**Top Level Newsletter:** **Connected Vehicle**

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Editor-in-Chief: Kay Das, IEEE Life Member,

Systems Research Development and Innovation

**Vol 13.0 (this issue)**

**- Data Science/ AI/ Deep Learning/ 5G**

**- Global Navigation Satellite System (GNSS)**

**- mmWave Vehicular Communications**

Previous issues:

Vol 12.1:

- 7 topics on Autonomous Vehicles Technology

- 1 topic on 5G Radio Access Network Slicing

Vol 11.0:

- Autonomous Vehicles Should Start Small, Go Slow

- 5G Radio Access Network Slicing

- Autonomous Driving – Sensing and Perception

Vol 10.0: GNSS Special Issue, Intelligent Transport Systems magazine, Fall 2020.

Vol 9.1: Data Science and AI for Communications

Vol 8.0: Cloud-Based AI (ABI Research publication)

Vol 7.0: COVID-19 and Connected Vehicle

Vol 6.0: Proceedings of the IEEE, Internet of Vehicles,

Vol 5.1: Co-operative Automated Driving

Vol 4.0: Current Sensor Technology

This newsletter is intended to provide the IEEE member with a top level briefing of the subject under review. Instead of a cumulative approach, as adopted previously, it will now only feature new content. For older content, please access previous volumes.

The objective is to provide a platform for fast learning and quick overview so that the reader may be guided to the next levels of detail and gain insight into correlations between the entries to enable growth of the technology. Intended audiences are those that desire a quick introduction to the subject and who may wish to take it further and deepen their knowledge. This includes those in industry, academia or government and the public at large. Descriptions will include a range of flavors from technical detail to broad industry and administrative issues. A (soft) limit of 200 to 300 words is usually set for each topic, but not rigorously exercised. As descriptions are not exhaustive, hyperlinks are occasionally provided to give the reader a first means of delving into the next level of detail. However, it is not the intent to make this a forest of hyperlinks. The reader is encouraged to develop a first level understanding of the topic in view. The emphasis is on brief, clear and contained text. There will be no diagrams in order to keep the publication concise. Related topics in the case of Connected Vehicle technology, such as 5G cellular and the Internet of Things will be included. The terms Connected Vehicle and Automated Driving will be used inter-changeably. The publication will be updated periodically. Articles from other published sources than IEEE that add to the information value will occasionally be included.

This newsletter forms part of the regional Advanced Technology Initiative (ATI) of which connected vehicles form a constituent part. Technical articles solely from IEEE journals/magazines are referred to by their Digital Object Identifier (DOI) or corresponding https link. The link for each article is provided. Those readers who wish to delve further to the complete paper and have access to IEEE Explore ([www.ieeexplore.ieee.org](http://www.ieeexplore.ieee.org)) may download complete articles of interest. Those who subscribe to the relevant IEEE society and receive the journal may already have physical or electronic copies. In case of difficulty please contact the editor at [kaydas@mac.com](mailto:kaydas@mac.com). The objective is to provide *top level guidance* on the subject of interest. As this is a collection of summaries of already published articles and serves to further widen audiences for the benefit of each publication, no copyright issues are foreseen.

Readers are encouraged to develop their own onward sources of information, discover and draw inferences, join the dots, and further develop the technology. Entries in the newsletter are normally either editorials or summaries or abstracts of articles. Where a deepening of knowledge is desired, reading the full article is recommended.

