Digital Image Processing

EE368/CS232

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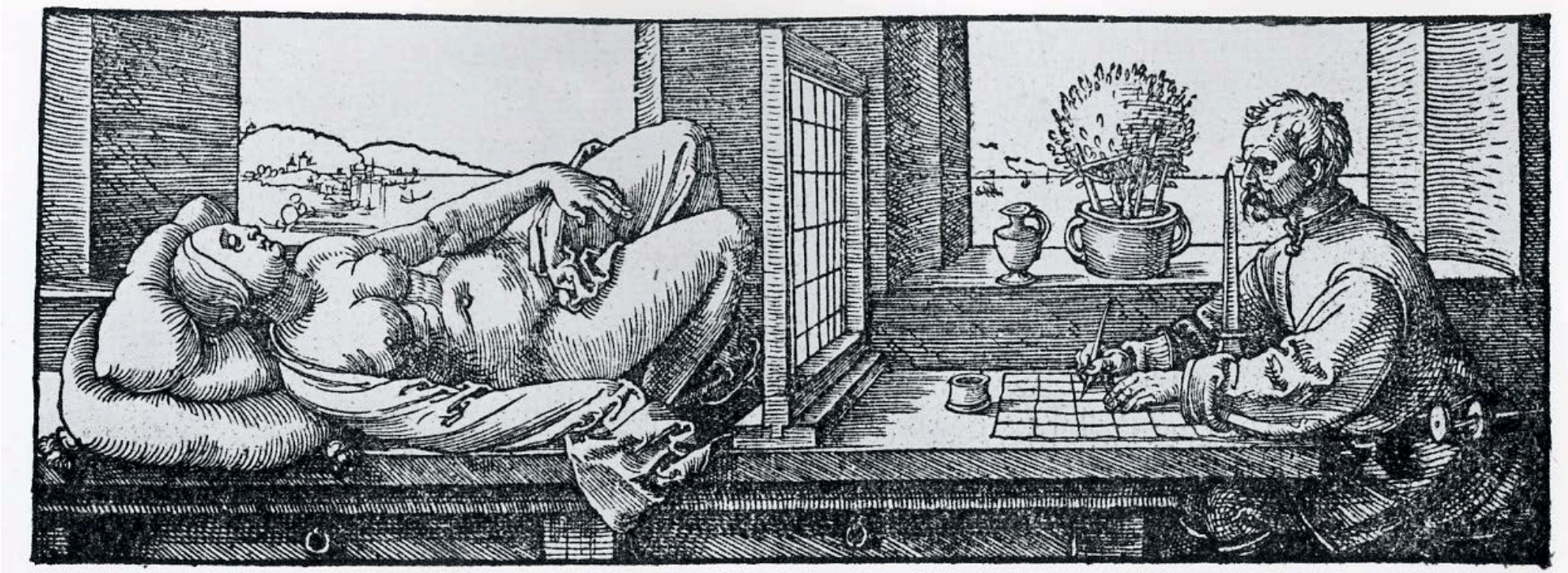
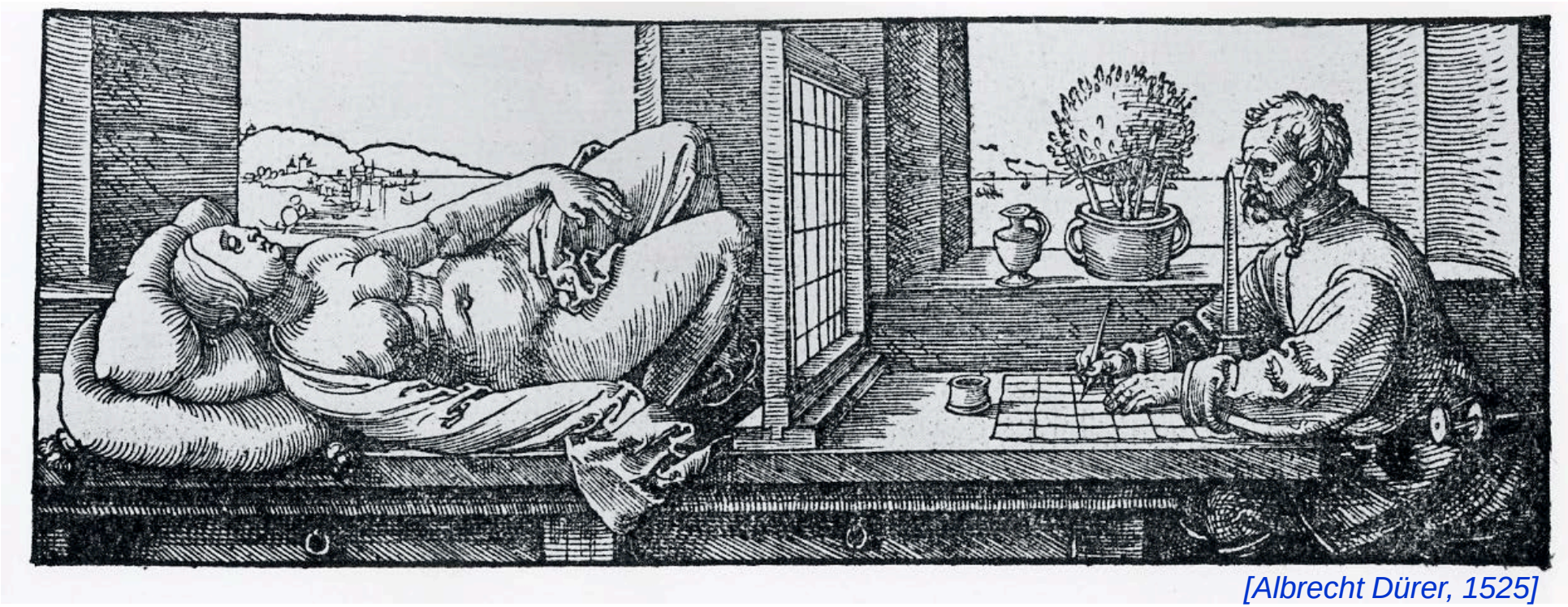
What is an image?



[Albrecht Dürer, 1525]

What is an image?



