

Digital Image Processing

EE368/CS232

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Imaging



[Albrecht Dürer, 1525]

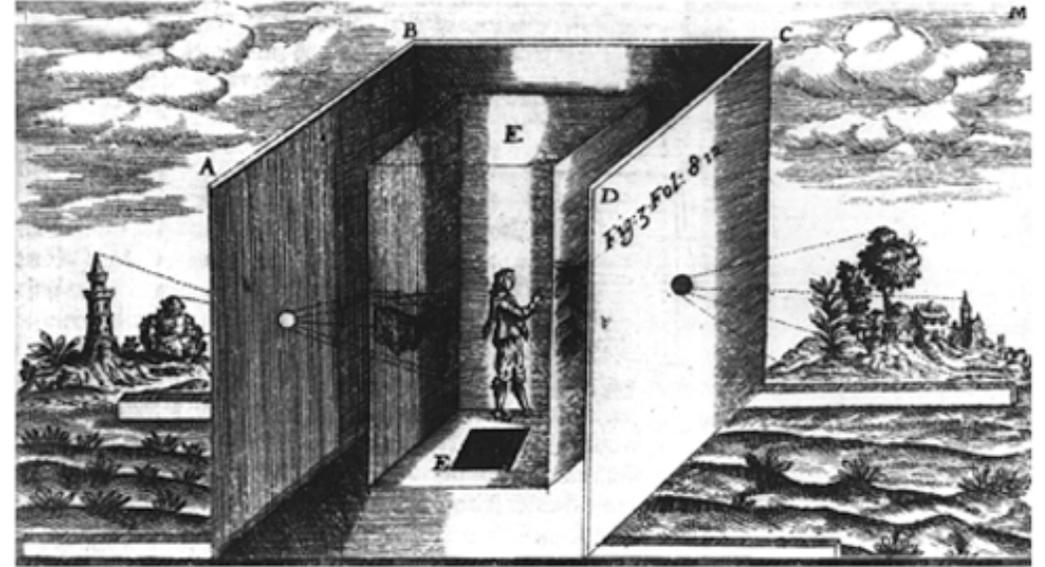
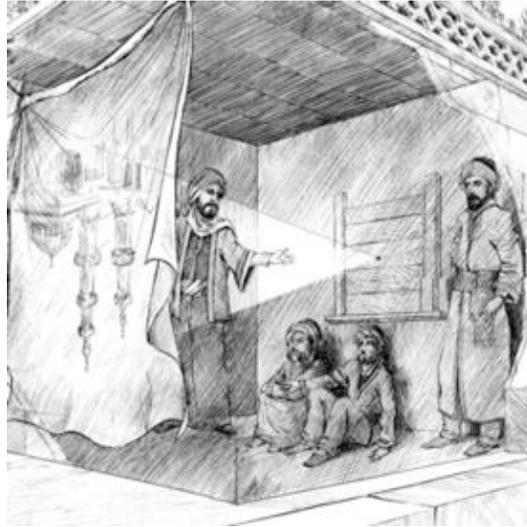
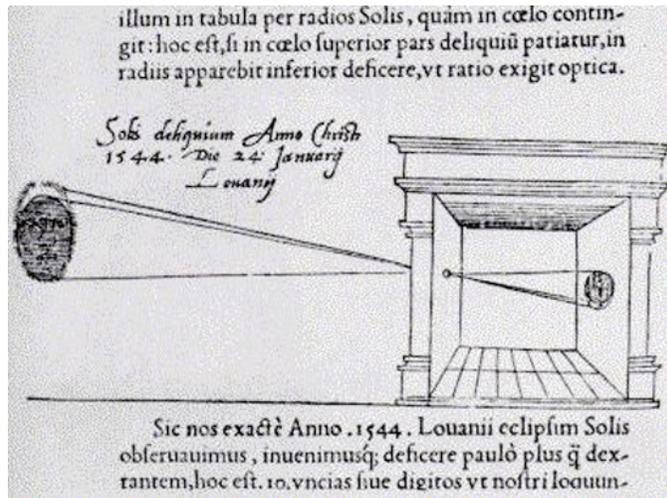
Imaging



[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

Imaging



Dark chamber with lenses [Kircher 1646]

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- 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

