Guest Editorial
Location-Awareness for Radios and Networks, Part I

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LOCALIZATION-awareness using radio signals stands to revolutionize the fields of navigation and communication engineering. It can be utilized to great effect in the next generation of cellular networks, mining applications, health-care monitoring, transportation and intelligent highways, multi-robot applications, first responders operations, military applications, factory automation, building and environmental controls, cognitive wireless networks, commercial and social network applications, and smart spaces. A multitude of technologies can be used in location-aware radios and networks, including GNSS, RFID, cellular, UWB, WLAN, Bluetooth, cooperative localization, indoor GPS, device-free localization, IR, Radar, and UHF. The performances of these technologies are measured by their accuracy, precision, complexity, robustness, scalability, and cost. Given the many application scenarios across different disciplines, there is a clear need for a broad, up-to-date and cogent treatment of radio-based location awareness.

This special issue aims to provide a comprehensive overview of the state-of-the-art in technology, regulation, and theory for "Location-Aware Radios and Networks." It also presents a holistic view of research challenges and opportunities in the emerging areas of localization. We received a total of 120 submissions, spanning a broad range of topics from cooperative and network localization and mapping, device-free localization, location information for resource planning, and interference management in the localization process, to sparsity exploiting sensing and decision for efficient localization, and fundamental limits of localization algorithms. After a thorough peer-review process, 27 articles are selected and will be presented in a sequence of two parts. The first part consists of 13 articles, which are summarized below.

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The first article in this part I is entitled "Mobile Node Localization via Pareto Optimization: Algorithm and Fundamental Performance Limitations," authored by De Angelis & Fichione. In this article, the fundamental performance of linear fusion of multiple measurements of the position of mobile nodes is presented, and a new distributed recursive position estimator are proposed. The Cramér-Rao lower bounds for the parametric and a posteriori cases, are investigated. The proposed estimator combines information coming from ranging, speed, and angular measurements, which is jointly fused by a Pareto optimization problem, where the mean and the variance of the localization error are simultaneously minimized. A distinguished feature of the proposed method is that it assumes a simple dynamical model of the mobility and therefore, it is applicable to a large number of scenarios, providing good performance.

Ataei *et al.* in the second article, "Localization and Location Verification in Non-Homogeneous One-Dimensional Wireless Ad-Hoc Networks," explore the hop-count properties of one-dimensional wireless ad-hoc networks, where the nodes are placed independently and identically distributed, according to a Poisson distribution with an arbitrary density function. The authors present exact expressions to calculate the probability mass function of two hop count random variables: 1) the number of hops, needed for a node located at an arbitrary location in the network, to receive a message from a node located at one end of the linear network, and 2) the number of hops, needed for a node located at one end of the network, to receive a message from a node at an arbitrary location.

In the third article, "Distributed Localization of a RF target in NLOS Environments," Xu *et al.* propose, analyze, and validate a distributed expectation maximization (EM) algorithm, for localizing targets in non-line-of-sight (NLOS) conditions. Localization based on angle of arrival (AOA) and time difference of arrival (TDOA) measurements leads to errors up to 15 meters, which is comparable to centralized EM.

Since spectrum sensing can benefit from position knowledge of primary users (PU), the article considers the joint estimation of the PU emission state and its position. The resulting method, termed deep sensing, is advocated for 5G communications in their article entitled "Deep Sensing for Future Spectrum and Location Awareness 5G Communications" by B. Li *et al.*

In underwater localization, acoustic communication results in long delays. In the fifth article, Ramezani & Leus develop a medium access control (MAC) protocol, which harnesses the long propagation delays to efficiently schedule transmissions for the purpose of localization. Details can be found in their article "Localization Packet Scheduling for Underwater Acoustic Sensor Networks."