[Albrecht Dürer, 1525]

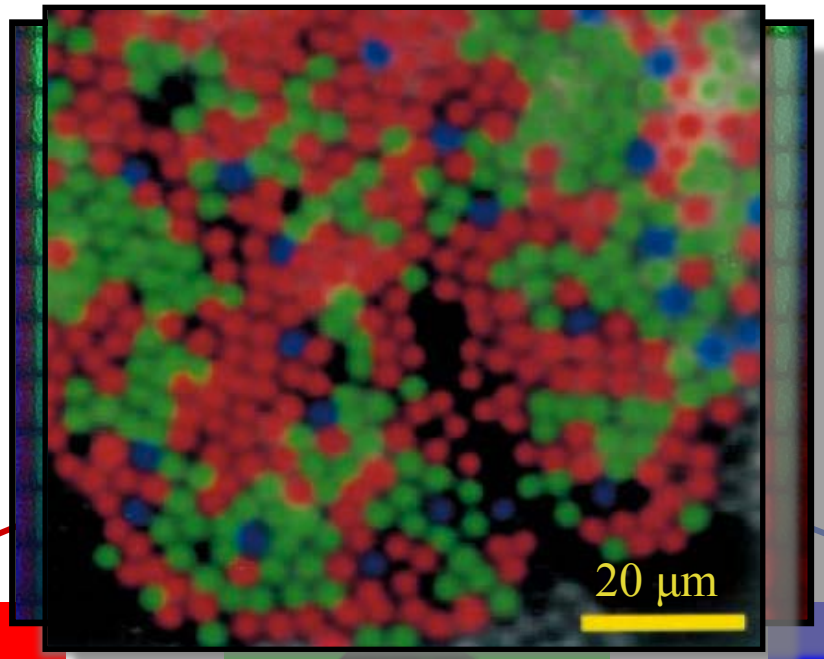
- **Image**: a visual representation in form of a function $f(x,y)$ where f is related to the brightness (or color) at point (x,y)
- Most images are defined over a rectangle
- Continuous in amplitude and space

Digital Images and Pixels

- **Digital image**: discrete samples $f[x,y]$ representing continuous image $f(x,y)$
- Each element of the 2-d array $f[x,y]$ is called a **pixel** or **pel** (from “picture element“)

200x200 100x100 50x50 25x25

Color Components



Red $R[x,y]$

Green $G[x,y]$

Blue $B[x,y]$

Monochrome image

$R[x,y] = G[x,y] = B[x,y]$

Why do we process images?

- Acquire an image
  - *Correct aperture and color balance*
  - *Reconstruct image from projections*
- Prepare for display or printing
  - *Adjust image size*
  - *Color mapping, gamma-correction, halftoning*
- Facilitate picture storage and transmission
  - *Efficiently store an image in a digital camera*
  - *Send an image from space*
- Enhance and restore images
  - *Touch up personal photos*
  - *Color enhancement for security screening*
- Extract information from images
  - *Read 2-d bar codes*
  - *Character recognition*
- Many more ... image processing is ubiquitous





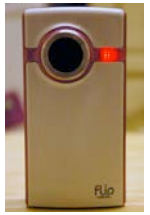
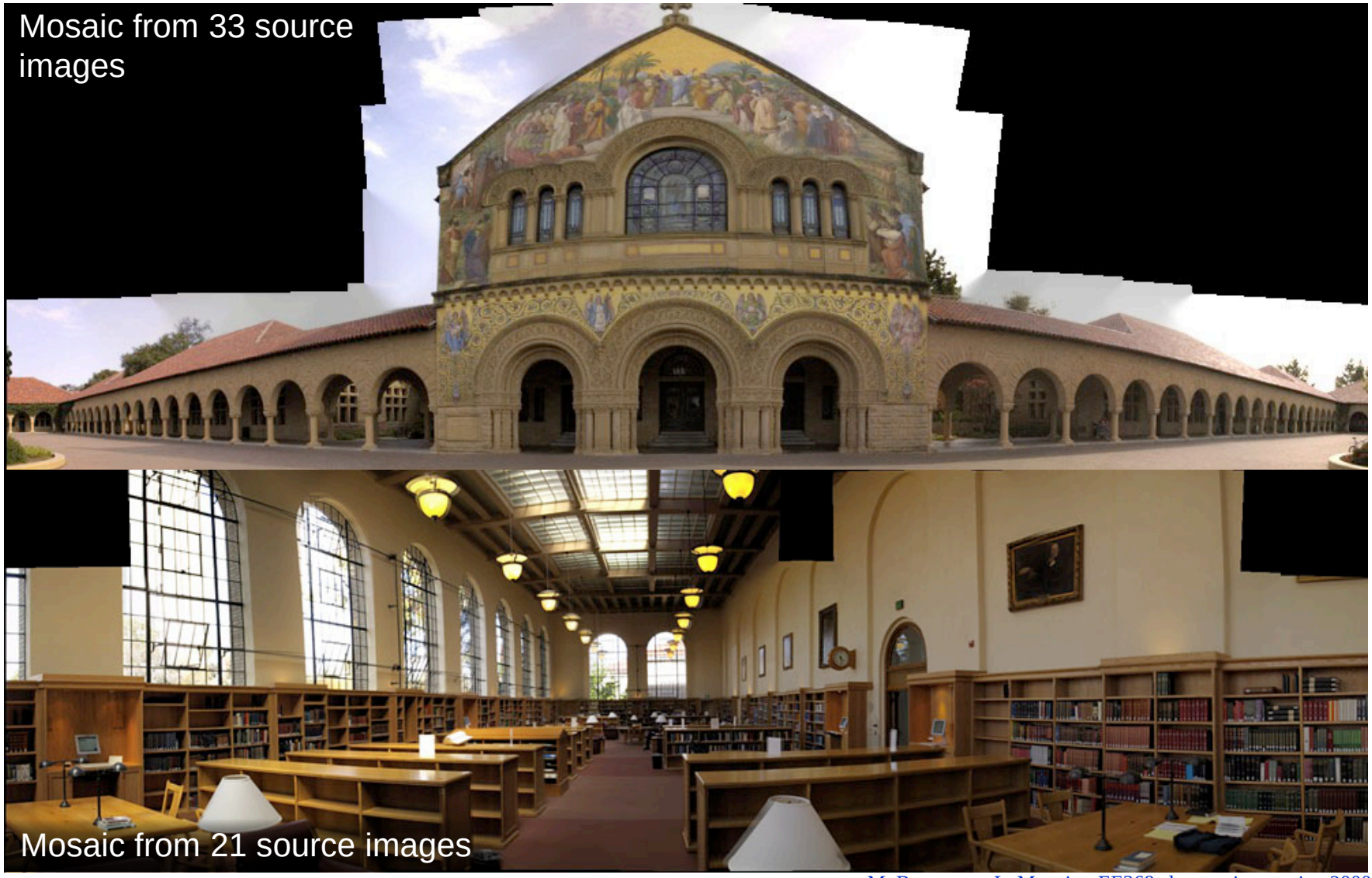



