Digital Image Processing
EE368/CS232

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What is an image?

[Albrecht Dürer, 1525]

What is an image?

[Albrecht Dürer, 1525]

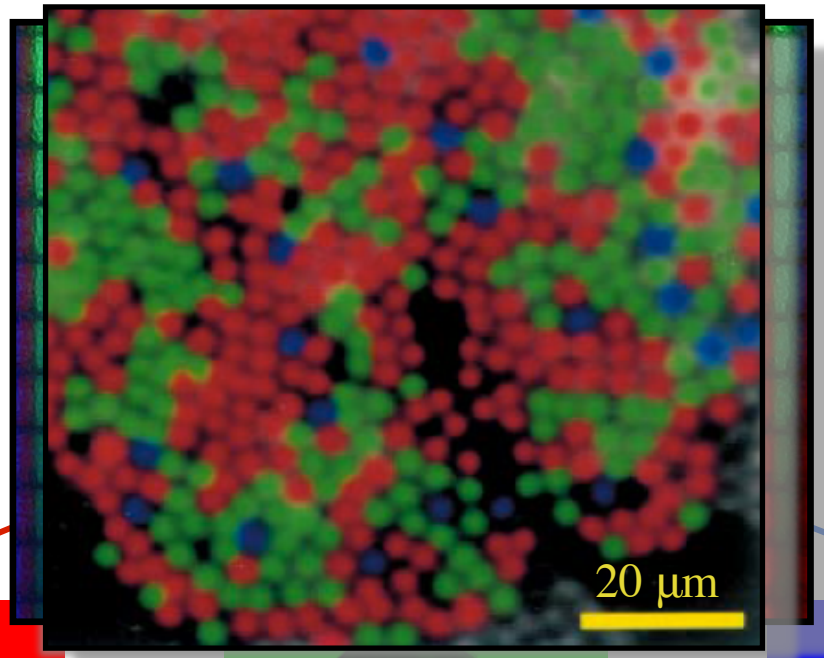
- **Image**: a visual representation in form of a function $f(x,y)$ where f is related to the brightness (or color) at point (x,y)
- Most images are defined over a rectangle
- Continuous in amplitude and space

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“)

