KECE471 Computer Vision

Introduction

Chang-Su Kim

Some figures are excerpted from the book “Computer Vision Algorithms and Applications” by R. Szeliski

Course Outline

- Pre-requisites
  - Signals and Systems
  - High School Math
  - or **Common Sense**

- Course Homepage
  - Homepage: http://portal.korea.ac.kr → http://mcl.korea.ac.kr

- Questions
  - You are welcome to come to my office (Engineering Bldg, Rm 215) and ask any questions any time
  - Tel: 02-3290-3217
  - Email: changsukim@korea.ac.kr

Course Outline

- Assessment Methods
  - Assignments & Attendance: 30%
    - Small coding projects
    - Problem solving assignments
  - Mid-term Exam: 30%
  - Final Exam: 40%

- Textbook and References
  - Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2011. (http://szeliski.org/Book/)
  - David A. Forsyth and Jean Ponce, *Computer Vision: A Modern Approach*, Prentice Hall, 2003.
  - Linda G. Shapiro and George C. Stockman, *Computer Vision*, Prentice Hall, 2001.

Tentative Course Outline

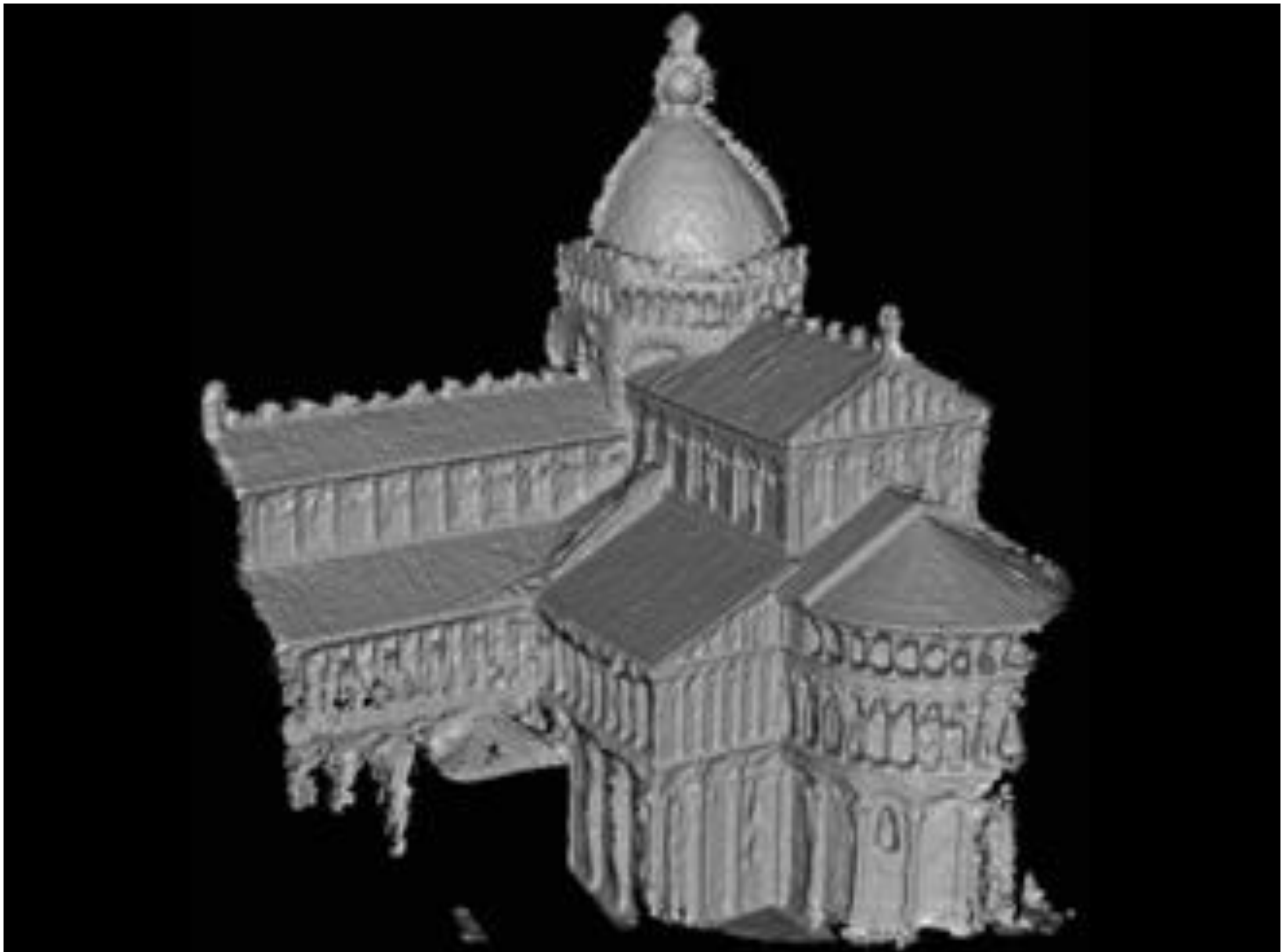
Week	Topics	Events
1	Introduction, Binary Image Analysis	
2	Binary Image Analysis	
3	Pattern Recognition Concept	
4	Filtering and Enhancing Images	
5	Edge Detection	
6	Segmentation	
7	Segmentation	
8		Mid exam (23 APR 2013)
9	Segmentation	
10	Pyramidal Image Representation	
11	Pyramidal Image Representation	
12	Texture	
13	Texture	
14	Stereo	
15	Motion	
16		Final exam (18 JUN 2013)

What is computer vision?

