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The digital optics revolution in recent years has dramatically enhanced and empowered innovation in all facets of modern life encompassing healthcare, structural safety, and recreation. In the last two decades, digital photoelasticity has seen great developments and it has now matured into a well-developed technique for reliable measurement of stress and strain distributions in engineering applications. Photoelasticity basically provides contours of principal stress/strain difference (isochromatic fringes) and principal stress/strain direction (isoclinic fringes). Two principal approaches have been in use: one that uses phase shifting with a monochromatic source and the other that uses color information for data reduction. Accurate results are guaranteed with proper choice of phase-unwrapping algorithms and suitable smoothing methodologies. Demonstration of the application of digital photoelasticity to solve a variety of problems would promote its wider use. This special section with nine papers addresses all of these concerns.

Micromechanical analysis of particulate materials, such as powders and grains, has wide-ranging application, from chemical, pharmaceutical, food, geotechnical, mechanical, minerals, and material-processing sectors, to beach sandcastles. Antony et al. have shown the use of digital photoelasticity for such a study. They have shown that unlike a granular surrounding, the shear stress distributions of inclusions in powder surroundings tend to display a continuum-like behavior under external compression. In the case of inclusions surrounded by grains, they have observed that the peak value in maximum shear stresses occurs within the inclusions, which deviates from that of Hertzian analysis.

Photoelasticity was one of the earliest techniques to experimentally quantify stress fields in the vicinity of a crack-tip. In fatigue crack growth, crack closure phenomenon is elusive to record experimentally. Through the use of phase shifting, Vasco-Olmo and Díaz have successfully quantified the reduction in the stress intensity factor of a crack in a polycarbonate specimen subjected to fatigue loading due to plasticity-induced crack closure. Polycarbonate is a birefringent material that is ductile enough to grow fatigue cracks.

If the interest is only to evaluate principal stress difference, the use of color information has attracted the attention of researchers, as one image is sufficient for analysis. This provides an advantage for conducting dynamic studies. One of the issues in such methodologies is the evaluation of fringe orders beyond three. Swain et al. have presented an interesting method that uses only two of the three color information coupled with an image normalization procedure to evaluate fringe orders up to 10 for a class of simple fringe fields.

In conventional photoelasticity, the isoclinic values are easy to determine, whereas the isochromatic evaluation other than at the fringe points is tedious. However, in digital photoelasticity, evaluation of isoclinics posed a serious challenge, as these are not defined at isochromatic skeletons. From the principles of continuum mechanics, the stress field is continuous and hence the principal stress directions also must be continuous. To achieve this, Ramesh et al. have reported an elegant smoothing methodology. The algorithm presented is robust and can in principle be used for a variety of experimental fringe patterns.

Photoelasticity is easily employable for determining the stresses in structural materials that are transparent and birefringent, such as glass and polymeric materials. Scafidi et al. have provided a review of various digital photoelastic methods to determine the residual stresses in glass and the development of swelling stresses induced by hydrothermal water uptake in aging epoxy–based thermoset polymers. An explanation on the increase of fracture toughness of hydrothermally aged epoxies is provided with the use of digital photoelastic measurement.

Wu and Huang have done a systematic study on the role of spatial and temporal phase unwrapping of isochromatic phasemaps. Use of multiwavelengths or multiple loads to get additional data for phase unwrapping has been classified as temporal phase unwrapping. The issues that need to be taken care in temporal phase unwrapping have been brought out by them.

Of late stress field study of biomedical applications is gaining importance, and the first challenge lies in the selection of suitable surrogate materials to model complex human physiological systems. The next is the simulation of the complex three-dimensional nature of biological load systems. Tomlinson and Taylor in their pilot study have reported the comparison of gelatine, konjac, and agar on their utility to model human tissue. Digital photoelasticity is used to visualize the penetration of a needle tip in simulated human tissue. They have also reported another pilot study that visualizes the stress field in the brain of a small baby when it is shaken. To make the problem domain easy to handle, they have simulated a 2-D model of the brain.

Surendra and Simha have championed the case of using syntactic recognition of intensity patterns for devising efficient digital photoelastic algorithms. They have done both an analytical and experimental study to capture the nature of an intensity field in the neighborhood of isotropic points (IP). They have suggested that the IPs are better analyzed in polar coordinates and have shown that in isolated IPs, the intensity variation is quadratic.

Photoelastic methods have been mostly in use for materials that exhibit stress-induced birefringence. In high-energy

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physics, biomedical devices, and security and inspection machines, scintillating crystals are used, which are naturally birefringent. Analysis of such materials pose a challenge and Montalto et al. have devised a new laser-based conoscopic technique to analyze the stress fields that could achieve a spatial resolution of 0.1 mm.

Future applications of digital photoelasticity for visualizing stress waves under impact loading will be a great boon for automobile and earthquake engineering. The general perception of photoelasticity limited to visible colors and elastic materials has been surpassed in recent studies of temporarily birefringent materials responding to a wide range of ultraviolet-infrared wavelengths spanning the electromagnetic spectrum. One can also expect exciting new prospects for combining stress-induced optical and acoustic birefringence for extending photoelasticity to partially or even completely opaque materials. Increasing demands for nondestructive and noninvasive techniques for monitoring machines and human beings will usher in an entirely novel and new era for harvesting digital photoelasticity. It is indeed amazing to conclude here that optics in general and photoelasticity in particular continue to inspire innovative ideas for modern technology.

Finally, I would like to thank all the authors for their contributions and the reviewers for their valuable comments to ensure high quality papers. I would also like to thank Prof. Rajpal Sirohi for prompting me to embark on this task and also my thanks are due to SPIE and *Optical Engineering* for providing both the opportunity and technical support for publishing this special section.

Krishnamurthi Ramesh is credited with publishing the first monograph on *Digital Photoelasticity-Advanced Techniques and Applications*, Springer 2000. He has been a voracious writer on experimental mechanics/photoelasticity. The chapters contributed by him in books include “Photoelasticity,” in *Springer Handbook of Experimental Solid Mechanics* (2008), “Experimental Stress Analysis – An Overview,” in *Optical Methods for Solid Mechanics*, Wiley-VCH (2012), and “Digital Photoelasticity,” in *Digital Optical Measurement Techniques and Applications*, ARTECH House (2015). He has also written the first interactive multimedia e-book on *Experimental Stress Analysis* (2009) published by IIT Madras. His video lectures on experimental stress analysis are available free for the world community. http://www.nptel.iitm.ac.in/courses/112106068/1