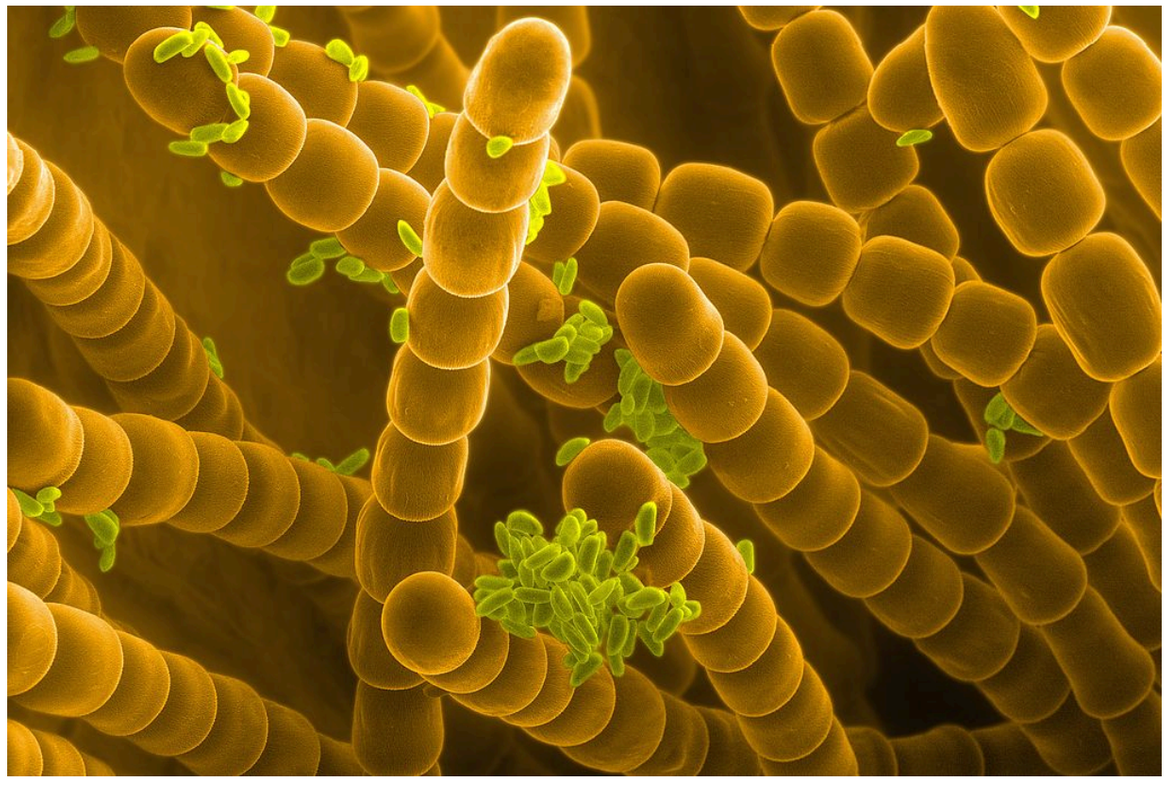
COL 783
Digital Image Analysis

Instructor: Rahul Narain

