



- Aguido Adri. (2024, October 25). Kerugian Ekonomi yang Ditimbulkan dari Kemacetan Lalu Lintas Jakarta Mencapai Rp 71,4 Triliun Per Tahun. *Kompas.Id*.
- Albdairi, M., & Ghazi, A. (2024). Impact of Aggressive HGV Platoons and Human-Driven Heavy Goods Vehicles on Signalized Intersections Performance. *International Journal of Research In Science & Engineering*, 43, 53–67. <https://doi.org/10.55529/ijrise.43.53.67>
- Altamimi, H., Varga, I., & Tettamanti, T. (2023). Urban Platooning Combined with Dynamic Traffic Lights. *Machines*, 11(9), 920. <https://doi.org/10.3390/machines11090920>
- Araghi, S., Khosravi, A., & Creighton, D. (2015). *Distributed Q-learning Controller for a Multi-Intersection Traffic Network* (pp. 337–344). [https://doi.org/10.1007/978-3-319-26532-2\\_37](https://doi.org/10.1007/978-3-319-26532-2_37)
- Arel, I., Liu, C., Urbanik, T., & Kohls, A. G. (2010). Reinforcement learning-based multi-agent system for network traffic signal control. *IET Intelligent Transport Systems*, 4(2), 128–135. <https://doi.org/10.1049/iet-its.2009.0070>
- Asep Yusuf Anshori. (2024, July 30). Gara-gara Macet, Kerugian Ekonomi Kota Bandung Tembus Rp12 Triliun Per Tahun. *Prfmnews.Id*.
- Ault, J., & Guni, S. (2021). Reinforcement learning benchmarks for traffic signal control. *Thirty-Fifth Conference on Neural Information Processing Systems Datasets and Benchmarks Track (Round 1)*.
- Ault, J., Hanna, J. P., & Sharon, G. (2019). *Learning an Interpretable Traffic Signal Control Policy*.
- Bao, J., Wu, C., Lin, Y., Zhong, L., Chen, X., & Yin, R. (2023a). A scalable approach to optimize traffic signal control with federated reinforcement learning. *Scientific Reports*, 13(1). <https://doi.org/10.1038/s41598-023-46074-3>
- Bao, J., Wu, C., Lin, Y., Zhong, L., Chen, X., & Yin, R. (2023b). A scalable approach to optimize traffic signal control with federated reinforcement learning. *Scientific Reports*, 13(1). <https://doi.org/10.1038/s41598-023-46074-3>
- Belal Natafqi, M., Osman, M., Sleiman Haidar, A., & Hamandi, L. (n.d.). *Smart Traffic Light System Using Machine Learning*.
- Bie, Y., & Qiu, T. Z. (2021). Connected Vehicle-Cooperative Adaptive Cruise Control Algorithm to Divide and Reform Connected Vehicle Platoons at Signalized Intersections to Improve Traffic Throughput and Safety. *Transportation Research Record: Journal of the Transportation Research Board*, 2675(9), 995–1005. <https://doi.org/10.1177/03611981211005456>
- Cai, C., & Wei, M. (2024). Adaptive urban traffic signal control based on enhanced deep reinforcement learning. *Scientific Reports*, 14(1), 14116. <https://doi.org/10.1038/s41598-024-64885-w>
- Calvert, S. C., Schakel, W. J., & van Arem, B. (2019). Evaluation and modelling of the traffic flow effects of truck platooning. *Transportation Research Part C: Emerging Technologies*, 105, 1–22. <https://doi.org/10.1016/j.trc.2019.05.019>
- Calvo, J. A., & Dusparic, I. (2018). *Heterogeneous Multi-Agent Deep Reinforcement Learning for Traffic Lights Control*.
- Casas, N. (2017). *Deep Deterministic Policy Gradient for Urban Traffic Light Control*.
- Chen, C., Wang, J., Xu, Q., Wang, J., & Li, K. (2020). *Mixed platoon control of automated and human-driven vehicles at a signalized intersection: dynamical analysis and optimal control*. <http://arxiv.org/abs/2010.16105>
- Choe, C.-J., Baek, S., Woon, B., & Kong, S.-H. (n.d.). *Deep Q Learning with LSTM for Traffic Light Control*.
