

Preface

Since Dennis Gabor introduced the hologram in 1947, the coherence imaging approach has been used to generate stunning images and has found application in diverse fields such as optical recording media and security encoding. With the development of modern photonics technology, the field of holography has been greatly advanced with the laborious need for recording and developing photographic films replaced by the use of digital photography. In fact, the new field of digital holography has enabled a rapid expansion in the use of coherence methods for imaging and microscopy, thanks to the development of digital technology and of some key elements such as high-resolution pixelated detectors in all regions of the electromagnetic spectrum, from UV to long IR, high-power compact lasers, spatial light modulators, and especially the increased computational power of modern PC processors. Moreover, the incredibly improved capability for data storage allows the possibility of capturing and managing huge numbers of images. In combination with the development of efficient computational algorithms for image processing and new strategies for conception and design of optical and optoelectronic systems, these advances have enabled novel methods for coherent imaging and microscopy to become useful in biology and microfluidics.

This text seeks to provide an overview of the current state of the field for the application of digital holography for microscopic imaging. One of the aims of this book is to present the best “work in progress” in microscopy based on using coherent light sources to people outside the optics community, to provide readers with the tools for understanding these novel techniques and thus the ability to judge what new capabilities will be important and potentially challenging for their research.

The text has been divided into three sections, covering areas of active research in this field. The first section presents an overview of recent advances in the methods of digital holography. Subjects examined in this section include the basis of image formation in digital holography and the role of coherence, such as the degree of coherence in the illumination. This section also includes discussion of the unique ability to numerically manipulate the digital holograms to produce additional visual representations, such as images comparable to those that would be obtained using traditional phase microscopy imaging methods.

The ability to obtain phase information from the recorded data is a significant strength of the digital holography approach. The second section of this text focuses

on novel phase microscopy implementations of digital holography. A clear advantage of digital holography is that quantitative phase information is obtained, addressing a shortcoming of traditional phase microscopy methods which make quantitative analysis difficult. In this section, experimental digital holography methods are discussed which have been developed for specific imaging applications, such as imaging of microlens arrays. Additional topics include the use of novel devices such as spatial light modulators and spectral domain detection, as well as application of phase imaging to biological samples and dynamic phenomena.

The third section of this text discusses current research into improving the performance of digital holography. Topics here include an examination of the nature of image formation as a means to improve phase retrieval and enhancing the numerical aperture of the collected signal to improve spatial resolution. The ability to obtain super-resolved imaging information is a compelling topic also covered in this section. The final chapter shows how coherence imaging can be extended to three-dimensional applications by using speckle pattern analysis. We wish to thank Dr. Francesco Merola (CNR-INO) for helping us in the process: his fruitful cooperation has been truly appreciated.

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