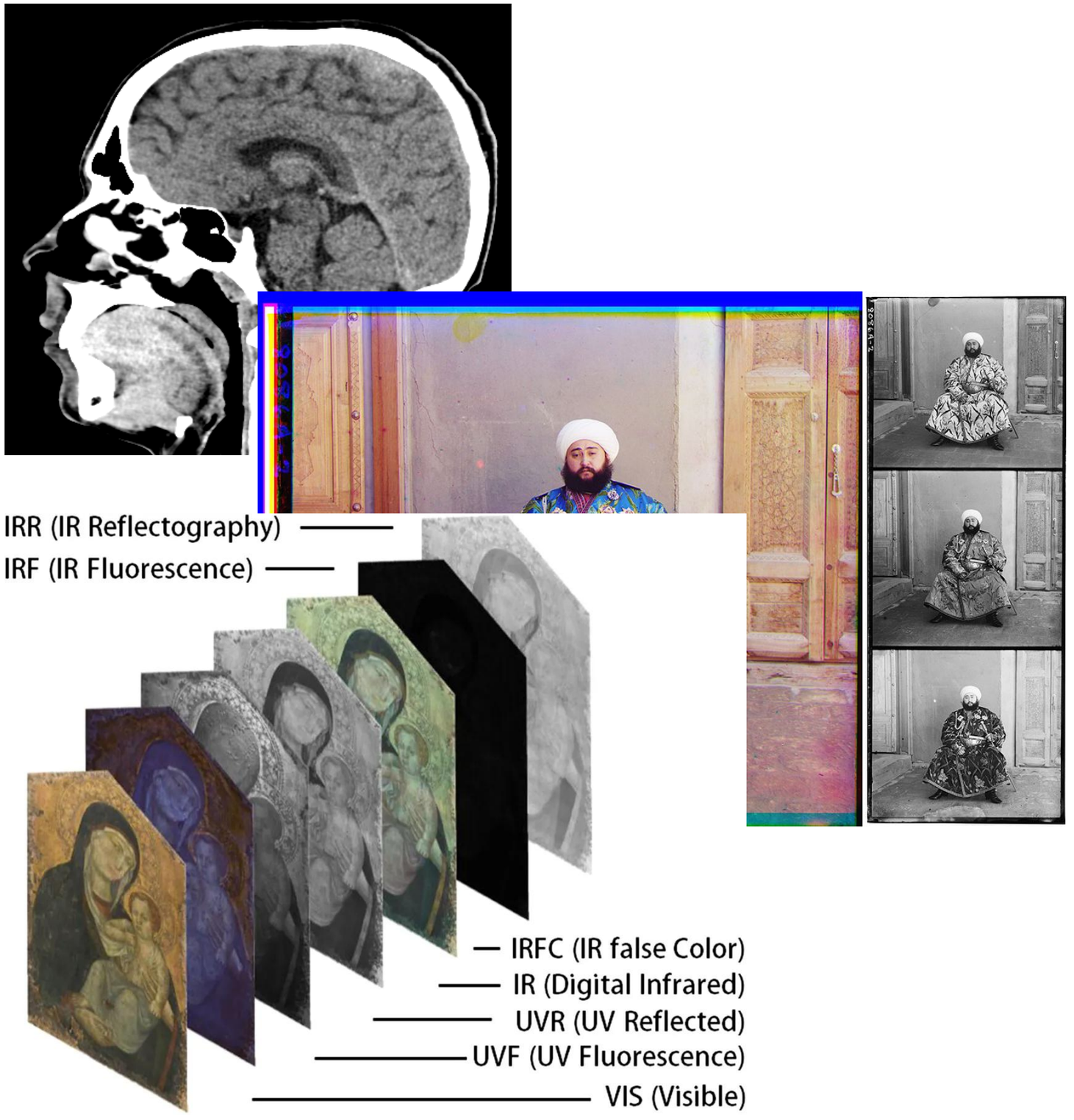
1st Semester, 2019-20


KOREA



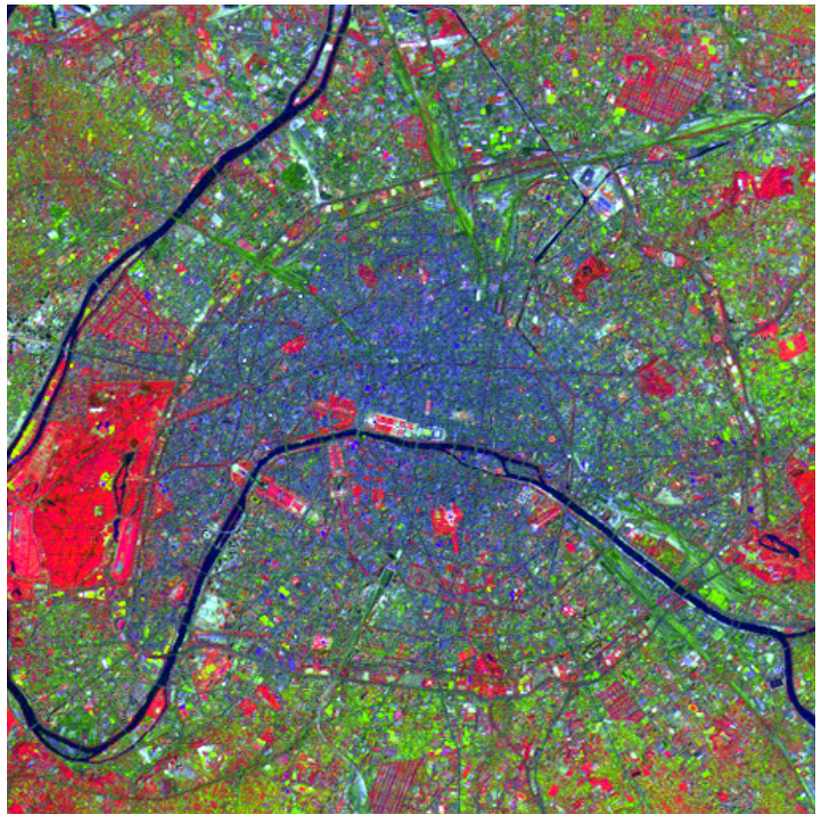
