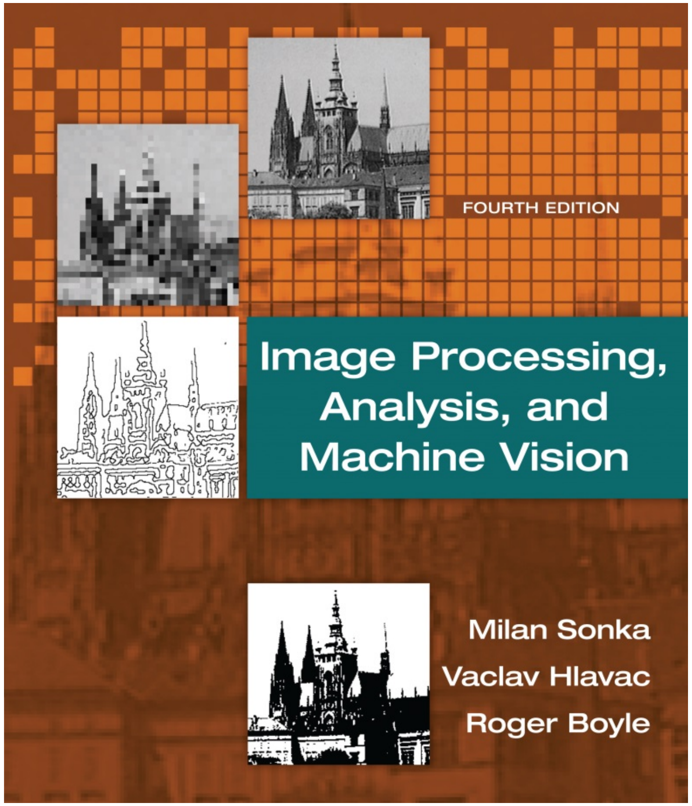

Chapter 1
Introduction

Learning Objectives

- To understand computer vision and its difficulties
- To learn the different methods of image representation and image analysis tasks

1.1 Motivation

- Computer vision
  - Duplicate the effect of human vision
  - Electronically perceive and understand an image
- Task of giving computers the ability to see
  - Converting 3D world with 2D sensors
  - Loss of information

Example

- Animal Movement
  - Appears simple to humans
  - Black and white, repeated movement
  - See sequence of operations

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Figure 1.1: A frame from a video of a typical farm-yard scene: the cow is one of a number walking naturally from right to left. *Courtesy of D. R. Magee, University of Leeds.*

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Figure 1.3: Three frames from a cow sequence: notice the model can cope with partial occlusion as the animal enters the scene, and the different poses exhibited. *Courtesy of D. R. Magee, University of Leeds.*