Nguyen *et al.* develop a machine learning-based algorithm to improve the accuracy of device-based localization using ultrawide bandwidth and time-of-arrival, based on IEEE 802.15.4-2011 standard. Their underlying approach is presented in the sixth article, "Machine Learning for Wideband Localization," which is based on identifying and mitigating NLOS signals using relevance vector machine (RVM) techniques. It further proposes a localization algorithm, called two-step iterative (TSI) algorithm, which can converge in finite steps.

The seventh article, "Occupancy Estimation Using Only WiFi Power Measurements" by Depatla *et al.* proposes an approach for counting the total number of people walking in an area, based on only WiFi power measurements between a pair of stationary transmitter/receiver antennas. The approach is based on the probabilistic characterization of the impact of the total number of people on two phenomena: the scattering and the LOS blocking, and developing a mathematical expression for the pdf of the received signal amplitude. The paper validates the proposed framework by running extensive indoor and outdoor experiments.

The next four articles address algorithms for energy-efficient localization networks. The eighth article by Moragrega *et al.*, "Potential Game for Energy-Efficient RSS-based Positioning in Wireless Sensor Networks" investigates a game theoretical algorithm for resource planning of networks, using location information and metrics. The network aims at positioning and tracking nodes using RSS measurements. The transmit power levels of the anchor nodes are selected according to a two-fold criterion: minimum power level and desired positioning quality for users, assessed by the geometric dilution of precision metric. The proposed algorithm minimizes the number of anchor nodes that collaborate in positioning, thus saving energy. A distributed solution for the implementation is presented that requires low computational complexity.

The ninth article, "New Efficient Indoor Cooperative Localization Algorithm with Empirical Ranging Error Model," by S. Li *et al.* presents an efficient cooperative localization algorithm that can be applied to a real indoor localization system with a non-Gaussian ranging error distribution is proposed. To this end, the authors propose an asymmetric double exponential ranging error model based on empirical ranging data. An efficient cooperative localization algorithm based on distributed belief propagation is then proposed. The communication and computational cost is reduced by passing approximate beliefs represented by Gaussian distributions between neighbors and by using an analytical approximation to compute peer-to-peer messages.

The tenth article by Dai *et al.* considers a joint design of location inference and power control of agents in "Energy-Efficient Network Navigation Algorithms." The article first determines the confidence region for location inference by using Fisher information analysis. The authors further design a robust energy allocation strategy that minimizes the location inference errors of the agents within the confidence region. The performance is then assessed in a simulation environment.

In the eleventh article, based on WiFi fingerprints via ZigBee interference signatures, Niu *et al.* design an energy-efficient indoor localization system called ZIL (ZigBee-assisted Indoor Localization) in the article "ZIL: An Energy-Efficient Indoor Localization System Using ZigBee radio to Detect WiFi Fingerprints." Real-world physical properties are mined and used to design the localization algorithm in indoor environment. ZIL algorithm is implemented on TelosB motes and extensive experiments are carried out to verify its performance. This algorithm achieves comparable performance to the state-of-the-art WiFi fingerprint-based approaches, and can save energy on average about 68% compared with the technologies based on WiFi interface.

In the twelfth article, "Magicol: Indoor Localization Using Pervasive Magnetic Field and Opportunistic WiFi Sensing," Shu *et al.* present the fusion of magnetic and WiFi signals for indoor localization and tracking. They further utilize particle filters to maximize the accuracy, and an on-demand WiFi scan strategy for energy savings. Furthermore, the authors conduct extensive experiments at different indoor environments, including an office building, an underground parking garage, and a supermarket, to demonstrate the achieved performance.

In the final article, Liu *et al.* explore the use of location information to realize secure transmission for wiretap channels. Assuming that the only information available on an eavesdropper is a noisy estimate of its location, a relay-aided secure transmission scheme is proposed to maximize the effective secrecy throughput. The results of this paper "Location-Based Secure Transmission for Wiretap Channels" reveal the impact of the location uncertainty on the achievable secrecy performance.

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