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Principles of Digital Image Processing

Advanced Methods

With 129 figures, 6 tables and 46 algorithms

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Preface

This is the 3rd volume of the authors' textbook series on ***Principles of Digital Image Processing*** that is predominantly aimed at undergraduate study and teaching:

Vol. 1: ***Fundamental Techniques***,
Vol. 2: ***Core Algorithms***,
Vol. 3: ***Advanced Methods*** (this volume).

While it builds on the previous two volumes and relies on the their proven format, it contains all new material published by the authors for the first time. The topics covered in this volume are slightly more advanced and should thus be well suited for a follow-up undergraduate or Master-level course and as a solid reference for experienced practitioners in the field.

The topics of this volume range over a variety of image processing applications, with a general focus on "classic" techniques that are in wide use but are at the same time challenging to explore with the existing scientific literature. In choosing these topics, we have also considered input received from students, lecturers and practitioners over several years, for which we are very grateful. While it is almost unfeasible to cover all recent developments in the field, we focused on popular "workhorse" techniques that are available in many image processing systems but are often used without a thorough understanding of their inner workings. This particularly applies to the contents of the first five chapters on automatic thresholding, filters and edge detectors for color images, and edge-preserving smoothing. Also, an extensive part of the book is devoted to David Lowe's popular *SIFT* method for invariant local feature detection, which has found its way into so many applications and has become a standard tool in the industry, despite (as the text probably shows) its inherent sophistication and complexity. An additional "bonus chapter" on *Synthetic*

Gradient Noise, which could not be included in the print version, is available for download from the book's website.

As in the previous volumes, our main goal has been to provide *accurate*, *understandable* and *complete* algorithmic descriptions that take the reader all the way from the initial idea through the formal description to a working implementation. This may make the text appear bloated or too mathematical in some places, but we expect that interested readers will appreciate the high level of detail and the decision not to omit the (sometimes essential) intermediate steps. Wherever reasonable, general prerequisites and more specific details are summarized in the Appendix, which should also serve as a quick reference that is supported by a carefully compiled index. While space constraints did not permit the full source code to be included in print, complete (Java) implementations for each chapter are freely available on the book's website (see below). Again we have tried to make this code maximally congruent with the notation used in the text, such that readers should be able to easily follow, execute and extend the described steps.

Software

The implementations in this book series are all based on Java and ImageJ, a widely used programmer-extensible imaging system developed, maintained, and distributed by Wayne Rasband of the National Institutes of Health (NIH).[1] ImageJ is implemented completely in Java and therefore runs on all major platforms. It is widely used because its "plugin"-based architecture enables it to be easily extended. Although all examples run in ImageJ, they have been specifically designed to be easily ported to other environments and programming languages. We chose Java as an implementation language because it is elegant, portable, familiar to many computing students, and more efficient than commonly thought. Note, however, that we incorporate Java purely as an instructional vehicle because precise language semantics are needed eventually to achieve ultimate clarity. Since we stress the simplicity and readability of our programs, this should not be considered production-level but "instructional" software that naturally leaves vast room for improvement and performance optimization. Consequently, this book is not primarily on Java programming nor is it intended to serve as a reference manual for ImageJ.

Online Resources

In support of this book series, the authors maintain a dedicated website that provides supplementary materials, including the complete Java source code,

[1] http://rsb.info.nih.gov/ij/.

the test images used in the examples, and corrections. Readers are invited to visit this site at

www.imagingbook.com

It also makes available additional materials for educators, including a complete set of figures, tables and mathematical elements shown in the text, in a format suitable for easy inclusion in presentations and course notes. Also, as a free add-on to this volume, readers may download a supplementary "bonus chapter" on synthetic noise generation. Any comments, questions, and corrections are welcome and should be addressed to

imagingbook@gmail.com

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