**1. Data Science and Artificial Intelligence for Communications, Irena Atov et al**

(IEEE Communications Magazine, Vol 58, Issue 10, October 2020 , (pp56-57)

**Editorial**: Welcome to the October issue of the Data Science and Artificial Intelligence for Communications Series.We featured previous work this series in Vol 9.1 so this is a continuation. The popularity of this Series continues to grow, attracting a lot of attention from both researchers and practitioners who are working to address various challenges in the network field through the advances of artificial intelligence (AI), machine learning (ML), and big data analysis. This trend toward learning-based, data-driven approaches has been mainly motivated by two things: the amount of available data retrieved from devices and network equipment, and the need to tune large numbers of network operational parameters in order to meet the frequently changing needs of the services. Indeed, 5G and the rise of new services – the Internet of Things (IoT), connected vehicles, augmented and virtual reality (AR/VR), and so on – are expected to make traffic much more dynamic, thus requiring frequent network reconfiguration. Although AI/ML/deep learning (DL) technologies promise to shed light on this huge amount of data and provide the means for automation, significant challenges remain. Smart and scalable approaches are needed to activate their potential gains in the complex real-world scenarios spanning wireless, edge, and cloud computing infrastructures today. In addition, fundamental questions and challenges related to embedding of these technologies in the wireless context, and especially in the lower layers of the protocol stack, need to be overcome to truly enable the “pervasive intelligence” promised by future beyond 5G networks. A number of challenges set physical layer deep learning (PHY-DL) apart from other learning domains where digital signal processing (DSP) constraints and hardware limitations have to be considered down to the clock cycle level.

The first article, “Deep Learning at the Physical Layer: System Challenges and Applications to 5G and Beyond” below discusses a series of system-level issues for real-time PHY-DL and overviews the state of the art in addressing these challenges. Through their millimeter-wave (mmWave) testbed, the authors present preliminary results in the area of adaptive beam alignment and consider a roadmap of future research opportunities.

**DOI:** [**https://doi.org/10.1109/MCOM.2020.9247523**](https://doi.org/10.1109/MCOM.2020.9247523)

**2. Deep Learning at the Physical Layer: System Challenges and Applications to 5G and Beyond), Francesco Restuccia et al**

(IEEE Communications Magazine, Vol 58, Issue 10, October 2020) **,** (pp 58-64)

The unprecedented requirements of IoT have made fine-grained optimization of spectrum resources an urgent necessity. Thus, designing techniques able to extract knowledge from the spectrum in real time and select the optimal spectrum access strategy accordingly has become more important than ever. Moreover, 5G networks will require complex management schemes to deal with problems such as adaptive beam management and rate selection. Although deep learning (DL) has been successful in modeling complex phenomena, commercially available wireless devices are still very far from actually adopting learning-based techniques to optimize their spectrum usage. In this article, we first discuss the need for real-time DL at the physical layer, and then summarize the current state of the art and existing limitations. We conclude the article by discussing an agenda of research challenges and how DL can be applied to address crucial problems in 5G and beyond networks.

Sub-titles: Why Deep Learning at the Physical Layer/ System Requirements and Challenges/ Designing Features and Addressing Stochasticity/ The Way Ahead/ Applications to 5G and Beyond/ Conclusions

**DOI:** [**https://doi.org/10.1109/MCOM.001.2000243**](https://doi.org/10.1109/MCOM.001.2000243)

**3. An Experimental Evaluation of Global Navigation Satellite System/Inertial Navigation System-Verification Strategies for Vehicular Applications, Daniele Borio**

(IEEE Intelligent Transportation Systems Magazine, Vol 12 Issue 3, Fall 2020, pp 25 – 35),

An effective way to detect the presence of a spoofing attack is to verify Global Navigation Satellite System (GNSS) data with measurements from other sensors, such as inertial navigation systems (INSs). In this article, uncoupled GNSS/INS-verification approaches are experimentally evaluated in an automotive context. The approaches are uncoupled in the sense that GNSS and INS sensors are operated independently without an exchange of information. The techniques considered are the magnitude verification (MAV) technique, where the acceleration and angular velocity magnitudes are compared, and the horizontal components (HoCs)-verification strategy, which requires the vertical alignment of GNSS and INS sensor frames. The analysis shows the effectiveness of these types of procedures and discusses their limitations; for example, in low-dynamic conditions, when low accelerations and angular velocities are recorded. Possible enhancements are also discussed.

