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Despeckle Filtering for Ultrasound Imaging and Video

Volume I: Algorithms and Software

Second Edition

Christos P. Loizou

Constantinos S. Pattichis

*SYNTHESIS LECTURES ON
ALGORITHMS AND SOFTWARE IN ENGINEERING*

Andreas Spanias, Series Editor

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Preface

Speckle can be modeled as a multiplicative noise source that degrades image and video quality and the visual evaluation in ultrasound and SAR imaging. This necessitates the need for robust despeckling techniques in a wide spectrum of the aforementioned imaging applications. Despeckle filtering is a rapidly emerging research area with several applications for ultrasound images and videos. The goal for this book is to introduce the theoretical background (equations), the algorithmic steps, and the MATLAB™ code for the following group of despeckle filters: linear filtering, nonlinear filtering, anisotropic diffusion filtering, and wavelet filtering. The filters covered represent only a snapshot of the vast number of despeckle filters published in the literature. Moreover, selected representative applications of image despeckling covering a variety of ultrasound image processing tasks are presented. Most importantly, a despeckle filtering and evaluation protocol is proposed based on texture analysis, image quality evaluation metrics, and visual evaluation by experts. The source code of the algorithms presented in this book has been made available on the web, thus enabling researchers to more easily exploit the application of despeckle filtering in their problems under investigation.

This book is organized into eight chapters. Chapter 1 presents a brief overview of ultrasound imaging and video, speckle noise, modeling, and filtering. Chapter 2 covers the evaluation methodology based on texture and statistical analysis, image quality evaluation metrics, and the experiments carried out for visual evaluation. The theoretical background (equations), the algorithmic steps, and the MATLAB™ code of selected despeckle filters are presented for linear despeckle filtering, for nonlinear despeckle filtering, for diffusion despeckle filtering and for wavelet despeckle filtering in Chapters 3–6, respectively. Chapter 4 presents the applications of despeckle filtering techniques in ultrasound images of the carotid and cardiac ultrasound images. Chapter 7 discusses, compares, and evaluates the proposed despeckle filtering techniques. Chapter 8 presents the summary and future directions, where a despeckling filtering protocol is also proposed. Finally, at the end of this book, an Appendix provides details about two different despeckle filtering MATLAB™ toolboxes for ultrasound imaging and video of the carotid artery.

This book is intended for all those working in the field of image and video processing technologies, and more specifically in medical imaging and in ultrasound image and video pre-processing and analysis. It provides different levels of material to researchers, biomedical engineers, computing engineers, and medical imaging engineers interested in developing imaging systems with better quality images, limiting the corruption of speckle noise.

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ABSTRACT

It is well known that speckle is a multiplicative noise that degrades image and video quality and the visual expert's evaluation in ultrasound imaging and video. This necessitates the need for robust despeckling image and video techniques for both routine clinical practice and tele-consultation. The goal for this book (book 1 of 2 books) is to introduce the problem of speckle occurring in ultrasound image and video as well as the theoretical background (equations), the algorithmic steps, and the MATLAB™ code for the following group of despeckle filters: linear filtering, nonlinear filtering, anisotropic diffusion filtering, and wavelet filtering. This book proposes a comparative evaluation framework of these despeckle filters based on texture analysis, image quality evaluation metrics, and visual evaluation by medical experts. Despeckle noise reduction through the application of these filters will improve the visual observation quality or it may be used as a pre-processing step for further automated analysis, such as image and video segmentation, and texture characterization in ultrasound cardiovascular imaging, as well as in bandwidth reduction in ultrasound video transmission for telemedicine applications. The aforementioned topics will be covered in detail in the companion book to this one. Furthermore, in order to facilitate further applications we have developed in MATLAB™ two different toolboxes that integrate image (IDF) and video (VDF) despeckle filtering, texture analysis, and image and video quality evaluation metrics. The code for these toolsets is open source and these are available to download complementary to the two books.

KEYWORDS

speckle, despeckle, noise filtering, ultrasound, ultrasound imaging, ultrasound video, cardiovascular imaging and video, SAR, texture, image quality, video quality, carotid artery

To my Family
Christos P. Loizou

To my Family
Constantinos S. Pattichis

*“Show thyself in all things an example of good works,
in teaching, in integrity and dignity;
let thy speech be sound and blameless,
so that anyone opposing may be put to shame,
having nothing bad to say for us.
Exhort slaves to obey their masters,
pleasing them in all things and not opposing them.”*

Titus 2:7–9.