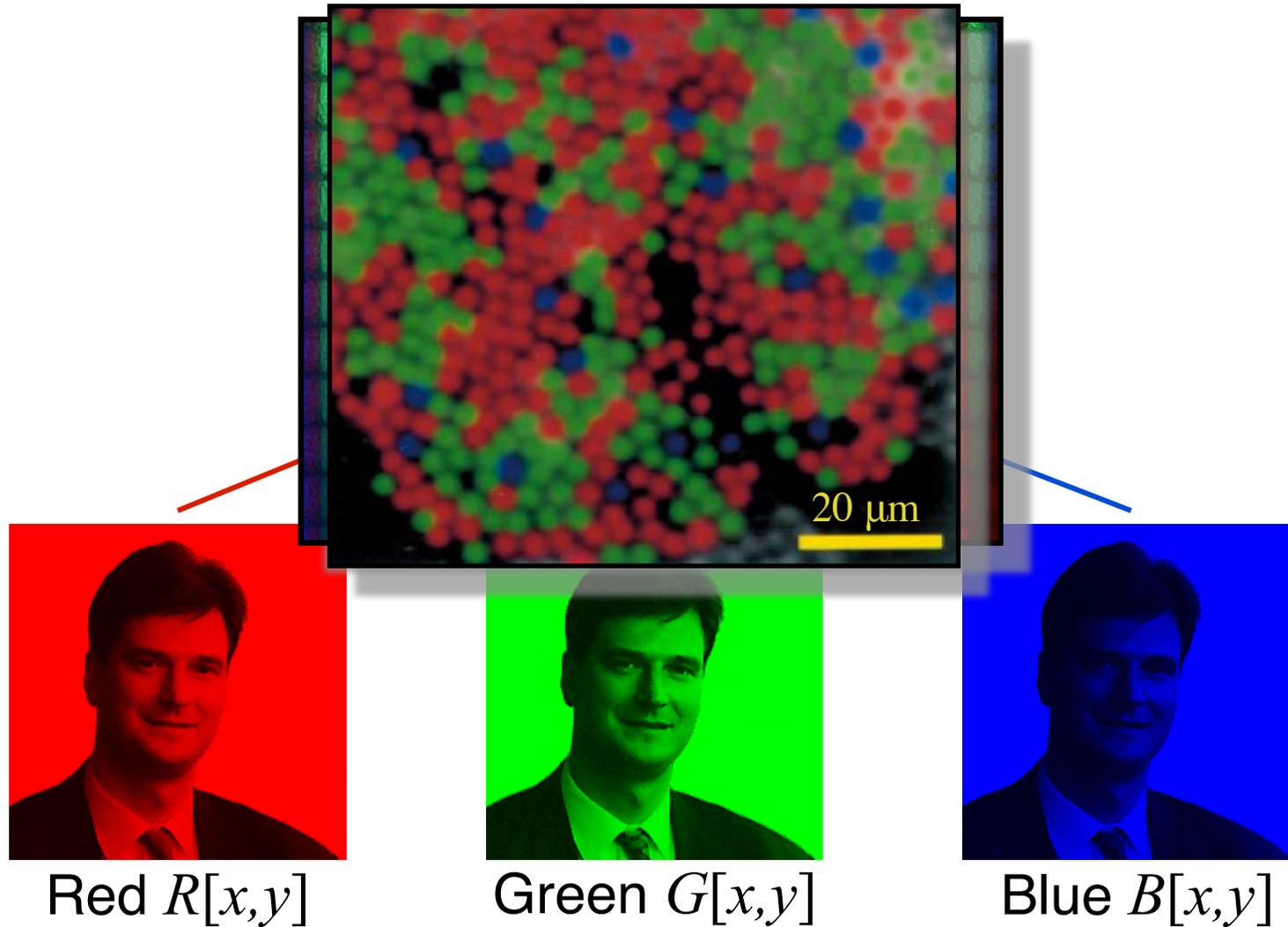


50x50



25x25

Color Components



Monochrome image