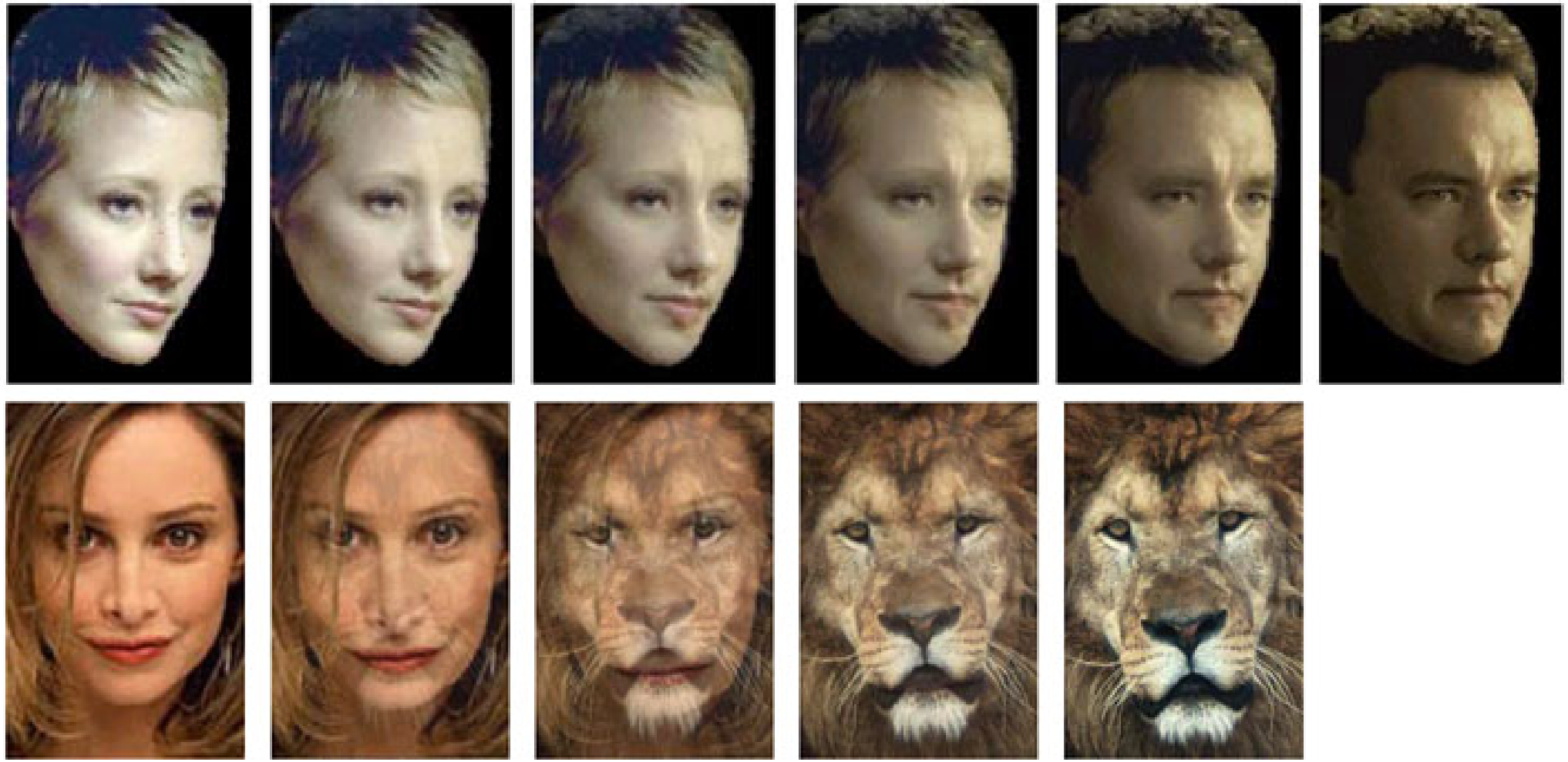

Image Processing Examples



source: M. Borgmann, L. Meunier, EE368 class project, spring 2000.

Image Processing Examples

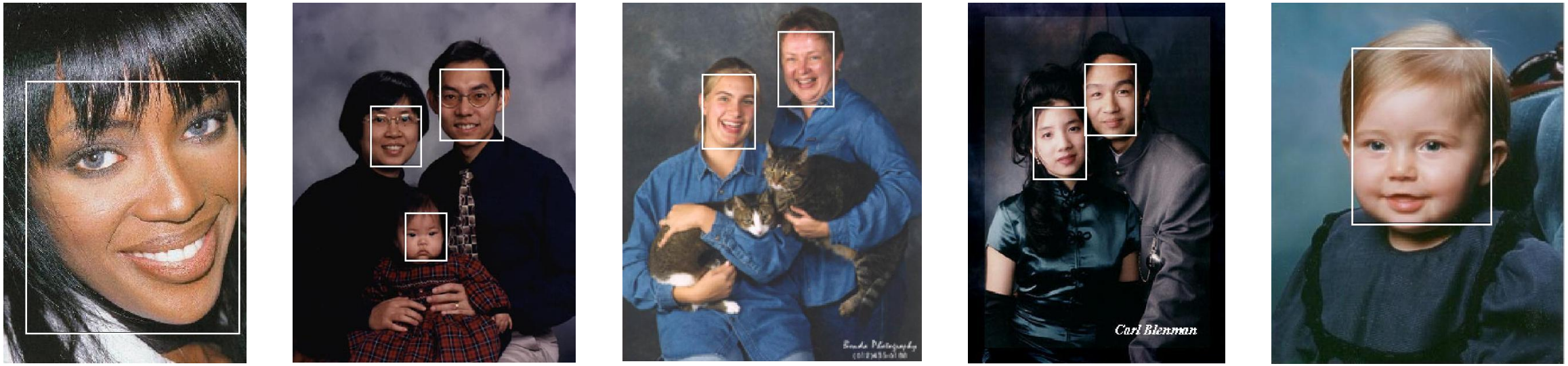
Face morphing



Source: Yi-Wen Liu and Yu-Li Hsueh, EE368 class project, spring 2000.