- Chowdhury, T., Park, P. Y., & Gingerich, K. (2023). Operational Impact of the Through-Traffic Signal Prioritization for Heavy Commercial Vehicle Platooning on Urban

- Arterials. *Transportation Research Record: Journal of the Transportation Research Board*, 2677(2), 62–77. <https://doi.org/10.1177/03611981221127287>
- Chu, T., Wang, J., Codeca, L., & Li, Z. (2020). Multi-agent deep reinforcement learning for large-scale traffic signal control. *IEEE Transactions on Intelligent Transportation Systems*, 21(3), 1086–1095. <https://doi.org/10.1109/TITS.2019.2901791>
- Coskun, M., Baggag, A., & Chawla, S. (2018). Deep Reinforcement Learning for Traffic Light Optimization. *2018 IEEE International Conference on Data Mining Workshops (ICDMW)*, 564–571. <https://doi.org/10.1109/ICDMW.2018.00088>
- de Curtò, J., de Zarzà, I., Cano, J. C., Manzoni, P., & Calafate, C. T. (2023). Adaptive Truck Platooning with Drones: A Decentralized Approach for Highway Monitoring. *Electronics*, 12(24), 4913. <https://doi.org/10.3390/electronics12244913>
- Deng, Z., Yang, K., Shen, W., & Shi, Y. (2023). Cooperative Platoon Formation of Connected and Autonomous Vehicles: Toward Efficient Merging Coordination at Unsignalized Intersections. *IEEE Transactions on Intelligent Transportation Systems*, 24(5), 5625–5639. <https://doi.org/10.1109/TITS.2023.3235774>
- Faber, T., Sharma, S., Snelder, M., Klunder, G., Tavasszy, L., & van Lint, H. (2020). Evaluating Traffic Efficiency and Safety by Varying Truck Platoon Characteristics in a Critical Traffic Situation. *Transportation Research Record: Journal of the Transportation Research Board*, 2674(10), 525–547. <https://doi.org/10.1177/0361198120935443>
- Fakhfakh, F., Tounsi, M., & Mosbah, M. (2020). Vehicle Platooning Systems: Review, Classification and Validation Strategies. *International Journal of Networked and Distributed Computing*, 8(4), 203. <https://doi.org/10.2991/ijndc.k.200829.001>
- Fattah, Md. A., Morshed, S. R., & Kafy, A.-A. (2022). Insights into the socio-economic impacts of traffic congestion in the port and industrial areas of Chittagong city, Bangladesh. *Transportation Engineering*, 9, 100122. <https://doi.org/10.1016/j.treng.2022.100122>
- Feng, L., Zhao, X., Chen, Z., & Song, L. (2024). An adaptive coupled control method based on vehicles platooning for intersection controller and vehicle trajectories in mixed traffic. *IET Intelligent Transport Systems*, 18(8), 1459–1476. <https://doi.org/10.1049/itr2.12523>
- Foerster, J., Nardelli, N., Farquhar, G., Afouras, T., Torr, P. H. S., Kohli, P., & Whiteson, S. (2017). Stabilising experience replay for deep multi-agent reinforcement learning. *ArXiv*.
- Gao, J., Shen, Y., Liu, J., Ito, M., & Shiratori, N. (2017). *Adaptive Traffic Signal Control: Deep Reinforcement Learning Algorithm with Experience Replay and Target Network*.
- Gao, W., Shi, Y., & Chen, S. (2019). Scalable Platooning Based on Directed Information Flow Topology With Granulating Method. *IEEE Access*, 7, 176634–176645. <https://doi.org/10.1109/ACCESS.2019.2958314>
- Garg, D., Chli, M., & Vogiatzis, G. (2018). Deep Reinforcement Learning for Autonomous Traffic Light Control. *2018 3rd IEEE International Conference on Intelligent Transportation Engineering (ICITE)*, 214–218. <https://doi.org/10.1109/ICITE.2018.8492537>
- Ge, H., Song, Y., Wu, C., Ren, J., & Tan, G. (2019). Cooperative deep Q-learning with Q-value transfer for multi-intersection signal control. *IEEE Access*, 7, 40797–40809. <https://doi.org/10.1109/ACCESS.2019.2907618>
- Genders, W., & Razavi, S. (2018). Evaluating reinforcement learning state representations for adaptive traffic signal control. *Procedia Computer Science*, 130, 26–33. <https://doi.org/10.1016/j.procs.2018.04.008>



- Genders, W., & Razavi, S. (2019a). *An Open-Source Framework for Adaptive Traffic Signal Control*. <http://arxiv.org/abs/1909.00395>
- Genders, W., & Razavi, S. (2019b). Asynchronous n-step Q-learning adaptive traffic signal control. *Journal of Intelligent Transportation Systems*, 23(4), 319–331. <https://doi.org/10.1080/15472450.2018.1491003>
- German Aerospace Center (DLR). (2025, April). *Trip in SUMO*. SUMO - DOC.
