Guest Editorial Preface

Special Issue on Positioning Technologies

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First of all, we would like to thank the Editor-in-Chief Seppo Virtanen for the opportunity to assemble this special issue. The cooperation was once again very smooth. These articles are based on the best papers and invited talks of the International Conference on Localization and Global Navigation Satellite Systems (ICL-GNSS) 2011. We express our warmest gratitude to the reviewers of the extended papers, for their valuable comments and suggestions to further improve the manuscripts.

Driven by both market trends and legal regulations, there is a high demand for providing a robust localization solution, which will be available continuously, regardless the specific environment, i.e., outdoors and indoors, and which would overcome and complement the drawbacks of the current stand-alone single-frequency satellite-based navigation systems. The availability of user geolocation information is expected to be the ‘killer enabler’ of mobile device related applications, such as personal navigation, local information guides, wireless vehicle security and tracking systems, lost child tracking systems, fleet management, mobile workforce management, location-based advertisements, wireless fraud detection, mobility-based insurance policies, and so on. Many wireless positioning solutions exist nowadays, but each of them has advantages and limitations. Moreover, the continuous development of the Global Navigation Satellite Systems (GNSS), such as the European satellite system, Galileo, the Indian GPS-Aided GEO-Augmented Navigation (GAGAN), the Russian GLONASS system, the Chinese BEIDOU/COMPASS system, or the U.S. Global Positioning System (GPS) modernization, shows that position-location services and applications will be of utmost importance in years to come. The research and development activities on wireless location techniques and technologies have been increasing at a fast pace during past years and currently represent one of the most timely and challenging research topics in the wireless electronics field.

International Conference on Localization and GNSS 2011 was the inaugural annual localization event held in Tampere, Finland. This special issue consists of some of the
most interesting papers that were selected for inclusion in the journal after some extension and suggested enhancements. At the end there is also a conference report on the ICL-GNSS 2011 event. ICL-GNSS is devoted to all aspects of localization, positioning and navigation, whether using satellites, communication network signals, inertial sensors, or any signal of opportunity. The conference uses peer review of full papers, and is technically co-sponsored by the Communications Society of IEEE.

One of the hot issues in satellite-based positioning is the concern on the security of the very vulnerable weak signals from space that are used in positioning. In their paper “Recent Trends in Interference Mitigation and Spoofing Detection” the researchers from Turin, Italy, tackle this important issue. The paper gives a classification of intentional and unintentional threats, such as interference, jamming and spoofing, and discusses some of the recent trends concerning techniques for their detection and mitigation. A wide range of recent civil applications related to user’s safety or featuring financial implications would be deeply affected by interfering or spoofing signals created intentionally. Smart spoofers track the location of the target GNSS receiver and use this information, along with a GNSS signal generator, to create strong GNSS signals that lead the target astray. The paper presents several techniques to detect and countermeasure even very sophisticated spoofing attempts. The complexity of a spoofing/interference monitoring unit may be challenging and the requirements for the computational capabilities and memory size make, at present, these techniques more suitable for high-end receivers.

The researchers from Worchester, MA, have a very specific localization application in Body Area Networks (BAN). They are tracking capsules used for medical inspections inside the human body. In their paper “Challenges in Channel Measurement and Modeling for RF Localization inside the Human Body” they begin by determining the bounds on the performance of Received Signal Strength (RSS) based localization of a micro-robot inside the digestive system of the human body using known location of body mounted sensors. It is shown that using RSS-based localization one may achieve accuracies around a few centimeters inside the human body. In order to gain more accuracy, the researchers are investigating the use of Time-of-Arrival (TOA) based localization. There are fundamental differences, e.g., between indoor positioning and doing localization inside the human body, such as the dense medium (mostly liquid) and heterogeneity (different tissues) in the human body case. In traditional TOA localization applications the time of flight of a transmitted pulse is measured at the receiver and distance is estimated by multiplying the time of flight with the velocity of propagation (normally the speed of light). Because of the heterogeneous body and the absence of body-mounted sensors in most of the practical cases, determining the propagation velocity is challenging. Using phantoms or 3D computer simulations of the radio propagation inside the human body are needed to characterize the propagation. However, TOA-based methods may currently introduce errors in the order of centimeters when used for in-body measurements, and future research is needed for more accurate results in practical applications.

