation control
- **Data Storage**: CSV/JSON files storing time-series traffic data
- **Data Processing**: Preprocessing stage for data cleaning and normalization
- **ML Models**: For prediction and reinforcement learning tasks
- **Visualization**: Matplotlib, Seaborn, Grafana, or Plotly Dash for analytics

System Architecture – Diagram



Experimental Setup

- **Hardware**: Standard computer setup (SUMO and Python are lightweight and scalable)
- **Software**:
  - SUMO (Simulation of Urban Mobility)
  - Python with TraCI API
  - Matplotlib/Seaborn for visualization
  - Grafana or Plotly Dash for advanced dashboards
- **Datasets**:
  - Primary output: `synCity_dataset.csv`
  - ML-ready time-series data with vehicle-infrastructure synchronization
- **Evaluation Metrics**:
  - Traffic flow improvement (delay reduction, throughput)
  - ML model accuracy and RL performance
  - Dataset completeness and real-world pattern similarity

Conclusion

- Developed SynCity framework for synchronized urban traffic management using AV-infrastructure synergy
- Created comprehensive simulation environment using SUMO with real-time data collection via TraCI
- Generated ML-ready datasets enabling training of predictive models and reinforcement learning agents
- Established foundation for dynamic traffic signal control and cooperative intersection management
- Future work: Integration with real-world traffic data, multi-city scalability testing, and enhanced V2X communication protocols
- Potential impact: Reduced congestion, improved traffic flow, lower emissions, and enhanced urban mobility

References (1/2)

1. Lopez, P. A., Behrisch, M., Bieker-Walz, L., Erdmann, J., Flötteröd, Y. P., Hilbrich, R., Lücken, L., Rummel, J., Wagner, P., & Wießner, E. (2018). Microscopic Traffic Simulation using SUMO. In *The 21st IEEE International Conference on Intelligent Transportation Systems*. ▸ Open Paper
2. Alvarez Lopez, F. M., et al. (2018). "The SUMO-RL framework: A general-purpose modular framework for Traffic Signal Control." *arXiv preprint arXiv:1811.05046*. ▸ Open Paper
3. Krajzewicz, D., Erdmann, J., Behrisch, M., & Bieker, L. (2012). Recent Development and Applications of SUMO - Simulation of Urban MObility. *International Journal on Advances in Systems and Measurements, 5*(3&4), 128-138. ▸ Open Paper
4. Walraven, E., Spaan, M. T. J., & Bakker, B. (2016). A Multi-Agent Deep Reinforcement Learning approach for Traffic Signal Control. *Proceedings of the 2016 IEEE 19th International Conference on Intelligent Transportation Systems (ITSC)*. ▸ Open Paper
5. Gatfor, V., Ghorbanni, H., & Singh, P. (2021). A review on traffic datasets for machine learning applications. *arXiv preprint arXiv:2109.15175*. ▸ Open Paper
6. Every, A., & Wu, F. (2020). T-Intersection: A Reinforcement Learning Environment for Traffic Signal Control. *2020 IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC)*, 1-6. ▸ Open Paper

References (2/2)

7. Hayat, A., G Nadeem, M. F., & Al-Kabbi, M. (2023). A SUMO-based dataset for continuous traffic signal control. *Data in Brief, 48*, 109153. Open Paper
8. Codeca, L., Frank, R., & Engel, T. (2017). Simulating Autonomous and Connected Vehicles with SUMO, Veins, and OMNeT++. *Proceedings of the 3rd OMNeT++ Community Summit*. Open Paper
9. Mo, Y., Li, R., Li, M., Ouyang, Y., & Kay, J. (2022). A review of traffic data collection methods and their applications in intelligent transportation systems. *IET Intelligent Transport Systems, 16*(9), 1145-1165. Open Paper
10. Polyak, B. T. (1964). Some methods of speeding up the convergence of iteration methods. *USSR Computational Mathematics and Mathematical Physics, 4*(5), 1-17. Open Paper

Thank You!

Team SynCity