- Gershenson, C., & Rosenblueth, D. A. (2012). Adaptive self-organization vs static optimization. *Kybernetes*, 41(3/4), 386–403. <https://doi.org/10.1108/03684921211229479>
- Jang, I., Kim, D., Lee, D., & Son, Y. (2018). An Agent-Based Simulation Modeling with Deep Reinforcement Learning for Smart Traffic Signal Control. *2018 International Conference on Information and Communication Technology Convergence (ICTC)*, 1028–1030. <https://doi.org/10.1109/ICTC.2018.8539377>
- Jayashree, R., P, D. S., S, R., R, R., & N, P. K. (2022). A Study on The Impact of Road Traffic Congestion at Vadapalani-Chennai. *2022 IEEE Conference on Interdisciplinary Approaches in Technology and Management for Social Innovation (IATMSI)*, 1–6. <https://doi.org/10.1109/IATMSI56455.2022.10119455>
- Jin, L., Čičić, M., Amin, S., & Johansson, K. H. (2018). Modeling the Impact of Vehicle Platooning on Highway Congestion. *Proceedings of the 21st International Conference on Hybrid Systems: Computation and Control (Part of CPS Week)*, 237–246. <https://doi.org/10.1145/3178126.3178146>
- Junaidi, D. R., Ma, M., & Su, R. (2022). Secure Vehicular Platoon Management against Sybil Attacks. *Sensors*, 22(22), 9000. <https://doi.org/10.3390/s22229000>
- Kasi, K., & Karuppanan, G. (2024). Framework to Identify Vehicle Platoons under Heterogeneous Traffic Conditions on Urban Roads. *Sustainability*, 16(2), 724. <https://doi.org/10.3390/su16020724>
- Lee, S., Oh, C., & Lee, G. (2021). Impact of Automated Truck Platooning on the Performance of Freeway Mixed Traffic Flow. *Journal of Advanced Transportation*, 2021, 1–13. <https://doi.org/10.1155/2021/8888930>
- Li, D., Wu, J., Zhu, F., Chen, T., & Wong, Y. D. (2023). Modeling adaptive platoon and reservation-based intersection control for connected and autonomous vehicles employing deep reinforcement learning. *Computer-Aided Civil and Infrastructure Engineering*, 38(10), 1346–1364. <https://doi.org/10.1111/mice.12956>
- Li, L., Member, S., Lv, Y., & Wang, F.-Y. (2016). *Traffic Signal Timing via Deep Reinforcement Learning* (Vol. 3, Issue 3). <http://ieeexplore.ieee.org>.
- Liang, X., Du, X., Wang, G., & Han, Z. (2019a). A Deep Reinforcement Learning Network for Traffic Light Cycle Control. *IEEE Transactions on Vehicular Technology*, 68(2), 1243–1253. <https://doi.org/10.1109/TVT.2018.2890726>
- Liang, X., Du, X., Wang, G., & Han, Z. (2019b). A Deep Reinforcement Learning Network for Traffic Light Cycle Control. *IEEE Transactions on Vehicular Technology*, 68(2), 1243–1253. <https://doi.org/10.1109/TVT.2018.2890726>
- Lin, Y., Dai, X., Li, L., & Wang, F.-Y. (2018). *An Efficient Deep Reinforcement Learning Model for Urban Traffic Control*.
- Liu, H., Lu, X.-Y., & Shladover, S. E. (2019). Traffic signal control by leveraging Cooperative Adaptive Cruise Control (CACC) vehicle platooning capabilities. *Transportation Research Part C: Emerging Technologies*, 104, 390–407. <https://doi.org/10.1016/j.trc.2019.05.027>
- Liu, X.-Y., Ding, Z., Borst, S., & Walid, A. (2018). *Deep Reinforcement Learning for Intelligent Transportation Systems*. <http://arxiv.org/abs/1812.00979>



- Luo, H., Bie, Y., & Jin, S. (2024). Reinforcement Learning for Traffic Signal Control in Hybrid Action Space. *IEEE Transactions on Intelligent Transportation Systems*, 25(6), 5225–5241. <https://doi.org/10.1109/TITS.2023.3344585>
- Marshall, W. E., & Dumbaugh, E. (2020). Revisiting the relationship between traffic congestion and the economy: a longitudinal examination of U.S. metropolitan areas. *Transportation*, 47(1), 275–314. <https://doi.org/10.1007/s11116-018-9884-5>
- Matowicki, M., & Pribyl, O. (2023). On quantification of traffic congestion impacts on socio-economic aspects in cities. *2023 Smart City Symposium Prague (SCSP)*, 1–6. <https://doi.org/10.1109/SCSP58044.2023.10146238>
- Mnih, V., Kavukcuoglu, K., Silver, D., Rusu, A. A., Veness, J., Bellemare, M. G., Graves, A., Riedmiller, M., Fidjeland, A. K., Ostrovski, G., Petersen, S., Beattie, C., Sadik, A., Antonoglou, I., King, H., Kumaran, D., Wierstra, D., Legg, S., & Hassabis, D. (2015). Human-level control through deep reinforcement learning. *Nature*, 518(7540), 529–533. <https://doi.org/10.1038/nature14236>
- Mnih, V., Puigdomènech Badia, A., Mirza, M., Graves, A., Harley, T., Lillicrap, T. P., Silver, D., & Kavukcuoglu, K. (2016). *Asynchronous Methods for Deep Reinforcement Learning*.
