

**Title:**

Control of Road Traffic Systems: a Multi-Scale Perspective

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**Abstract:**

The impact of successful research in road traffic control spans across various domains, including the scientific, technological, social, and economic spheres. Its significance is profound, as it directly influences safety, quality of life, climate neutrality, energy resource utilization, and transportation costs. However, the development of effective methods and algorithms for road traffic management encounters notable methodological challenges. Traditionally, traffic control strategies have relied on infrastructure-based approaches. Yet, the rapid advancements in automotive technologies, traffic sensors, data processing, and communication have created unprecedented opportunities for the exploitation of connected and automated vehicles (CAVs), offering innovative solutions to longstanding traffic control challenges. This talk will address these challenges and advancements, beginning with an overview of classical traffic control concepts. It will then focus on emerging research trends that exploit the multi-scale nature of traffic systems, from the microscopic scale of the individual CAV to the macroscopic scale of the traffic flow. Furthermore, it will illustrate how these aspects can efficiently coexist within an advanced vehicular traffic control system that optimizes the traffic throughput and mitigates the environmental impact.

**Relevant Publications:**

1. Ferrara, S. Sacone, S. Siri, "Freeway Traffic Modelling and Control", Springer, 2018 (Monography)
2. Silvia Siri, Cecilia Pasquale, Simona Sacone, Antonella Ferrara, "Freeway Traffic Control: a Survey", **Automatica**, Volume 130, August 2021, <https://doi.org/10.1016/j.automatica.2021.109655>.
3. C. Pasquale, S. Sacone, S. Siri and A. Ferrara, "Traffic-Prediction-Based Optimal Control of Electric and Autonomous Buses," **IEEE Control Systems Letters**, vol. 6, pp. 3331-3336, 2022, doi: 10.1109/LCSYS.2022.3184264.
4. Paola Goatin, Chiara Daini, Maria Laura Delle Monache, and Antonella Ferrara, "Interacting moving bottlenecks in traffic flow", Special Issue on "Traffic and Autonomy", **AIMS Networks and Heterogeneous Media**, Volume 18, Issue 2, pp. 930-945, 2023. doi: [10.3934/nhm.2023040](https://doi.org/10.3934/nhm.2023040)
5. A. Ferrara, G. P. Incremona, E. Birliba and P. Goatin, "Multi-Scale Model-Based Hierarchical Control of Freeway Traffic via Platoons of Connected and Automated Vehicles," **IEEE Open Journal of Intelligent Transportation Systems**, vol. 3, pp. 799-812, 2022, doi: 10.1109/OJITS.2022.3217001.
6. C. Pasquale, S. Sacone, S. Siri and A. Ferrara, "Hierarchical Centralized/Decentralized Event-Triggered Control of Multiclass Traffic Networks," in **IEEE Transactions on Control Systems Technology**, vol. 29, no. 4, pp. 1549-1564, July 2021, doi: 10.1109/TCST.2020.3016341.
7. Piacentini G., Incremona G.P., Ferrara A., "A Hierarchical MPC and Sliding Mode Based Two-Level Control for Freeway Traffic Systems with Partial Demand Information", **European Journal of Control**, Volume 59, Pages 152-164, 2021, <https://doi.org/10.1016/j.ejcon.2021.03.007>.
8. G. Piacentini, P. Goatin and A. Ferrara, "Traffic Control Via Platoons of Intelligent Vehicles for Saving Fuel Consumption in Freeway Systems," in **IEEE Control Systems Letters**, vol. 5, no. 2, pp. 593-598, April 2021, doi: 10.1109/LCSYS.2020.3004754

9. Piacentini G., Goatin P., Ferrara A., “A macroscopic model for platooning in highway traffic”, **SIAM Journal on Applied Mathematics**, Volume 80, Issue 1, Pages 639-656, 2020. DOI: 10.1137/19M1292424, URL: <http://epubs.siam.org/toc/smjmap/80/1>
10. Pasquale C., Sacone S., Siri S. and Ferrara A., “Traffic Control for Freeway Networks with Sustainability-Related Objectives: Review and Future Challenges”, **Annual Reviews in Control**, Volume 48, Pages 312-324, 2019. <https://doi.org/10.1016/j.arcontrol.2019.07.002>
11. C. Canudas de Wit and A. Ferrara, “A Variable-Length Cell Transmission Model for Road Traffic Systems”, **Transportation Research Part C: Emerging Technologies**, Vol. 97, Pages 428-455, December 2018, <https://doi.org/10.1016/j.trc.2018.07.023>
12. Antonella Ferrara, Simona Sacone and Silvia Siri, “Design of networked freeway traffic controllers based on event-triggered control concepts”, **International Journal of Robust and Nonlinear Control**, Volume 26, Issue 6, April 2016, Pages 1162–1183, DOI: 10.1002/rnc.3386.
13. Antonella Ferrara, Simona Sacone and Silvia Siri, “Event-triggered model predictive schemes for freeway traffic control”, **Transportation Research Part C: Emerging Technologies**, Volume 58, Part C, September 2015, Pages 554–567, DOI: 10.1016/j.trc.2015.01.020.
14. Antonella Ferrara, Alberto Nai Oleari, Simona Sacone and Silvia Siri, “Freeway Networks as Systems of Systems: A Distributed Model Predictive Control Scheme”, **IEEE Systems Journal**, Vol. 9, nr. 1, pp. 312- 323, March 2015, doi. [10.1109/SYSoSE.2012.6384191](https://doi.org/10.1109/SYSoSE.2012.6384191)
15. Chiara Daini, Paola Goatin, Maria Laura Delle Monache, Antonella Ferrara, “Centralized Traffic Control via Small Fleets of Connected and Automated Vehicles”, (Invited Session paper), Proc. European Control Conference, ECC 2022, London UK, July 2022.
16. Simona Sacone, Cecilia Pasquale, Silvia Siri, Antonella Ferrara “Centralized and Decentralized Schemes for Platoon Control in Freeway Traffic Systems” (Invited Session paper), Proc. IEEE Conference on Decision and Control (CDC), Austin, Texas, virtual, 2021.
17. Carlo Cenedese, Michele Cucuzzella, Antonella Ferrara, John Lygeros, “A Novel Control-Oriented Cell Transmission Model Including Service Stations on Highways”, Proc. IEEE Conference on Decision and Control (CDC), Cancun, Mexico, December 2022.
18. Carlo Cenedese, Michele Cucuzzella, Adriano Cotta Ramusino, Davide Spalenza, John Lygeros, Antonella Ferrara, Optimal service station design for traffic mitigation via genetic algorithm and neural network, Proc. IFAC World Congress 2023, Yokohama, Japan, July 2023.
19. Ayda Kamalifar, Carlo Cenedese, Michele Cucuzzella, Antonella Ferrara, A new control-oriented METANET model to encompass service stations on highways, (Invited Session paper), Proc. 2024 European Control Conference (ECC), Stockholm, Sweden, June 2024.
20. Ayda Kamalifar, Carlo Cenedese, Michele Cucuzzella, Antonella Ferrara, Infrastructure-dependent ramp-metering control for METANET-s, to be presented at the 2024 63rd IEEE Conference on Decision and Control (CDC 2024), (Invited Session paper), Milan, December 16-19, 2024.