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

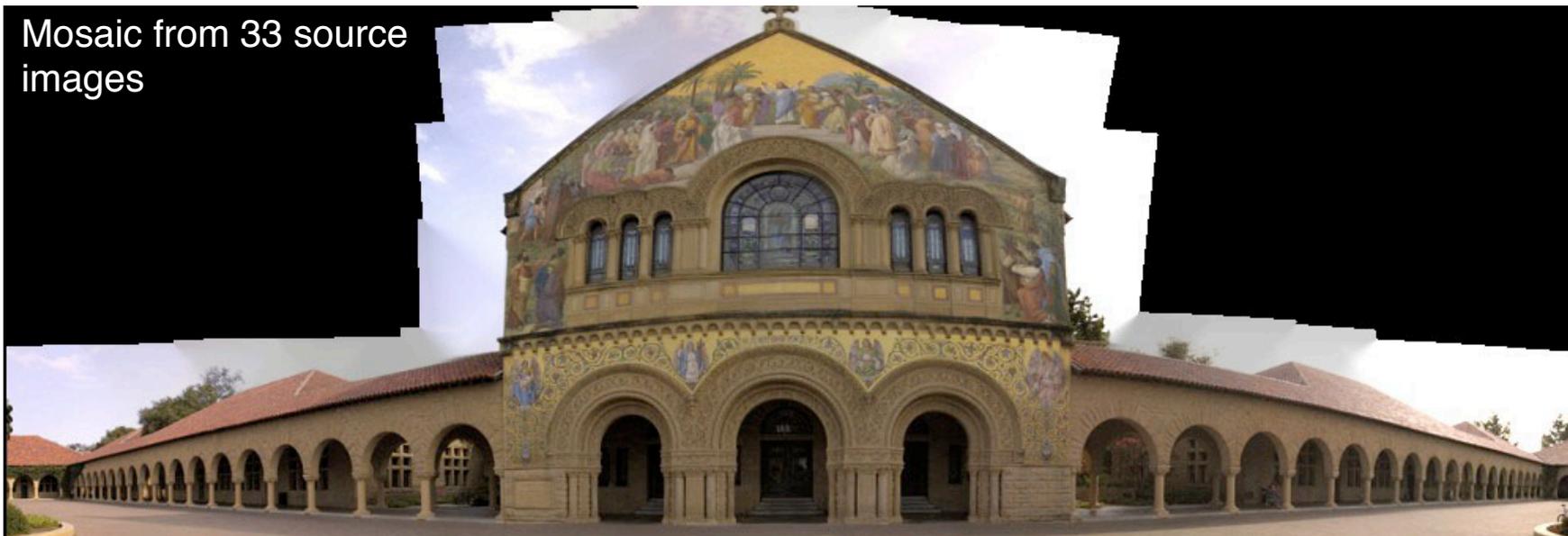
Why do we process images?