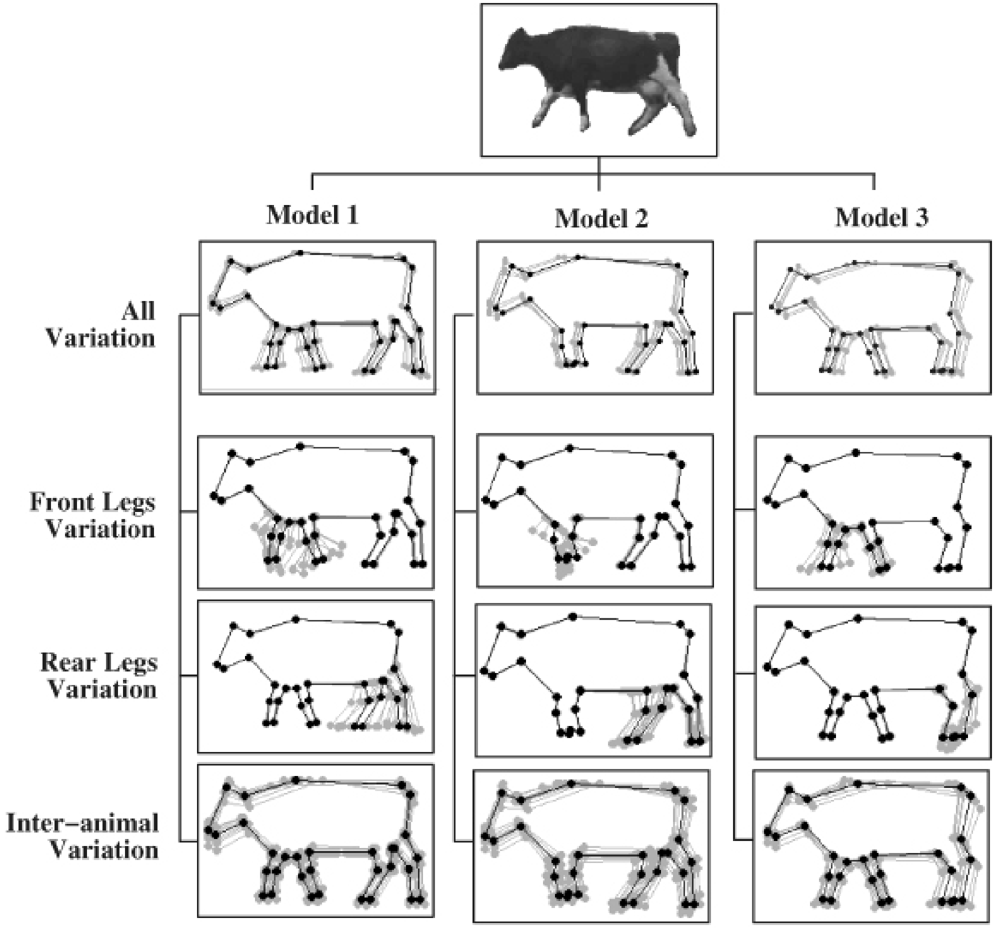

Figure 1.2: Various models for a cow silhouette: a straight-line boundary approximation has been learned from training data and is able to adapt to different animals and different forms of occlusion. *Courtesy of D. R. Magee, University of Leeds.*

Sequence of Operations

- Image capture
- Early processing
- Segmentation
- Model Fitting
- Motion Prediction
- Qualitative/Quantitative Conclusion

1.2 Why is Computer Vision Difficult?

- Loss of Information in 3D to 2D
  - Geometric properties modeled by pinhole model
  - Corresponds to mathematical model of perspective projection
  - Maps points along rays, does not preserve angles/collinearity

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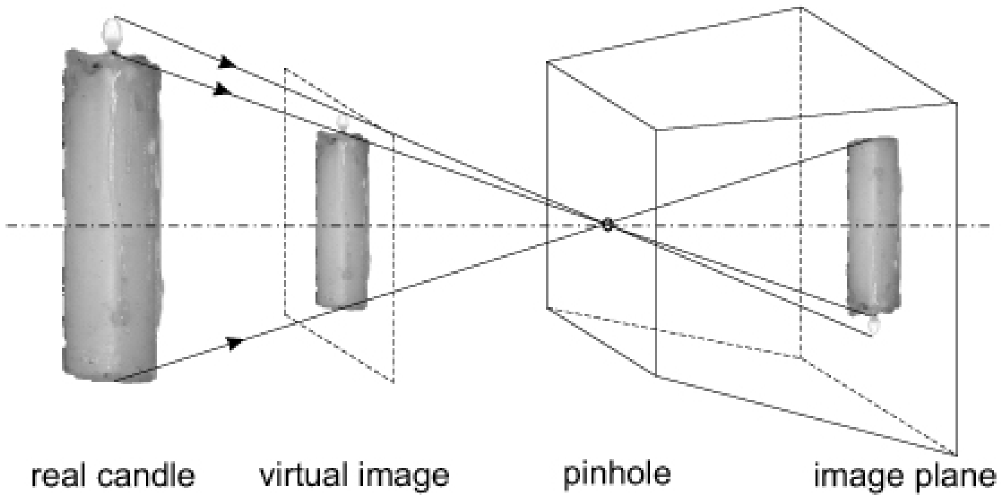