From the analysis, it emerged that IMU measurements can be used to verify GNSS information even when data from smartphones are used. The smartphones, however, have to be of sufficient quality to provide reliable angular velocity information. The tests performed demonstrated that the horizontal angular velocity provides the most reliable information when low vehicle dynamics are experienced. This is due to the fact that verification strategies based on the measurement magnitude lose direction information, which is fundamental for correlation purposes. The analysis also showed the limitations of these data-verification strategies and the need for integrated approaches that implement zero-velocity detection, outlier removal, and adopt an adaptive behavior depending on the vehicle dynamics.

Sub-titles: (Introduction)/Data Verification Strategies/ Experimental Set-up/ Results/ Discussion/ Conclusions

**DOI:** [**https://doi.org/10.1109/MITS.2020.2994070**](https://doi.org/10.1109/MITS.2020.2994070)

**4. Object-Detection-Aided GNSS and Its Integration with Lidar in Highly Urbanized Areas, Weisong Wen et al**

(IEEE Intelligent Transportation Systems Magazine, Vol 12 Issue 3, Fall 2020, pp53-69)

Positioning is a key function for autonomous vehicles that requires globally referenced localization information. Lidar-based mapping, which refers to simultaneous localization and mapping (SLAM), provides continuous positioning in diverse scenarios. However, SLAM error can accumulate through time. Besides, only relative positioning is provided by SLAM. The Global Navigation Satellite System (GNSS) receiver is one of the significant sensors for providing globally referenced localization, and it is usually integrated with lidar in autonomous driving. However, the performance of the GNSS is severely challenged due to the reflection and blockage caused by buildings in super-urbanized cities, including Hong Kong,Tokyo; and New York, resulting in the notorious non-line-of-sight (NLOS) receptions. Moreover, the uncertainty of the GNSS positioning is ambiguous, leading to the incorrect tuning of its weight during GNSS-lidar integration. This article innovatively employs lidar to identify the NLOS measurement of the GNSS receiver using point-cloud-based object detection. Measurements from satellites suffering from NLOS reception will be excluded based on the proposed fault detection and exclusion (FDE) algorithm. Then, GNSS-weight least-square positioning is conducted based on the surviving measurements from FDE. The noise covariance of the GNSS positioning is calculated by considering the potential location errors caused by the NLOS and the remaining LOS measurements. The improved GNSS result and its corresponding noise covariance are integrated with lidar through a graph-based SLAM-integration framework. Experimental results indicate that the proposed GNSS-lidar integration can obtain improved positioning accuracy in a highly urbanized area in Hong Kong.

Sub-titles: (introduction)/ Lidar Odometry and its Co-variance Estimation/ Object Detection Aided GNSS Positioning and its Covariance estimation/ Graph-based GNSS- Lidar Integration/ Experimtneal Evaluation/ Conclusions and Future Work

**DOI:** [**https://doi.org/10.1109/MITS.2020.2994131**](https://doi.org/10.1109/MITS.2020.2994131)

**5. Key Technologies, Modeling Approaches, and Challenges for Millimeter-Wave Vehicular Communications, J. Martin Vega et al**

(IEEE Communications Magazine, October 2018, Vol 56 Issue 10,pp 28-35)

Millimeter-wave communications have been recently proposed as a promising candidate to fulfill the connectivity requisites imposed over autonomous driving. The need for transmission capabilities of multiple gigabits per second for autonomous vehicles is the main driving factor for millimeter-wave technology. However, there are other paramount requirements, such as short delays, high reliability, security, and support for both unicast and broadcast communications, which must be carefully addressed before this technology becomes a reality. In this article we first review the state-of-the art modeling frameworks that are being considered for vehicular communications. Then we explore the key technologies that will enhance the suitability of millimeter-wave communications for autonomous driving, and we investigate the main challenges that need to be overcome. Finally, we envision that a combination of analog/ hybrid beamforming with a location-based beam search protocol, using full duplex radio and physical layer key generation, has the potential of fulfilling the requirements of autonomous driving technology.