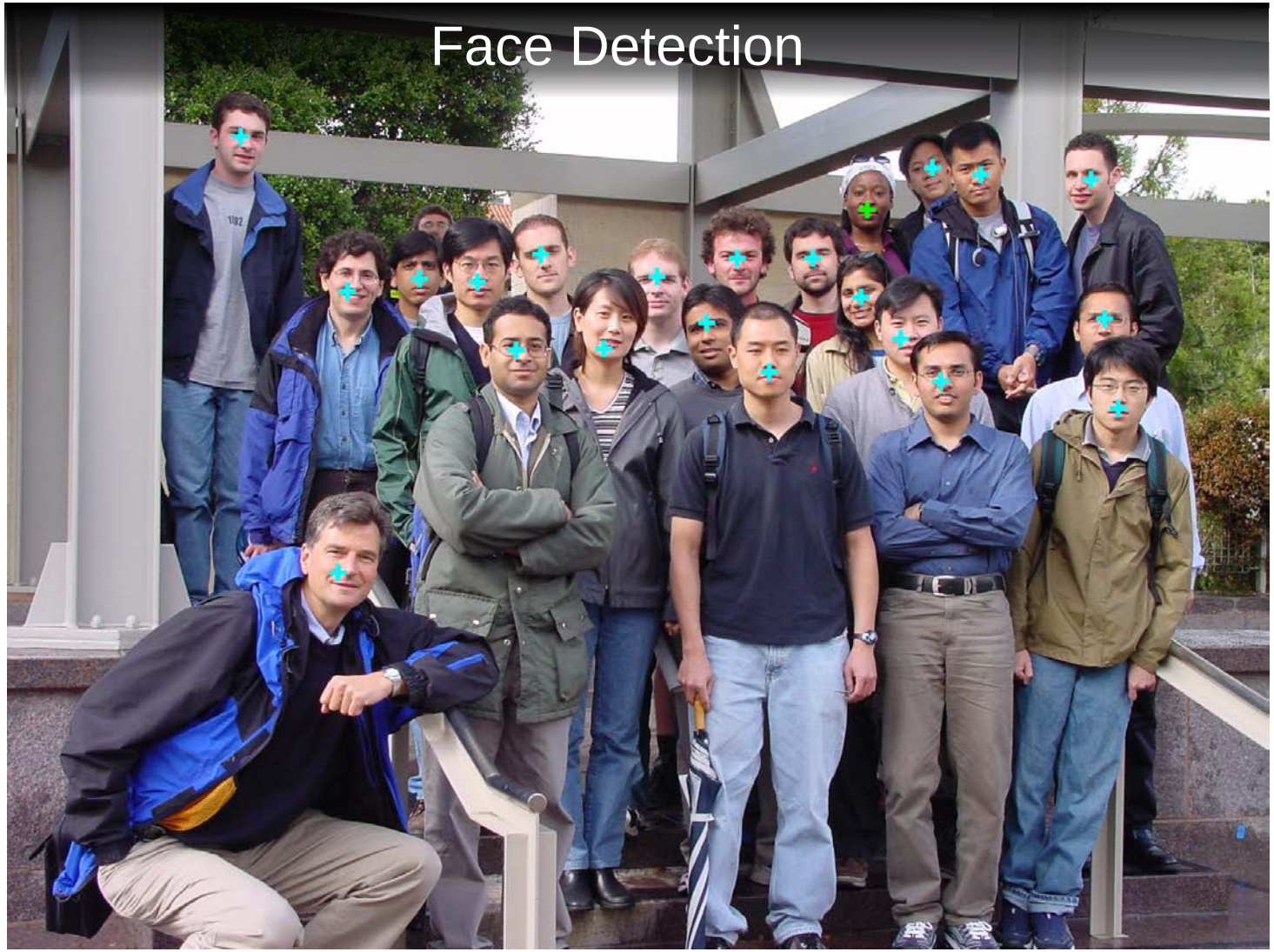
Image Processing Examples

Face Detection



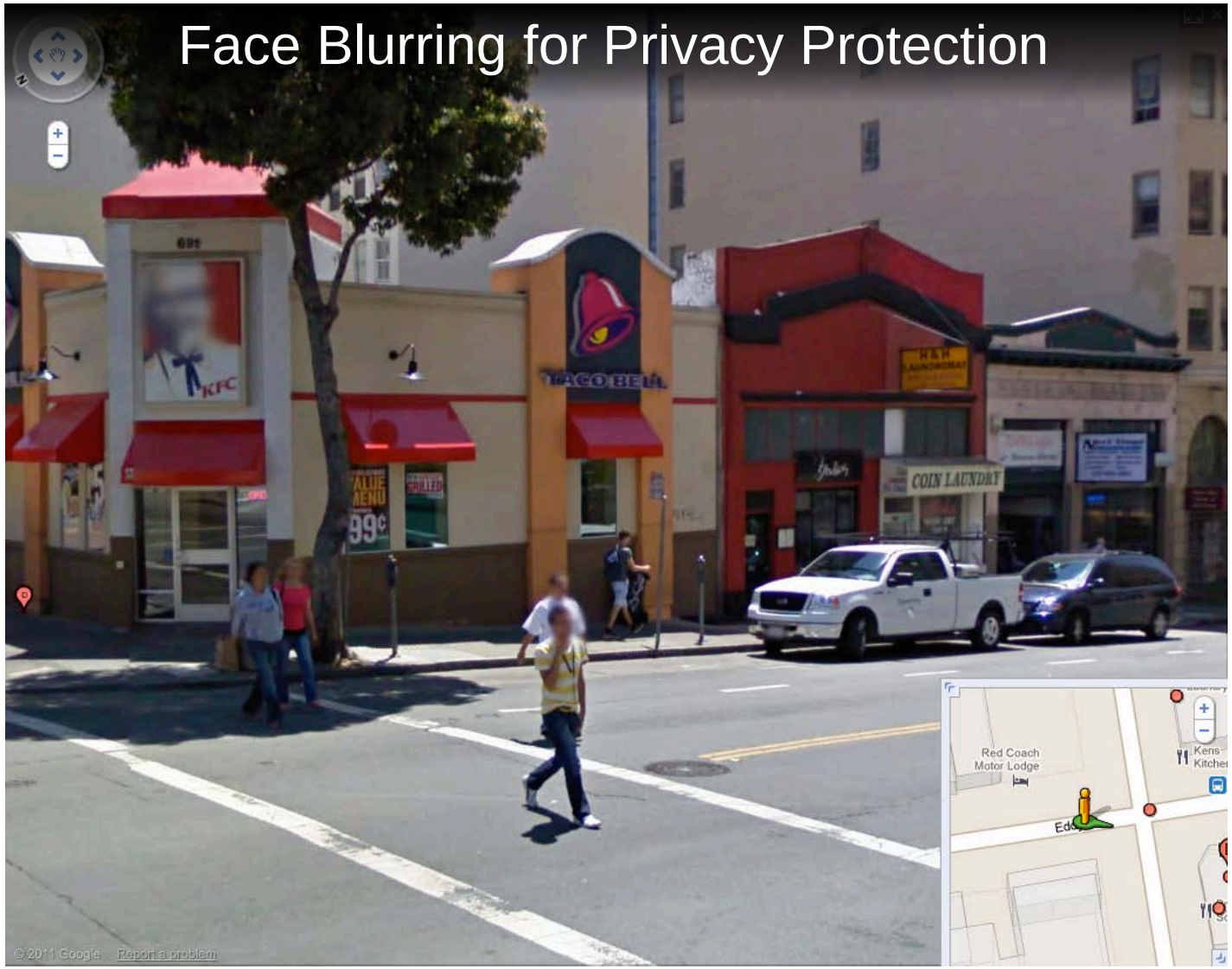
source: Henry Chang, Ulises Robles, EE368 class project, spring 2000.

Image Processing Examples