Figure 1.4: The pinhole model of imaging geometry does not distinguish size of objects. © *Cengage Learning 2015.*

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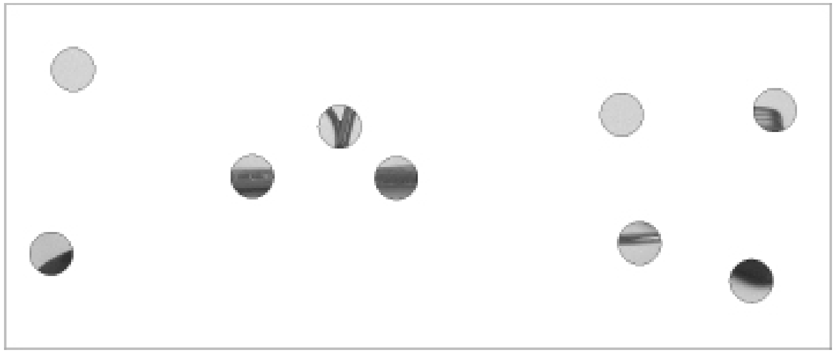

Figure 1.5: Illustration of the world seen through several keyholes providing only a local context. It is very difficult to guess what object is depicted; the complete image is shown in Figure 1.6. © *Cengage Learning 2015.*

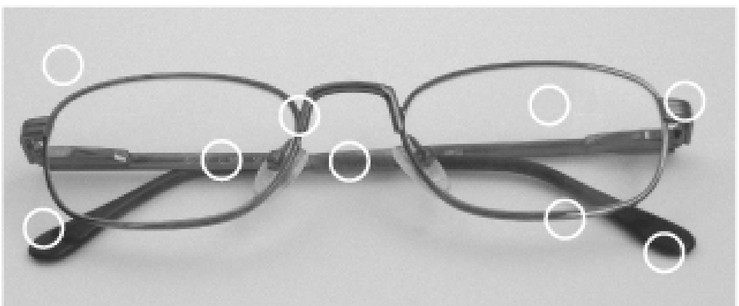

Figure 1.6: It is easy for humans to interpret an image if it is seen globally: compare to Figure 1.5. *© Cengage Learning 2015.*

Computer Vision Difficulties

- Interpretation of Images
  - Capability to understand observations
  - Can be seen as a mapping
  - Image data -> model
- Noise
  - Present in each measurement in the real world
  - Need mathematical methods to cope with uncertainty
  - Makes image analysis much more complicated

Computer Vision Difficulties

- Too Much Data
  - Images and videos are big
  - Processor and memory requirements
  - Need efficiency in problem solutions
- Brightness Measured
  - Complicated image formation physics
  - Radiance (brightness, image intensity) depends on irradiance (light source type, intensity, position), observer's position, surface local geometry, and surface reflectance properties

Computer Vision Difficulties

- Local window vs. need for global view
  - Computer sees image through keyhole
  - Difficult to interpret image if seen locally
  - Important how context is taken into account for image analysis

1.3 Image representation and image analysis tasks

- Image understanding
  - Attempt to find relation between input image and previous models of observed world
  - Transition from input image to model reduces information contained in image to relevant information for application domain
  - Process divided into multiple steps/layers

Image Representation

- Can be divided into four levels
- Boundaries between individual levels are inexact
- Flow of information does not need to be unidirectional
- Categorized as low-level image processing and high-level image understanding

Low-Level Processing

- Methods use minimal knowledge about content of images
- Low level methods
  - Image compression, pre-processing methods for noise filtering
  - Edge extraction, image sharpening
- Uses data which resembles input image
- Image is digitized before processing by computer

High-Level Processing

- Based on knowledge, goals, and plans of how to achieve goals
- Tries to imitate human cognition/ability to make decisions
- Begins with some form of formal model of world
- “Reality” perceived in form of digitized images is compared to model
- Low-level image processing used to find information to update model

Expectations

- Computer vision expected to solve complex tasks
- Goal is to obtain similar results to those provided by biological systems