Types of image data

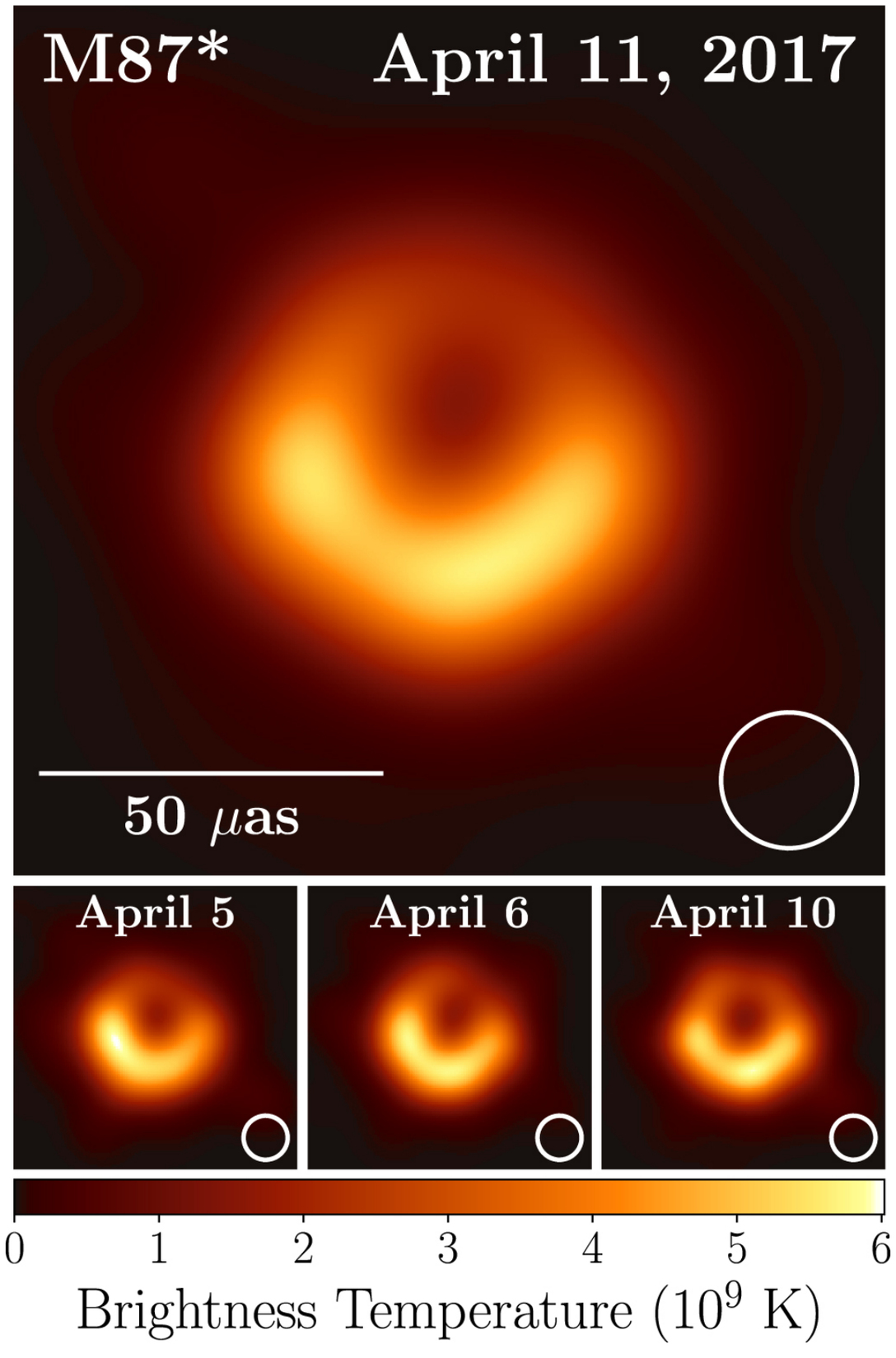
- Intensity
- Colour (RGB)
- Multispectral