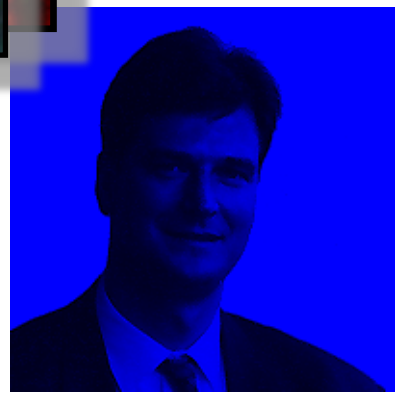
200x200 100x100 50x50 25x25

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







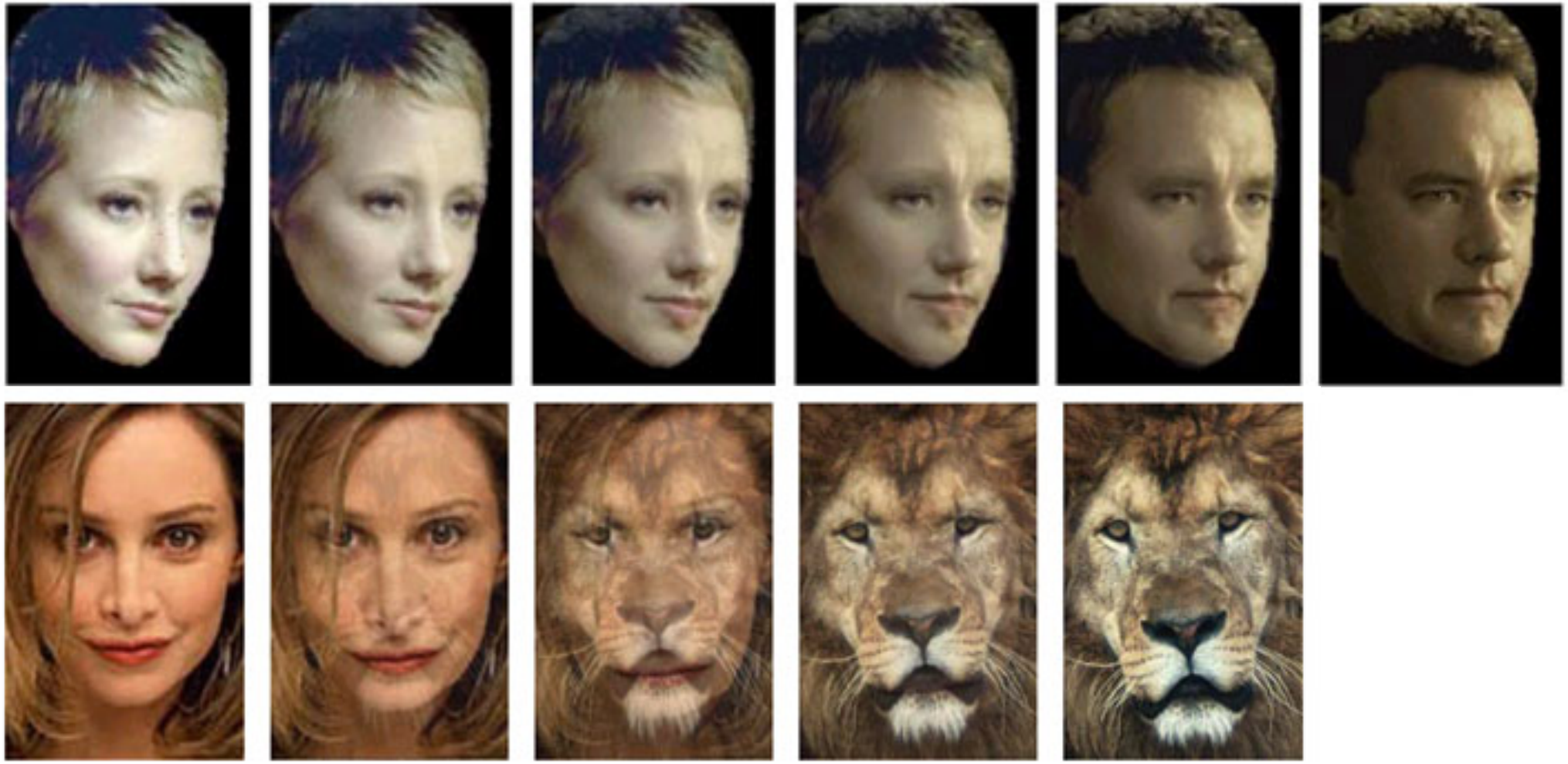


Image Processing Examples

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

Image Processing Examples

