Experimental methods of stress analysis continue to hold their own in spite of the appeal of analytical solutions, which are seen to be elegant and challenging in some cases; and numerical methods, which are considered convenient and inexpensive given the abundance of user-friendly, commercially-available software and powerful, fast personal computers today. Photoelasticity is, arguably, the most favored in the pantheon of the experimental techniques. However, no revolutionary developments have occurred in the methods used for photoelastic studies for a very long time (The latest is, perhaps, the Photo Stress photoelastic coating method, introduced in 1956.) During this same period, great strides have been made in the field of digital image processing. It was inevitable; therefore, that some intersection of these two fields would occur. Digital photoelasticity - a product of this cross-fertilization - has been the subject of a number of journal articles, but very few books. Perhaps many considered writing a book at this stage in the development of the subject rather daunting. The author of the book under review is to be applauded for being brave enough to take on this task. The result is a textbook containing 11 chapters, in which the basic principles of the various strands of the subject are explained in detail, and the salient features of various applications illustrating the use of these principles are presented.

In Chapter 1(Transmission photoelasticity), all the rudiments and fundamental concepts of photoelasticity are described in succinct fashion. Thus, myriad topics are covered, these being: the nature of light, polarization, the passage of light through isotropic and crystalline media, light ellipse, retardation and wave plates, the stress-optic law, the arrangements of optical elements in a plane polariscope and a circular polariscope, determination of isoclinic and isochromatic fringe order at a point, compensation techniques, calibration of photoelastic model materials, fringe ordering, determination of the sign of the boundary stresses, methods of resolving the ambiguity on the principal stress direction, the key features of three-dimensional photoelasticity and integrated photoelasticity, and model to prototype relations.

In Chapter 2 (Reflection photoelasticity), the focus is this technique, which is a variant of transmission photoelasticity and is useful for stress analysis of opaque prototypes. The chapter begins with a clear description of the basic principle of the technique, comparing and contrasting it with the more well-known transmission photoelasticity. This is followed by an abbreviated account of the development of photoelastic coatings from their first use by Mesnager in 1930 to the derivation, by Zandman et al in 1962, of correction factors for interpreting fringe patterns. Following this, various aspects of the technique are described, with the topics covered including the optical arrangement of reflection polariscope, stress and strain-optic relations for a photoelastic coating, correction factors for photoelastic coatings, the Poisson's ratio...
mismatch problem, the desirable properties of a photoelastic coating, considerations in selection of the coating thickness, collection of the basic data (fringe order and isoclinic parameter) and methods of analyzing them, and examples of application of photoelastic coatings.

The concepts covered in Chapter 3 (Digital image processing) are those that are needed for understanding the role of digital image processing in photoelasticity. The chapter opens with a presentation of a number of basic ideas, such as image sampling and quantization, and then a wide array of relevant concepts are covered in more detail, among which are characteristics of video standards in use today, image sensors, a number of basic relationships and mathematical operations between pixels (such as neighbors of a pixel and arithmetic operations), the basic steps in image processing, the elements of a typical image processing system, the structure and design of software, various tools for image understanding (such as pseudo coloring and three-dimensional intensity plots), and techniques for image enhancement and segmentation (such as histogram equalization and dynamic thresholding).

The material presented in Chapter 4 (Fringe multiplication, fringe thinning, and fringe clustering) could be divided into three parts. In the first, there are descriptions of digital techniques to effect these operations. Among the topics covered are image subtraction of bright and dark-field images and half-fringe photoelasticity. In the second part, algorithms developed for use in conjunction with the intensity-based methods of fringe processing are presented, among which are masked-based algorithms for skeleton extraction and the row-wise scanning algorithm for fringe skeletonization. In the third part of the chapter, the issues covered include applications of the algorithms, improvements to global thinning algorithms, and evaluation of the performance of various fringe-thinning algorithms.

In Chapter 5 (Phase shifting, polarization stepping, and Fourier transform methods), copious details of these techniques are presented. The chapter begins with a summary of the early attempts to automate polarisopes, highlighting the contributions of people such as Zandman, Sapaly, Allison, Nurse, Redner, and Marston. Following this, the basic principles of phase shifting are described followed by expositions on a wide range of topics, such as the generic arrangement of plane and circular polarisopes, whole field evaluation of photoelastic data using these polarisopes, sources of error and methods of minimizing their impact on the results obtained. In the middle part of the chapter, there is a short description of polarization stepping for isoclinic determination, a method that was introduced by Brown and Sullivan in 1990. Three Fourier transform methods for photoelastic data acquisition use of carrier fringes, multiple polarization stepped images, and load stepping are described in later sections of the chapter. The chapter ends with comments on the relative attractions and drawbacks of the three groups of techniques covered.