- 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

Mosaic from 33 source images



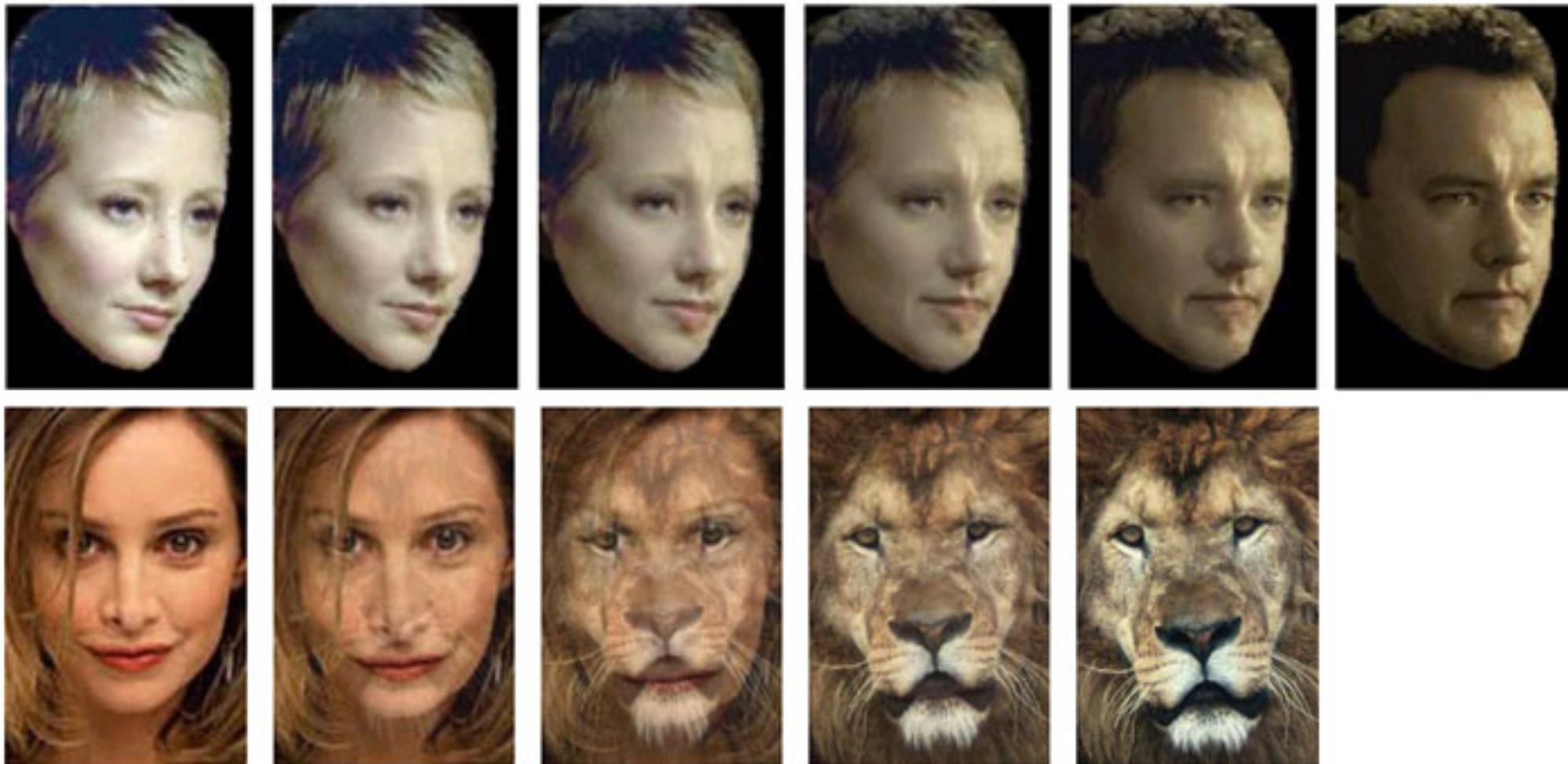
Mosaic from 21 source images



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

Image Processing Examples

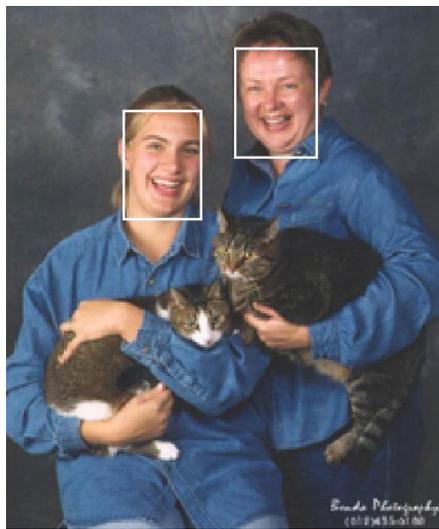
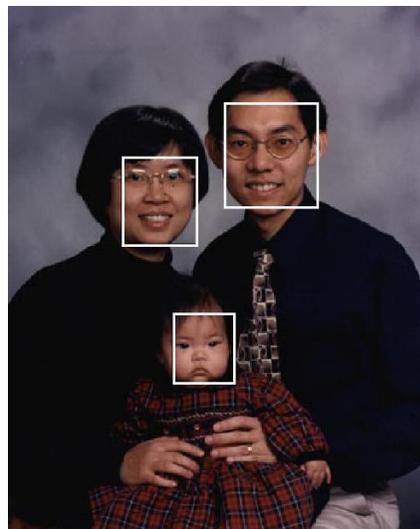
Face morphing