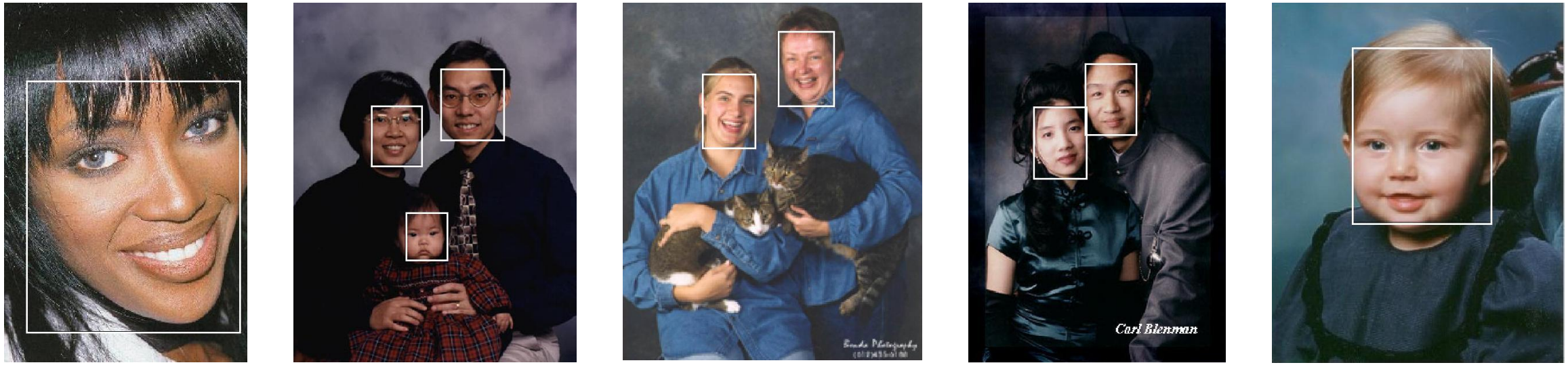
Face morphing



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

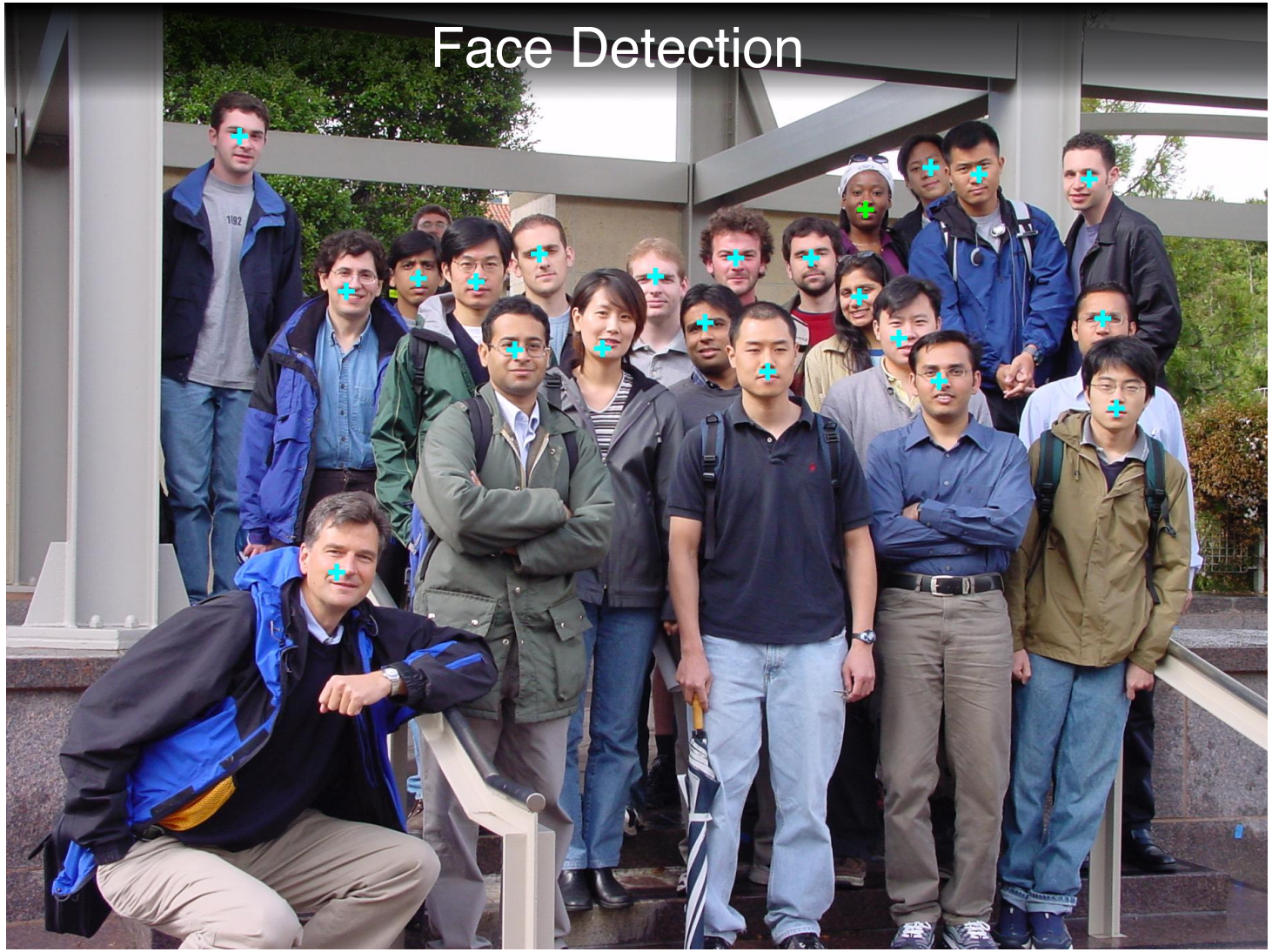
Image Processing Examples

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

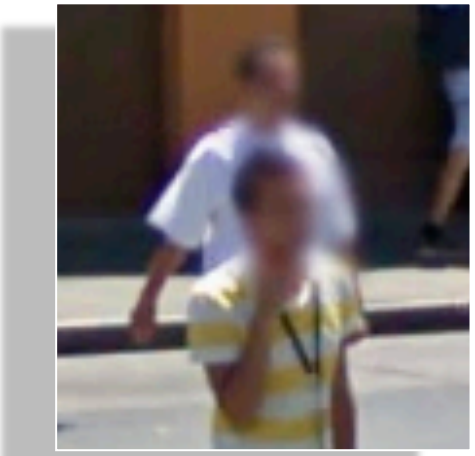
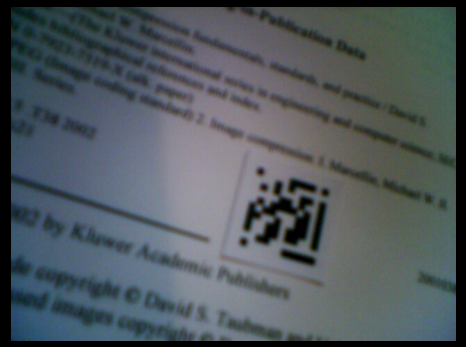