source: Michael Bax, Chunlei Liu, and Ping Li, EE368 class project, spring 2003.

Image Processing Examples



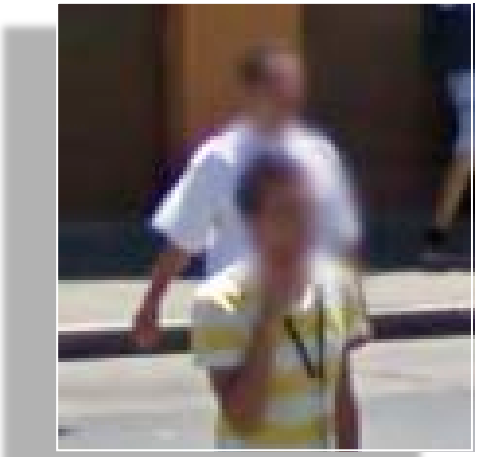
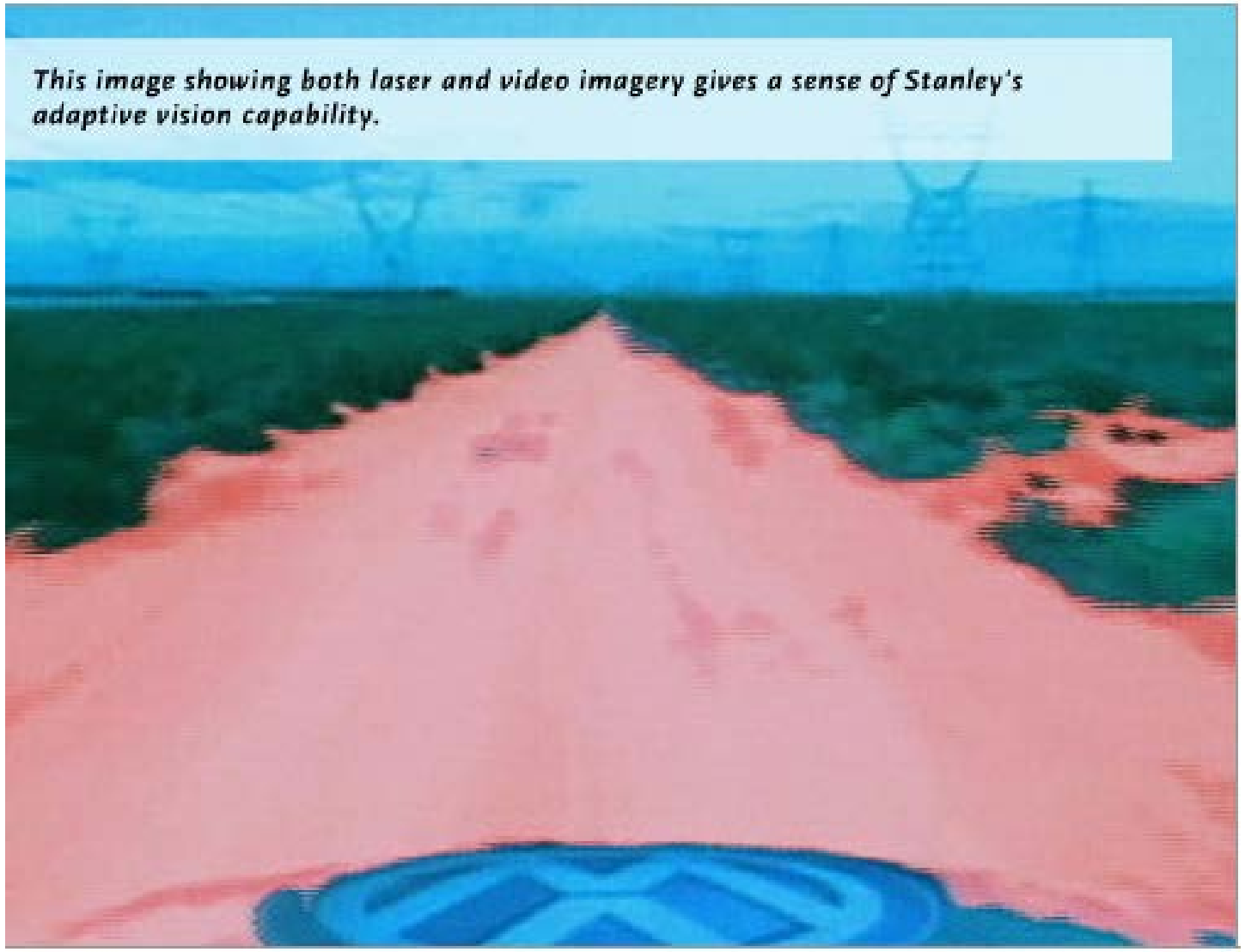
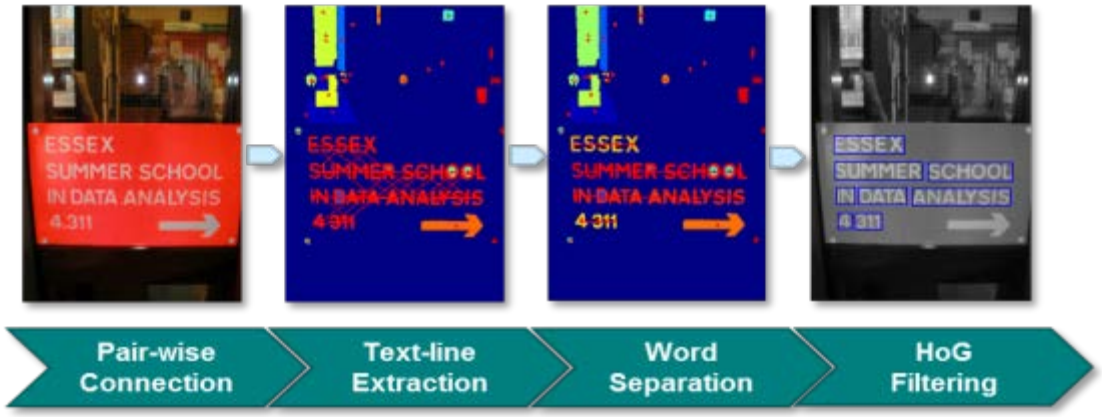