Whereas the first two papers are based on two of the invited talks delivered at ICL-GNSS, the third paper “Theoretical Analysis of Overlay GNSS Receiver Effects” is coming from the winners of the best paper award. Overlay receivers use smart mixing to a single Intermediate Frequency (IF) to receive multiple frequency bands of interest using a single baseband hardware implementation. In the GNSS case, the reception of multiple constellations (such as GPS, GLONASS and Galileo) transmitting on multiple bands brings along several advantages. The solution availability is improved due to increased number of satellites in more optimal geometries. The first-order ionospheric bias can be removed using multiple bands, and therefore provide a higher positioning accuracy. Multi-band reception also provides resilience against jamming and unintentional interference. The challenges of multi-band reception are a much
higher required bandwidth, higher sampling rates, often several reception chains, a higher digital bandwidth (the raw sample rate from the front-end output to the baseband signal processing) and more self-generated interferences. The authors use overlay technique and investigate the effects of intentional signal overlay in the analog front-end to validate the combined use of a unique front-end baseband chain, and to improve the receiver efficiency in terms of cost, size, power consumption, and digital bandwidth. A general overlay based front-end architecture is presented in the paper, enabling the joint reception of two signals broadcast in separate frequency bands, sharing just one common LP/AGC/ADC baseband stage. It demonstrates that a dual-frequency (Galileo) E1 / E5 based overlay receiver provides the advantages of fast acquisition, high-accuracy tracking, and ionosphere-free pseudorange measurements, while enabling an efficient implementation.

The researchers from the Finnish Geodetic Institute are addressing one of the indoor localization methods in their article “Motion Restricted Information Filter for Indoor Bluetooth Positioning.” In their approach, fingerprints of received signal strength indicators (RSSI) are used for localization. Due to the relatively long interval between the available consecutive Bluetooth signal strength measurements, they propose a method of information filtering with speed detection, which combines the estimation information from the RSSI measurements with the prior information from the motion model. Speed detection is further assisted to correct the outliers of position estimation. The field tests that they have carried out show that the new algorithm proposed applying information filter with speed detection improves the horizontal positioning accuracy of indoor navigation, achieving a 4.2 m positioning accuracy on average. The accuracy of their method compares favorably with the Bayesian static estimation method and the point Kalman filter.

The last research paper of this issue comes from Istituto Superiore Mario Boella, Italy. The paper “A Simulation Tool for Real-Time Hybrid-Cooperative Positioning Algorithms” addresses the need for verifying the cooperative positioning methods combined with traditional satellite-based positioning or terrestrial signals. In particular, the simulation tool presented in this paper simulates devices belonging to a peer-to-peer (P2P) wireless network where peers, equipped also with a GNSS receiver, cooperate among them by exchanging aiding data in order to improve both positioning accuracy and availability. They also propose a method to increase the robustness of cooperative algorithms based on the estimated position covariance matrix. In particular, the proposed approach assures a faster estimation convergence and improved accuracy while lowering computational complexity and network traffic. They also present results from tests on the sensitivity of the implemented positioning algorithms in two different scenarios, first in presence of high level of pseudorange noise and then in presence of a malicious peer in the P2P network. Thus, they are also concerned about the positioning signal reliability that was one of the highlighted topics in the previous issue of this journal.

These papers are good samples on some of the most interesting aspects dealt with in the conference. Hoping to see you in ICL-GNSS in the coming years! Look out for the future issues of ICL-GNSS at http://www.icl-gnss.org.

ACKNOWLEDGMENT

The views expressed in this article are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.