Applications

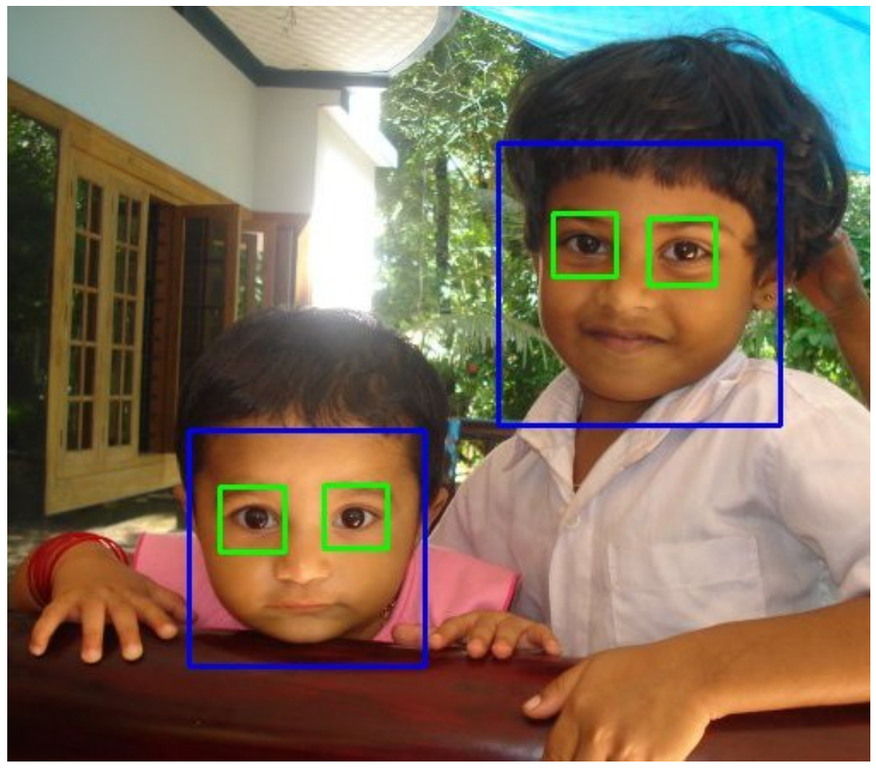
- Medical imaging
- Remote sensing
- Astronomy
- Computer vision
- Computational photography




M87*
April 11, 2017
50 μas
April 5
April 6
April 10
0
1
2
3
4
5
6
Brightness Temperature (10^9 K)

Applications

- Medical imaging
- Remote sensing
- Astronomy
- **Computer vision**
- Computational photography



Applications

- Medical imaging
- Remote sensing
- Astronomy
- Computer vision
- **Computational photography**