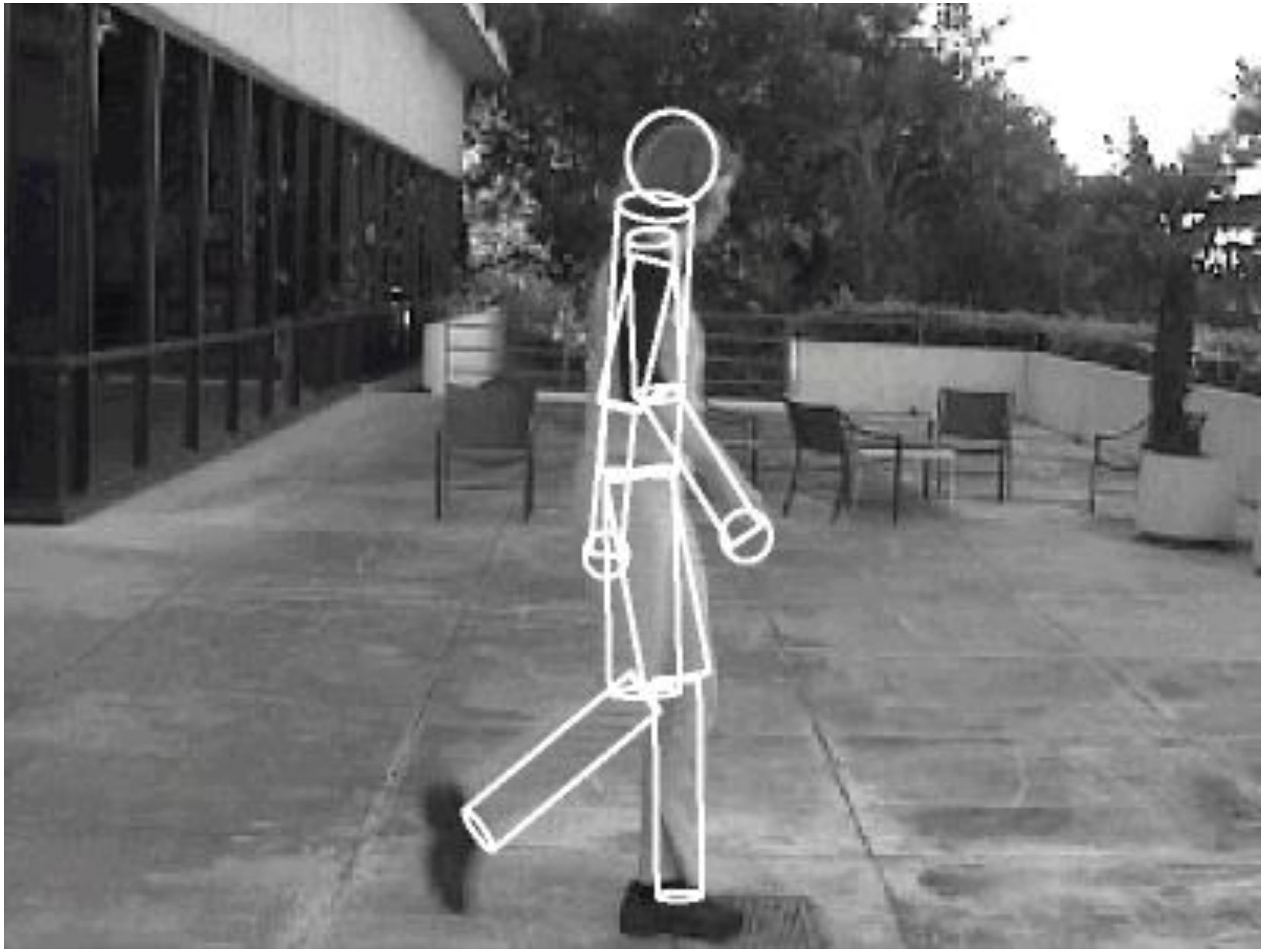
HVS and Computer

Examples

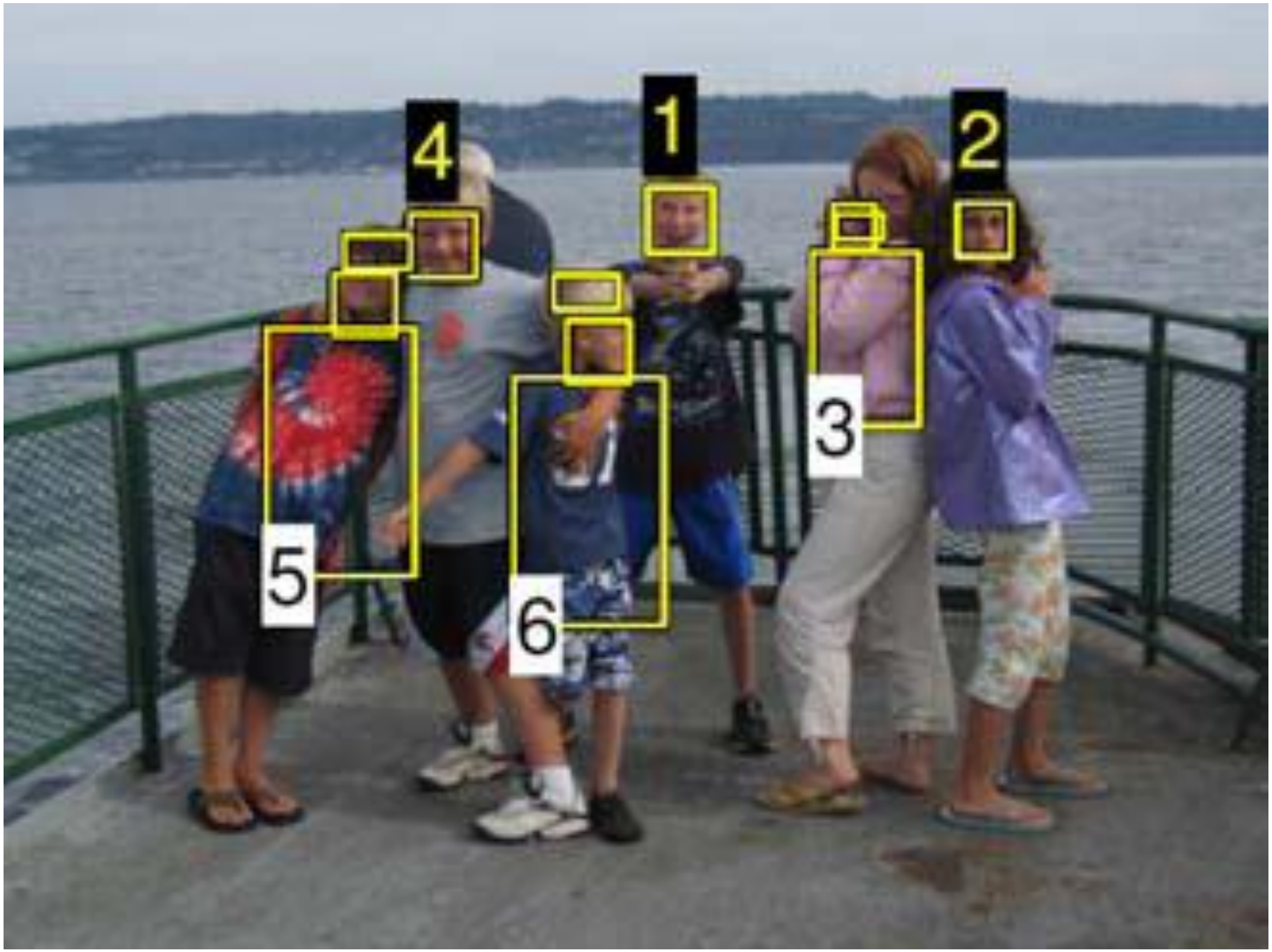
Examples



Examples

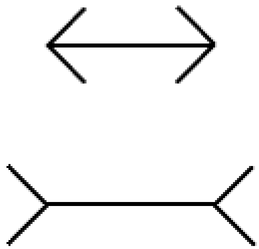


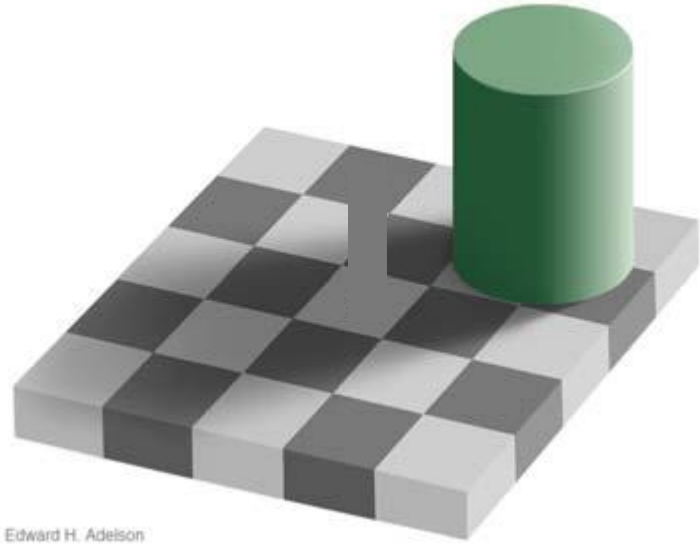
Examples

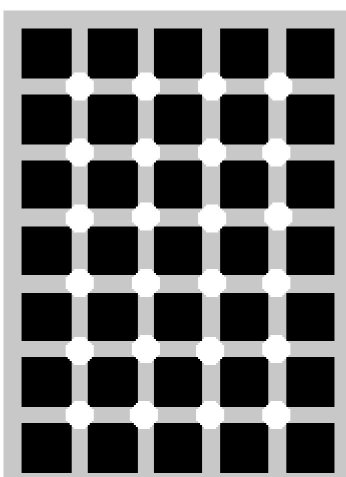


HVS

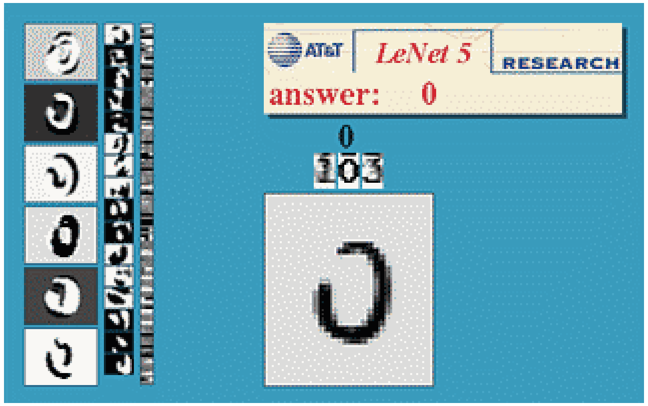
- Side results

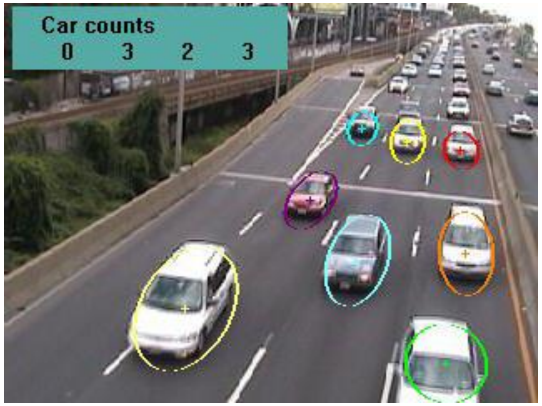




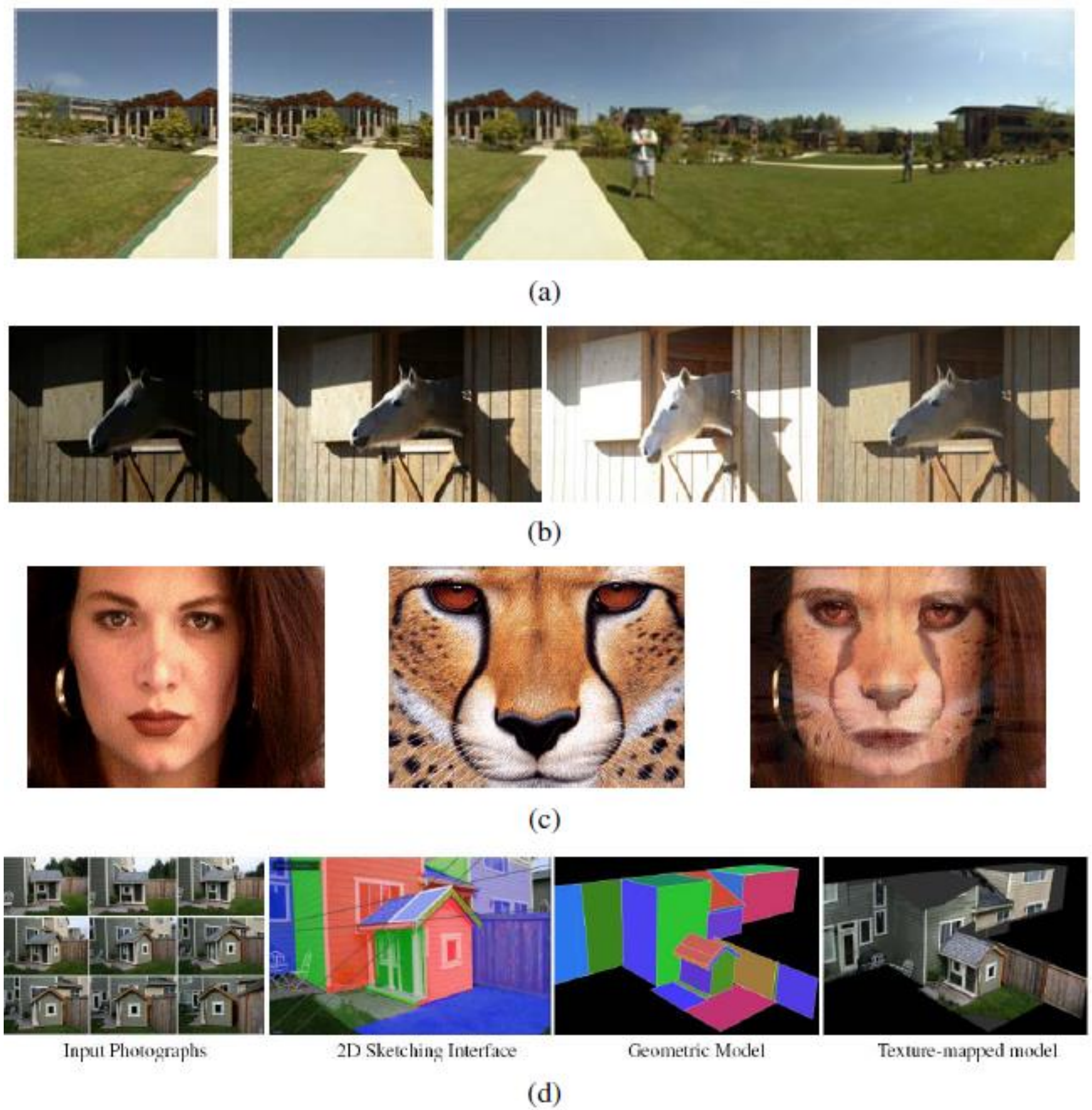


Applications

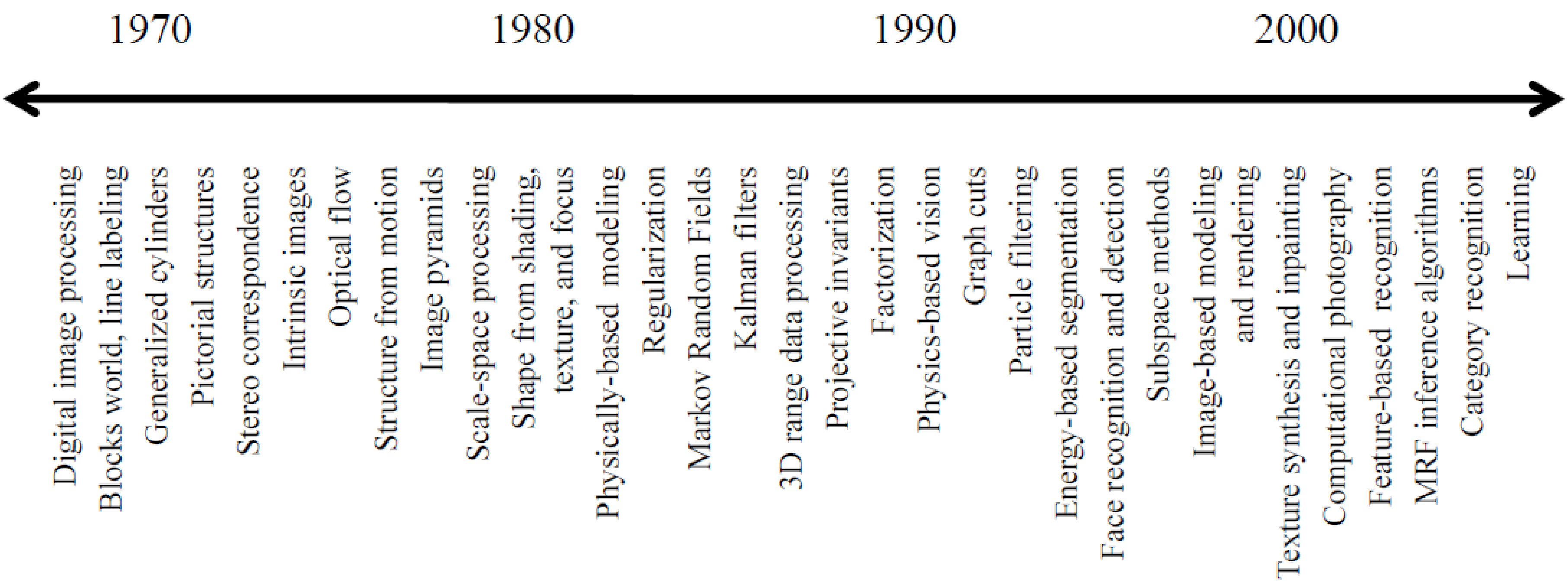




Applications



A Brief History



- Short history
- Recent big bang

Hot!

Google Scholar

Search Scholar

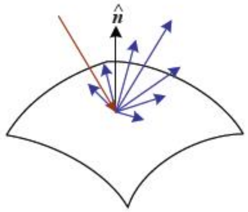
- English
  - Business, Economics & Management
  - Chemical & Material Sciences
  - Engineering & Computer Science
  - Health & Medical Sciences
  - Humanities, Literature & Arts
  - Life Sciences & Earth Sciences
  - Physics & Mathematics
  - Social Sciences
- Chinese
- Portuguese
- German

Top publications - English   Learn more

	Publication	h5-index	h5-median
1.	Nature	355	495
2.	The New England Journal of Medicine	329	495
3.	Science	311	431
4.	The Lancet	248	381
5.	Cell	223	343
6.	Proceedings of the National Academy of Sciences	217	280
7.	Journal of Clinical Oncology	205	306
8.	Chemical Reviews	193	339