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

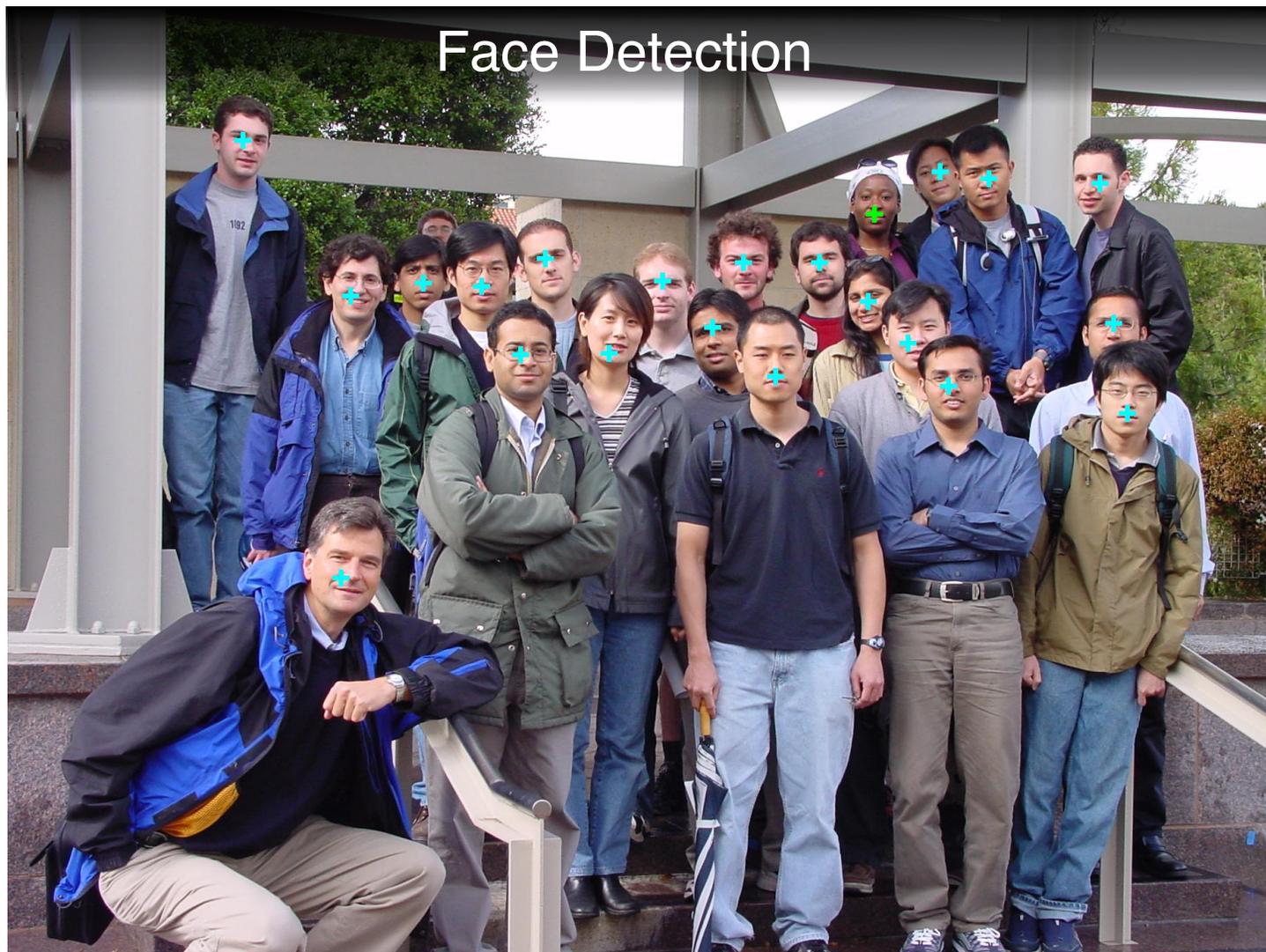
Image Processing Examples

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

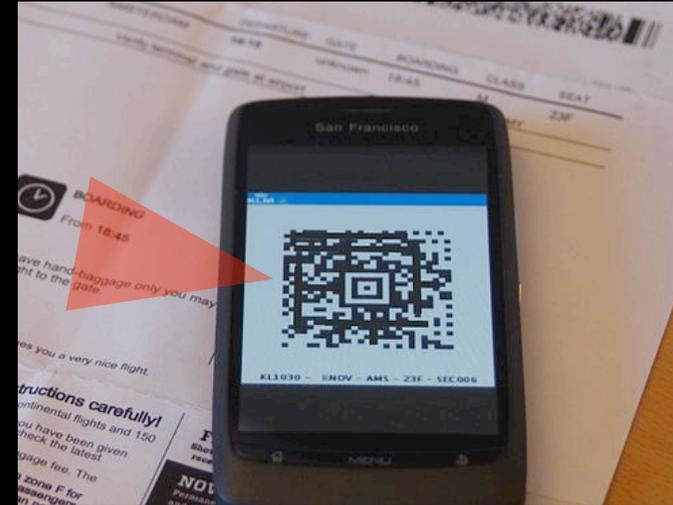
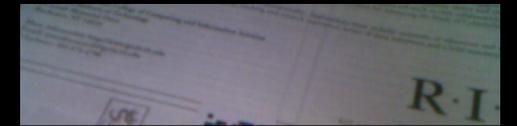
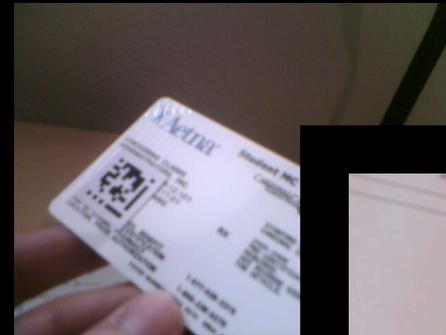
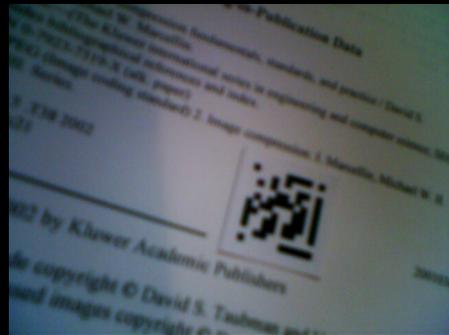