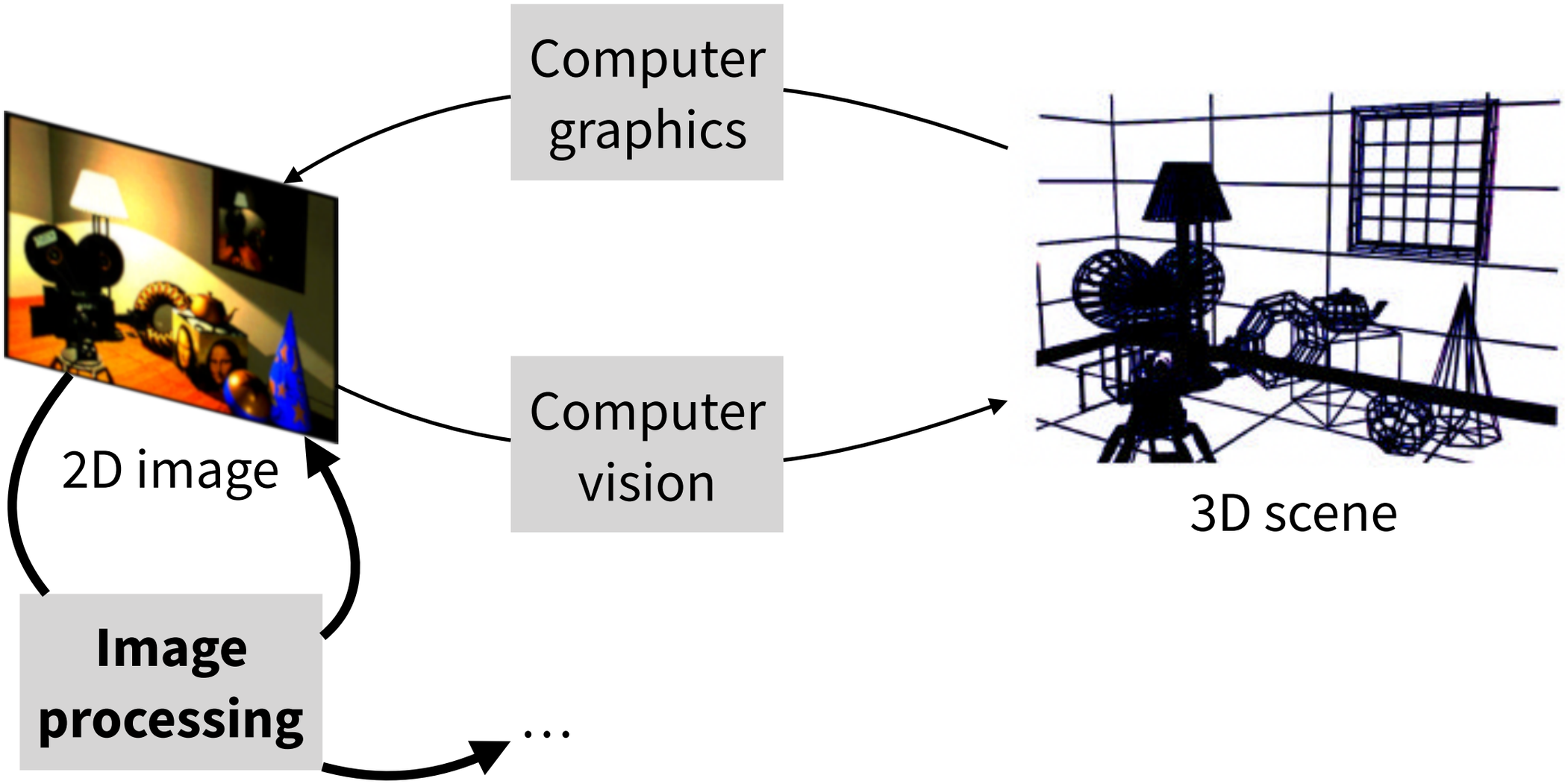
Key topics

- **Enhancement and restoration:**
  Improve the appearance of an image
  Make subtle features more visible
  Correct intensity and colour balance
  Reconstruct image from measurements

- **Compression:**
  Store and transmit images in fewer bytes

- **Segmentation, analysis, classification:**
  Read information (bar codes, QR codes, text)
  Detect and recognize objects
  Track motion, estimate 3D depth

Related fields



Related fields

- Computer graphics
- Computer vision
- Signal processing
- Imaging and display technology
- Visual perception

About this course

People

- **Instructor:**
  Rahul Narain (narain@iitd.ac.in)
  Office hours: Bharti IIA-517, by appointment

- **TAs:**
  Indu Joshi (csz168121@iitd.ac.in)
  Vijay Kumar (anz188061@iitd.ac.in)
  Office hours: TBA

Logistics

- **Course webpage:** http://www.cse.iitd.ac.in/~narain/courses/col783i1920/
- **Moodle** for assignment submissions, **Piazza** for course announcements. Links on course webpage, Piazza access code “col783”. Make sure to sign up!
- **Textbook:** Gonzalez and Woods, *Digital Image Processing*, 3rd ed.
- **Prerequisites:** COL 106: *Data Structures & Algorithms*, ELL 205: *Signals & Systems*, or equivalent(s)

Assignments

5 programming assignments over the semester

- 2 weeks per assignment, ~1 week gap between them
- All assignments should be done *individually*
- **Programming language:** Your choice. I recommend Python, Matlab, or C++
- **Late policy:** 5 free late days across all assignments. Use them as you like. Any delay after 5 late days are used = 0 marks.

Evaluation

Grade breakdown:

- Programming assignments: 50% (5 × 10%)
- Minor 1: 15%
- Minor 2: 15%
- Major: 20%

Audit criterion: 50% in exams and overall grade of C

Collaboration policy

Collaboration = good. Cheating = very bad! What's the difference?

- No sharing of (parts of) code
- No written notes (physical or electronic)
- *Kyunki Saas Bhi Kabhi Bahu Thi* rule
- Full disclosure of collaborators

Summary

- Course webpage, Moodle, Piazza
- 5 assignments (50% weightage)
- Collaborate, don’t cheat!

Questions?

Digital image fundamentals

What is an image?