9.	Physical Review Letters	191	263
10.	Journal of the American Chemical Society	190	250
11.	Nature Genetics	188	270

65.	IEEE Conference on Computer Vision and Pattern Recognition, CVPR	118	167

Many Interesting Topics



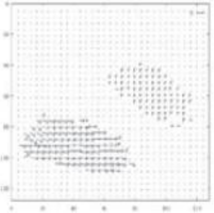
2. Image Formation

3. Image Processing

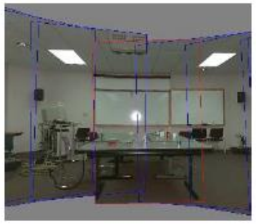
4. Features

5. Segmentation

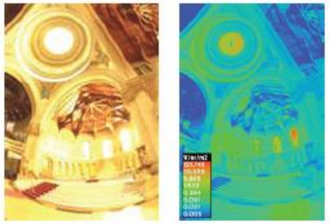
6-7. Structure from Motion



8. Motion



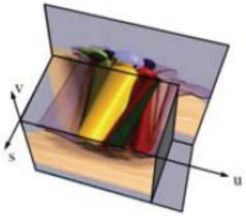
9. Stitching



10. Computational Photography

11. Stereo

12. 3D Shape



13. Image-based Rendering

14. Recognition

What is Computer Vision?

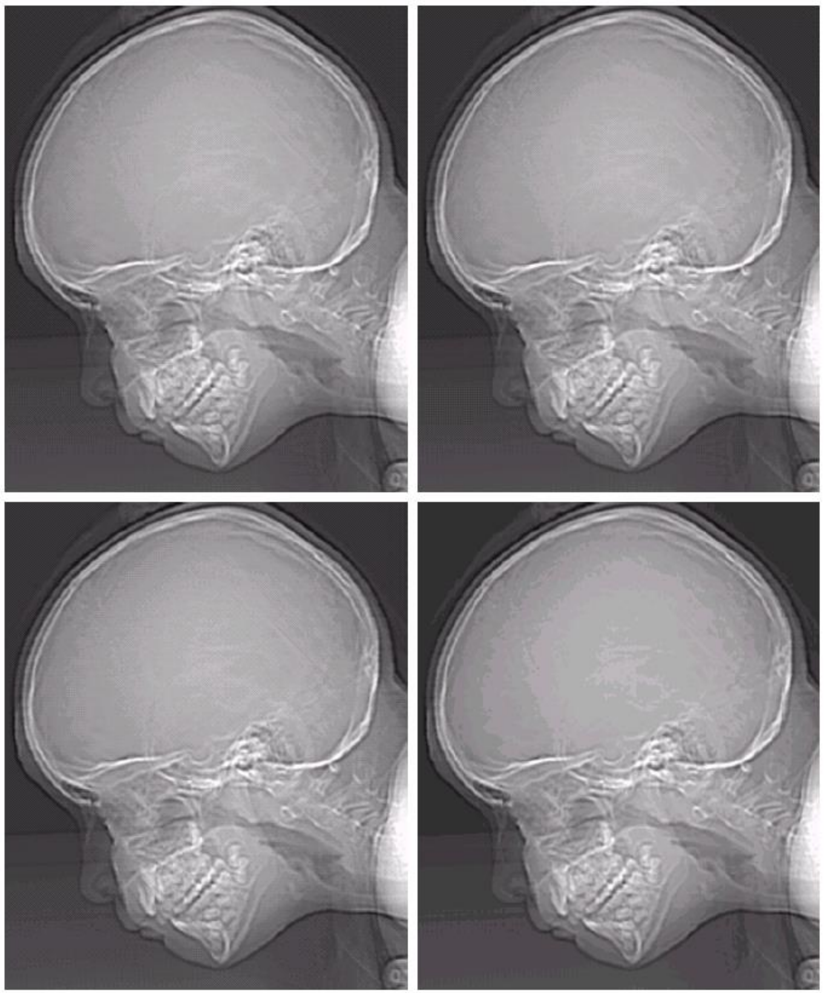
- Develop computational algorithms to mimic or replace the functionality of human visual system

Preview

Tentative Course Outline

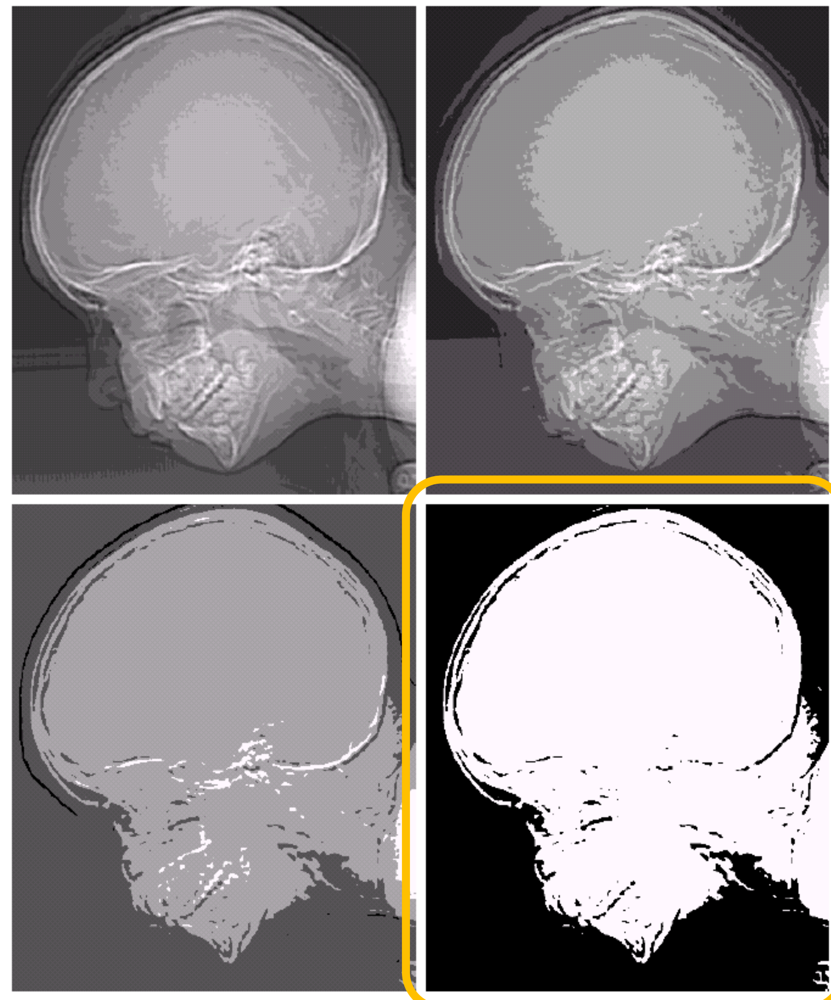
Week	Topics	Events
1	Introduction, Binary Image Analysis	
2	Binary Image Analysis	
3	Pattern Recognition Concept	
4	Filtering and Enhancing Images	
5	Edge Detection	
6	Segmentation	
7	Segmentation	
8		Mid exam (23 APR 2013)
9	Segmentation	
10	Pyramidal Image Representation	
11	Pyramidal Image Representation	
12	Texture	
13	Texture	
14	Stereo	
15	Motion	
16		Final exam (18 JUN 2013)