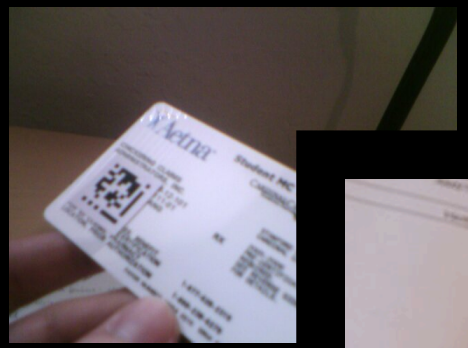
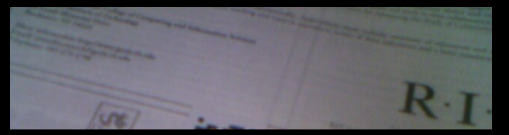
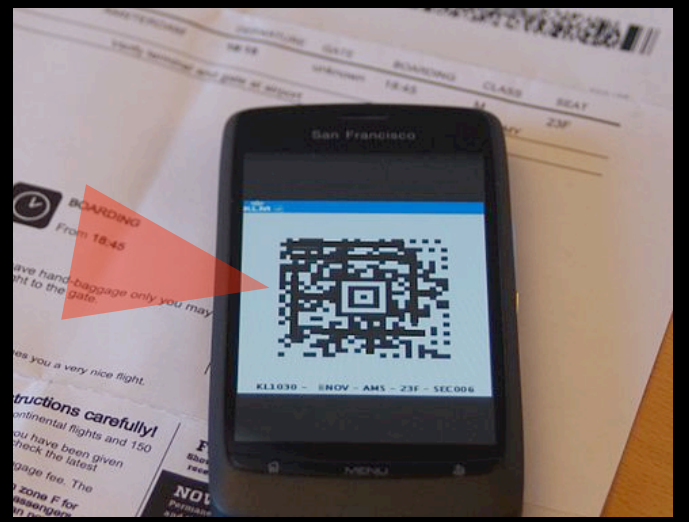


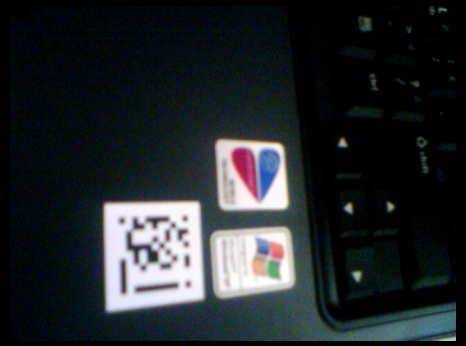
Image Processing Examples

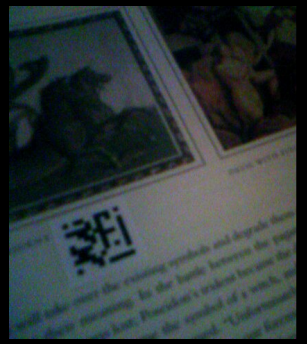
http://cs.stanford.edu/group/roadrunner/stanley.html