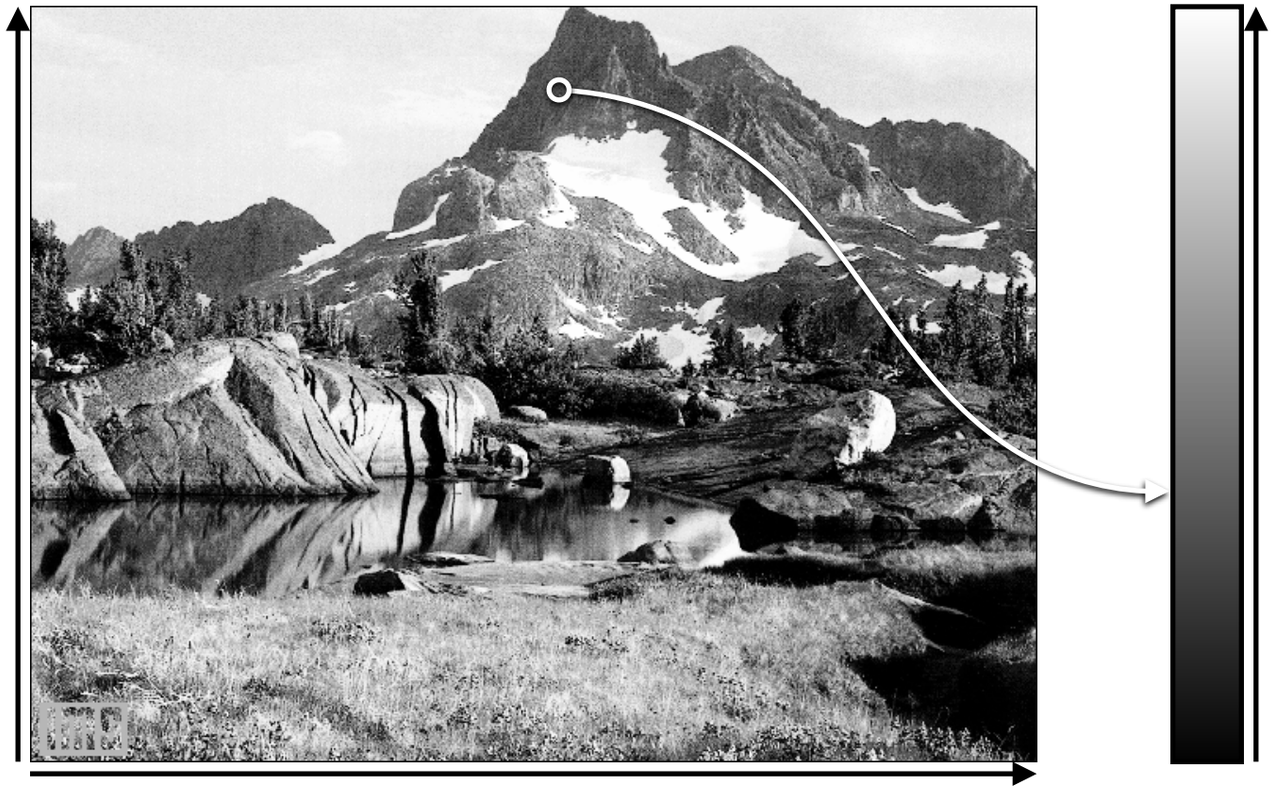
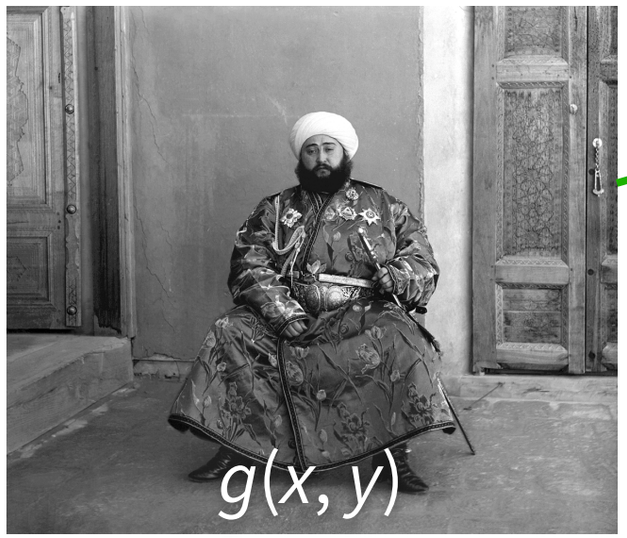


Image: a two-dimensional signal $f(x, y)$ representing visual information

- Domain of (x, y) is usually a rectangle
- $f(x, y)$ is the intensity (or colour) at point (x, y)