Sub-titles: Motivation: State of the Art/ Modelling Frameworks: Spatial Modelling/ Key Technologies for mmWave Vehicular Comms, Beam Management and Analog Precoding, Medium Access Control, Physical Layer Security/ Challenges and Research Directions: Delay and Reliability, Security, Broadcasting/ Conclusion.

**DOI:** [**https://doi.org/10.1109/MCOM.2018.1800109**](https://doi.org/10.1109/MCOM.2018.1800109)

**6**, **Deep-Urban Unaided Precise Global Navigation Satellite System Vehicle Positioning**,

[**Todd E.**](https://ieeexplore.ieee.org/author/37581442800)**et al**

(IEEE Intelligent Transportation Systems Magazine, Vol 12 Issue 3, Fall 2020, pp109-122)

**Introduction paragraphs excerpt**: Future vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) connectivity will permit vehicles to relay their positions and velocities to each other with millisecond latency, enabling tight, coordinated platooning and efficient intersection management. More ambitiously, broadband V2V and V2I enabled by 5G wireless networks will permit vehicles to share unprocessed or lightly processed sensor data. Ad hoc networks of vehicles and infrastructure will then function as a single sensing organism. The risk of collisions, especially with pedestrians and cyclists—notoriously unpredictable and much harder to sense reliably than vehicles—will be significantly reduced as vehicles and infrastructure contribute sensor data from multiple vantage points to build a blind spot-free model of their surroundings.

Such collaborative sensing and traffic coordination requires vehicles to know and share their own position. How accurately? The proposed Dedicated Short Range Communications basic safety message, a first step in V2V coordination, does not yet define a position accuracy requirement, effectively accepting whatever accuracy a standard Global Navigation Satellite System (GNSS) receiver provides]. But automated intersection management, tight-formation platooning, and the unified processing of sensor data—all involving vehicles of different makes that may not share a common map—will be greatly facilitated by globally referenced positioning with sub-30-cm accuracy….

Carrier-phase-based GNSS positioning—also referred to as *precise GNSS positioning* even though it actually offers absolute accuracy, not just precision (repeatability)—can meet the most demanding accuracy requirements envisioned for automated and connected vehicles but has historically been either too expensive or too fragile, except in open areas with a clear view of the overhead satellites, for widespread adoption. Coupling a carrier-phase differential GNSS (CDGNSS) receiver with a tactical-grade inertial sensor, enables robust high-accuracy positioning even during the extended signal outages common in dense urban areas. But GNSS-inertial systems with tactical-grade inertial measurement units (IMUs) cost tens of thousands of U.S. dollars and have proven stubbornly resistant to commoditization. Coupling a GNSS receiver with automotive- or industrial-grade IMUs is much more economical and significantly improves performance,…..

**Abstract**: This article presents the most thorough study to date of vehicular carrier-phase differential. CDGNSS positioning performance in a deep urban setting unaided by complementary sensors. Using data captured during approximately 2 h of driving in and around the dense urban center of Austin, Texas, a CDGNSS system is demonstrated to achieve 17-cm-accurate 3D urban positioning (95% probability) with a solution availability greater than 87%. The results are achieved without the aid of inertial, electro-optical, or odometry sensors. The development and evaluation of the unaided, GNSS-based precise positioning system is a key milestone toward the overall goal of combining precise GNSS, vision, radar, and inertial sensing for all-weather, high-integrity, high-absolute-accuracy positioning for automated and connected vehicles. The system described and evaluated herein is composed of a densely spaced reference network, a software-defined GNSS receiver, and a real-time kinematic (RTK) positioning engine. A performance- sensitivity analysis reveals that navigation data wipe off for fully modulated GNSS signals and a dense reference network are key to high-performance urban RTK positioning. A comparison with existing unaided systems for urban GNSS processing indicates that the proposed system has significantly greater availability or accuracy.

Sub-titles: Introduction/ Challenges of Mobile Precise Positioning in Urban Environments/ System Description/ etc.

**DOI:** [**https://doi.org/10.1109/MITS.2020.2994121**](https://doi.org/10.1109/MITS.2020.2994121)