EE368 Spring 2006 Project:
Visual Code Marker Recognition

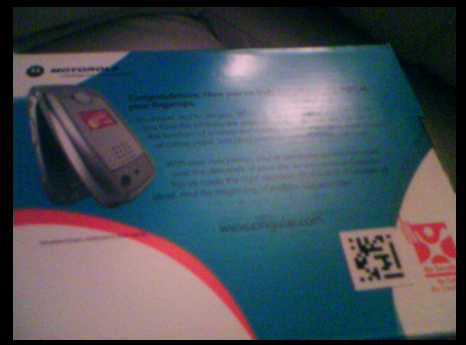










EE368 Spring 2007 Project: Painting Recognition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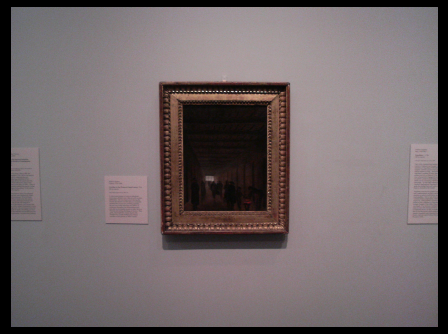
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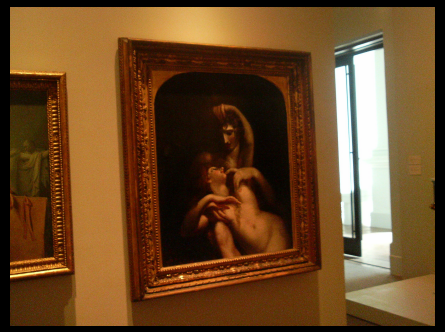
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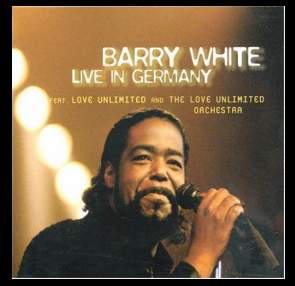
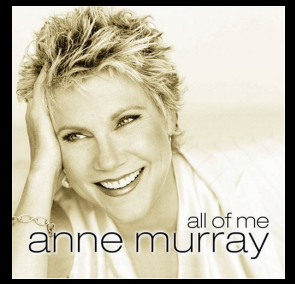
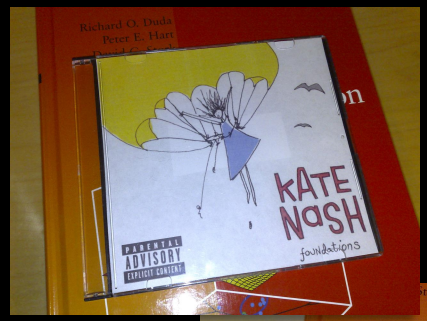
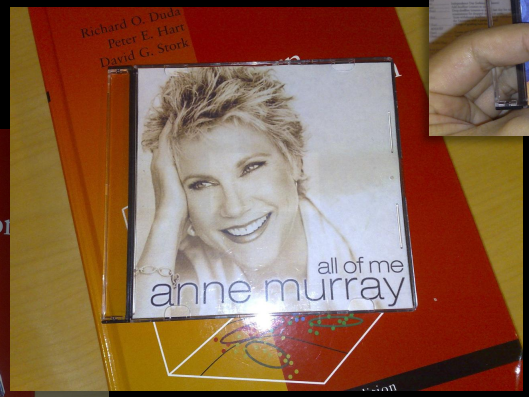
EE368 Spring 2007 Project: Painting Recognition

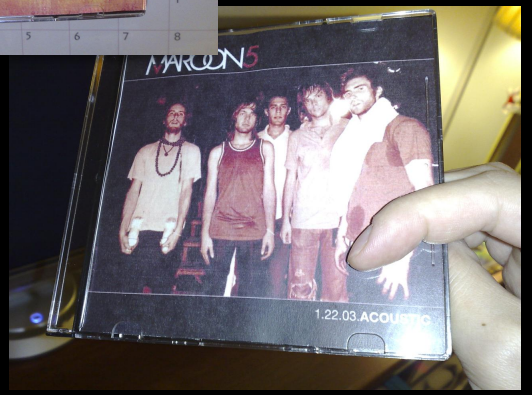
EE368 Spring 2008 Project: CD Cover Recognition