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Guest Editors
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Jari Nurmi is a professor of Computer Systems at Tampere University of Technology (TUT), Finland. He has held various research, education and management positions at TUT and in the industry since 1987. He got a PhD degree from TUT in 1994. His current research interests include System-on-Chip integration, embedded and application-specific processor, multiprocessor and reconfigurable architectures, and FPGA, integrated circuit and embedded software implementations of positioning, DSP and digital communication systems (including Software-Defined Radio). He is leading a group of about 20 researchers. Dr. Nurmi is the general chairman of the annual International Symposium on System-on-Chip (SoC) and its predecessor SoC Seminar in Tampere since 1999, and a board member of ICL-GNSS, SoC, FPL, DASIP and NORCHIP conference series. He was also the general chair of FPL 2005, SiPS 2009, ICL-GNSS 2011, DASIP 2011 conferences, and is the local chair of Embedded Systems Week 2012. He was the head of the national TELESOC graduate school 2001-2005. He is the author or co-author of over 250 international papers, editor of Springer book Processor Design: System-on-Chip Computing for ASICs and FPGAs, co-editor of Kluwer book Interconnect-centric Design for Advanced SoC and NoC, associate editor of the International Journal of Embedded and Real-Time Communication Systems, and is now editing Springer books on “GALILEO Positioning Technology” and “Computation Platforms for SDR.” He has supervised 113 MSc theses and 14 Doctoral theses at TUT, and been the opponent or reviewer of 18 PhD theses in other universities worldwide. He is a senior member in IEEE Circuits and Systems Society, Communications Society, Computer Society, Signal Processing Society, and Solid-State Circuits Society. In 2004, he was a co-recipient of Nokia Educational Award, and the recipient of Tampere Congress Award 2005. He was awarded one of the Academy of Finland Research Fellow grants for 2007-2008, and in 2011 he was a co-recipient of IIDA Innovation Award. He is also reviewing projects for EU and project proposals for national funding agencies in Belgium, Canada, The Netherlands, Saudi-Arabia, Slovenia, Sweden, and Switzerland.

Elena Simona Lohan received the MSc degree in Electrical Engineering from "Politehnica" University of Bucharest, Romania, in 1997, the Diplome d'Etudes Approfodies (DEA) degree in Econometrics, at École Polytechnique, Paris, France, in 1998, and the PhD degree in Telecommunications from Tampere University of Technology (TUT) in 2003. In 2007 she was nominated at TUT as an Adjunct Professor in the field of “Wireless communication techniques for personal navigation.” Since November 2003, she has been working as a Senior Researcher at TUT and she has been acting as a group leader for the mobile positioning activities at the Department of Communications Engineering. She is the Principal Investigator in a research project funded by the Academy of Finland (focusing on indoor location), and she has been involved (as technical group leader) in two European GNSS-related projects: GREAT and GRAMMAR, dealing with Galileo mass-market receivers. She has more than 80 international journal and conferences articles related to CDMA-based signal processing in navigation and communications. In 2009, she was the main organizer of a 3-day summer course on “Wireless Positioning” at TUT. She is also a founding member of ICL-GNSS conference steering committee.
Stephan Sand (MSc EE 2001, Dipl-Ing 2002, DrSc ETH Zurich 2010) is currently managing and working on multi-sensor navigation research projects at the Institute of Communications and Navigation, German Aerospace Center (DLR), Oberpfaffenhofen, Germany. He was visiting researcher at NTT DoCoMo R&D Yokosuka, Japan in 2004 and at the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland in 2007 working in the area of wireless communications. Stephan has authored and co-authored more than 80 technical and scientific publications in conferences and journals in the areas of wireless communication and multi-sensor navigation. He has been involved in several research projects on mobile radio funded by the European Commission (4MORE, NEWCOM, COST289, PLUTO) and by international industry cooperation. In the GJU/GSA project GREAT and the EU FP7-ICT collaborative project WHERE, he has been leading the work on hybrid location determination. He was the coordinator of the recent EU FP7 project GRAMMAR on Galileo mass-market receivers. He is a member of ICL-GNSS steering committee.

John Raquet is an Associate Professor of Electrical Engineering at the Air Force Institute of Technology (AFIT), where he is also the Director of the Advanced Navigation Technology (ANT) Center. The ANT Center consists of 22 faculty members, 6 staff members, and over 40 students working to solve a wide variety of navigation problems. Dr. Raquet’s research interests include non-GNSS navigation technology, sensor integration, and GNSS receiver processing. He has published over 100 navigation-related conference and journal papers and taught 40 navigation short courses to a number of different organizations. He is currently the Chair of the Satellite Division of the Institute of Navigation. He has a PhD in geomatics engineering from the University of Calgary, an MS in aero/astro engineering from the Massachusetts Institute of Technology, and a BS in astronautical engineering from the U.S. Air Force Academy. He was a visiting professor at Tampere University of Technology in 2010, and he is a member of ICL-GNSS steering committee.