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EDITORIAL

IEEE ACCESS SPECIAL SECTION: POSITIONING AND NAVIGATION IN CHALLENGING ENVIRONMENTS

Positioning and navigation have been playing a great role in a variety of military and civilian applications and location-based services, especially due to the advent of advanced information and communication technologies and continuous performance enhancement and modernization of the four global navigation satellite systems (GNSS). Although great progress and many achievements have been made in positioning and navigation over the past few decades, there are a range of significant issues, especially in challenging environments, which need to be considered and suitable solutions are required.

One challenging environment is the complex indoor environment where a pedestrian goes through different scenarios, such as from one floor to another floor of a large multi-floor building, or from one building to another neighboring building. Thus, in the design of next-generation (beyond 5G) communication systems, the positioning functions need to be enabled and standardization of positioning technology such as in 3GPP should be taken into account. The second challenging environment is the underground mines, where the GNSS receivers usually cannot produce valid position information due to blockage of satellite signals, and high humidity and irregular space distribution are also a significant issue. Deep underground mining is inevitable as natural resources of the earth's surface and shallow sea are becoming scarce. Another challenging environment is the deep sea, where there are abundant minerals on and under the deep seabed, such as polymetallic nodules, natural gas, and oil. Positioning and navigation is important for vehicles and robots to pick up the seabed surface minerals and to perform drilling and extraction of minerals under the seabed. One more challenging environment is the outer space. It is crucial to provide accurate and reliable position and navigation information for spacecraft and/or space robots to approach and then land on the target planet (e.g., the Moon, Mars or asteroid).

Positioning and navigation is vital for safe, reliable, and effective operations in challenging environments such as those mentioned above. This Special Section aims to report the recent advances on positioning and navigation in such challenging scenarios. The Call for Papers attracted great attention from the scientific community in positioning and navigation; 47 submissions were received and each submission was peer-reviewed by at least two independent reviewers. Based on the review reports of up to three review rounds, ten articles were accepted for inclusion in the Special Section. The ten accepted articles can be broadly categorized into three groups in terms of operation scenarios. The first group, with four articles, deal with positioning and navigation in indoor environments; the second group, with four articles, tackles problems of positioning and navigation in the air and space; the third group, with two articles, copes with positioning and navigation problems in underground mines and underwater.

In [A1], Chan et al. discuss a system for multi-modal sensor fusion for smartphone localization. The solution statistically fuses WiFi measurements and inertial sensor data through a particle filter, which is enhanced by a neural network that models WiFi-based ranging observations, trained by crowdsourcing. Experimental results demonstrate the feasibility of the approach.

In [A2], Staroverov and Panov extend the standard task formulation and establishes landmarks in the form of room locations and types. Agents can build hierarchical policy based on these landmarks to the extent that they can use skills that can be overlaid and reused in a variety of navigation tasks. They validated the possibility of transferring trained policies to real robots and achieved high success rates for validation scenarios in a photorealistic Habitat simulator.

In [A3], Huang and Wu propose a Direction of Arrival (DoA) module for Search and Rescue (SaR) or anti-drone applications, which uses patch antennas and a rat-race coupler as the receivers. They also propose an angular estimation for WiFi positioning using optimally placed DoA antennas and a pseudo-inverse algorithm. These schemes are validated in a 100m $\times$ 100m area to obtain small average positioning errors and angular errors.

In [A4], Brotchie et al. investigate the performance and limitations of classical and modern probabilistic Bayesian approaches and proposes an attitude estimation approach on the special rotation group using a maximal entropy distribution called the SO(3) filter. Experiments were conducted and performance comparisons were made. The experimental results showed that the SO(3) filter achieved better attitude estimation performance and better robustness

than the extended Kalman filter and the untraced Kalman filter.

In [A5], Che et al. design a coupling navigation framework and a detumbling controller. The relative navigation method, which incorporates the momentum transfer information and the visual guidance, is developed to estimate states of the target. The combination of two types of information ensures that the estimator can be used continuously in free-floating and contact modes without the need for measuring interaction forces. A numerical example is provided to illustrate the effectiveness of the designed framework.

In [A6], Yue et al. propose a method in which information from various sensors is used to control a robot such that it can reliably and stably approach, locate, and identify obstacles. A novel mobile robot for power transmission line inspection was developed according to the requirements of the inspection tasks and characteristics of the obstacles on power lines. A prototype was tested and validated under laboratory conditions.

In [A7], Prol et al. present the benefits and challenges of PNT solutions via LEO satellites. The current satellite-based positioning systems mainly rely on Medium Earth Orbit (MEO) systems such as GPS and Galileo. Due to high signal attenuation caused by long distance propagation, GNSS signals are vulnerable to interfering signals such as jamming and spoofing. Hence, an alternative PNT solution, such as the LEO-based one, is desirable. This article addresses several aspects of implementing a LEO-based PNT system.

