Editorial:

30th Anniversary Special Issue on Future Signal Processing

The 30th anniversary of Digital Signal Processing also marks an era of transition. The challenges and the emphases of digital signal processing are changing. Past decades were characterized in challenges in fast transforms, efficient data compression, coding, filtering and their applications in telecommunications, radar, speech, image and video processing. Linear and Gaussian models and linear filters, transforms dominated the methodologies developed. The field is currently facing important changes in a number of new directions.

The most prominent change signal processing field is changing is introduced by the arrival of deep learning. Deep learning has responded efficiently to the increasing need and emphasis of signal processing in "understanding" data. Various real life applications require drawing features from data, a priori non-defined, in a blind fashion. The black-box nature of deep learning combined with its nonlinear modelling/processing capabilities acted as a remedy for the lack of enough nonlinear signal processing methodology. The black-box nature of deep-learning provides us with not only an advantage of not needing a-priori defined parametric models but also its biggest challenge: "interpretability". We still do not fully understand the meaning of weights in the intermediate layers of deep neural networks. The complexity, as in the number of layers, and number of nodes are decided by trial and error. Another shortcoming of deep learning is its deterministic nature. We do not yet have an estimate for the theoretical bounds of generalization of deep learning. The future performance of deep learner is dictated by the training corpus. We do not have yet means to know when a training corpus would be enough to teach the deep neural network all possible future outcomes. These shortcomings will be addressed in the coming years by signal processing researchers who are the best prepared to answer these questions.

Other challenges include increasing demands of communications in 5G, 6G and beyond, which require higher bit rate communications and higher compression rates and coding schemes that approach channel capacities. Again in the context of communications, joint design of radar and communications systems is the growing realm and we will see the merging of these two fields.

Image and video understanding give increasingly more emphasis on understanding and will require more semantic approaches which will need to go beyond modern machine learning approaches.

Another growing realm is big data which requires analyzing and processing data in interacting groups rather than single signals. This is the driving motive behind the emerging research into graph signal processing. Time-varying graphs or multimodal graphs are the challenges of the future.

To commemorate the 30th anniversary of DSP, we have invited several leading experts to report on state of the art research and their projections on the challenges for "Future Signal Processing". The issue starts with a paper written by ex-Editors-in-Chief on the history of our journal. We are very proud to have the contribution of Prof Erdal Arikan, the inventor on polar coding as the next article: it provides important insights of potentials of ideas that lead to polar coding in signal processing related topics such as compressed sensing. The following article is in the field of graph signal processing contributed by S. Aviyente and is studying community detection in dynamic networks. The next paper by O. Arikan *et al* introduces a very interesting normal formulation of understanding in signal processing, namely semantic

signal processing which joins the advantages of signal processing and machine learning and goes beyond.

Next, is an article by Amin *et al* providing a state of the art of joint radar-communications systems and provides perspectives into the future of the field. Dogancay *et al* contributed with an article on interpretation of remote sensing images with pattern recognition and machine learning methods. State of the art and future directions in understanding of data from emerging technology LIDAR are discussed in the next paper by Sziranyi and Benedek. Two well developed methodologies, time-frequency analysis (by Akan et al.) and optical signal processing (by Kutay and Ozaktas) and their current trends and future potentials are discussed in the next two papers.

Following are two articles on biomedical applications: artificial intelligence applications in histology (Morales et al) and sensing applications in cardiology and respiratory system (Cetin et al). The issue ends with two papers on applications of machine learning methods. Schroeder et al discuss the application of Complex Neural Networks in Wireless Networks and Molina et al discuss deep learning methods in inverse problems in image processing.

We hope that this special issue would be inspiring to the signal processing community and would lead to new research.

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