Multi-agent Systems Project Report: Traffic Simulation based on Real-Time Information

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Abstract

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Contents

1 Introduction

Traditionally, real-time information (RTI) was used by transit providers for operation and control. In today's age of always-on telecommunication devices and sensor input of an armada of connected input devices through the "Internet of Things" (IoT) movement, this information is also increasingly utilized by travellers themselves for route planning. This includes car routes as well as coordinating public transport timetables or available ride-sharing resources.

In this work, we will simulate, display and analyze the dynamic movement and interaction of travelling & planning agents within a traffic coordination setting.

To this end, a multi-agent system (MAS) is implemented which takes formal network graphs and specific user input regarding the simulation scale to then simulate a continuously spawning group of car-agents traversing the network with the goal to arrive at an assigned location as fast as possible. An internal coordination unit in the form of a planner-agent distributes route information according to the type of agent it is being queried from. The architecture setup is based on propositions from provided sources ([Mastio et al., 2015], [Brakewood and Watkins, 2018]). Random events altering the state of the network take place to simulate traffic incidents and to provoke agents to deviate from initial plans.

Having run the simulation and persisted the simulation run in respective log-files, a web-based frontend implementation reads network- and log-files to visualize the network graph and temporal agent-behavior. The visualization allows for selection of graph and run-data and displays the read and interpreted data. This should allow the observer to understand the car-agent's behavior and make numeric analysis results more visually interpretable.

This report is structured as follows: Following this introductory description of context and task, section 2 will inspect related work surrounding the field of RTI traffic simulation and derived research and system implementation propositions. These are then being put into application context in section 3 where the implemented MAS and respective architectural constraints are outlined. Next, section 4 continues to describe the frontend visualization and transitions into the traffic performance analysis in form of agent arrival-time metrics being is read from persisted system logs and put into perspective within this report's section 5. Finally, section 6 presents the findings and concludes this project's report.

2 Related Work

Simulating development of traffic is a well-traversed research topic regarding scheduling and network traversal simulation problems. Throughout application, dedicated simulators have been applied frequently and early-on like the popular "Multi-agent Transport Simulator" (MATSim) [Sezen, 2003] or "Repast Simphony" [Zargayouna et al., 2013] alongside dedicated extensions like the Symphony-based "SM4T Simnulator" [Ksontini et al., 2016]. Such applications provide advantages like automated timetables for public transport, advanced types of travelling agent and unified logging formats for simulation runs. Resorting to holistic solutions like the above mentioned is especially useful for non-technological research regarding behavioral analysis or city planning [Brakewood and Watkins, 2018]. If the multi-agent system aspects are predominant though (as is the case in this work), adapting similar implementation structures whilst doing the actual agent implementation work (done here) proves beneficial.

In contrast to fully incorporated applications, some approaches in literature already shift focus towards surrounding aspects surrounding of traffic simulation, like focusing on the distributing simulation [Mastio et al., 2015].

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3 MAS Traffic Simulator Backend

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4 Web-based Simulation Frontend

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5 Agent Performance Analysis

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6 Conclusion

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References

[Brakewood and Watkins, 2018] Brakewood, C. and Watkins, K. (2018). A literature review of the passenger benefits of real-time transit information. *Transport Reviews*, pages 1–30.

[Ksontini et al., 2016] Ksontini, F., Zargayouna, M., Scemama, G., and Leroy, B. (2016). Building a realistic data environment for multiagent mobility simulation. In *Agent and Multi-Agent Systems: Technology and Applications*, pages 57–67. Springer.

[Mastio et al., 2015] Mastio, M., Zargayouna, M., and Rana, O. (2015). Towards a distributed multiagent travel simulation. In *Agent and Multi-Agent Systems: Technologies and Applications*, pages 15–25. Springer.

[Sezen, 2003] Sezen, B. (2003). Modeling automated guided vehicle systems in material handling.

[Zargayouna et al., 2013] Zargayouna, M., Zeddini, B., Scemama, G., and Othman, A. (2013). Agent-based simulator for travelers multimodal mobility. In *KES-AMSTA*, pages 81–90. Citeseer.