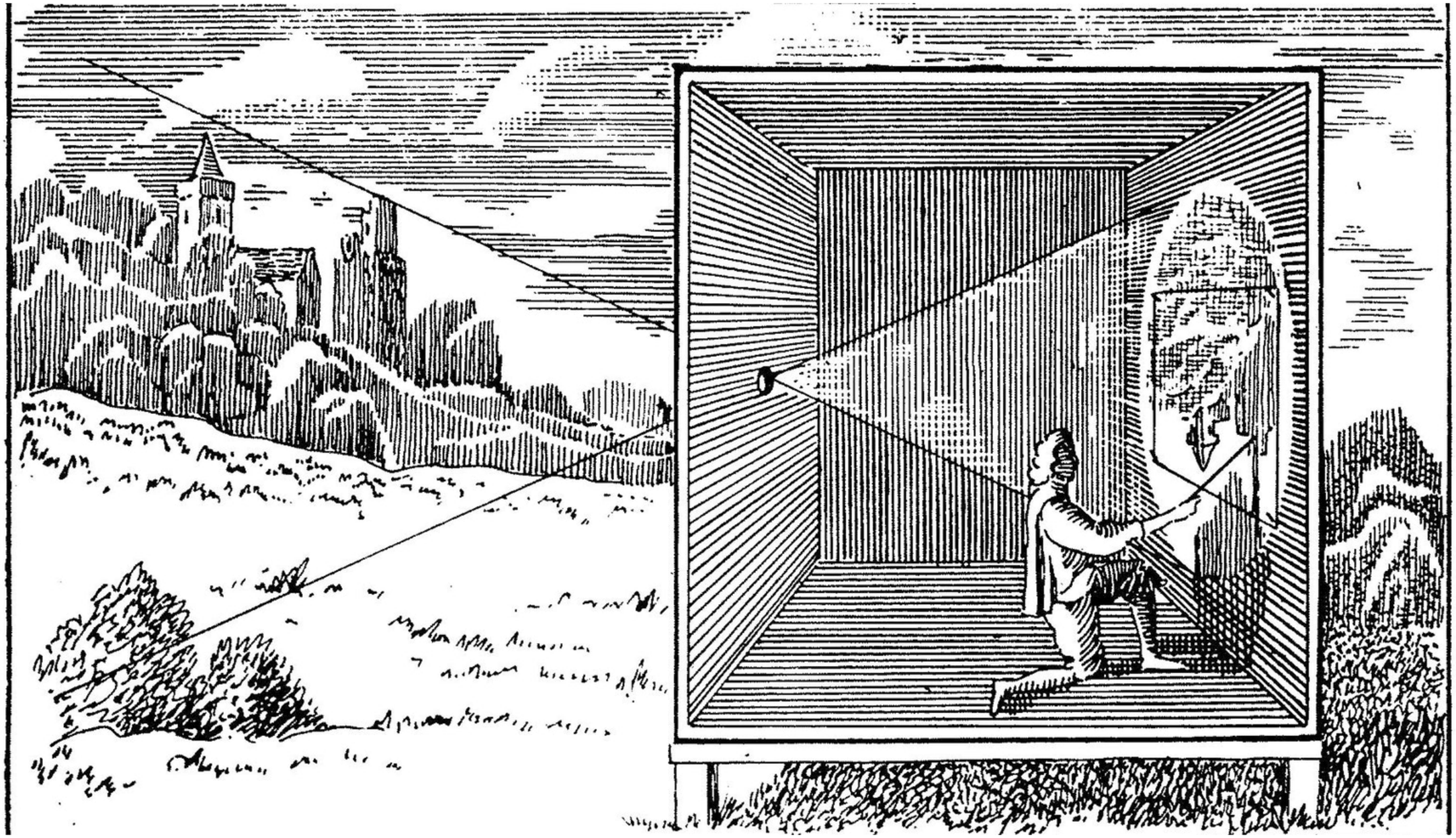


Colour channels

$f(x, y) = (r, g, b)$

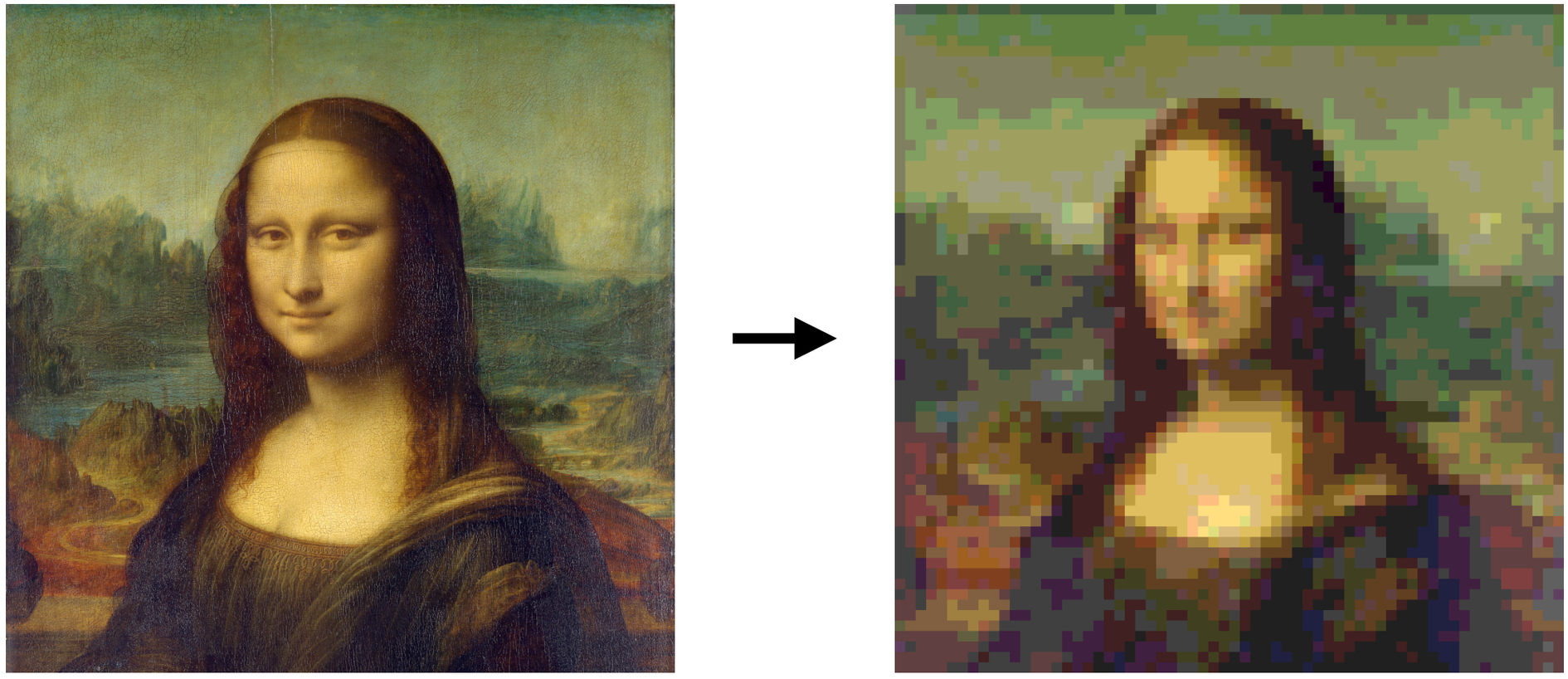
