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Optical and Hybrid Imaging and Processing for Big Data Problems

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The scientific community has been dealing with big data for a long time. Due to advancement in sensing, networking, and storage technology, other domains such as business, health, and social media followed. Data are considered the gold of the 21st century and are being collected, stored, and analyzed at a rapid pace. The amount of data being collected creates a compelling case for investing in hardware and software research to support generating even more data from new sensors and with better quality. It also creates a compelling case for investing in research and development of new hardware and software for data analytics. This special section of *Optical Engineering* explores the optical and hybrid imaging and processing technology that will enable capturing and analyzing large amounts of data or help stream the data for further exploration and analysis.

The paper "Design for source-and-detector configuration of a ring-scanning-based near-infrared optical imaging system" by J.-M. Yu, M.-C. Pan, and M.-C. Pan describes the design scheme of the source-and-detector arrangement of a ring scanning–based near-infrared optical system. The new design helps reduce the time required for data acquisition by dividing circular scanning into several zones, each of which includes n sources and l detectors; i.e., m zones and n sources along with l detectors per zone. The influences of the source-and-detector arrangement on the resulting images are evaluated and a formula to estimate the scanning time is provided. Reducing data acquisition time for images is important for real time and streaming data analysis. Several domains can benefit from such advancements.

The paper titled "Full-range in-plane rotation measurement for image recognition with hybrid digital-optical correlator" by T. Zheng et al. is an excellent example of the kind of research and development needed in order to speed up the analysis of images. Several applications can benefit from the ability to compute the correlation of images at a high speed. The algorithm will help compare images in the absence of coordinate matching or geo-registration since it uses the two-step rotation with finer resolution in the second step. Health, astronomy, remote sensing, and other domains will find this algorithm very useful. Also, enhancing the speed of image correlation will introduce new challenges to consequent steps in the image-analysis pipeline since the data will be produced faster.

The paper "Three random phase encryption technology in the Fresnel diffraction system based on computer-generated hologram" by S. Xi et al. proposes a new method for image encryption using a Fourier computer-generated hologram (CGH) in the encryption system of multiple Fresnel diffraction transforms with phase masks. The first two papers demonstrated technologies for speeding up image acquisition and correlation computing (image analysis); however, images have to be transferred over the network for analysis purposes. There are several domains that require high security for image transmission over the network. The proposed algorithms are very useful, and in some cases necessary, to guarantee the security or privacy of transferred images.

The paper titled "Acceleration of split-field finite difference time-domain method for anisotropic media by means of graphics processing unit computing" by J. Francés et al. discusses the implementation of split-field finite difference time domain applied to light-wave propagation through periodic media with an arbitrary anisotropy method in graphics processing units (GPUs). The authors also elaborate on the performance of the CPU and GPU implementation in several different applications such as in binary phase grating in dielectric medium and gratings in liquid crystal medium.

The last paper in the special section titled "Shoreline extraction from light detection and ranging digital elevation model data and aerial images" by A.Yousef, K. Iftekharuddin, and M. Karim discusses the implementation of two innovative algorithms for extracting shorelines from images depending on the available data sources. The first algorithm uses multistep morphological techniques to detect and eliminate outliers from waves; in addition, it uses Hough transform to identify and eliminate objects such as docks, bridges, and fishing piers. The second algorithm uses training data and support vector machines classifier to segment the data into water and land. The performance is compared to other techniques to show the effectiveness of the new approach.

Although the set of papers in this special section is relatively small, the diversity of the topics discussed and the techniques used to speed up data acquisition and analysis is still apparent. This is an attempt to encourage the optics community to engage in the emerging data-intensive applications field and explore how optical engineering can contribute to the state of the art to extract the knowledge buried in these data. Hardware-accelerated algorithms such as the ones discussed in the first two papers are important for speeding up data analysis. The rest of the papers contributed algorithms that are useful for the data mining community in general. We hope this issue will spur new activities and collaboration in this emerging field.

Khan M. Iftekharuddin is a professor and chair in the Department of Electrical and Computer Engineering at Old Dominion University (ODU). He serves as the director of ODU Vision Lab. He is also a member of the biomedical engineering program at ODU. Much of his research has focused on different aspects of computer vision and signal/image-processing problems. He is the principal author of a book, several book chapters, and more than 150 refereed journal and conference papers. He serves as an associate editor for multiple journals, including *Optical Engineering*, and *Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization*. He is a Fellow of SPIE, and a Senior Member of both IEEE and OSA.

Abdul Awwal currently works at the National Ignition Facility (NIF) of the Lawrence Livermore National Laboratory (LLNL). From 1989 to 2001, he was with Wright State University. His areas of interest include automated optical alignment, pattern recognition, and optoelectronic computing. He is the author of 75 articles in refereed journals, a text book on *Optical Computing*, an SPIE field guide on image processing, and an edited book on *Adaptive Optics for Vision Sciences*. He received two R&D 100 awards for an adaptive optics phoropter and an automated alignment system for laser fusion. He is a fellow of SPIE and OSA, and served as founding Chair for four SPIE conferences.

S. Susan Young is a research scientist with the U.S. Army Research Laboratory. Previously, she was with Roswell Park Cancer Institute and Eastman Kodak Company. She received a PhD in electrical engineering at SUNY Buffalo. She has published over 70 technical papers and has eight patents in inventions related to medical diagnostic imaging, computer vision, and image superresolution. She coauthored the textbook Signal processing and performance analysis for imaging systems, published by Artech House in 2008. She serves as an associate editor of *Optical Engineering*. She is a recipient of 2007 and 2012 U.S. Army Research and Development Achievement Awards.

Ghaleb M. Abdulla works in the Data Science Group at LLNL. He earned his PhD in computer science from Virginia Tech in 1998. He earned his bachelor's degree in electrical and computer engineering from Yarmouk University in Jordan. Before joining LLNL, he worked for the Dow Chemical Company at the business intelligence center. His research interests include scientific data management, information organization, information storage and retrieval, and data mining.