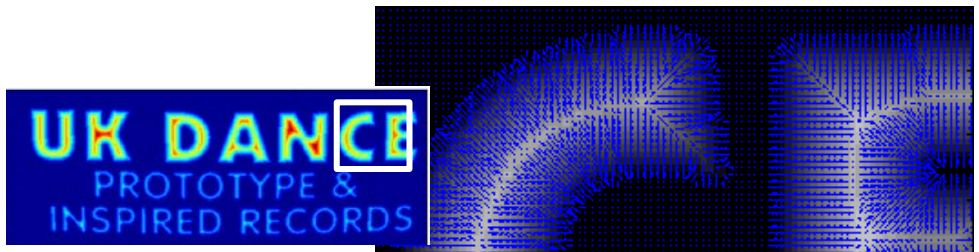
Image Processing Examples

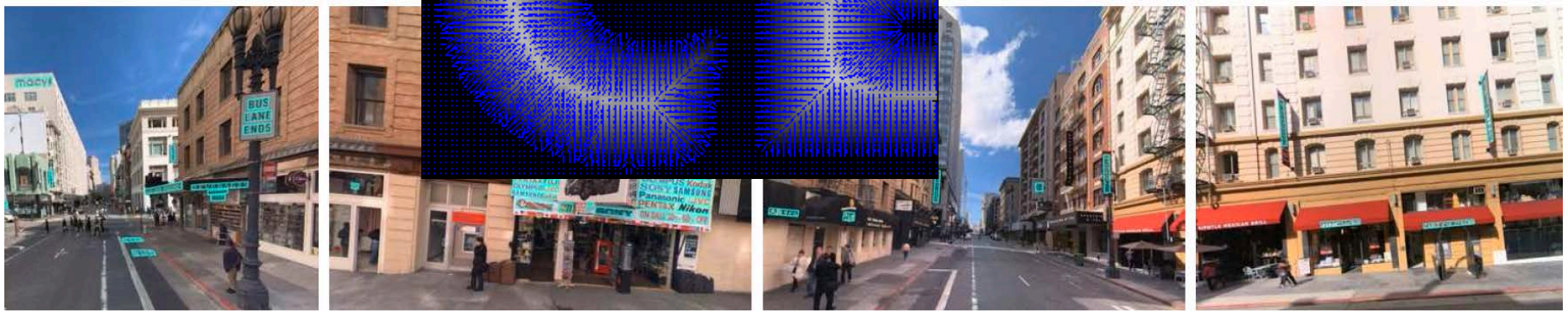


http://cs.stanford.edu/group/roadrunner/stanley.html

Image Processing Examples

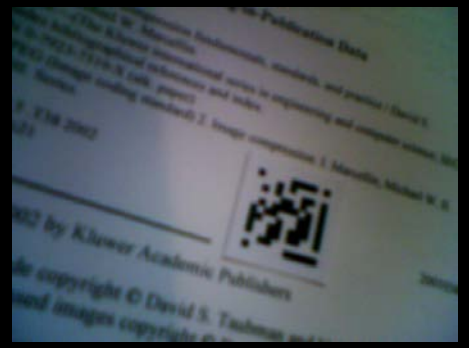


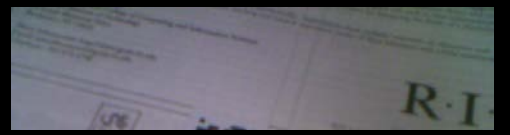
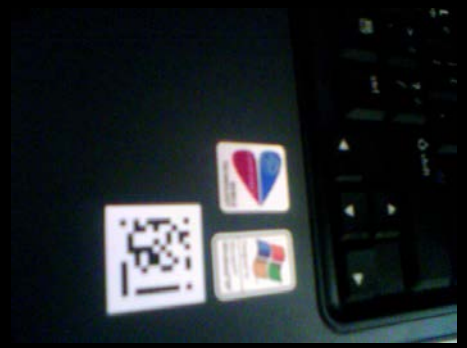