Image Processing Examples



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

EE368 Spring 2006 Project: Visual Code Marker Recognition



EE368 Spring 2007 Project: Painting Recognition



1



2



3



4



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6



7



8



9

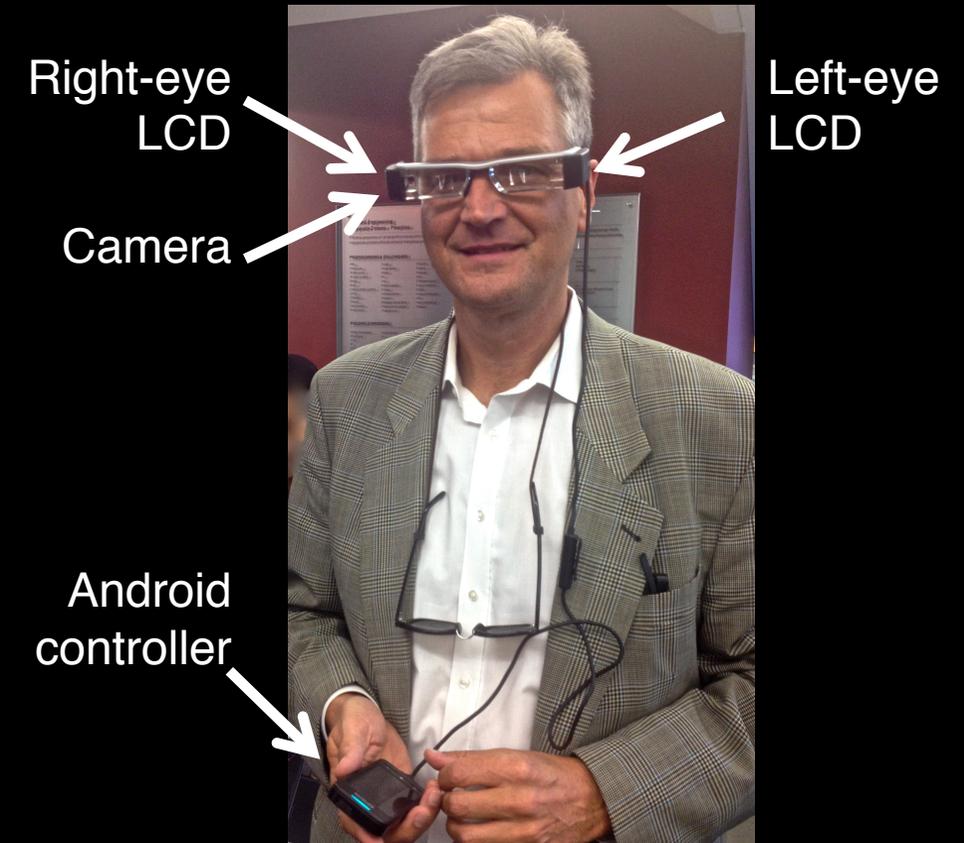


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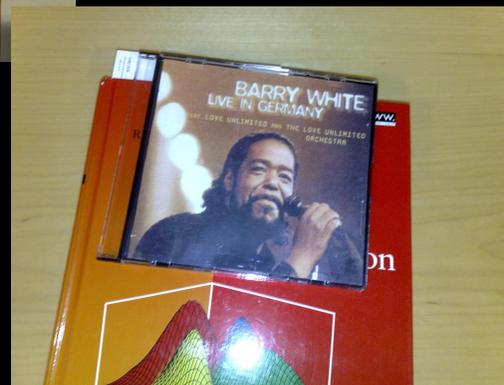
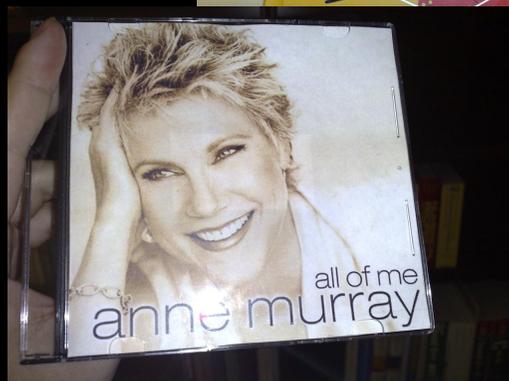
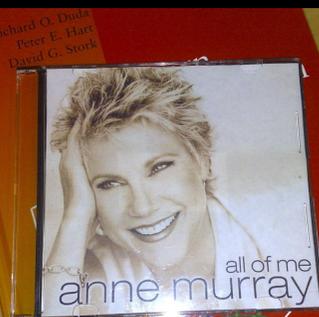
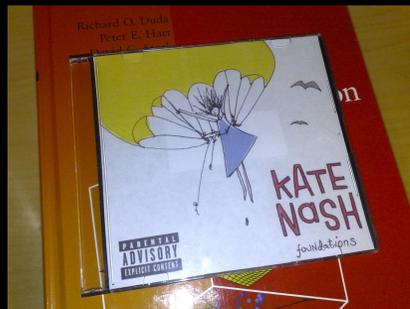
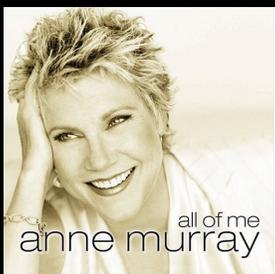
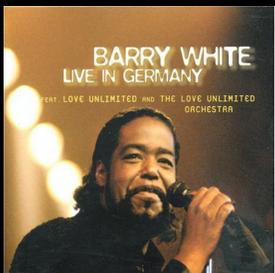
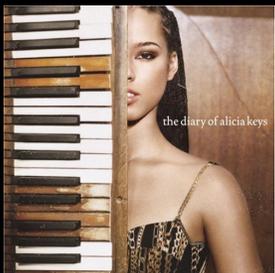
EE368 Spring 2007 Project: Painting Recognition