All the topics treated in Chapter 6 (Phase unwrapping and optically enhanced tiling in digital photoelasticity) are related to improving the quality of the data collected. Among them are boundary detection, removal of binary noise at discrete points in a phase map, algorithms for phase unwrapping, parameters that affect phase unwrapping, digital magnification of high fringe density zones, cementing of an optically magnified tile with the original image, and optically enhanced tiling applied to a circular disc and ring subjected to diametral compression loading.
Spectral content analysis and the techniques that need color image processing hardware are the subject of Chapter 7 (Colour image processing techniques.) The first part of the chapter contains a short description of the main features of the two main color models used for image processing: the red-blue-green (RGB) and the hue saturation-intensity (HIS) models. The second part of the chapter deals with color image processing systems, the spectral response of a color camera, the light intensity transmitted in white light for various polariscope arrangements, principles, calibration, and an application of three fringe photoelasticity, and phase shifting in color domain. The third part is dedicated to spectral content analysis and the tricolor photoelastic method.

Chapter 8 (Evaluation of contact stress and fracture parameters) deals with the use of digital photoelasticity for the determination of these characteristics, which are known to play influential roles in the service performance of a wide assortment of mechanical components and systems. Among the topics covered are the basic data required and their digital acquisition, the stress analysis for two cylindrical bodies in contact, evaluation of contact stress parameters by least squares analysis, the stress field equations in the vicinity of a crack tip, evaluation of mixed-mode stress field parameters using least squares analysis, and experimental validation of the stress field parameters for Mode I and Mixed-Mode loadings. The uses of a number of the principles described are illustrated with respect to an application problem, that of a spur gear, for which the values of a large number of parameters such as fracture toughness and the constant stress term, contact length and friction coefficient were obtained and are presented.

Considered in Chapter 9 (Stress separation techniques) are the auxiliary methods used to obtain the individual values of the principal stresses or, in a more complete sense, the values of all the elements of stress tensor. The chapter opens with a brief survey of experimental methods (the oblique incidence method, the conventional shear difference technique, and the Tesar shear difference technique), numerical methods (finite difference method, stress difference elasticity concept, and the least squares method), and hybrid methods. Following this survey, various details (such as finite element formulation and discretization of the domain) are provided about relatively new approach in which phase shifting and the finite element analysis method are combined. Also, descriptions of the application of the approach to an example problem—that of a finite plate, containing a hole, in Uniaxial tension are given. The chapter ends with discussions on the use of integrated photoelasticity concepts for stress separation, stress separation in 3D photoelasticity, and stress separation in reflection photoelasticity.

In Chapter 10 (Fusion of digital photoelasticity, rapid prototyping, and rapid tolling technologies), the interconnectedness between these three state-of-the-art methods is explored. Thus, among the topics covered are the application of rapid prototyping processes for fabricating models to be used in photoelastic studies, illustration of this application using photoelastic models made using fused deposition modeling and then coated with a photoelastic coating, and digital photoelastic characterization of a model fabricated using a rapid tooling process.

The subjects of Chapter 11 (Recent developments and future trends) are newly emergent concepts and research ideas at various stages of maturity. Among the recent developments discussed are the methods for determining the characteristic parameters for a given length of the light path, namely the axis of the retarder, retardation introduced by the retarder, and the rotary power of the rotator; tensorial tomography; new digital image
processing hardware, such as improved frame grabbers, progressive scan cameras, and time-delay and integration (TDI) sensors; new digital image processing software, such as the Matrox Imaging Library and the FRN_DAT package; digital dynamic photoelasticity, using charge coupled devices and TDI cameras; and the use of photoelasticity for the stress analysis components and structures fabricated from filamentary composite materials. Among the future trends identified are the potential for using Windows-based software for, for example, fringe unwrapping; use of applets; development of device independent software; and the use of wavelet transforms for isochromatic fringe ordering.

The book has many attractive features, some of which have to do with substance and others with style. In the former category, the following features may be cited: meticulous use of Jones calculus to set up the governing equations (where applicable) and the various optical arrangements; a comprehensive treatment of the relevant concepts in each chapter; incorporation of recent developments in other fields into photoelastic evaluation, such as direct analysis of parts fabricated using fused deposition modeling; inclusion of a long list of references, most of which were very recent, at the end of each chapter; and a writing style that is consistently perspicacious. As for aesthetics, the material in the book is arranged in an orderly manner, and there are copious supporting materials (211 figures and 39 tables), including clear and sharp fringes in the reproduced photoelastic images.

The book has two shortcomings. First, many of the exercises given at the end of each chapter are not of the requisite standard for the intended readership of senior level undergraduate and graduate students. (There are too many descriptive questions). Second, the book does not contain list of acronyms and symbols. Inclusion of these lists would have facilitated reading in cases where the symbol or acronym is not defined in the page being read.

The author has produced a first-class textbook that should find widespread use among students, researchers, and design engineers in many branches of engineering. The present reviewer thus recommends Digital Photoelasticity: Advanced Techniques and Applications with the warmest enthusiasm.