Binary Image Analysis

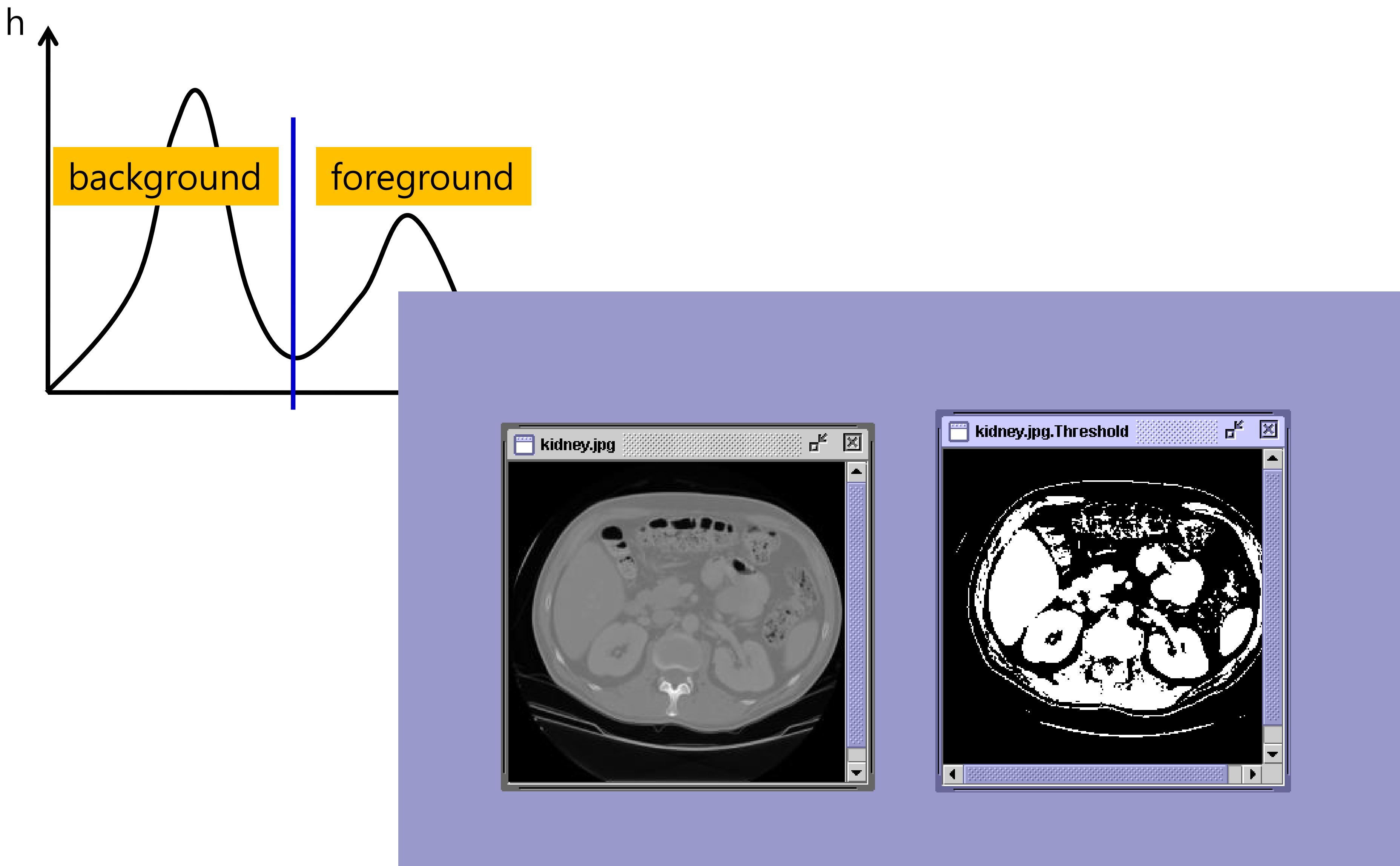


a b
c d

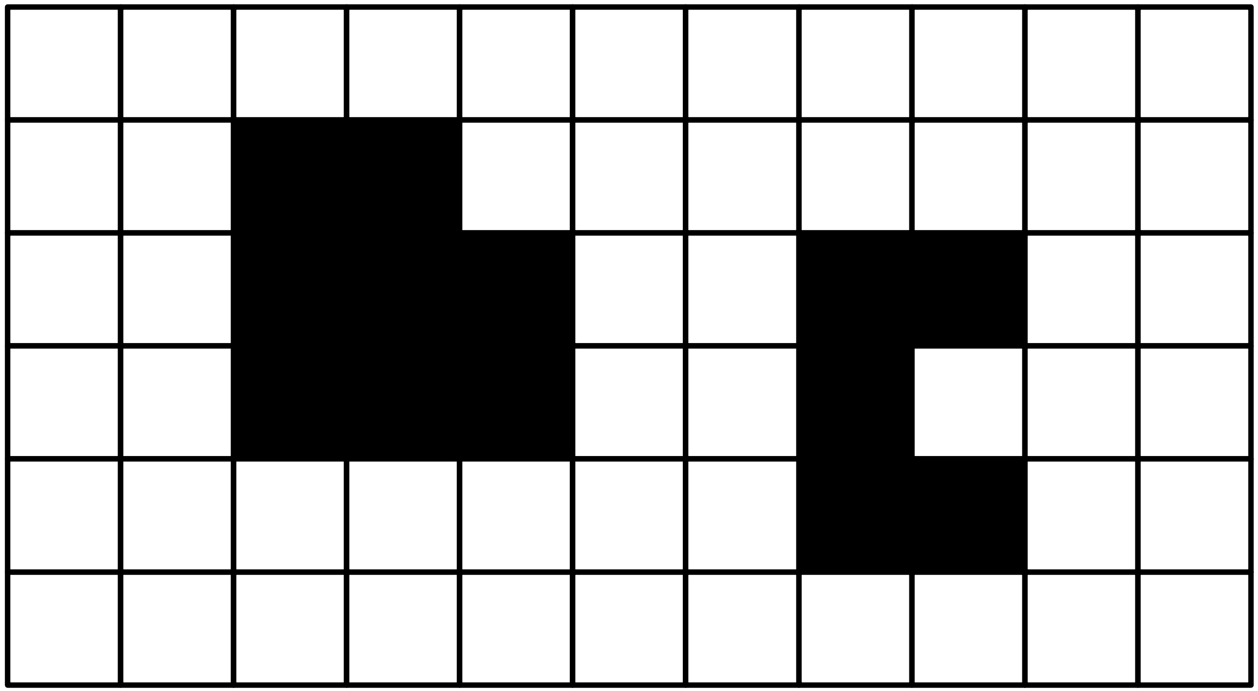
FIGURE 2.21
(a) 452 × 374, 256-level image. (b)–(d) Image displayed in 128, 64, and 32 gray levels, while keeping the spatial resolution constant.



Binary Image Analysis



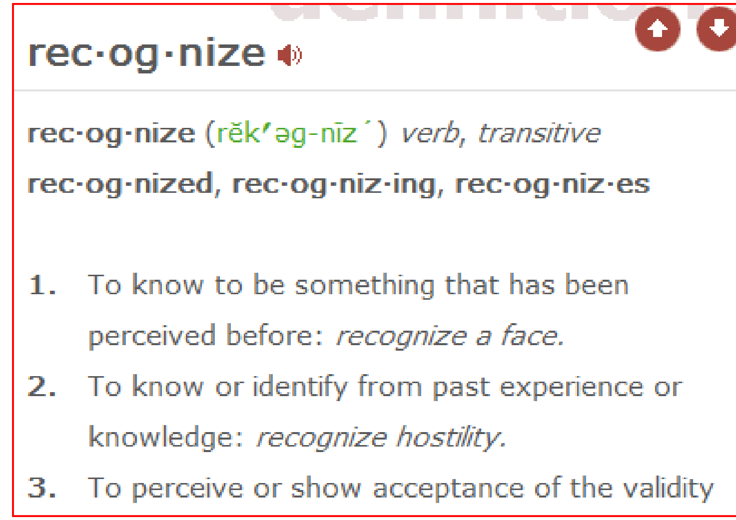
Binary Image Analysis



How many objects are there?

Pattern Recognition Concepts

- Recognition
  - To know that  is an apple from our knowledge



rec·og·nize

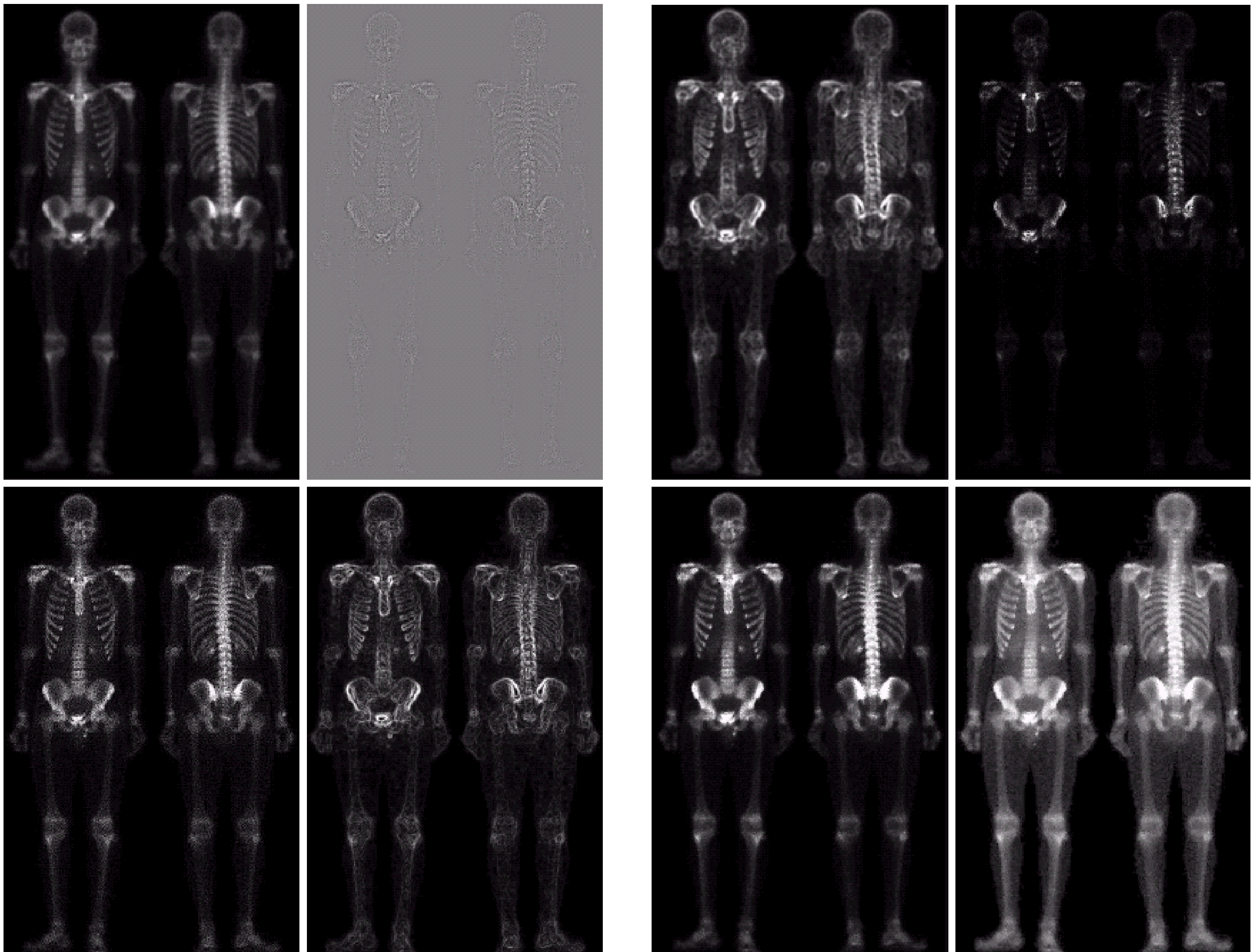
rec·og·nize (rĕk′əg-nīz′) *verb, transitive*
rec·og·nized, rec·og·niz·ing, rec·og·niz·es