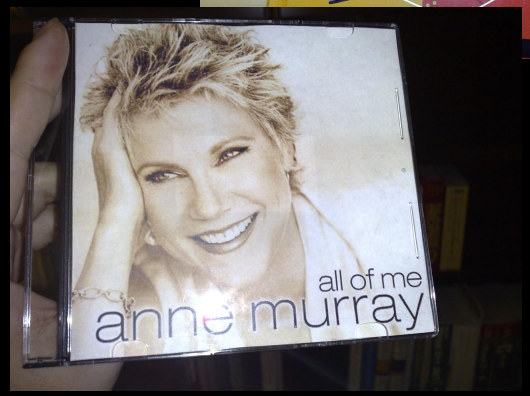


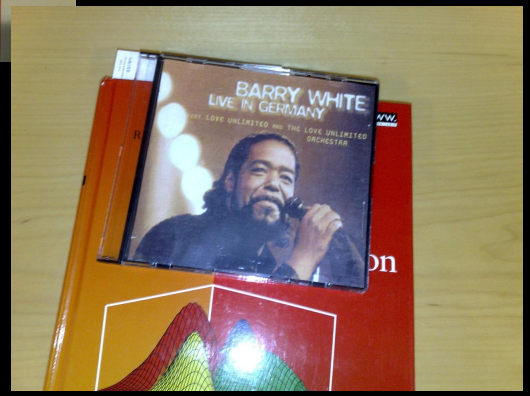




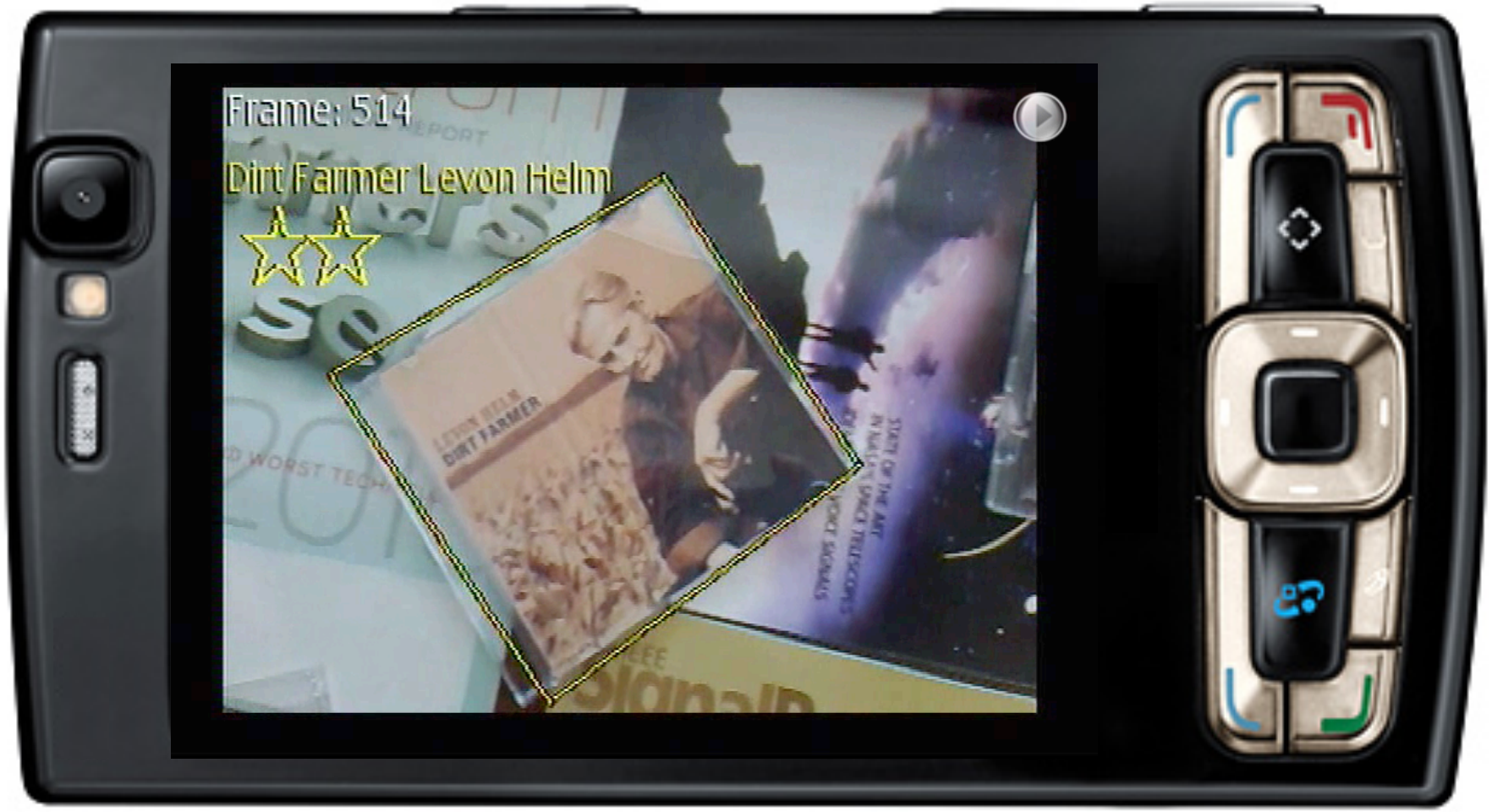








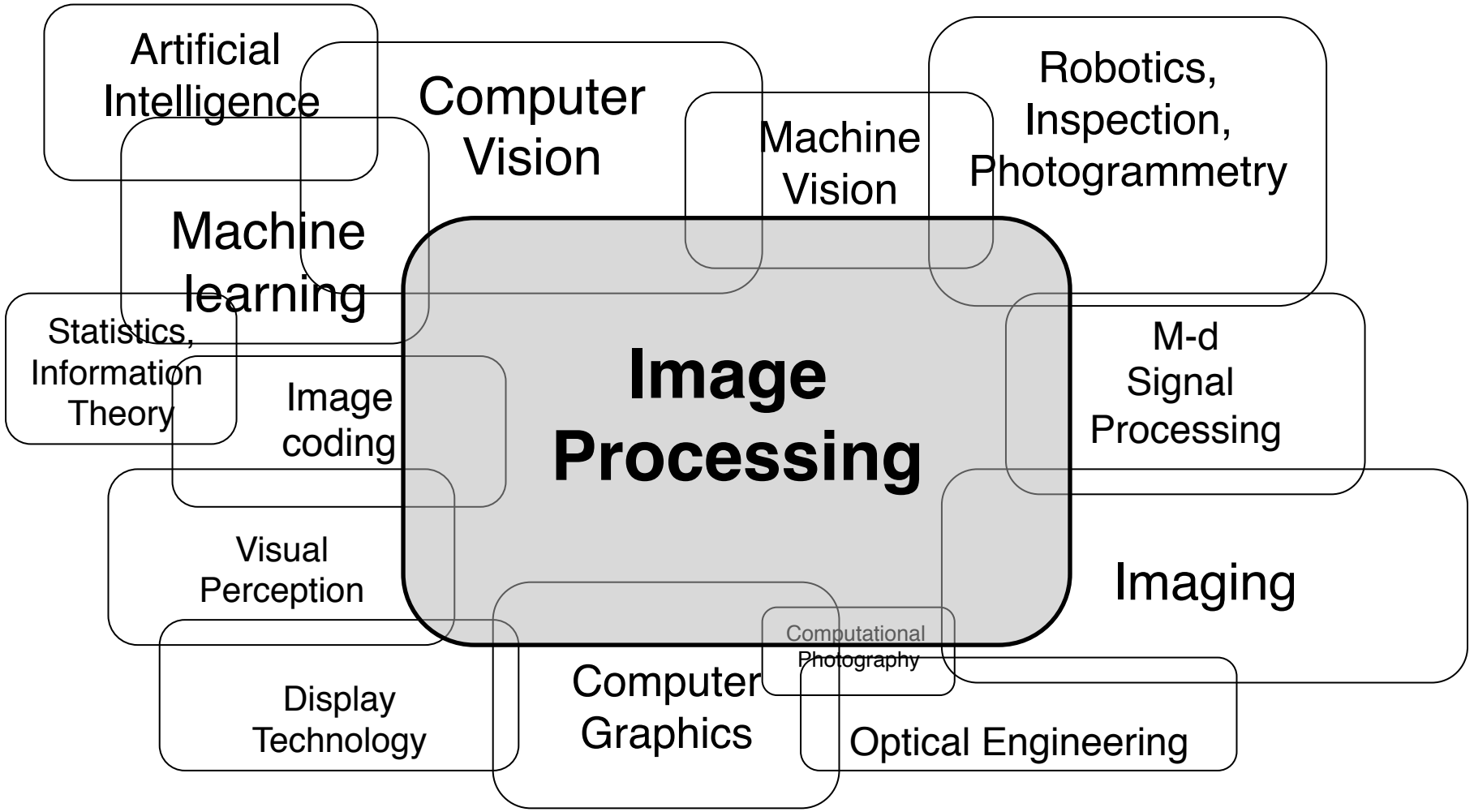
CD Cover Recognition on Cameraphone



EE368/CS232 Topics

- Point operations/combining images/histograms
- Color science
- Image thresholding/segmentation
- Morphological image processing
- Image filtering, deconvolution, template matching
- Eigenimages, Fisherimages
- Edge detection, keypoint detection
- Scale-space image processing
- Image matching, image registration

Image Processing and Related Fields



EE368/CS232 Organisation

- Lectures
  - MWF 9:30 am – 10:45 am in Packard 101 for 7 weeks
  - Mandatory attendance: participation grade is reduced, if 4-6 lectures are missed; drop or fail class, if more than 6 are missed.
  - Lecture videos on OpenEdX: view after class, or before, or not at all.