In [A8], Nicola et al. demonstrate the testing and validation results of the Galileo Open Service Navigation Message Authentication (OSNMA) module. It describes the processing of the Galileo E1-B navigation messages, as observed during the early days of public observation, to analyze the authenticated data carried by the signal in space, and applies the OSNMA protocol to authenticate the navigation message. A software receiver was implemented for monitoring the parameters transmitted in the navigation messages, analyzing all the steps required by the authentication process and evaluating the performance of a GNSS receiver capable of decoding authenticated messages.

In [A9], Park and Kim introduce a localization method for underwater environments that fuses inertial sensors, Doppler-velocity log, and an acoustic imaging sonar. The experimental results show the validity of the proposed approach and its promise for underwater operations.

In [A10], Etxeberria-Garcia et al. propose a method to build a ground truth database for urban underground environments where GPS may be unavailable. It also proposes the EnlightenGAN algorithm to overcome the impact of harsh lighting conditions on visual odometry (VO) algorithms. In addition, experiments were conducted in a real city subway scene, and the results showed that the EnlightenGAN algorithm could effectively improve the performance of the existing VO algorithms.

Finally, the Lead Editor and the Guest Editors would like to thank all the authors who submitted their research articles to the Special Section. They highly appreciate the contributions of the reviewers for their constructive comments and suggestions. They would also like to thank the IEEE ACCESS editorial staff for their support.

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APPENDIX: RELATED ARTICLES

[A1] H.-W. Chan, P.-Y. Wu, A. I.-C. Lai, and R.-B. Wu, "Fusion-based smartphone positioning using unsupervised calibration of crowdsourced Wi-Fi FTM," *IEEE Access*, vol. 10, pp. 96260–96272, 2022.

[A2] A. Staroverov and A. I. Panov, "Hierarchical landmark policy optimization for visual indoor navigation," *IEEE Access*, vol. 10, pp. 70447–70455, 2022.

[A3] S.-Y. Huang and R.-B. Wu, "Positioning for search and rescue in GPS-denied area by distributed WiFi RSS-based DoA modules," *IEEE Access*, vol. 10, pp. 76105–76113, 2022.

[A4] J. Brotchie, W. Li, A. Kealy, and B. Moran, "Evaluating tracking rotations using maximal entropy distributions for smartphone applications," *IEEE Access*, vol. 9, pp. 168806–168815, 2021.

[A5] D. Che, Z. Zheng, and J. Yuan, "An innovate detumbling method for a non-cooperative space target via repeated tentative contacts," *IEEE Access*, vol. 10, pp. 64435–64450, 2022.

[A6] X. Yue, Y. Feng, B. Jiang, L. Wang, and J. Hou, "Automatic obstacle-crossing planning for a transmission line inspection robot based on multisensor fusion," *IEEE Access*, vol. 10, pp. 63971–63983, 2022.
[A7] F. S. Prol, R. M. Ferre, Z. Saleem, P. Valisuo, C. Pinell, E. S. Lohan, M. Elsanhoury, M. Elmusrati, S. Islam, K. Celikbilek, K. Selvan, J. Yliaho, K. Rutledge, A. Ojala, L. Ferranti, J. Praks, M. Z. H. Bhuiyan, S. Kaasalainen, and H. Kuusniemi, "Position, navigation, and timing (PNT) through low Earth orbit (LEO) satellites: A survey on current status, challenges, and opportunities," *IEEE Access*, vol. 10, pp. 83971–84002, 2022.
[A8] M. Nicola, B. Motella, M. Pini, and E. Falletti, "Galileo OSNMA public observation phase: Signal testing and validation," *IEEE Access*, vol. 10, pp. 27960–27969, 2022.
[A9] J. Park and J. Kim, "Robust underwater localization using acoustic image alignment for autonomous intervention systems," *IEEE Access*, vol. 10, pp. 58447–58457, 2022.
[A10] M. Etxeberria-Garcia, M. Zamalloa, N. Arana-Arexolaleiba, and M. Labayen, "Visual odometry in challenging environments: An urban underground railway scenario case," *IEEE Access*, vol. 10, pp. 69200–69215, 2022.

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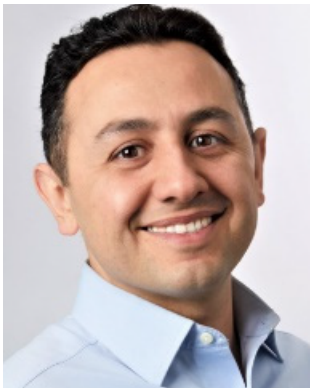

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