1. To know to be something that has been perceived before: *recognize a face.*
2. To know or identify from past experience or knowledge: *recognize hostility.*
3. To perceive or show acceptance of the validity

- Computer vision
  - To make useful decision based on sensed images
  - It includes visual pattern recognition

Image Filtering and Enhancement

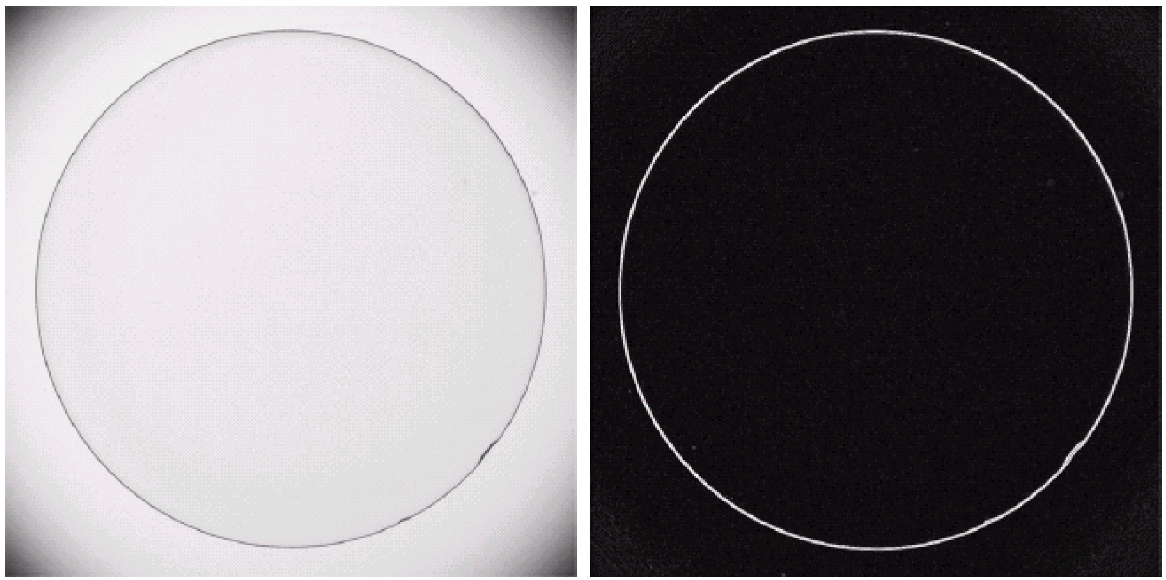
(a) original (b) Laplacian of (a) (e) smoothed (a) (f) = (c)x(e)



(c) = (a)+(b) (d) gradient of (a) (g) = (a)+(f) (h) power-law transform of (g)

Image Filtering and Enhancement

Input image Gradient image



a b

FIGURE 3.45 Optical image of contact lens (note defects on the boundary at 4 and 5 o'clock). (b) Sobel gradient. (Original image courtesy of Mr. Pete Sites, Perceptics Corporation.)

Edge Detection

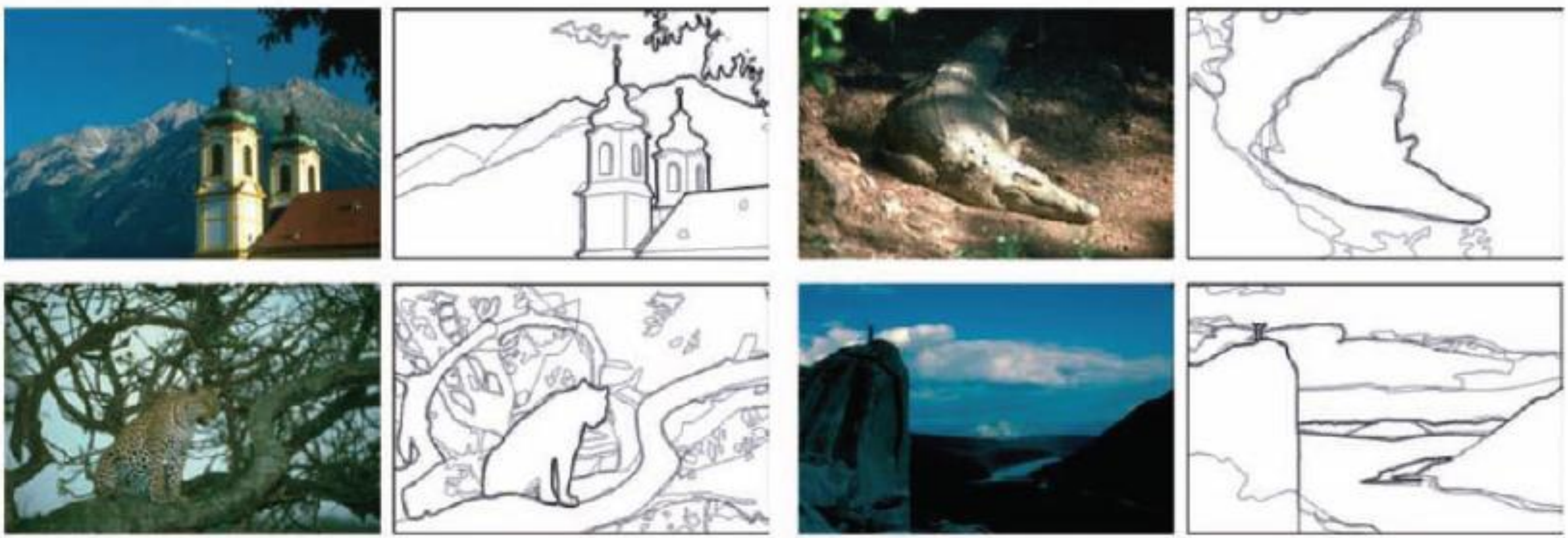


Figure 4.31 Human boundary detection (Martin, Fowlkes, and Malik 2004) © 2004 IEEE. The darkness of the edges corresponds to how many human subjects marked an object boundary at that location.

Edge Detection

Edge Detection

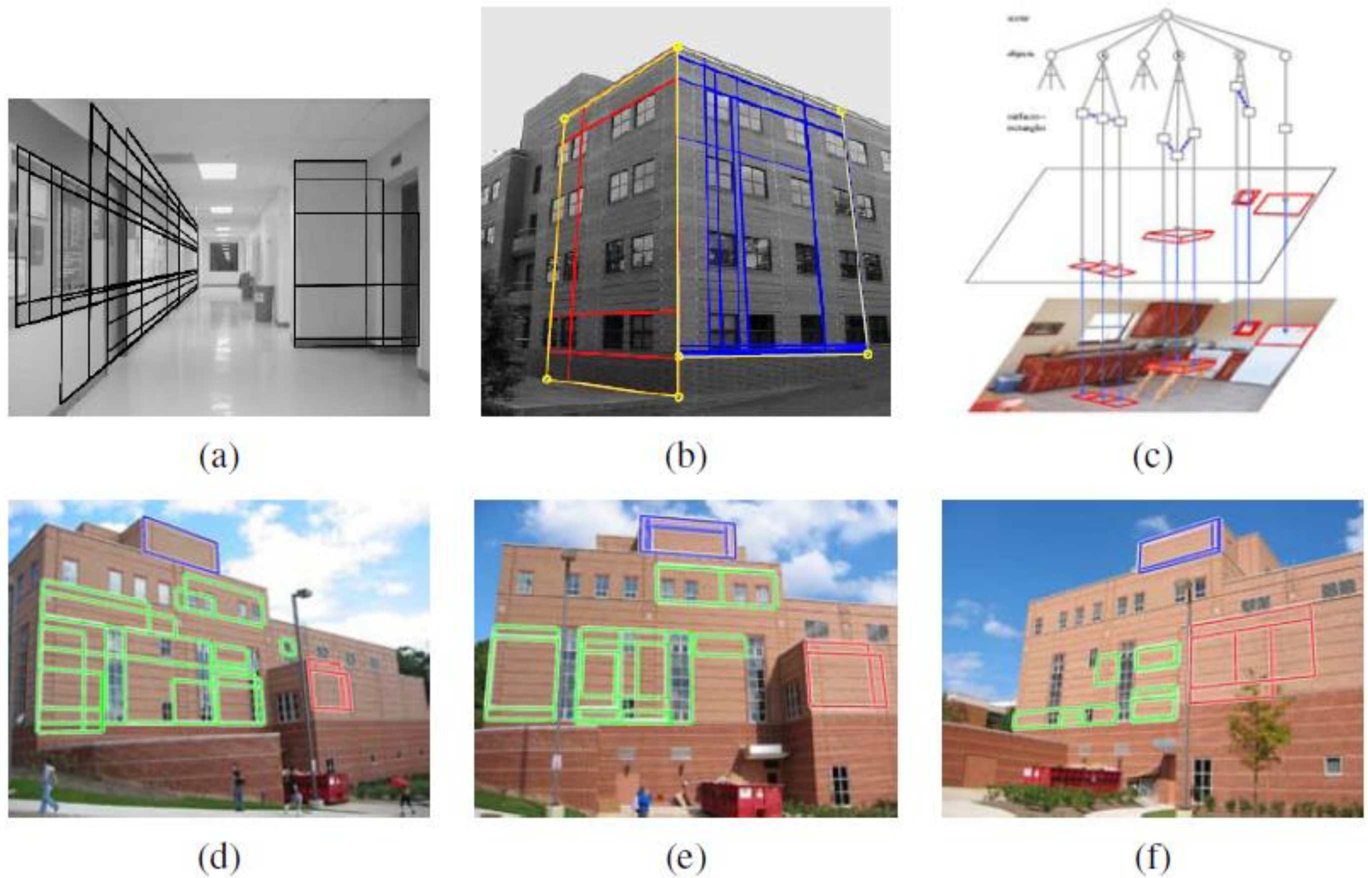


Figure 4.47 Rectangle detection: (a) indoor corridor and (b) building exterior with grouped facades (Košecká and Zhang 2005) © 2005 Elsevier; (c) grammar-based recognition (Han and Zhu 2005) © 2005 IEEE; (d–f) rectangle matching using a plane sweep algorithm (Mičušìk, Wildenauer, and Košecká 2008) © 2008 IEEE.