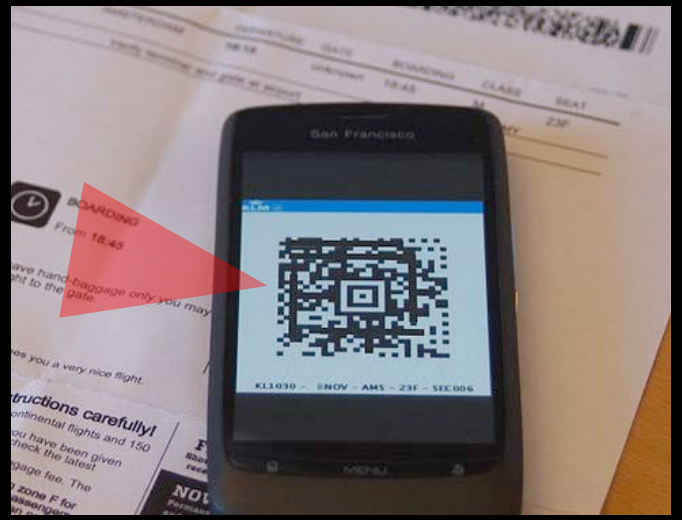
Source: Huizhong Chen, Sam Tsai, Bernd Girod, Stanford, 2012

EE368 Spring 2006 Project:
Visual Code Marker Recognition







EE368 Spring 2007 Project: Painting Recognition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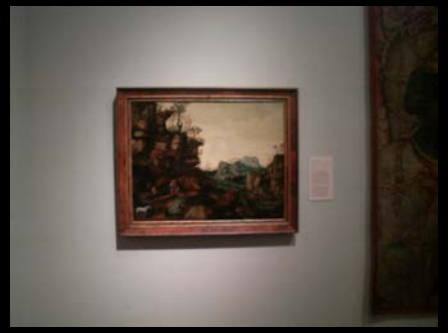
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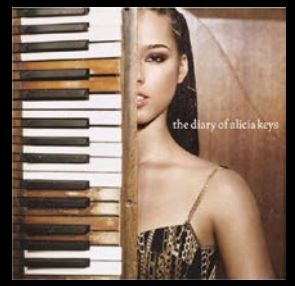
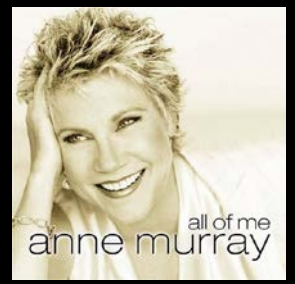
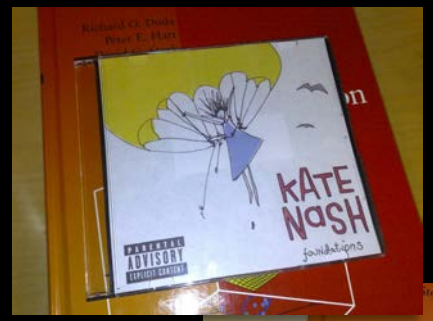
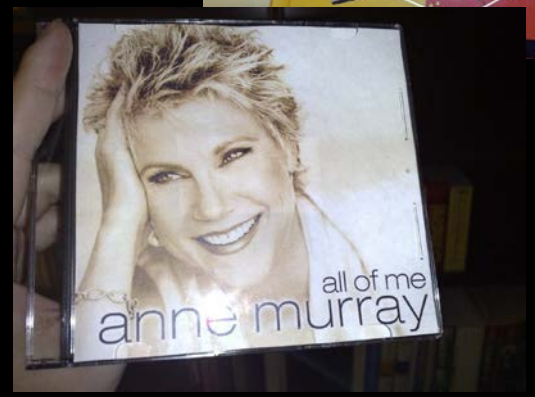
EE368 Spring 2007 Project: Painting Recognition

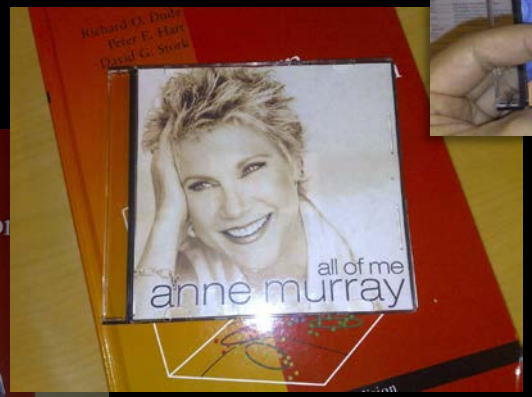
EE368 Spring 2008 Project:
CD Cover Recognition

