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Agents in Traffic and Transportation (ATT 2022): Revised and Extended Papers

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Societal impact has become one of the established factors for the evaluation of scientific research, and it is basically the common element shared by the *Sustainable Development Goals* defined by the United Nations.[1] *Sustainable transport* is considered a crucial element of Goal 11 on *Sustainable Cities and Communities*, although it also has apparent implications and relationships with Goal 9 on *Industry, Innovation and Infrastructure*. In a reality where urbanization has led to over 4 billion people residing in urban areas,[2] it becomes evident why the application of Artificial Intelligence (AI) to traffic and transportation stands out as one of the most impactful domains, significantly influencing the daily lives of the majority of humanity. From research challenges that have always been present at the same time in the most widely adopted AI textbook [7] and in the popular culture such as AI based autonomous driving systems, to probably less popular (but already at the level of technology transfer) approaches to logistic planning and optimization, traffic control, and many more cases, AI has already delivered significant results and it represents a promising approach for many open problems in traffic and transportation.

Due to the intrinsically distributed nature of the studied phenomena, taking place at different scales in space and time, and sometimes involving the coordinated efforts of distinct autonomous entities carrying out different functions, Distributed Artificial Intelligence has always represented a natural approach to most of the traffic and transportation problems [2]. Transportation may be seen as a large composition of subsystems (and interacting with other systems that do not deal with transportation), influencing one another, often in a non trivial way, but still preserving a high degree of autonomy. The understanding, design, effective management of overall transportation systems depends on the ability to understand, design, and coordinate its subsystems. This often represents an interdisciplinary challenge since we are not just dealing with large scale, dynamic systems, but also with the fact that the overall settings is quite complex [3], thus being characterized by a variety of players (users, authorities, etc.), possibly with conflicting goals and constraints within the overall system.

This Special Issue presents a selection of innovative and novel solutions, mostly related to traffic management, taken from different perspectives. These range from machine learning and data-driven approaches for extraction of relevant information (e.g., video footage for the characterization of traffic scenarios), to reinforcement learning approaches (e.g., for intelligent traffic signal control, and for dealing with routing of connected and autonomous vehicles), also including optimization approaches for vehicle routing, which consider fairness along with other efficiency measures.

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[1] https://sdgs.un.org/
[2] https://ourworldindata.org/urbanization

The contributions included in the present collection are revised and extended articles that were presented at the 12th International Workshop on Agents in Traffic and Transportation (ATT 2022) held in conjunction with the IJCAI-ECAI 2022, the 31st International Joint Conference on Artificial Intelligence, in Vienna (Austria) on July 25th, 2022. The workshop, as well as the conference in which it took place, was held in presence, and it has seen a very active and lively participation by speakers and an audience that were very happy to meet in person after the long restrictions imposed by the COVID19 pandemic.

ATT 2022 continued thus a long success story of the eleven previous editions:[3] ATT 2020 [5], held in conjunction with the 24th European Conference on Artificial Intelligence in a virtual form (a selection of revised and extended papers was published as a special issue in this journal [6]); ATT 2018 [1], held in Stockholm, Sweden together with ECAI/IJCAI, AAMAS and ICML conferences (FAIM 2018); ATT 2016 [4], held in New York, the USA, in conjunction with IJCAI 2016; ATT 2014, held in Paris, France, in conjunction with AAMAS 2014;[4] ATT 2012,[5] held in Valencia, Spain 2012, in conjunction with AAMAS 2012 (a selection of revised and extended papers was published as a special issue [8]); ATT 2010, held in Toronto, Canada, co-located with AAMAS 2010; ATT 2008, held in Estoril, Portugal, co-located with AAMAS 2008 [7]; ATT 2006, held in Hakodate, Japan, co-located with AAMAS 2006; ATT 2004, held in New York, the USA, co-located with AAMAS 2004; ATT 2001, held in Sydney, Australia, co-located with ITS 2001 – Intelligent Transportation Systems Conference; and ATT 2000, held in Barcelona, Spain, co-located with the 4th International Conference on Autonomous Agents – Agents 00.

