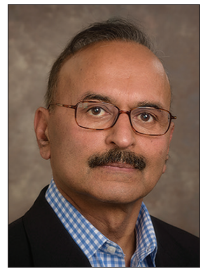
RADIO COMMUNICATIONS: COMPONENTS, SYSTEMS, AND NETWORKS



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Over time, radio has encompassed a steadily broadening range of technologies. Many of these were originally developed for other purposes, and adapted for the radio art. For example, the Ruhmkorff coils used in early spark transmitters were created for medical and lighting applications. Digital techniques were, of course, invented to solve hard problems in code breaking, but later utilized for signal processing and channel coding. And now — artificial intelligence (AI) has moved out of the realm of computer science and is beginning to be applied to radio communications!

Machine learning is one of the most promising AI tools, and is providing a new window into the intrinsic characteristics of next generation wireless networks. This has allowed networks to learn, reason, and adapt by observing the interaction dynamics among their resources. Machine learning has been applied to fourth generation (4G) and 5G networks, cognitive radio, massive multiple-input multiple-output (MIMO), heterogeneous networks, device-to-device communications, and so on. It can be utilized for channel estimation, user location behavior, spectrum sensing and detection, anomaly/fault/intrusion detection, signal classification, and so forth.

In keeping with this tendency of the radio art to absorb disparate technologies, this issue of the Radio Communications Series brings together three articles covering widely differing topics. The first, "Antenna Count for Massive MIMO: 1.9 GHz vs. 60 GHz," is "traditional RF." It compares the capacity trade-off between the number of antennas in the 1.9 GHz personal communication services (PCS) band vs. the 60 GHz mmWave band. Conventional thinking is that mmWave complements massive MIMO: mmWave requires massive MIMO to provide sufficient link budgets, but massive MIMO requires tremendous numbers of antennas that are far easier to achieve at 60 GHz than 1.9 GHz. However, the authors challenge the assumption that such large antenna scale is actually required. The article surveys some of the link modeling parameters for both mmWave and massive MIMO, and then goes on to model some simple scenarios to show that far fewer antennas are needed. In fact, in some scenarios (e.g., interference-limited multi-cell) a comparable number of antennas could provide similar performance for these two widely differing frequency bands.

The second article in this issue wanders much further afield technically. "Learning Radio Resource Management in RANs: Framework, Opportunities, and Challenges," addresses the application of machine learning to radio resource management (RRM). Machine learning and radio communications are distinct disciplines: one is the province of computer scientists and AI researchers, while the other is the domain of RF engineers. However, artificial neural networks are now seeing wide application in many diverse areas, such as face recognition, medical diagnosis, autonomous vehicles, and image processing; why not radio systems? In particular, the radio channel is complex, and its optimal utilization has been and continues to be a hard problem; artificial neural networks may be another option to solving such problems. The authors duly present an introductory overview of neural networks, and briefly cover RRM in cellular networks. They then illustrate how neural networks could be applied to RRM in order to improve power control and rate adaptation in 5G radio access.

Our third article, "Deep Learning Convolutional Neural Networks for Radio Identification," takes the application of machine learning techniques even further. The authors consider the problem of uniquely identifying individual radios by looking at the signal signature of their transmitters. Using signature analysis on radio transmitters is not new, but has generally been restricted to identifying a type of radio rather than a particular piece of hardware. As the authors note, neural networks are widely used for classification and pattern recognition. The article proposes that the raw digital in-phase/quadrature (I/Q) samples from a software defined radio be directly fed to a neural network, which is then trained to identify and classify unique signal characteristics such as I/Q imbalance and carrier frequency offset, eventually deriving a "fingerprint" that identifies the transmitter with a high degree of accuracy.

We would of course be unable to bring you these issues of our Series without the contributions of the authors. To our diligent but unsung reviewers go our appreciation of their efforts in helping the authors improve their papers, as well as assisting us in selecting the highest-quality submissions. We are of course grateful for the support of our Editor-in-Chief and the publication staff. And we encourage our readership to send in contributions to be considered for publication!