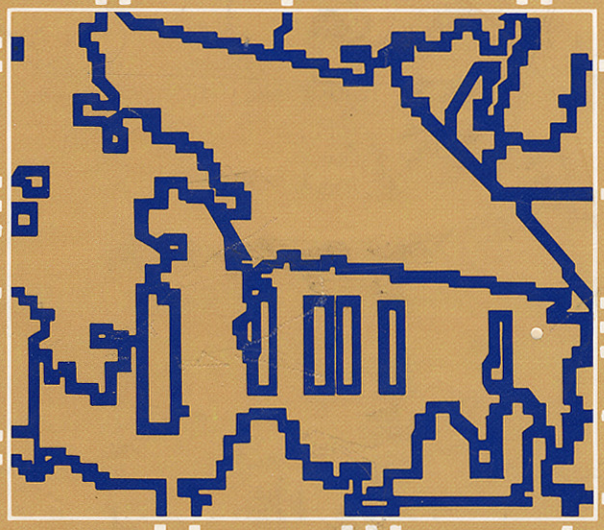
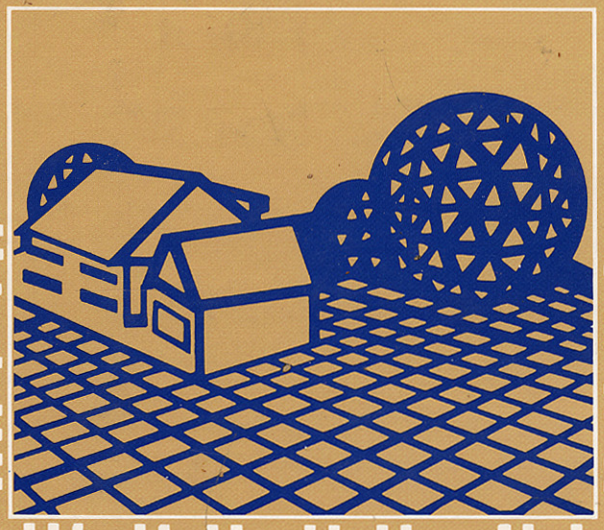
COMPUTER VISION

DANA H. BALLARD • CHRISTOPHER M. BROWN





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Preface

The dream of intelligent automata goes back to antiquity; its first major articulation in the context of digital computers was by Turing around 1950. Since then, this dream has been pursued primarily by workers in the field of *artificial intelligence,* whose goal is to endow computers with information-processing capabilities comparable to those of biological organisms. From the outset, one of the goals of artificial intelligence has been to equip machines with the capability of dealing with sensory inputs.

Computer vision is the construction of explicit, meaningful descriptions of physical objects from images. Image understanding is very different from image processing, which studies image-to-image transformations, not explicit description building. Descriptions are a prerequisite for recognizing, manipulating, and thinking about objects.

We perceive a world of coherent three-dimensional objects with many invariant properties. Objectively, the incoming visual data do not exhibit corresponding coherence or invariance; they contain much irrelevant or even misleading variation. Somehow our visual system, from the retinal to cognitive levels, understands, or imposes order on, chaotic visual input. It does so by using *intrinsic information* that may reliably be extracted from the input, and also through assumptions and *knowledge* that are applied at various levels in visual processing.

The challenge of computer vision is one of *explicitness.* Exactly what information about scenes can be extracted from an image using only very basic assumptions about physics and optics? Explicitly, what computations must be performed? Then, at what stage must domain-dependent, prior knowledge about the world be incorporated into the understanding process? How are world models and knowledge represented and used? This book is about the representations and mechanisms that allow image information and prior knowledge to interact in image understanding.

Computer vision is a relatively new and fast-growing field. The first experiments were conducted in the late 1950s, and many of the essential concepts

have been developed during the last five years. With this rapid growth, crucial ideas have arisen in disparate areas such as artificial intelligence, psychology, computer graphics, and image processing. Our intent is to assemble a selection of this material in a form that will serve both as a senior/graduate-level academic text and as a useful reference to those building vision systems. This book has a strong artificial intelligence flavor, and we hope this will provoke thought. We believe that both the intrinsic image information and the internal model of the world are important in successful vision systems.

The book is organized into four parts, based on descriptions of objects at four different levels of abstraction.

1. Generalized images—images and image-like entities.
2. Segmented images—images organized into subimages that are likely to correspond to "interesting objects."
3. Geometric structures—quantitative models of image and world structures.
4. Relational structures—complex symbolic descriptions of image and world structures.

The parts follow a progression of increasing abstractness. Although the four parts are most naturally studied in succession, they are not tightly interdependent. Part I is a prerequisite for Part II, but Parts III and IV can be read independently.

Parts of the book assume some mathematical and computing background (calculus, linear algebra, data structures, numerical methods). However, throughout the book mathematical rigor takes a backseat to concepts. Our intent is to transmit a set of ideas about a new field to the widest possible audience.

In one book it is impossible to do justice to the scope and depth of prior work in computer vision. Further, we realize that in a fast-developing field, the rapid influx of new ideas will continue. We hope that our readers will be challenged to think, criticize, read further, and quickly go beyond the confines of this volume.

D. H. Ballard
C. M. Brown

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Finally, thanks go to Jane Ballard, mostly for standing steadfast through the cycles of elation and depression and for numerous engineering-to-English translations.

As Pat Winston put it: "A willingness to help is not an implied endorsement." The aid of others was invaluable, but we alone are responsible for the opinions, technical details, and faults of this book.

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The authors wish to credit the following sources for figures and tables. For complete citations given here in abbreviated form (as "from . . ." or "after . . ."), refer to the appropriate chapter-end references.

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CGIP

Computer Graphics and Image Processing

COMPSAC

IEEE Computer Society's 3rd International Computer Software and Applications Conference, Chicago, November 1979.

CVS

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PRIP

IEEE Computer Society Conference on Pattern Recognition and Image Processing, Chicago, August 1979.

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DANA H. BALLARD ▪ CHRISTOPHER M. BROWN

What information about scenes can be extracted from an image using only basic assumptions about physics and optics?

How are images segmented into meaningful parts?

At what stage must domain-dependent, prior knowledge about the world be incorporated into the understanding process?

How are world models and conceptual knowledge represented and used?

These and many other questions, inherent in this relatively new and fast-growing field, are explored and answered in **Computer Vision** by **Dana H. Ballard** and **Christopher M. Brown.** The authors assemble crucial material from many disciplines including artificial intelligence, psychology, computer graphics, and image processing to form a practical text and reference for anyone involved in building vision systems.

Ballard and Brown write in their preface, "**Computer Vision** has a strong artificial intelligence flavor, and we hope this will provoke thought. The text shows how both intrinsic image information and internal models of the world are important in successful vision systems."

Divided into four parts, **Computer Vision** offers descriptions of objects at four levels of abstraction:

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