- Mousavi, S. S., Schukat, M., & Howley, E. (2017). Traffic light control using deep policy-gradient and value-function-based reinforcement learning. *IET Intelligent Transport Systems*, 11(7), 417–423. <https://doi.org/10.1049/iet-its.2017.0153>
- Moyano, A., Stepniak, M., Moya-Gómez, B., & García-Palomares, J. C. (2021). Traffic congestion and economic context: changes of spatiotemporal patterns of traffic travel times during crisis and post-crisis periods. *Transportation*, 48(6), 3301–3324. <https://doi.org/10.1007/s11116-021-10170-y>
- Müller, A., & Sabatelli, M. (2022). *Safe and Psychologically Pleasant Traffic Signal Control with Reinforcement Learning using Action Masking*.
- Nishi, T., Otaki, K., Hayakawa, K., & Yoshimura, T. (2018). Traffic Signal Control Based on Reinforcement Learning with Graph Convolutional Neural Nets. *2018 21st International Conference on Intelligent Transportation Systems (ITSC)*, 877–883. <https://doi.org/10.1109/ITSC.2018.8569301>
- Onyeneke, C. (2018). Modeling the Effects of Traffic Congestion on Economic Activities - Accidents, Fatalities and Casualties. *Biomedical Statistics and Informatics*, 3(2), 7. <https://doi.org/10.11648/j.bsi.20180302.11>
- Park, S., Han, E., Park, S., Jeong, H., & Yun, I. (2021). Deep Q-network-based traffic signal control models. *PLOS ONE*, 16(9), e0256405. <https://doi.org/10.1371/journal.pone.0256405>
- Pedoman Kapasitas Jalan Indonesia (2023).
- Putri, A., Joelianto, E., & Sutarto, H. Y. (2023). On Max Pressure Urban Traffic Control with Learning. *2023 IEEE 9th Information Technology International Seminar (ITIS)*, 1–6. <https://doi.org/10.1109/ITIS59651.2023.10420295>
- Qi, L., Sun, Y., & Luan, W. (2024). Large-Scale Traffic Signal Control Based on Multi-Agent Q-Learning and Pressure. *IEEE Access*, 12, 1092–1101. <https://doi.org/10.1109/ACCESS.2023.3345343>
- Schulman, J., Levine, S., Moritz, P., Jordan, M. I., & Abbeel, P. (2015). *Trust Region Policy Optimization*.
- Schulman, J., Moritz, P., Levine, S., Jordan, M., & Abbeel, P. (2015). *High-Dimensional Continuous Control Using Generalized Advantage Estimation*.
- Schulman, J., Wolski, F., Dhariwal, P., Radford, A., & Klimov, O. (2017). *Proximal Policy Optimization Algorithms*.



- Sethi, S. (2024). AI Reinforcement Learning Traffic System Implementations and Limitations. *International Journal of High School Research*.  
<https://doi.org/10.36838/v6i4.16>
- Sethuraman, G., Liu, X., Bachmann, F. R., Xie, M., Ongel, A., & Busch, F. (2019). Effects of Bus Platooning in an Urban Environment. *2019 IEEE Intelligent Transportation Systems Conference (ITSC)*, 974–980. <https://doi.org/10.1109/ITSC.2019.8917041>
- Shabestary, S. M. A., & Abdulhai, B. (2018). *2018 IEEE Intelligent Transportation Systems Conference : November 4-7, Maui, Hawaii*. IEEE.  
<https://doi.org/10.1109/ITSC.2018.8569549>
- Smith, S. W., Kim, Y., Guanetti, J., Li, R., Firoozi, R., Wootton, B., Kurzhanskiy, A. A., Borrelli, F., Horowitz, R., & Arcaç, M. (2020). Improving Urban Traffic Throughput With Vehicle Platooning: Theory and Experiments. *IEEE Access*, 8, 141208–141223.  
