Advances and Trends in Research and Development of Intelligent Transportation Systems: An Introduction to the Special Issue

IN JUNE 2004, the IEEE Technical Activities Board (TAB) voted to transfer the current Intelligent Transportation Systems Council (ITSC) to a new IEEE Intelligent Transportation Systems Society (ITSS) in 2005. On October 3 at the 2004 Annual IEEE International Conference on Intelligent Transportation Systems in Washington DC, ITSC held its last Administrative Committee Meeting and elected the President-Elect and 15 members of the Board of Governor (BOG) for ITSS. By creating the IEEE ITS Committee in 1993 and then the IEEE ITS Council in 1999, IEEE has made tremendous effort and progress in ITS technology, standards coordination, and rapid knowledge dissemination through professional meetings and publications in proceedings and the TRANSACTIONS. Clearly, the establishment of the new IEEE ITS Society represents a new era in ITS-related research and development in the history of IEEE communities.

We dedicate this last issue of the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS under the ITSC to recent advances and trends in research and development in ITS technology. While work to build the foundations of ITS technology has significantly accelerated in both industrial and research institutes over the last decade, many fundamental questions regarding design, modeling, sensing, control, optimization, communication, architecture, implementation, performance, reliability of intelligent transportation systems, etc. remain to be answered. Nevertheless, there has been a proliferation of ITS methods, techniques, and commercial products, many of which have already been used quite successfully in some real-world applications. Our goal for this Special Issue is to provide state-of-the-art concepts, methods, and practices in ITS. While several topics are well covered here, we must concede that some important areas remain to be treated elsewhere.

Papers for this Special Issue have been selected from over 300 papers presented at the 6th Annual IEEE International Conference on Intelligent Transportation Systems in Shanghai, China, from October 12 to 15, 2003. The peer-review process for this Special Issue was conducted only for the 97 submitted papers, which were extended versions of their conference originals. Due to the page budget imposed for Transactions in 2004, only 16 of the 23 accepted papers will be included in this part of the Special Issue; the remaining 7 papers will be published early next year. Broadly speaking, the topics treated in this Special Issue can be divided into three groups: 1) modeling, analysis, and control of traffic systems; 2) vision-based techniques for intelligent vehicles and traffic systems; and 3) emerging and other topics in ITS.

I. MODELING, ANALYSIS, AND CONTROL OF TRAFFIC SYSTEMS

The first group of papers addresses new methods for modeling, analysis, and control of traffic systems. The paper by Di Febbraro *et al.* presents a new approach for modeling an urban network of signalized intersections using hybrid Petri nets, in which vehicle flow behaviors are described by means of a time-driven model and traffic-light dynamics are represented by a discrete event model. Lin and Wang introduce an enhanced 01 mixed-integer linear programming formulation based on the cell-transmission model for the traffic-signal optimization problem. This formulation could be very useful in developing strategies for adaptive traffic-control systems and could also be used as a benchmark for examining the convergence behavior of heuristic algorithms or other approaches that are commonly used in this area. Chen *et al.* discuss the use of principal curves to describe and analyze the interaction among freeway traffic-stream variables and their joint behaviors without utilizing conventional assumptions made on the functional forms of interactions, as in previous studies. A dynamic analysis of freeway traffic is conducted by Figueiredo *et al.* by using a microscopic simulator of intelligent transportation systems (SITS) to reproduce real traffic conditions in an urban or nonurban network with different types of vehicles, drivers, and roads.

A multiagent system is developed by Zhang *et al.* for conducting spatial-temporal traffic data analysis based on global data management, a newly developed and important method that would enable traffic managers to have a global view of urban traffic status in the level of road networks. An accurate travel-time prediction is crucial to advanced traveler information systems. Wu *et al.* propose to use support vector regression (SVR) for travel-time prediction and compare their results to other baseline travel-time prediction methods using real highway traffic data. Their results prove that SVR is applicable and performs well for traffic data analysis.

For the three short papers, Yang *et al.* discuss a new method of traffic-signal control for circulatory roadways of modern roundabouts that have more than two lanes, where vehicles weaving and merging could cause serious traffic congestion and delay, as well as severe safety problems. de Feijter *et al.* investigate the potential of using trip booking to improve the reliability of travel times and to increase the effective use of road capacity through the sharing of infrastructure between different transportation modalities, with each modality having its own operational time window. Finally, Ling and Wu present a study on

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the cyclist behavior at a signal-controlled intersection by collecting and analyzing traffic data using video cameras on cyclists' crossing speeds, crossing gap/lag acceptance behavior, and group-riding behavior. Their results are useful for understanding the performance of mixed traffic at signalized intersections and building microscopic simulation models.

II. Vision-Based Techniques for Intelligent Vehicles and Traffic Systems

Vision-base techniques for ITS, especially for intelligent vehicles, have recently become very popular research topics. The paper by Li *et al.* describes the current status of the Springrobot autonomous vehicle project, whose main objective is to develop a safety-warning and driver-assistance system, as well as an automatic pilot for driving in rural or unsignalized traffic environments. Detailed discussion on lane-detection algorithms for Springrobot is given. In another paper, He *et al.* present a road-area detection algorithm based on color images, which is composed of two modules: boundaries are first estimated based on the intensity image and road areas are subsequently detected based on the full-color image. Kim and Cohn introduce a camera-based system for potential use in collision warning for improving railroad grade crossing safety. Finally, Xiong and Debrunner propose a method of improving the accuracy and robustness of real-time car tracking by combining a color histogram feature with an edge-gradient-based shape feature under a sequential Monte Carlo framework.

III. Emerging and Other Topics in ITS

Intelligence and security informatics (ISI) is an emerging field of study aimed at developing advanced information technologies, systems, algorithms, and databases for national- and homeland-security-related applications, through an integrated technological, organizational, and policy-based approach. The paper by Chen *et al.* summarizes the broad application and policy context for this emerging field. Three detailed case studies are presented to illustrate several key ISI research areas, including cross-jurisdiction information sharing; terrorism information collection, analysis, and visualization; and smart-border and bioterrorism applications. A specific emphasis of this paper is to note various homeland-security-related applications that have direct relevance to transportation researchers and to advocate security informatics studies that tightly integrate transportation research and information technologies.

In the two short papers, Xu and Hancock construct an integrated logistics and transportation system to simulate enterprise-wide freight movements and to study the interactive influences among, and the effects of, highly developed information technologies on logistic decision-making, freight-distribution patterns, and commercial vehicle operations. Blum *et al.* elicit the differences between intervehicle communication (IVC) networks and generic mobile *ad hoc* networks (MANETs) through simulations and mathematical models and then explore the impact of the differences on IVC communication.

A Special Issue in a journal such as the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS can only present a rather small number of papers describing previously unpublished original work that was completed in time for this Special Issue. Although we have made every effort to include a broad spectrum of recent ITS research, the coverage is by no means near complete.

Last but not least, we would like to take this opportunity to express our gratitude to all the reviewers of the Special Issue for their time and effort.

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