Image Segmentation

- Computer tries to separate objects from image background and from each other
- Total segmentation possible only for very simple tasks
- Low-level image processing techniques handle partial segmentation tasks, e.g. finding parts of object boundaries
- Other low-level operations: image compression, techniques to extract information from moving scenes

Low-level vs. High-level

- Differ in data used
- Low-level data comprised of original images represented by matrices composed of brightness values
- High-level data is only data relevant to high-level goals (data quantity reduced considerably)
- High-level data represent knowledge about image content, usually expressed in symbolic form

3D Vision Problems

- Adopt user's view
  - What human tasks can machines accomplish?
  - What is the relation of 3D vision tasks to low-level and high-level algorithmic methods?
  - Link between algorithmic components and representation
- Bottom-up and top-down approach
  - Adopted to fulfill 3D vision tasks

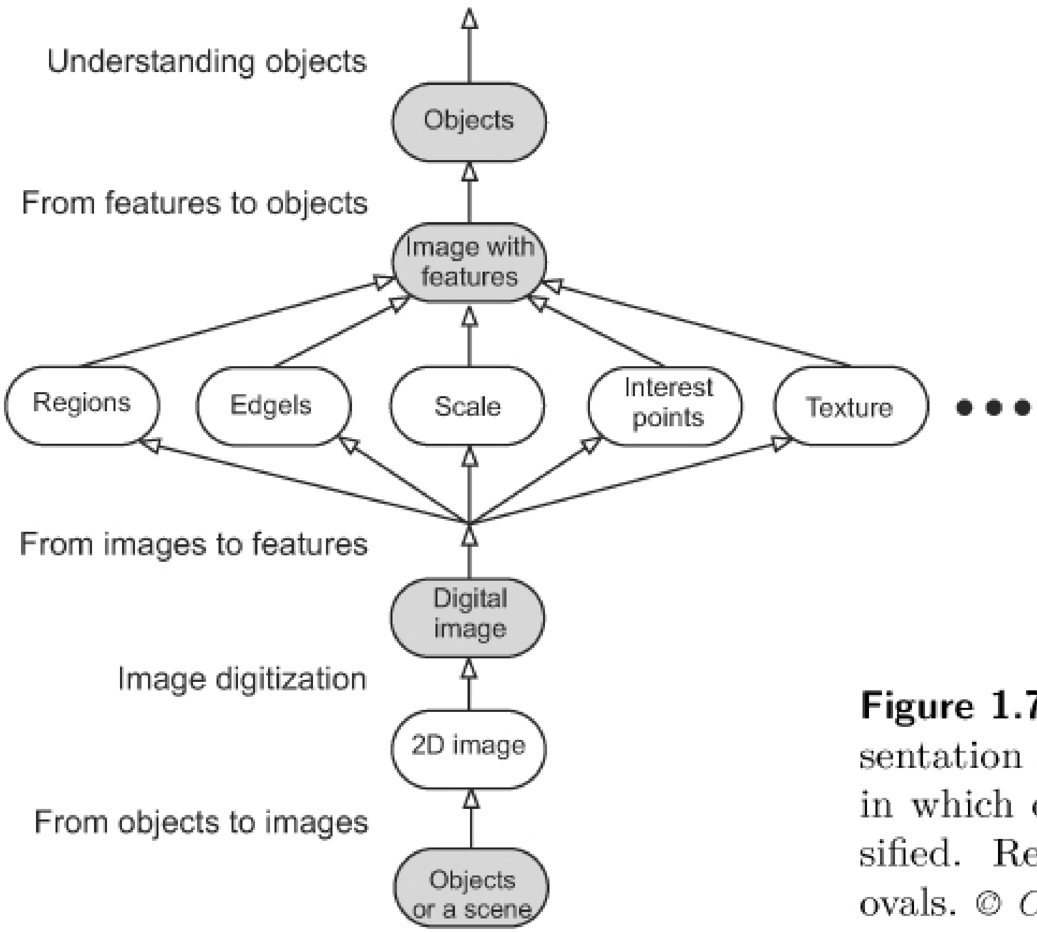

Figure 1.7: Four possible levels of image representation suitable for image analysis problems in which objects have to be detected and classified. Representations are depicted as shaded ovals. © *Cengage Learning 2015.*