<https://doi.org/10.1109/ACCESS.2020.3012618>
- Sutton, R. S., & Barto, A. G. (2018). *Reinforcement Learning: An Introduction*. A Bradford Book.
- Tan, T., Bao, F., Deng, Y., Jin, A., Dai, Q., & Wang, J. (2020). Cooperative Deep Reinforcement Learning for Large-Scale Traffic Grid Signal Control. *IEEE Transactions on Cybernetics*, 50(6), 2687–2700.  
<https://doi.org/10.1109/TCYB.2019.2904742>
- TomTom International BV. (2024). <https://www.tomtom.com/traffic-index/indonesia-country-traffic/>. Tomtom International Traffic Index.
- Van Der Pol, E., & Oliehoek, F. A. (2016). *Coordinated Deep Reinforcement Learners for Traffic Light Control*.
- Van Hasselt, H., Guez, A., & Silver, D. (2016). Deep Reinforcement Learning with Double Q-Learning. *Proceedings of the AAAI Conference on Artificial Intelligence*, 30(1).  
<https://doi.org/10.1609/aaai.v30i1.10295>
- Wan, C. H., & Hwang, M. C. (2018). Value-based deep reinforcement learning for adaptive isolated intersection signal control. *IET Intelligent Transport Systems*, 12(9), 1005–1010. <https://doi.org/10.1049/iet-its.2018.5170>
- Wang, L., Ma, Z., Dong, C., & Wang, H. (2023). Human-centric multimodal deep (HMD) traffic signal control. *IET Intelligent Transport Systems*, 17(4), 744–753.  
<https://doi.org/10.1049/itr2.12300>
- Wei, H., Zheng, G., Yao, H., & Li, Z. (2018). IntelliLight: A Reinforcement Learning Approach for Intelligent Traffic Light Control. *Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*, 2496–2505.  
<https://doi.org/10.1145/3219819.3220096>
- Wen, Q., & Hu, B.-J. (2021). Integrated Communication and Control Design for Fuel-Efficient Vehicle Platooning. *Electronics*, 10(24), 3117.  
<https://doi.org/10.3390/electronics10243117>
- Xu, M., Wu, J., Huang, L., Zhou, R., Wang, T., & Hu, D. (2020). Network-wide traffic signal control based on the discovery of critical nodes and deep reinforcement learning. *Journal of Intelligent Transportation Systems*, 24(1), 1–10.  
<https://doi.org/10.1080/15472450.2018.1527694>
- Xu, N., Zheng, G., Xu, K., Zhu, Y., & Li, Z. (2019). Targeted Knowledge Transfer for Learning Traffic Signal Plans. In *Lecture Notes in Computer Science()* (Vol. 11440, pp. 175–187). Springer Nature. [https://doi.org/10.1007/978-3-030-16145-3\\_14](https://doi.org/10.1007/978-3-030-16145-3_14)
- Yan, T., Zuo, L., Yan, M., & Zhang, J. (2023). A Deep Reinforcement Learning-Based Cooperative Traffic Signal System Through Dual-Sensing Max Pressure Control. *2023 9th International Conference on Mechanical and Electronics Engineering (ICMEE)*, 258–264. <https://doi.org/10.1109/ICMEE59781.2023.10525376>



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UNTUK KENDALI ALAT PEMBERI  
ISYARAT LAMPU LALU LINTAS CERDAS**

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- Yau, K. L. A., Qadir, J., Khoo, H. L., Ling, M. H., & Komisarczuk, P. (2017). A survey on Reinforcement learning models and algorithms for traffic signal control. In *ACM Computing Surveys* (Vol. 50, Issue 3). Association for Computing Machinery. <https://doi.org/10.1145/3068287>
- Zhang, R., Ishikawa, A., Wang, W., Striner, B., & Tonguz, O. K. (2021). Using Reinforcement Learning With Partial Vehicle Detection for Intelligent Traffic Signal Control. *IEEE Transactions on Intelligent Transportation Systems*, 22(1), 404–415. <https://doi.org/10.1109/TITS.2019.2958859>
- Zubillaga, D., Cruz, G., Aguilar, L., Zapotécatl, J., Fernández, N., Aguilar, J., Rosenblueth, D., & Gershenson, C. (2014). Measuring the Complexity of Self-Organizing Traffic Lights. *Entropy*, 16(5), 2384–2407. <https://doi.org/10.3390/e16052384>