Digital Image Analysis

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Digital Image Analysis

Selected Techniques and Applications

With 150 Illustrations



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Preface

The human visual system as a functional unit including the eyes, the nervous system, and the corresponding parts of the brain certainly ranks among the most important means of human information processing. The efficiency of the biological systems is beyond the capabilities of today's technical systems, even with the fastest available computer systems.

However, there are areas of application where digital image analysis systems produce acceptable results. Systems in these areas solve very specialized tasks, they operate in a limited environment, and high speed is often not necessary. Several factors determine the economical application of technical vision systems: cost, speed, flexibility, robustness, functionality, and integration with other system components. Many of the recent developments in digital image processing and pattern recognition show some of the required achievements. Computer vision enhances the capabilities of computer systems

- in autonomously collecting large amounts of data,
- in extracting relevant information,
- in perceiving its environment, and
- in automatic or semiautomatic operation in this environment.

The development of computer systems in general shows a steadily increasing need in computational power, which comes with decreasing hardware costs.

About This Book

This book is the result of the Austrian Joint Research Program (JRP) 1994–1999 on "Theory and Applications of Digital Image Processing and Pattern Recognition". This program was initiated by the Austrian Science Foundation (FWF) and funded research in 11 labs all over Austria for more than 5 years. Because the program has produced many scientific results in many different areas and communities, we collected the most important results in one volume. The development of practical solutions involving digital images requires the **cooperation** of specialists from many different scientific fields. The wide range of fields covered by the participating institutions fulfills this important requirement. Furthermore, the often very specialized vocabulary in the different disciplines makes it necessary to have experts in the different areas, which are in close contact and often exchange ideas. For this reason, active cooperation among the different groups has been declared an important goal of the research program. It has stimulated the research activities for each of the participating groups (and beyond) in a way that has a positive long-term effect for activities in this field in Austria. More details about the joint research program and the participating labs can be found on the CD included in this book.

This book is not a collection of research papers; it brings together the research results of the joint research program in a uniform manner, thereby making the contents of the more than 300 scientific papers accessible to the nonspecialist. The main motivation for writing this book was to bridge the gap between the basic knowledge available in standard textbooks and the newest research results published in scientific papers.

In particular the book was written with the following goals in mind:

- presentation of the research results of the joint research program in a unified manner;
- together with the accompanying CD, the book provides a quick overview of the research in digital image processing and pattern recognition in Austria from 1994–1999;
- parts of this book can serve as advanced courses in selected chapters in pattern recognition and image processing.

The book is organized in five parts, each dealing with a special topic. The parts are written in an independent manner and can be read in any order. Each part consists of several chapters and has its own bibliography. Each part focuses on a specific topic in image processing and describes new methods developed within the research program, but it also demonstrates selected applications showing the benefits of the methods. Parts I, III, and IV are more focused on methodological developments, and Parts II and V are more application oriented. New mathematical methods centered around the topic of image transformations is the main subject of Part I. Part II is mainly devoted to the computer science aspect of image processing, in particular how to handle this huge amount of information in a reasonable time. Parts III and IV are centered around algorithmic issues in image processing. Part III deals with graph-based and robust methods, whereas Part IV is focused on information fusion. 3D information is the main topic of Part V. Table 1 gives a concise overview of the parts and presents the main methods and selected applications for each part.

The Compact Disc

The CD included with this book presents the research program from a multimedia perspective. The CD contains a collection of html-files, which can be viewed by common Web-browsers. The CD has following features:

- the structure of the research program;
- the main topics of research;
- a collection of scientific papers produced during the research program;

- WWW-links to demo pages, which are maintained by the different labs;
- information about the participating labs; and
- the people working on the various projects.

The WWW-links to the demos on the CD should add to the "static" content of the book access to the latest developments of active research done in the labs. Although we are aware of the difficulties of maintaining Internet links over long periods, we have decided for this dynamic solution in order to communicate up-to-date results in such rapidly evolving technology as digital image processing.

Acknowledgments

This work was supported by the Austrian Science Foundation under grant S-70 and the Austrian national bank. We are indebted to Dr. Niel from FWF for continuing support. We would like to thank all our colleagues who have worked under the Joint Research Program S-70 for more than 5 years and who have produced the results in this book and on the CD. Special thanks go to Karin Hraby at the Pattern Recognition and Image Processing Lab who has supported the research program from the administrative side; without her invaluable help we would have spent much more time on administration than on research. For the production of the CD we would like to thank the Hagenberg team at the Fachhochschule Multimedia Design, especially Wilhelm Burger for producing the CD with his students. Special thanks to Tatjana Elssenwenger, Daniela Kreiss, and Manuela Mittermayr for their excellent work in preparing the CD and for their patience for working with us. Finally we would like to express our sincere thanks to all contributors to this book for their professional work and timely delivery of the chapters.

Vienna, Austria January 2001 Walter G. Kropatsch Horst Bischof

TABLE 1. Overview	of the	Book	Parts
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Methods

Selected Applications

I Mathematical Methods for Image Analysis

Time-frequency methods	Echocardiography					
Signal approximation	Geophysics					
Gabor analysis	Image reconstruction					
Wavelet analysis	Shape classification					
Stochastic shape theory	Image compression					
Non-linear optimizations	Image encryption					
Multilevel interpolation	Watermarking					
Chaotic Kolmogorov flows	-					
II Data	Handling					
Parallelization	Remote sensing					
Distributed processing	Radar data					
Data management	Art history					
Image databases	•					
III Robust and Adaptiv	ve Image Understanding					
Graphs	Technical drawings					
Image pyramids	Line images					
Irregular pyramids	Range images					
Robust methods	0 0					
Minimum Description Length						
Object recognition						
Structural features						
Grouping and Indexing						
Machine learning						
IV Information Fusion an	d Radiometric Models for					
Image Understanding						
Active fusion	Remote sensing					
Active recognition	Car recognition					
Reinforcement learning	View planning					
Generic object recognition	Land cover classification					
Radiometric models						
Sub-pixel analysis						
V 3D Reconstruction						
Image matching	Remote sensing					
Object reconstruction	Target localization					
Topographic mapping	Building extraction					
Vision-based navigation	Space exploration					
Rotating CCD cameras	Digital elevation models					
	Surveying					

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