Modern Algorithms for Image Processing

Computer Imagery by Example Using C#

Vladimir Kovalevsky
Dedicated to my wife, Dr. Baerbel Kovalevsky
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About the Author

Vladimir Kovalevsky received his diploma in physics from the Kharkov University (Ukraine), his first doctoral degree in technical sciences from the Central Institute of Metrology (Leningrad), and his second doctoral degree in computer science from the Institute of Cybernetics of the Academy of Sciences of the Ukraine (Kiev) where he headed the Department of Pattern Recognition for more than a decade.

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He has been a visiting researcher at the University of Pennsylvania, a professor at the Manukau Institute of Technology in New Zealand, and a professor at the Chonbuk National University in South Korea. He has reviewed for the journals *Applied General Topology*, *Computer Vision and Image Understanding*, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, and others.

Vladimir has been a plenary speaker at conferences in Europe, the United States, and New Zealand. His research interests include digital geometry, digital topology, computer vision, image processing, and pattern recognition. He has published four monographs and more than 180 journal and conference papers on image analysis, digital geometry, and digital topology.
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Introduction

This book presents a collection of algorithms and projects for processing two-dimensional images. I developed and investigated the algorithms. Special emphasis is placed on computer solutions of problems related to the improvement of the quality of images, with image analysis and recognition of some geometrically definable objects. New data structures useful for image analysis are presented. The description of all algorithms contains examples of source code in the C# programming language. Descriptions of projects contain source code that can be used by readers.

With this book I intend to help you develop efficient software for processing two-dimensional images. There are a lot of books on image processing, but important algorithms are missing from these books. I have developed many efficient algorithms as a new and important contribution to this area.

I have paid great attention to solutions of problems in image analysis. On the other hand, problems of improving the quality of images are important for the arts. My wife is a recognized specialist in the history of the arts, and her publications often use copies of famous pictures and drawings. The photographs of these artworks are often of low quality. Often photographs of historical drawings illustrating the work of a painter are of such low quality that it is almost impossible to clearly see the contents of the image. Improving these images is therefore very important. In such cases, the programs I have developed for improving the quality of pictures are very useful.

I have developed efficient algorithms for recognizing circles and ellipses in noisy images. These algorithms can be used for recognizing objects with a shape approximating a circle; for example, apples, mushrooms, and so on. They can also be used for recognizing bicycles in images of traffic because the wheels of bicycles are ideal circles, but if the bicycle is positioned in such a way that the plane of its frame is not orthogonal to the viewing ray, then its wheels look like ellipses rather than circles. I was therefore forced to develop efficient algorithms for recognizing ellipses in noisy images as well. My efforts were successful and the book contains a chapter devoted to the recognition of bicycles in noisy images.

The book contains descriptions of numerous algorithms for image analysis, including these:
• Manually controlled thresholding of shading corrected images.
• A fast algorithm for simultaneously labeling all connected components in a segmented image.
• A new efficient method of edge detection.
• A fast algorithm for approximating digital curves by polygons and for estimating the curvature of circular arcs approximating the curve.
• Algorithms for recognition and measurement of circular or elliptical objects in color images.

Among the algorithms for image improvement, the most important are the following:
• The algorithm for rectifying photographs of paintings taken at an oblique angle.
• An algorithm correcting images of nonuniformly illuminated scenes.
• The algorithm for improving the contrast of images of nonuniformly illuminated scenes.
• The best algorithm for reducing Gaussian noise (the so-called Sigma-Filter).
• The algorithm for reducing impulse noise.

All descriptions are followed by a pseudo-code similar to the C# programming language. Most of the descriptions contain source code that can be copied from the text and used directly in a Windows Forms program written in the C# .NET language.

All source code and figures are included in a download file (which you can access via the Download Source Code button located at www.apress.com/9781484242360) so you can see the colors.