Just as the preceding eleven workshops, also ATT 2022 engaged well reputed and emerging researchers from around the world from various areas of multi-agent systems, agent technologies, and AI in general that exchanged novel ideas, techniques, results, and open questions regarding scientific advancements in the design, implementation, and verification of next-generation agents in traffic and transportation. This special issue provides a wide view that shows the synergies between these areas and opens the possibility to tackle current traffic and transportation challenges in a successful advance in the current state of the art.

In the following, we give a short overview of the papers contained in the special issue.

The contribution by Vitor A. Fraga, Lincoln V. Schreiber, Marco Antonio C. da Silva, Rafael Kunst, Jorge L. V. Barbosa, Gabriel de O. Ramos, in the paper title "A machine learning pipeline for extracting decision-support features from traffic scenes", describes a modern deep learning based tool able to identify and track vehicles from traffic scenes (intersections, in particular), combined with an origin-destination identification algorithm able to propose the typically expected data structure describing the traffic demand. The overall pipeline, its internal structure, training, testing and evaluation procedures are presented and compared to the state-of-the-art.

Bharathkumar Hegde and Mélanie Bouroche, in their work titled "Multi-agent Reinforcement Learning for safe lane changes by connected and autonomous vehicles: A survey", discuss a particular task among those carried out by Connected Autonomous vehicles (CAVs) to improve the safety and efficiency of traffic by automating driving tasks. In particular, they discuss the relevance and difficulty of the task, then discuss reinforcement learning and multi-agent reinforcement learning applications to the problem, analyzing the state-of-the-art as well as research gaps and possible opportunities.

The paper titled "How to achieve fair and efficient cooperative vehicle routing?", authored by Aitor López Sánchez, Marin Lujak, Frederic Semet, Holger Billhardt, discusses issues arising when considering the dimension of *fairness* along with the traditional efficiency when facing a vehicle routing problem. In particular, the application context is related to agricultural mobile robots organized in cooperatives (particular business entities providing services to its members, who both own and exercise democratic control over the cooperative they are member of), whereas fairness refers to how their individual gain aligns with the gain of others.

Ana Lucia C. Bazzan, Vicente N. de Almeida, and Monireh Abdoos, in the paper titled "Transferring experiences in k-nearest neighbors based multiagent Reinforcement Learning: an application to traffic signal control", discuss adaptive control of traffic signals within a multiagent setting. Agents learn independently via a learning algorithm based on estimating Q-values from k-nearest neighbors, and they transfer relevant experiences, so as to avoid situations in which an agent lacks good experiences for taking a certain decision.

[3] http://www.ia.urjc.es/ATT/

[4] Proceedings available online: http://agents.fel.cvut.cz/att2014/.

[5] Proceedings available online: http://www.ia.urjc.es/att2012/.

In short, the scope of this special issue is to present a selection of very different results on how real-world complex transportation systems can be modelled, simulated, controlled and managed, employing and combining a wide array of AI-based techniques. We believe this selection will be of interest to researchers active in this field and beyond, and we certainly look forward to continuing our organizational effort to provide a venue for discussion on research and developments in the area of autonomous agents, multi-agent systems, and AI researches in general, applied to the context of traffic and transportation.

Acknowledgements

The ATT2022 workshop was held at the end of July 2022. The shared work to create this special issue started in the fall of 2022. It is always a journey to carry out this kind of collective enterprise, and of course the production of this collection of revised and extended works would not have been possible without the effort and commitment of authors and reviewers. Therefore, we want to thank all the authors and reviewers for their participation in this process with professionalism and commitment. Moreover, this special issue would not be possible without support from a highly committed Scientific Review Committee for the ATT 2022 workshop, composed of 34 researchers based in the EU, USA, Australia, Brazil, Japan, and India. We want to give special thanks to all peer reviewers for their considerable effort to provide high quality suggestions and detailed feedback. Sincere thanks also to highly responsive AI Communications Editors-in-Chief and the staff of AI Communications for their professional support.

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