Segmentation

Original image

2 clusters

5 clusters

10 clusters

20 clusters

50 clusters

Segmentation

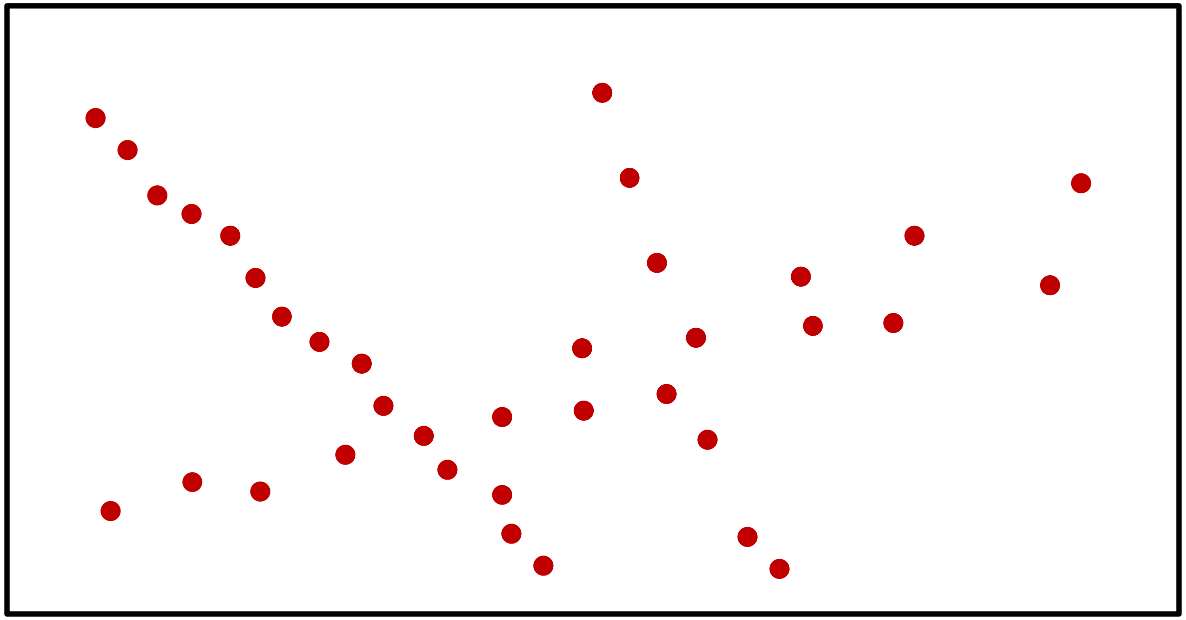
Image

Clusters on intensity

Clusters on color

K-means clustering using intensity alone and color alone
(5 clusters in each case)

Segmentation



- Three main questions
  - What line represents this set of points best?
  - Which lines gets which points?
  - How many lines are there?

Segmentation

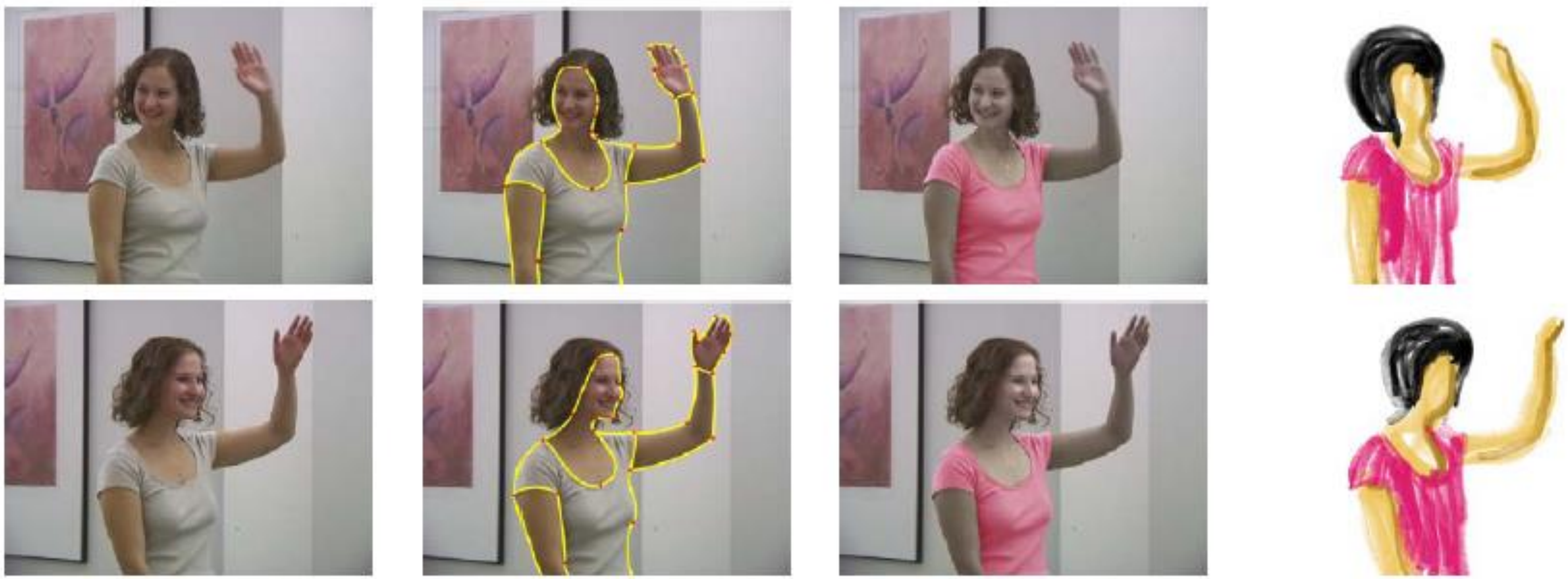
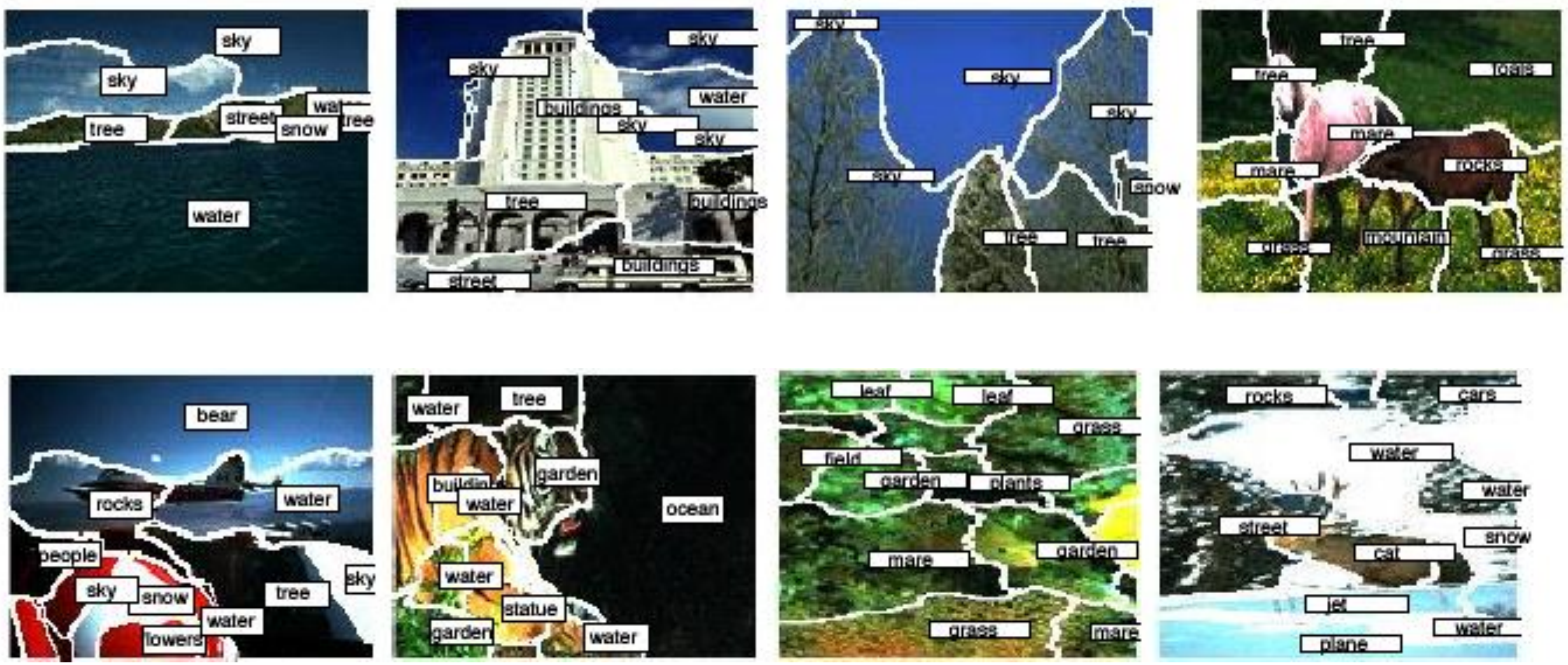
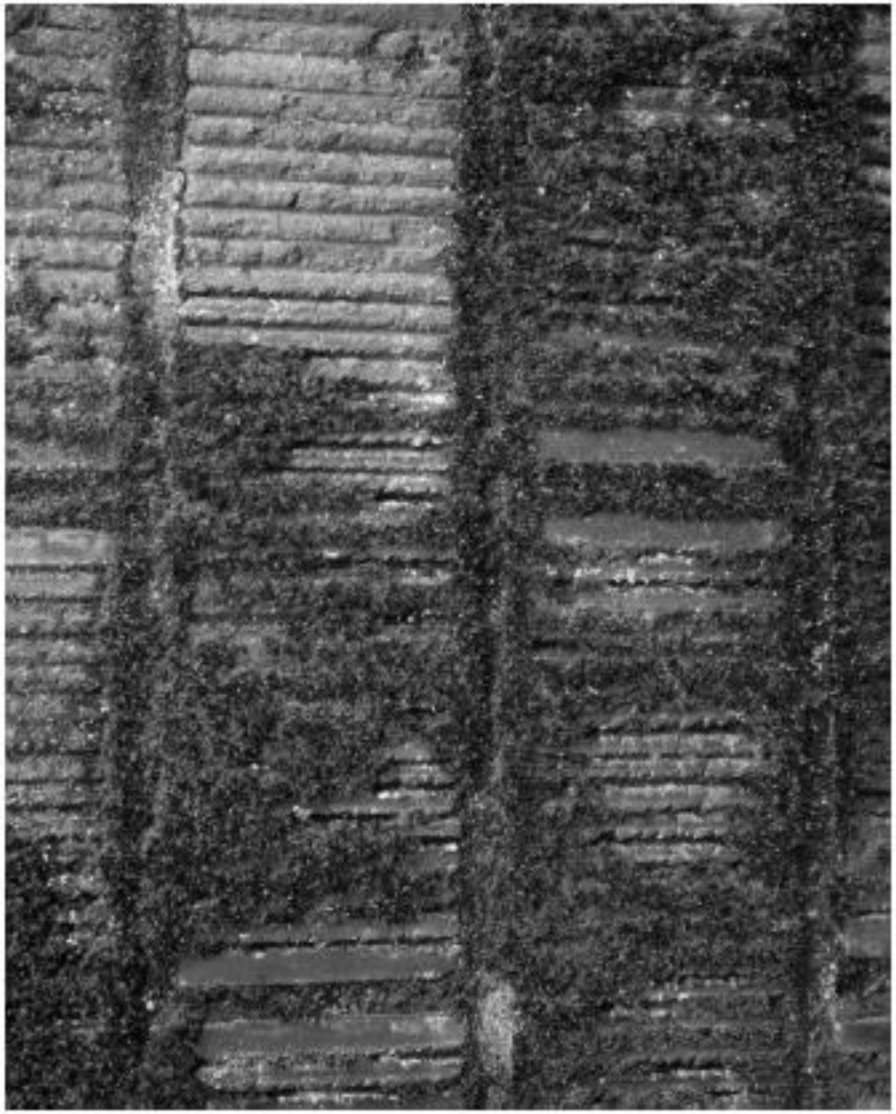