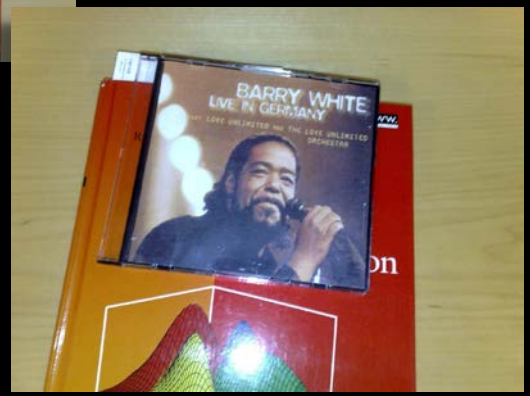












CD Cover Recognition on Cameraphone

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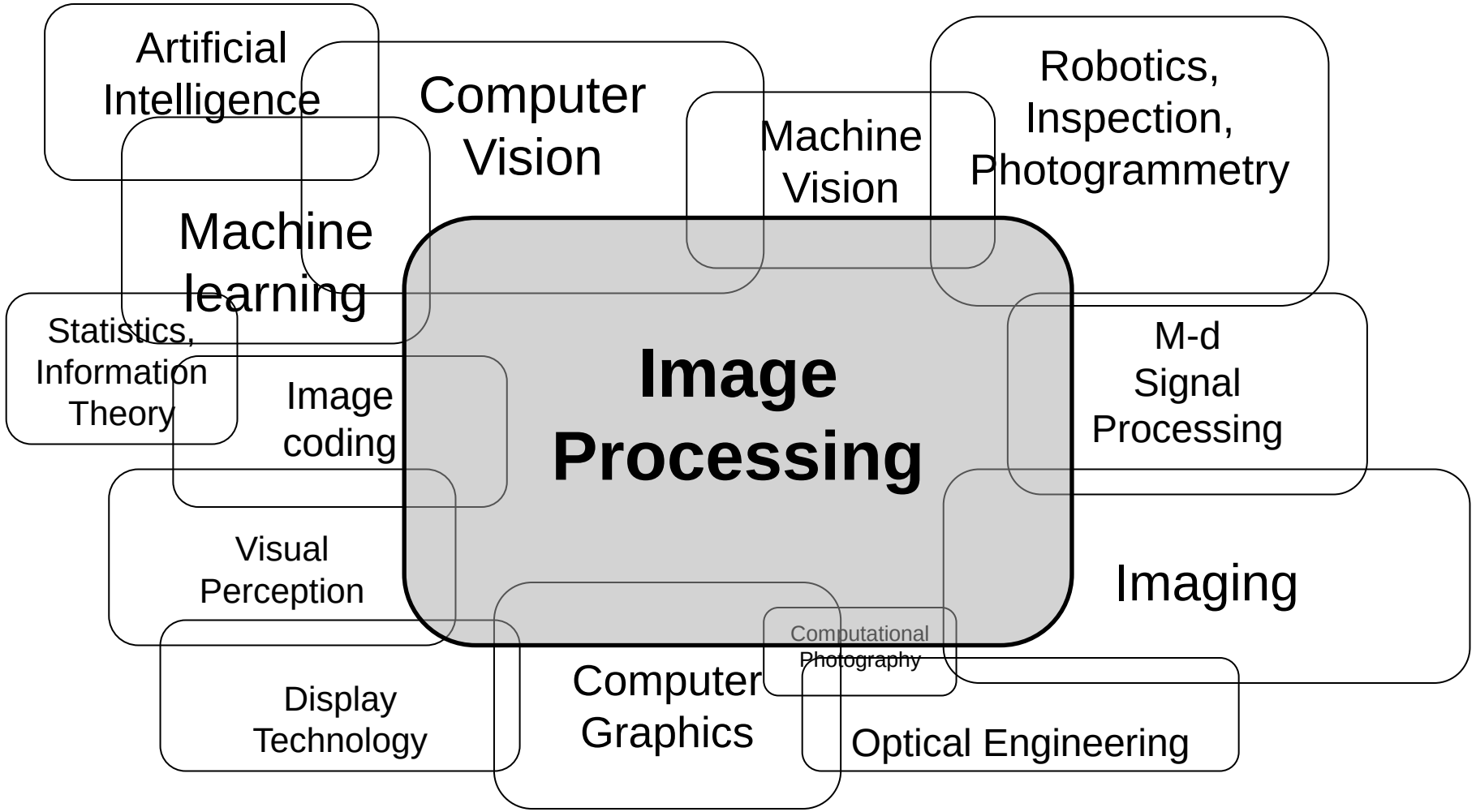
Scope of EE368/CS232

- Introductory graduate-level digital image processing class
- Emphasis on general principles, signals & systems angle
- Prerequisites: EE261, EE278B or equivalent recommended (but not required)
- Topics
  - Point operations, color
  - Image thresholding/segmentation
  - Morphological image processing
  - Image filtering, deconvolution
  - Feature extraction
  - Scale-space image processing
  - Image registration, image matching
  - Eigenimages

Image Processing and Related Fields



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EE368/CS232 Organisation

- Assistants
  - Course assistants: David Chen, Matt Yu
  - Administrative assistant: Kelly Yilmaz
- Office hours
  - Bernd Girod: Tu 1:30-3:00 p.m., Packard 373 (starting 4/16)
  - David Chen, We 5:00-7:00 p.m., Packard 021 (SCIEN Lab)
  - Matt Yu, Th 5:00-7:00 p.m., Packard 021 (SCIEN Lab)
  - SCPD Live Meeting session: Tu 6:00pm
- Class home page:

  http://www.stanford.edu/class/ee368
- Class Piazza page:

  http://piazza.com/class#spring2013/ee368

EE368/CS232 Organisation (cont.)

- Homeworks
  - Weekly assignments until midterm, require computer + Matlab
  - Usually handed out Fridays, due one week later, solve individually
  - First handed out on April 5
- Late Midterm
  - 24-hour take-home exam
  - 3 slots, **May 22-25**
- Final project
  - Individual or group project, plan for about 50-60 hours per person
  - Develop, implement and test/demonstrate an image processing algorithm
  - Project proposal due: **May 1, 11:59 p.m.**
  - Project presentation: Poster session, **June 5, 4-6:30 p.m.**
  - Submission of written report and source code: **June 5, 11:59 p.m.**
- Grading
  - Homeworks: 20%
  - Mid-term: 30%
  - Final project: 50%
  - No final exam.

SCIEN laboratory

- SCIEN = Stanford Center for Image Systems Engineering (http://scien.stanford.edu)
- Exclusively a teaching laboratory
- Location: Packard room 021
- 20 Linux PCs, scanners, printers etc.
  - Matlab with Image Processing Toolbox
  - Android development environment
- Access:
  - Door combination for lab entry will be provided by TA
  - Account on SCIEN machines will be provided to all enrolled in class

Mobile image processing

- Google gift: 40 Motorola DROID cameraphones
- Available for EE368/CS232 projects (must be returned after, sorry)
- Lectures on Android image processing in April
- Android development environment on your own computer or in SCIEN lab
- Programming in Java (C++ for OpenCV)

Reading

- Slides available as hand-outs and as pdf files on the web
- Popular text books
  - R. C. Gonzalez, R. E. Woods, „Digital Image Processing,“ 3rd edition, Prentice-Hall, 2008, $186.– ($147 on Amazon).
  - A. K. Jain, „Fundamentals of Digital Image Processing,“ Prentice-Hall, Addison-Wesley, 1989, $186.– ($141 on Amazon).
- Software-centric books
  - R. C. Gonzalez, R. E. Woods, S. L. Eddins, „Digital Image Processing using Matlab,“ 2nd edition, Pearson-Prentice-Hall, 2009, ca. $ 140.--.
  - G. Bradski, A. Kaehler, „Learning OpenCV,“ O‘Reilly Media, 2008, $ 50.00.
- Comprehensive state-of-the-art
  - Al Bovik (ed.), „The Essential Guide to Image Processing,“ Academic Press, 2009, $ 92.95.
- Journals/Conference Proceedings
  - IEEE Transactions on Image Processing
  - IEEE International Conference on Image Processing (ICIP)
  - IEEE Computer Vision and Pattern Recognition (CVPR)

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