Painting Recognition for Augmented Reality



EE368 Spring 2008 Project: CD Cover Recognition



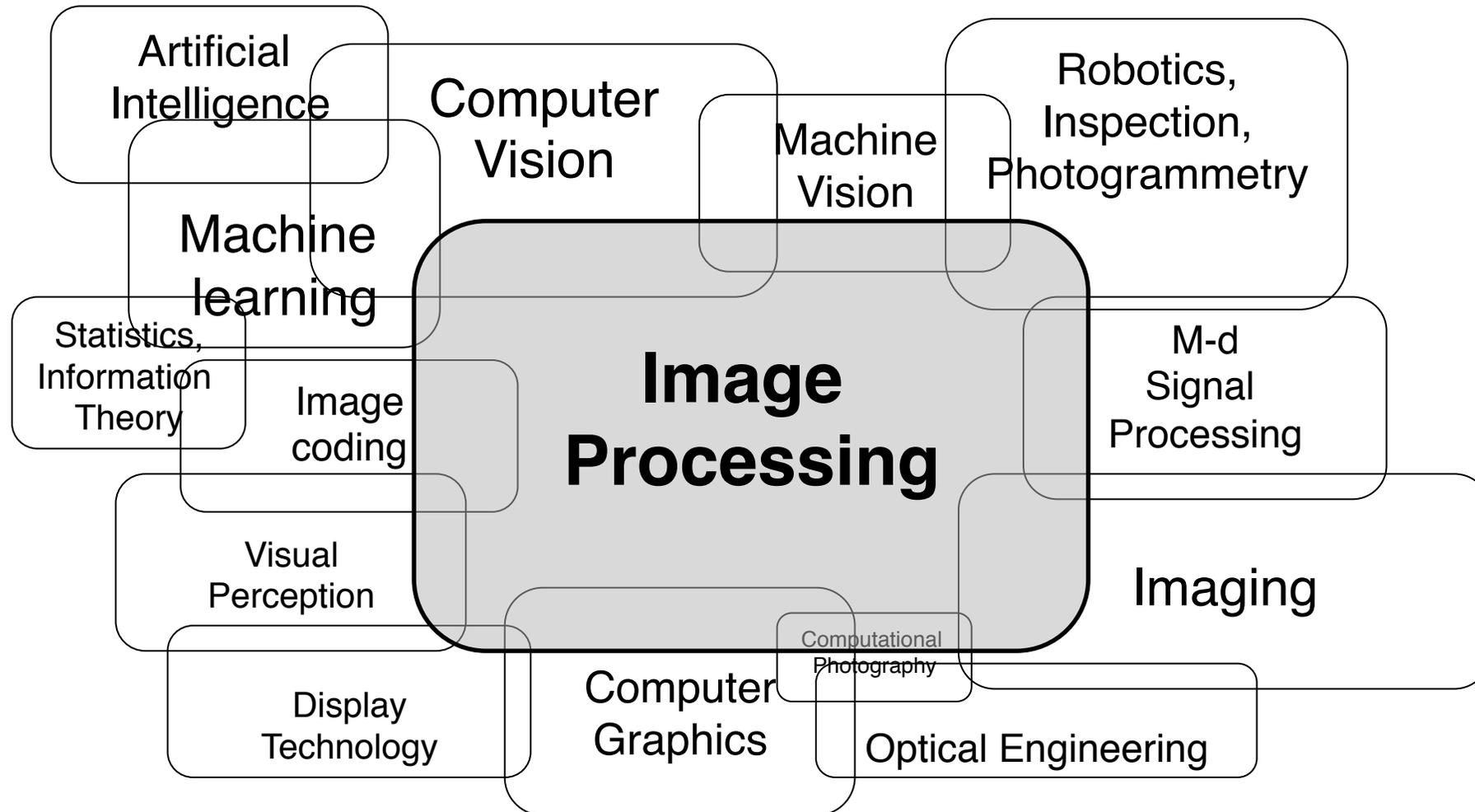
CD Cover Recognition on Cameraphone



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 Gates B03 for 7 weeks
- Attendance highly recommended.
- Lecture videos on OpenEdX: view after class, or before, or not at all.

■ Problem session: Fr 4:15-5:05 pm in Gates B01 for 7 weeks

■ Office hours

- Bernd Girod: Fr 11am - 12pm (after class), Packard 373
- Gordon Wetzstein: We 11am – 12pm (after class) , Packard 236
- Huizhong Chen: Mo 4-6 pm, Packard 339
- Jean-Baptiste Boin, Nicolas Jimenez (Android): TBA

■ Class Piazza page:

<https://piazza.com/stanford/spring2015/ee368>

EE368/CS232 Weekly Assignments

- Weekly problem assignments
 - Handed out Mondays, correspond to the lectures of that particular week
 - About 8-12 hours of work, requires computer + Matlab
 - Discussions among students encouraged, however, individual solution must be submitted.
 - Due 9 days later (Wednesday 9:30 am).
- Homework submission:
 - Electronic online submission via Scoryst.
 - Enrollment link: <https://scoryst.com/enroll/rq183Ub0qT/>
- Weekly lecture review and online quizzes
 - Multiple choice questions covering the lectures on OpenEdX (<https://suclass.stanford.edu>)
 - Review the corresponding module, if you are uncertain about your answer
 - Graded, solve individually, due at the same time as corresponding problem assignments
- First assignment handed out on March 30 (first day of class)

EE368/CS232 Midterm

- 24-hour take-home exam
- Problems similar to weekly assignments