Figure 5.12 Keyframe-based rotoscoping (Agarwala, Hertzmann, Seitz *et al.* 2004) © 2004 ACM: (a) original frames; (b) rotoscoped contours; (c) re-colored blouse; (d) rotoscoped hand-drawn animation.

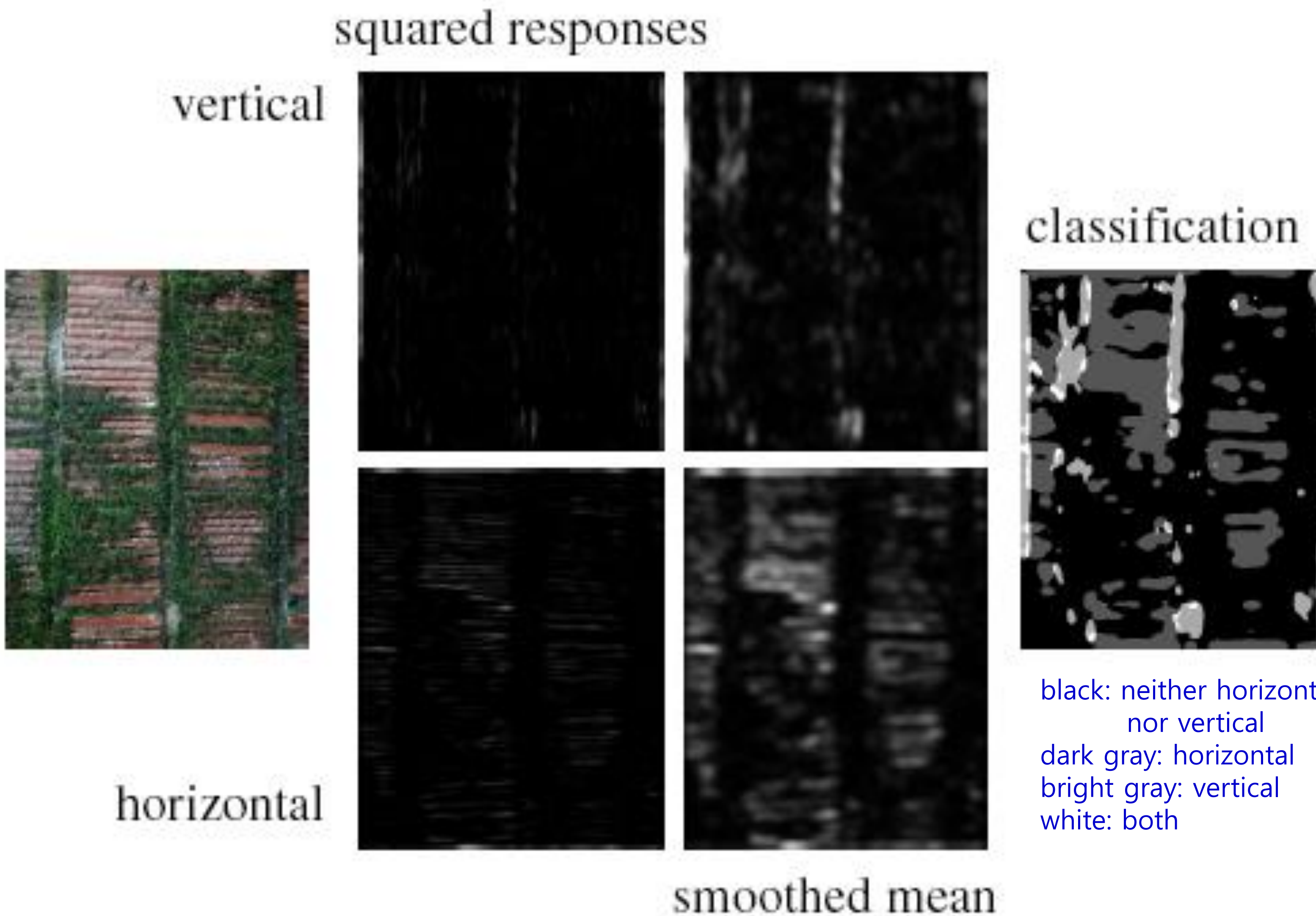
Segmentation



Texture



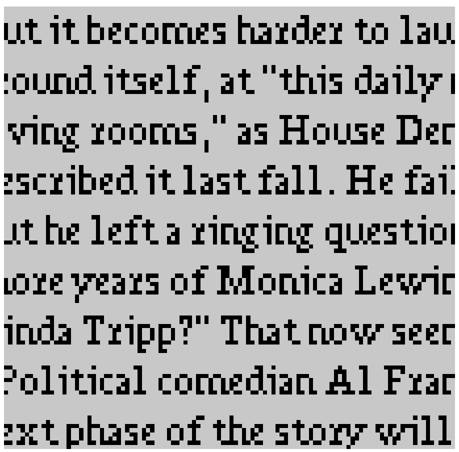
Texture



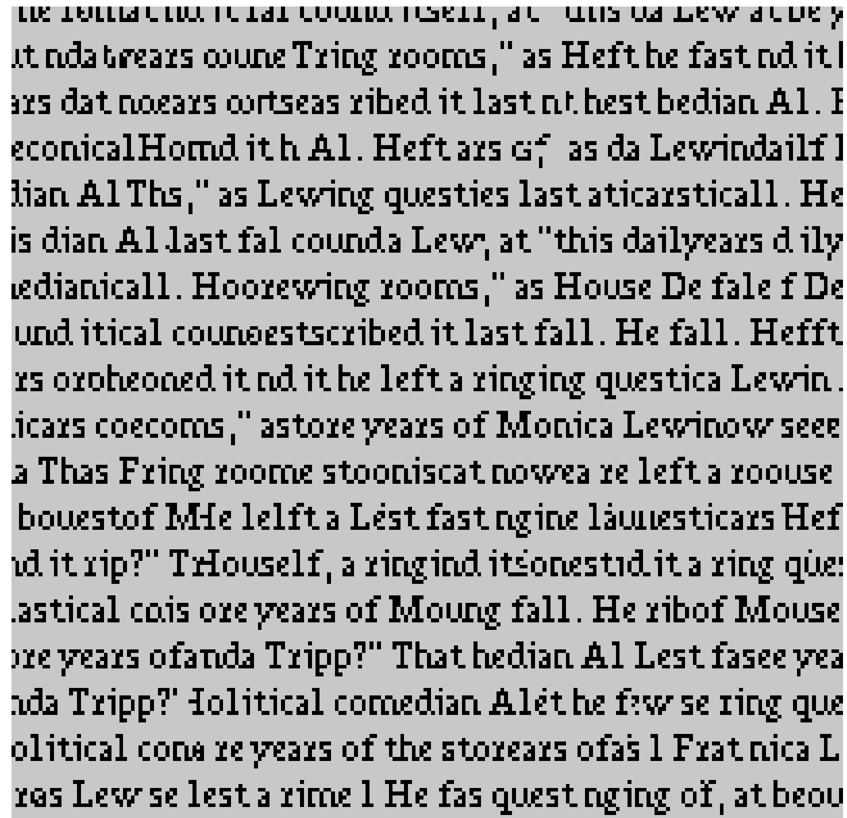
black: neither horizontal nor vertical
dark gray: horizontal
bright gray: vertical
white: both