- Problem session: Th 4-5 pm in Packard 277 for 7 weeks
- Office hours
  - Bernd Girod: Mo 11 am - 12pm (after class), Packard 373
  - David Chen: Mo 4-6 pm, Packard 353
  - Matt Yu: Tu 3-5pm, Packard 353
- Class Piazza page:

  https://piazza.com/class#winter2014/ee368

EE368/CS232 Organisation

- Weekly homework assignments
  - Handed out Mondays, correspond to the lectures of that particular week
  - Require computer + Matlab
  - Discussions among students encouraged, however, individual solution must be submitted.
  - Due 9 days later (Wednesday 9:30 am).
  - Online quiz questions count against participation grade.
- First release on January 6 (first day of class)
- Late Midterm
  - 24-hour take-home exam
  - 3 slots, **March 3-6**

EE368/CS232 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: **February 10, 11:59 p.m.**
- Project presentation: Poster session, **March 12, 4-6 p.m.**
- Submission of written report and source code:
  March 17, 11:59 p.m.

EE368/CS232 Grading

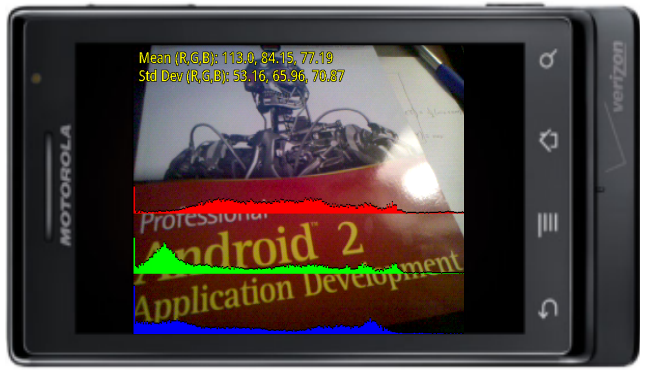
- Participation: 10%
- Homeworks: 20%
- Midterm: 30%
- Final project: 40%
- No final exam.

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 (optional)

- 40 Motorola DROID cameraphones available for class projects (must be returned after, sorry)
- Lectures on Android image processing in January
- Android development environment on your own computer or in SCIEN lab
- Programming in Java (C++ for OpenCV)



Reading

- Slides available as pdf files on the class website (click on  for source code and data)
  http://www.stanford.edu/class/ee368/handouts.html
- Popular text books
  - William K. Pratt, „Introduction to Digital Image Processing," CRC Press, 2013, $100.
  - 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)