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Special Section Guest Editorial: Machine Learning In Optics

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Special Section Guest Editorial: Machine Learning in Optics

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One of the benefits of research using machine learning techniques is the plethora of opportunities for creativity in problem solving. Certainly there is a lot of hype around artificial intelligence and the anticipated impact on society. Nonetheless, machine learning is a rapidly evolving field due to the large community of interdisciplinary researchers currently focused on the topic. Major breakthroughs in computer vision helped to inspire the intense focus on machine learning that we see across many fields of inquiry. This special section covers recent advances in machine learning through innovation in the science of optical systems.

Practicing researchers know the importance of data and good strategies for retention, analysis, and reproducible results. All data has variation, and the intent of machine learning techniques is to capture that variation and produce algorithms that have meaningful results. Algorithm design is as much an art as a science to tailor for variation. In the papers presented in this special section, the authors demonstrate novel approaches to solve some of the intricate challenges in the optical sciences using machine learning tools.

Zhang et al. present their novel approach of joint, sparse, model-based image fusion to fuse two images from different imaging modes using a learned dictionary at multiple scales. Image fusion is a current trending topic in machine learning research to bring forward the interest parts of each image into a single image. Human interpretation of the resulting scene is improved by context from each image.

Kyono et al. perform image quality assessment for ground-based telescopes using a machine learning approach. Their first application determines the resolvability prediction of an output blind deconvolution given a collection of telescope images; the intent is to save supercomputer resources if the computational image will not be a good result. Their second application is predicting the image quality on the Space-object National Imagery Interpretability Rating Scale (SNIIRS) as a means of estimating the information value of the resolved image.

Optical systems design can be changed by our understanding of machine learning principles to create novel, low-power implementations. Redman et al. use two different optical layouts to perform classification (binning of input data) by combining their optical design with compressed sensing theory using several low-resolution detectors. The approach casts the variation into a smaller decision space using optics. Redman notes that image quality does not need to be designed for human interpretability but rather can be matched to maximize performance of the algorithm.

Saeed et al. present an approach to perform handwritten script-to-text on scanned Arabic documents using maximally stable extremal regions as the feature vector. This is an interesting way to discern meaning in cursive handwriting across different writers, and we believe it has applicability to other problems in optics.

Oliveira et al. use machine learning in shearography, an important application for precision manufacturing precision. The convolutional U-net algorithm is used to perform segmentation on the interferogram to determine the locations of deformation. The algorithm shows promise on reduced measurement error with tighter bounds than conventional approaches. In the final paper in this special section, Theagarajan et al. combine a model-based approach with a convolutional neural network to perform target recognition in inverse synthetic aperture RADAR (ISAR) imagery. The investigation demonstrates how the approaches complement one another under common degradations in image formation, such as from object motion and clutter. The discussion on performance for the different ISAR data representations is thought provoking.

The guest editors wish to thank the *Optical Engineering* editorial team, the authors, and reviewers for their effort to present this section. Our goal with this special section is to inspire continued research into optics using machine learning where appropriate.