Guest Editorial
Special Issue on Artificial Transportation Systems and Simulation

INTELLIGENT Transportation Systems (ITS) has evolved a great deal within the last three decades; there is no doubt about that! Industry has now engaged as an active partner and great promoter of ITS' technological development. Governments all over the world are now prioritizing mobility as a key ingredient of their social and economical growth and policies. Indeed, sustainable transport systems have to be cost-effective, provide adequate and equal access for all, and reduce the environmental footprint compared with more conservative transport solutions. This implies changing the paradigm and requires enormous amounts of investments in infrastructure, as well as sophisticated organizations that know how to operate infrastructure and services.

It is quite acceptable that part of such a challenge is technological, and another considerable responsibility lies upon institutional, organizational, and financial aspects. However, and in spite of the great development in computer and communication technologies, future transport requirements stir up even more challenging issues, allowing for social and environmental aspects of urban systems where users, as well as their preferences, are a central concern. Moreover, users' interactions with ITS solutions have evolved into something different. As technology is now able to behave rather more intelligently than before, it transforms services into peers of users as they perceive, make decisions, and reason about the results of their actions, all the while seeking to benefit all parties. In fact, rather than increasing service capacity, one underlying approach of ITS-based solutions nowadays is to ensure productivity and mobility by making better use of existing infrastructure and services, furnishing them with smarter, greener, safer, and more efficient technologies.

The intrinsically complex and dynamic nature of a not-so-futuristic scenario is ever more evident nowadays and demands appropriate methodologies, tools, and means to design, test, and validate ITS-based technologies. Such a desirable setting gave rise to the concept of Artificial Transportation Systems (ATS), which extends the aim and purpose of traditional simulation techniques as they have historically been applied within transport engineering. Such a concept has initially been introduced by Prof. Fei-Yue Wang [1], [2] to offer an integrated emulation with real-time traffic information to support certain traffic decision-making. With the ability to integrate different transportation models and solutions in a virtual environment, ATS serve as an aid to support decisions made by engineers and practitioners in a controlled and safe manner. They also provide a natural ground where new approaches can be experimented upon while avoiding the natural drawbacks of dealing directly with real critical domains, such as ITS. Built on the theories and methodologies developed in a wide spectrum of disciplines, including social sciences, artificial intelligence and multi-agent systems, distributed computing, and virtual reality, many important issues arise in the ATS approach which challenge and motivate researchers and practitioners from multidisciplinary technical and scientific communities.

Given its ability to effectively address and assess innovations within ITS, the area of Artificial Transportation Systems and Simulation (ATSS) has gained great interest from the IEEE ITS Society, being awarded the creation of a Technical Activities Committee on its own right. The ATSS technical committee has since motivated and promoted the ATSS field, within the IEEE ITSS as well as other technical and scientific communities, both within and outside of the IEEE. As part of this effort, a successful series of biennial workshops has been organized by this committee and integrated the scientific programs of the IEEE ITS Annual Conferences, whose first edition was held in Shanghai, China, in 2004, followed by the editions held in Toronto, ON, Canada (2006); Beijing, China (2008); and Madeira, Portugal (2010). Besides the workshop series, a Special Session on ATSS was organized within the 2007 edition of the IEEE ITS Annual Conference, held in Seattle, WA, USA. These events have rapidly gained an international prominence and been established as the main forum for discussions on ATSS issues.

Almost a decade after the term was first coined, this Special Issue of the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS brings to the readers a collection of papers reporting the main advances and trends on ATS. These papers were selected among works presented during the 2007 Special Session and the 2008 Workshop on ATSS, as well as among other invited contributions submitted to the TRANSACTIONS. The main issues herein addressed can be divided into three major categories: modeling issues and metaphors for ATS models, architectures for ATS, and practical applications of ATS. Below, we briefly present this Special Issue's contributions, placing them in each of these three main groups.

