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Editorial

**Special Issue: Intelligent Vehicle Navigation (iVN)**

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## Special Issue: Intelligent Vehicle Navigation (*iVN*)

### Editorial

This is the first of two parts of this Special Issue on Intelligent Vehicle Navigation (*iVN*).

*iVN* as a core element of Intelligent Transport Systems (ITS), has the potential to make a significant contribution to tackling transport related problems including the alleviation of congestion and its negative impacts on health, the environment, safety and the economy. Furthermore, *iVN* brings with it the added potential for facilitating an unprecedented capability to gather data both in terms of quantity and quality that are required for effective planning for future service provision. Critical to the performance of *iVN* are the various relevant data (navigation sensor data, digital spatial road network data and attributes, and traffic information), and intelligent navigation algorithms that incorporate map-matching and route finding components. Although significant advances have been made in all of these areas, *iVN* still struggles to support the more demanding (e.g. mission critical) applications, especially those requiring high navigation accuracy, continuity, quality (integrity), reliability and availability. This is partly due lack of good quality data, reliable methods to integrate the data from different sources and poor treatment of the corresponding uncertainties in the data. This special issue of the Journal of Intelligent Transportation Systems focuses on *iVN* and presents papers on the latest research that addresses the issues identified above.

This issue contains five papers. The first paper, “**Integration of steering angle sensor with GPS and MEMS IMU for vehicular positioning**” by J. Gao, M. Petovello and M. E. Cannon, develops a novel integrated navigation system based on GPS, a Micro-Electro Mechanical System based Inertial Measurement Unit (MEMS IMU) and a steering angle sensor to enhance the positioning accuracy during GPS outages. This paper employs, for the first time, a centralized Kalman filter for the integration of the three sensors in the measurement domain (tight coupling). Field tests carried out to assess the performance of the integrated navigation system suggest significant improvements over the typical GPS/MEMS IMU integrated system, of 30% (suburban areas) and 32% (pseudo-urban areas). The integrated navigation system developed in this paper has the potential to support *iVN* applications requiring horizontal positioning accuracy at the meter-level.

The second paper, “**An integrated map-matching algorithm with position feedback and shape-based mismatch detection and correction**” by W. Chen, Z. Li, M. Yu, and Y. Chen, develops a tightly integrated map-matching algorithm (GPS/Dead Reckoning/spatial road network) to enhance positioning accuracy and reliability in dense urban areas where GPS is not reliable over extended periods of time. Given that the performance of a map-matching algorithm primarily depends on the quality of positioning fixes, this paper discusses how the quality of such fixes can be improved using optimal estimation of sensor errors and historical data (previous map-matched fixes) to control the growth of DR sensor errors. The new algorithm then employs a curve pattern matching method to automatically detect and correct any mismatches. The results of extensive field tests in the urban areas of Hong Kong indicate an improvement in the coverage over the case without DR feedback control of 6.5% (i.e. from 90% to 96.5%) with a horizontal accuracy of 10m (95%).

The third paper, “**A road matching method for precise vehicle localization using hybrid Bayesian network**” by C. Smaili, M.E. El Najjar, and F. Charpillat, also develops a new

map-matching algorithm that integrates data from the Anti-lock Braking System (ABS), differential GPS (dGPS) and spatial road network. The main contribution of this paper is to improve the performance of mapping position fixes (from the integrated ABS/dGPS) at intersections and matching them to the correct road segments using a Hybrid Bayesian Network (HBN) approach. The paper argues that when a vehicle either approaches an intersection or travels in vicinity of parallel-roads, especially in high density urban areas, several road segments become ‘candidates each with a relatively high level of confidence’ (instead of just one road segment as suggested by some existing algorithms). Therefore, multi-sensor fusion and multi-modal estimation are manipulated and managed until all ambiguities are eliminated. Field tests suggest that the new algorithm correctly identifies road segments near close to complex roundabouts.

The forth paper, “**Map-matching integrity using multi-hypothesis road tracking**” by M. Jabbour, P. Bonnifait and V. Cherfaoui, presents a new method to monitor the integrity of map-matching. This is required for mission (e.g. safety) critical ITS applications such as supporting Advanced Driver Assistance Systems (ADAS). Using a Multiple-Hypotheses Map-Matching (MHMM) approach, their integrity monitoring method warns the user if a map-matched positioning fix exceeds a pre-defined integrity threshold derived empirically from field tests. Data captured by a video camera are used in post-processing mode to generate a reference trajectory of the test vehicle. This is subsequently employed to quantify the performance of the new integrity monitoring method. Results show that the new algorithm is capable of a relatively high anomaly detection rate with a low a probability of missed detection.

The fifth paper, “**A new measure of travel time reliability for in-vehicle navigation systems**” by I. Kaparias, M.G.H. Bell and H. Belzner, introduces a new measure of travel time reliability for implementation in the dynamic routing algorithm of an intelligent in-car navigation system. While the other papers in this Special Issue aim at improving the positioning accuracy and integrity, this paper addresses the important issue of travel time reliability including its definition, impact on travellers’ route choice and role in routing algorithms. The paper comprehensively discusses the major drawbacks of current measures of travel time reliability and then develops two dimensionless travel time reliability indices referred to as the *lateness index* and *earliness index* at “link” and “route” levels. The paper argues and demonstrates that used as a part of in-car navigation systems, these indices result in travel time savings. The additional benefits are the reduction of the total travel time lost in the entire road network resulting in a decrease in fuel consumption and CO<sub>2</sub> emissions.

The papers presented in this first part of the Special Issue and the next, are testimony to the considerable momentum in research and development activities in Intelligent Vehicle Navigation (iVN) and its underpinning technologies, data and methods. It is our hope that the papers capture some of the major recent developments in iVN and that they act as a further stimulus for future research and development. Future processes and algorithms, in addition to accounting for limitations in both technology and data, should be flexible to accommodate rapid developments in the quality and quantity of the sensor outputs and spatial network data. It would be interesting to see if such developments result in a reduction in the complexity of iVN algorithms.