- Typically requires 5-6 hours of work
- 3 slots one week after the last lecture, **May 20-23**

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: **April 29, 11:59 p.m.**
- Project presentation: Poster session, **June 3, 4-6:30 p.m.**
- Remote SCPD students can alternatively submit a narrated video presentation
- Submission of written report and source code:
June 5, 11:59 p.m.

EE368/CS232 Grading

- Online quizzes: 10%
- Homework problems: 20%
- Midterm: 30%
- Final project: 40%
- No final exam.

In-class Discussions and iClickers

- Brief in-class quizzes integrated into the lectures
- iClickers allow you to share your answers instantaneously and anonymously.
- It's o.k. to make mistakes; you will not be graded.
- Take an iClicker before each class and return afterwards.

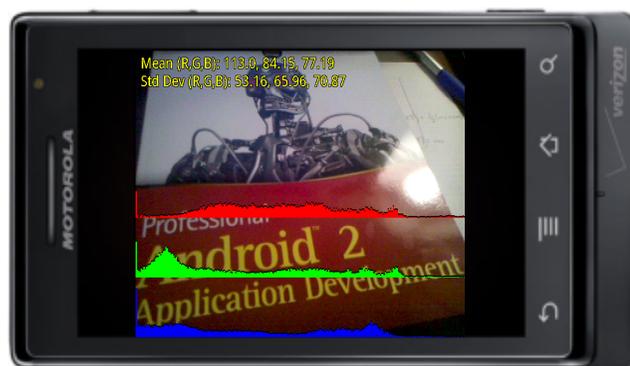


SCIEN Laboratory

- 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 online
- 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.
 - R. C. Gonzalez, R. E. Woods, „Digital Image Processing,“ **3rd edition**, Prentice-Hall, 2008.
 - A. K. Jain, „Fundamentals of Digital Image Processing,“ Prentice-Hall, Addison-Wesley, 1989.
- Software-centric books
 - R. C. Gonzalez, R. E. Woods, S. L. Eddins, „Digital Image Processing using Matlab,“ **2nd edition**, Pearson-Prentice-Hall, 2009.
 - G. Bradski, A. Kaehler, „Learning OpenCV,“ O‘Reilly Media, 2008.
- Comprehensive state-of-the-art
 - AI Bovik (ed.), „The Essential Guide to Image Processing,“ Academic Press, 2009.
- 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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