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There is a quite commonsense approach that preaches multi-agent systems as the main metaphor for ATS modeling. In ATS, in fact, complicated behaviors are expected to grow and emerge from simpler, albeit autonomous, entities that are geographically and functionally distributed throughout the system, cohabitating a common environment and able to show different social interactions. Vasirani and Ossowsky introduce an economic theory of the competitive computational market to transportation management and develop an online and distributed strategy to effectively solve the urban network design problem as a computational market, whereby the urban traffic planners trade the right to use the city's road network with drivers. The authors demonstrate the flexibility in the computation market formulation method to represent different control strategies and the advantage of the distributed control system in solving an NP-hard network design problem. Li and colleagues explore the concept of the emergent behavior of a system formed by simple entities whose behavior follows a rule-based approach. In their contribution, a rule-based iterative design process is presented, which is illustrated with an implementation of a multi-agent system in the Swarm platform. The authors display the ability of ATS to generate complex traffic phenomena from simple consensus rules, while a practical testing experiment can be easily prototyped with readily available multi-agent simulation platforms. In addition to the first two examples, Fernández and Ossowski look at the interactions of service providers and transport users and combine the concepts of multi-agent systems and service-oriented architecture as modeling metaphors to devise decision support systems specially tailored to support organizational models. Service providers are then dealt with as peers of users: a situation in which all aspects related to their interactions are represented and detailed in the proposed modeling approach. Agent organizations and transport services are combined to feature their ITS model of service management with on-the-fly adaptation, fault tolerance, and extensibility characteristics, and the model is illustrated with two scenarios in the transportation domain, namely, road traffic and bus fleet management.

For the architect behind the ATS concept, one feature is of major relevance, that is, the interaction between simulated scenarios and reality introduced by an in-the-loop emulation of real-time traffic information to support strategic decision-making of different sorts. Miao and colleagues introduce a game-engine-based modeling and computing platform for the creation of ATS. Among the major components of their system, emphasis is given to the artificial population module that is able to generate synthetic populations, taking into account their macroscopic and microscopic aspects. The platform is agent-oriented, modular, and distributed, allowing for mobile actors to be designed as actors in digital games. Features for the rapid prototyping of 3-D simulated environments are also implemented, while the authors illustrate the applicability of their platform in four experimental scenarios. The paper by Punzo and Ciuffo addresses an important issue in the use of driving simulators (DS) to study driver behavior under ITS: for the DS works with pre-defined traffic scenes which need to realistically represent the surrounding vehicles' response to the subject vehicle controlled by the ITS system under analysis whose driving behavior is unknown and is the subject of the study. The authors tackle this mutual-dependence by proposing an integration driving simulator and traffic microsimulation, with the latter feeds to the former real-time simulation of the surrounding traffic in response to the movements of the subject vehicle in the driving simulator. They demonstrate the concept in a case study integrating an existing traffic microsimulation package with an existing driving simulator facility.

Finally, and to illustrate how ATS can be potentially applied to and used in practical situations, we selected three contributions. In the paper by Claes et al., the authors use a bio-inspired approach to tackle problems in the ITS domain, applying, in a relatively innovative way, the concept of agent-based modeling in the field of traffic management. Their approach is based on delegate multi-agent systems, where an environment-centric co-ordination mechanism partially inspired by ant behaviors is used to anticipate traffic congestion in vehicle routing problems. To put it simply, ant-like agents are deployed to explore the environment on behalf of drivers so that congestion situations can be foreseen and prevented as vehicles' information is collected and distributed in a decentralized fashion. Different routing strategies are commented on and compared to support the authors' approach. Li and colleagues implemented an artificial urban transit system as an instance of an ATS, with which they are interested in coping with complex urban transit coordination. In their system, the authors are able to dynamically model passengers' behavior, including their preferences and route choices, and use the simulated results to predict transit demand. For the specific scenarios presented, authors show the applicability of their approach to simulate the general operation of subway rail and bus transport systems in the Beijing transit network. In the last paper, Illenberger and colleagues present a simulation-based investigation of the potential benefit of route-guidance information in the context of risk-sensitive travellers. The authors use a fully agent-based transport simulator to implement their agent-based model of a traveller behavior, in which risk averseness is implicitly controlled through a generic utility function. As for the practical application of their methodological approach, the authors suggest that private-sector traveller information providers would benefit from testing market strategies and identifying potential user groups, such as people with tight schedules, to whom information provided by advanced traveller information systems (ATIS) would really make a difference, whereas public-sector ATIS providers could benefit from it in other different ways.

We are very pleased with this interesting and motivating collection of papers for this Special Issue on Artificial Transportation Systems and Simulation, which we hope will serve as a source of inspiration and insight for many researchers both within the IEEE ITS Society and within other technical and scientific communities and which will no doubt foster further research in the field of ATSS. We hope our readers will enjoy the content of this issue. Finally, we would like to express our sincere gratitude to our fellow reviewers, who have assisted us in this arduous yet rewarding task of editing this Special Issue of the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS.

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