Figure 1.9: Another representation of Figure 1.8. © *R.D. Boyle 2015.*

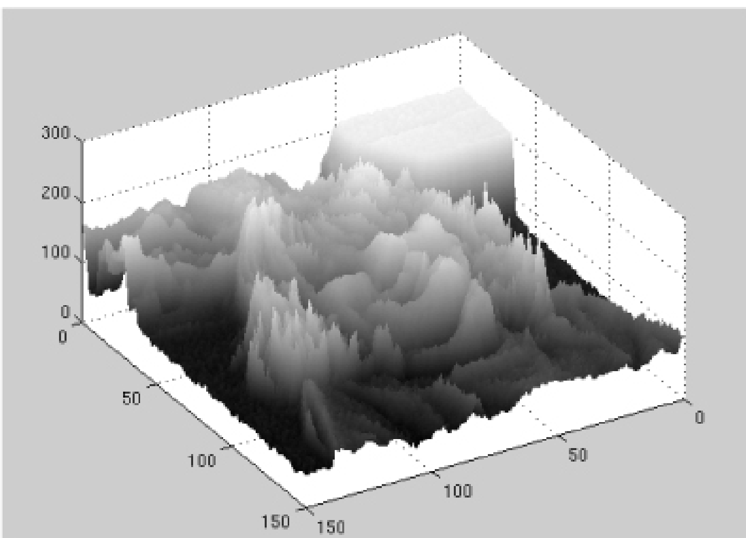

Figure 1.8: An unusual image representation. © *R.D. Boyle 2015.*

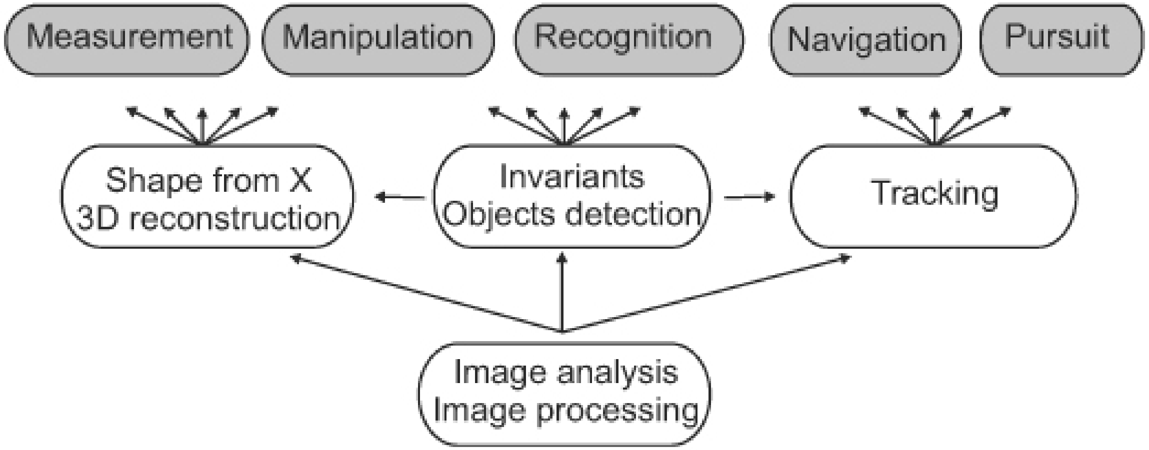

Figure 1.10: Several 3D computer vision tasks from the user's point of view are on the upper line (filled). Algorithmic components on different hierarchical levels support it in a bottom-up fashion. © *Cengage Learning 2015.*

1.4 Summary

- Computer mimicry of human vision is difficult
- Hope to examine pictures for quantitative/qualitative analysis
- Multiple standard and advanced AI techniques
- ‘High’ and ‘low’ levels of computer vision identified
- Image processing methods and steps