Preface

Real-time processing for digital imaging concerns efficient, deterministic implementation of algorithms whose inputs include digital images and whose outputs are digital images, numerical features, symbolic representations, or decisions. Practically, a real-time demand occurs when one is faced with composing an algorithm that must complete an imaging task within some given time frame. Computation bottlenecks appear in many forms and, to some extent, each requires its own real-time implementation via algorithm design, software, hardware, or a combination thereof; nevertheless, there are certain fundamental algorithms at the center of digital image processing and our focus is upon the structure, computation, and application of these algorithms. Specifically, we treat linear, matrix, and nonlinear algorithms that appear across a wide range of imaging applications. Among the applications discussed are noise suppression, edge detection, matched filtering, and data compression. Specific operations covered include linear convolution, the discrete cosine transform (DCT), the fast Fourier transform (FFT), the median filter, and the morphological gradient.

The imaging algorithms discussed tend to be computationally intensive, especially when directly implemented on standard sequential hardware. Various means of providing efficient computation are discussed. For instance, fast matrix transforms result from decomposing a matrix into a cascade of more easily computable matrices. Among the various hardware paradigms treated are pipelining, dataflow, and systolic arrays. Numerous aspects of programming languages are discussed, including parameter passing, recursion, typing, and exception handling. There is also a survey of commonly used languages and ways in which these contribute or do not contribute to real-time processing. Numerous optimization techniques such as loop unrolling and loop jamming are provided for avoiding unnecessary computation at run time.

Following an account of real-time issues in the first chapter, there is a chapter introducing the basic computer architectures that will play a role in finding hardware solutions for real-time imaging tasks. The chapter contains an introductory account of sequential processing in the von Neumann architecture. This has been included to provide those who are not familiar with assembly-level programming with the basic architectural concepts and terminology that will be used subsequently. The next three chapters treat linear, matrix transform, and nonlinear imaging algorithms. Actual applications are given and computational aspects of the algorithms are discussed. The final three chapters discuss three levels at which one can address real-time processing: parallel hardware, the programming language, and code optimization.