Texture

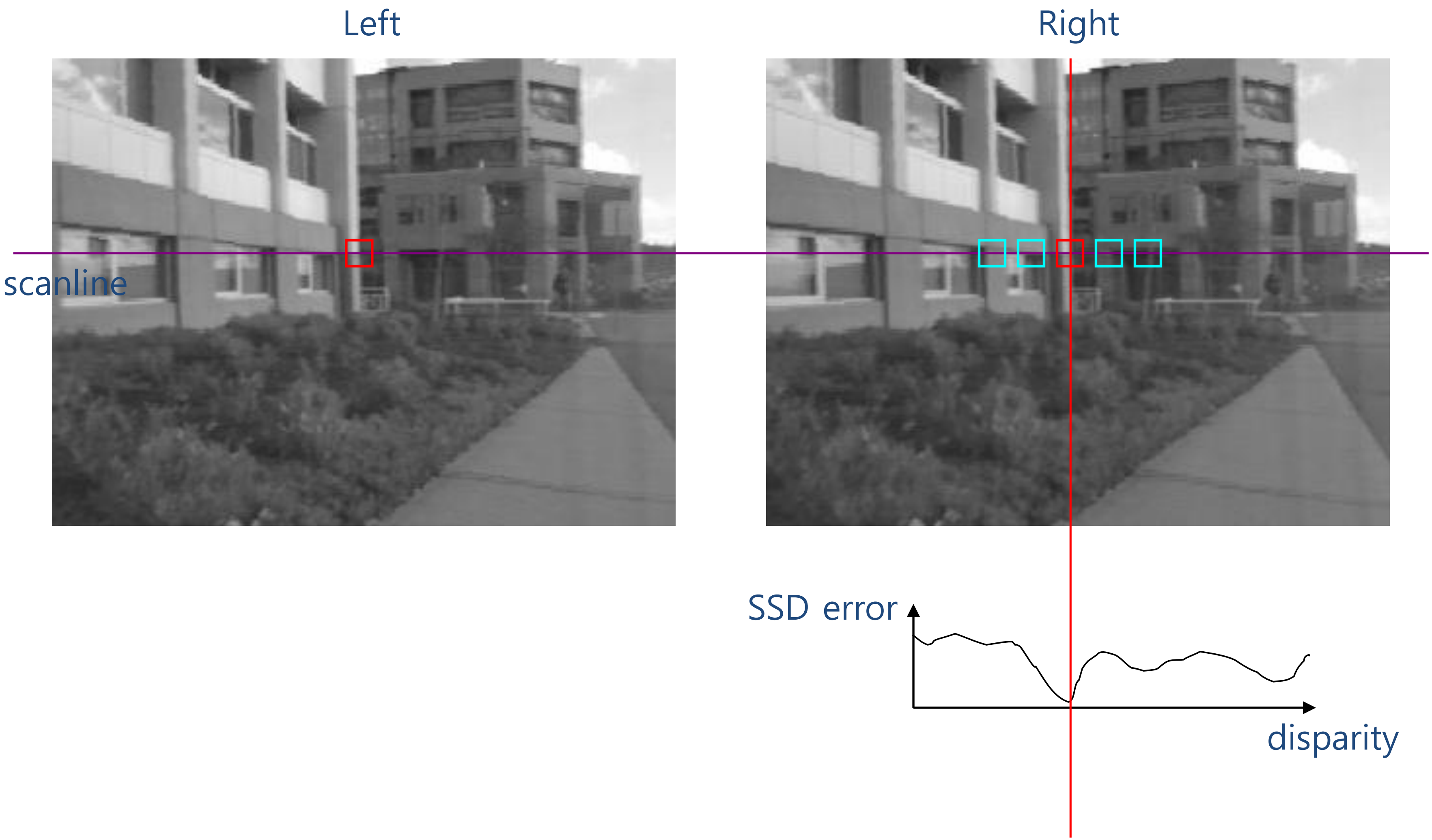
Example



Synthesized Texture



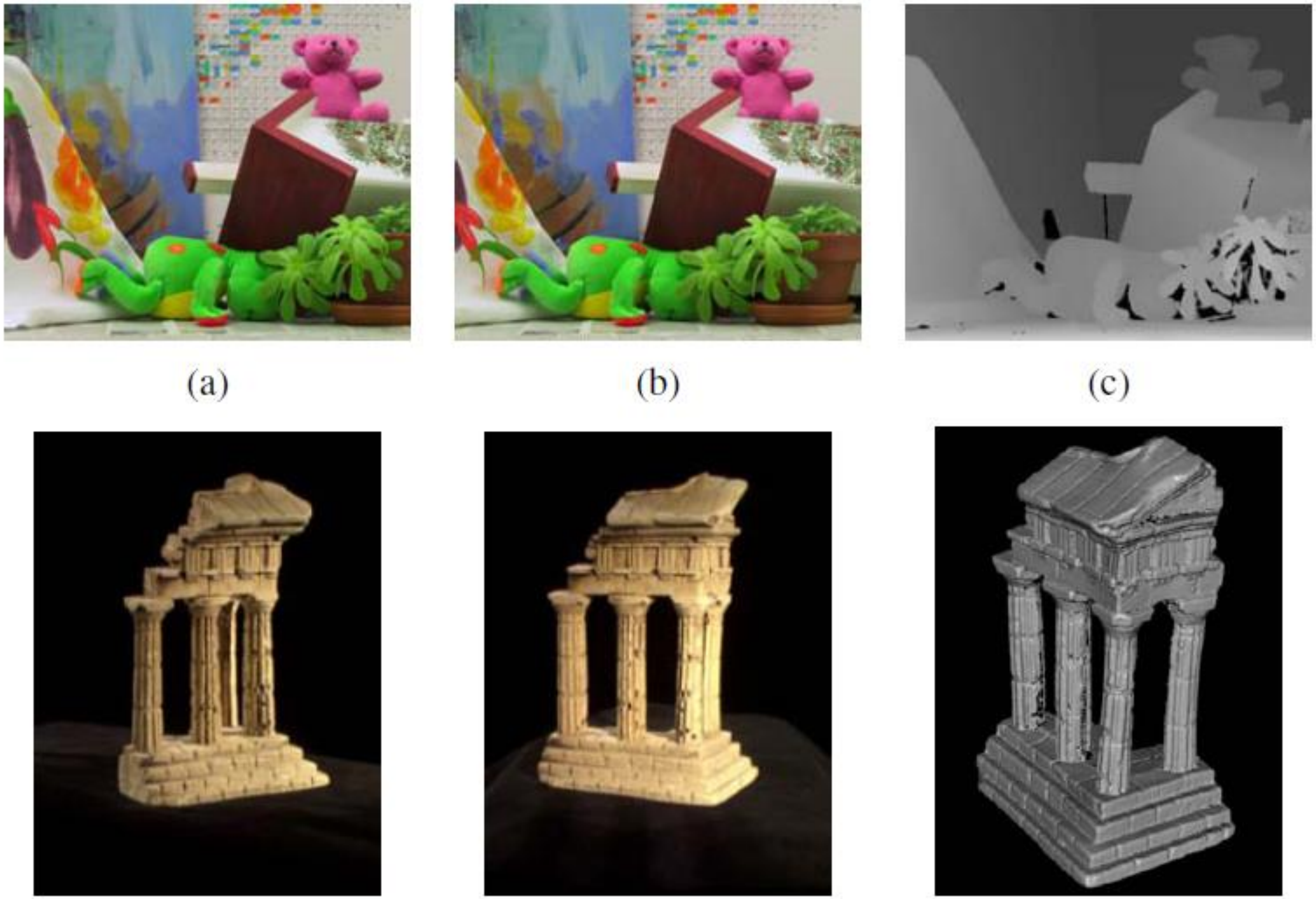
Stereo



Stereo

Disparity Map

Stereo



(a) (b) (c)

(d) (e) (f)

Motion

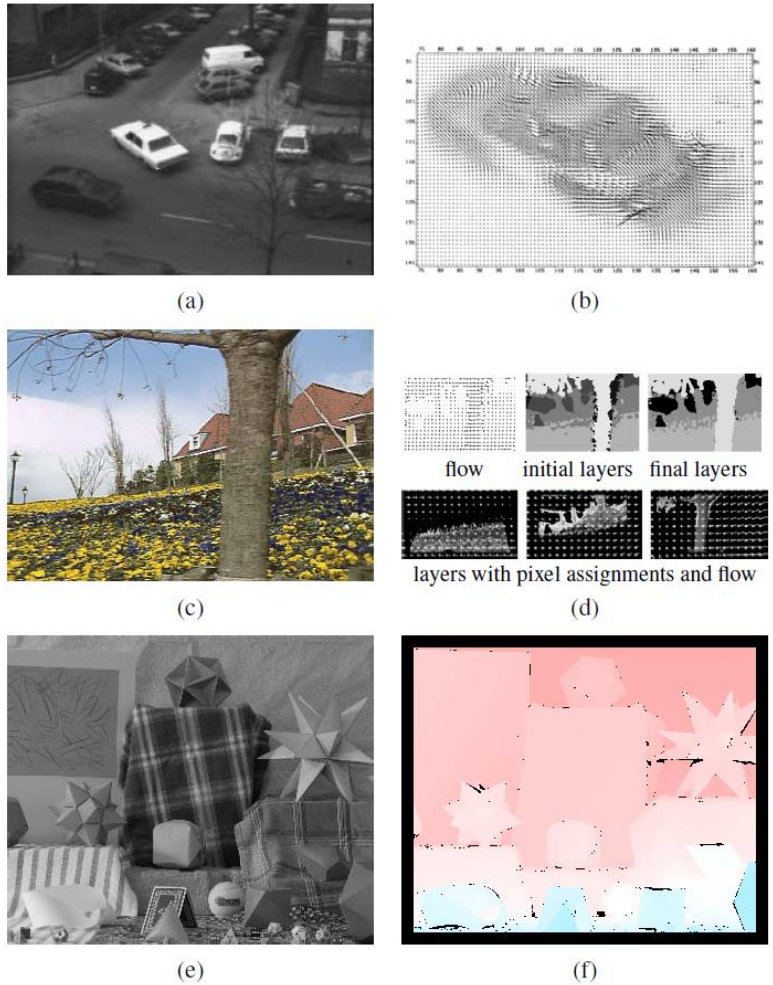


Figure 8.1 Motion estimation: (a–b) regularization-based optical flow (Nagel and Enkelmann 1986) © 1986 IEEE; (c–d) layered motion estimation (Wang and Adelson 1994) © 1994 IEEE; (e–f) sample image and ground truth flow from evaluation database (Baker, Black, Lewis *et al.* 2007) © 2007 IEEE.

Motion