

Preface

Digital holography is an emergent new imaging technology that inherits many of the unique capabilities of conventional holography but provides novel solutions to some of the key problems that have been limiting its applications and further development. By replacing the photochemical procedures with electronic imaging and having a direct numerical access to the complex optical field, a wide range of new imaging capabilities become available, many of them difficult or infeasible in conventional holography. In recent years, research activities in digital holography have seen exponential growth and application areas have been expanding especially in microbiology and medical imaging. Increasing number of researchers in traditional physics and electrical engineering departments as well as all other areas of engineering, biology, and medicine are interested in exploring the potential capabilities of digital holography. This book is intended to provide a brief but consistent introduction to the principles of digital holography as well as giving an organized overview of the large number of techniques and applications being developed. This will also shed some light on the range of possibilities for further developments. As such, the intended audience is the students and new researchers interested in developing new techniques and exploring new applications of digital holography.

First chapters, 1–5, describe the basic principles of digital holography. A brief history of holography, both conventional (or analog) and digital, is given in Chap. 1, followed by a brief summary of scalar diffraction theory and Fourier optics in Chap. 2 and a general description of the holography processes in Chap. 3. Chapter 4 describes basic numerical methods of calculating optical diffraction. Simulation examples are used to clarify the procedures as well as compare between different methods as clearly as possible. Chapter 5 describes general behavior of the digital holographic images as well as a small number of basic optical configurations that are used in, or are the starting points of, most digital holography experiments.

Chapters 6–10 describe specific techniques of digital holography in some detail. Chapter 6 highlights some of the theoretical developments that enhance the capabilities of digital holography and applications. The zero-order (or dc) and

twin-image terms are important issues in holography, and digital holography provides novel approaches, as described in Chap. 7. In particular, the phase-shifting techniques of Chap. 8 provide highly effective methods for removing the dc and twin terms. The concept of phase shifting is also applied to a number of other special techniques that lead to some quite remarkable capabilities, as will be seen in later chapters. Chapters 9 and 10 collect a number of techniques developed for special capabilities of digital holography imaging, grouped according to whether they involve reconfiguration of hardware or involve numerical processing only.

Final two chapters survey the techniques and applications of microscopy and low-coherence imaging. In Chap. 11, the digital holographic microscopy, and especially its applications in quantitative phase microscopy, are described. Special techniques of digital holographic microscopy, as well as related techniques for quantitative phase microscopy, are surveyed. Digital holographic imaging with low-coherence sources, described in Chap. 12, may hold particularly significant potential for novel imaging methods that have been very difficult or unfeasible in conventional holography.

It is to be noted that the biological microscopy applications of digital holography is emphasized here. This is one of the many areas one can expect significant amount of new development from. But it leaves some of the other major areas such as interferometric metrology and optical information processing outside the main scope of this book. Certainly the book has many deficiencies, both in content and presentations, but it is hoped that this will provide helpful starting materials and stimulus for entering the exciting and rapidly developing field of digital holography. Feedback of comments and corrections from readers addressed to mkkim@usf.edu would be most appreciated.

My sincere thanks go to all the students of our Digital Holography and Microscopy Laboratory at the University of South Florida, who have worked hard to produce many of the nice images that are touted here. Appreciation also goes to several colleagues who have given me insights and encouragements at important points of various phases of research represented here, including especially Profs. C.M. Lo and D. Richards. Special thanks to Ms. J. Burke of Springer for her unlimited patience and help with this book project. Financial support of the National Science Foundation during much of the research presented here is gratefully acknowledged. Finally, gratitude and affection to my family for putting up with my absurd work habit. Now I will go take the dogs out for a walk. . .

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