Monochrome image in RGB?

Image formation



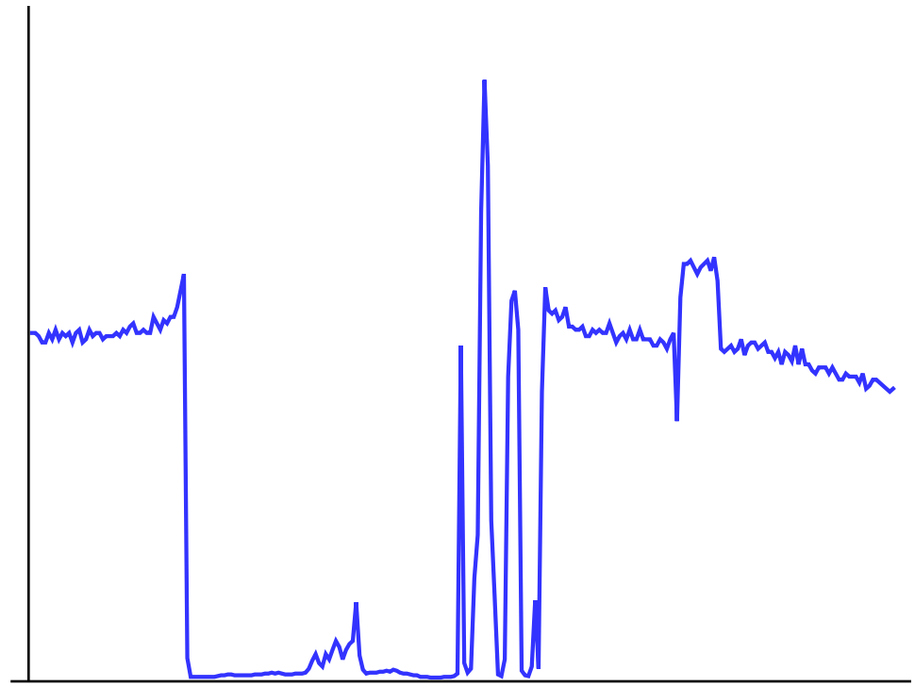
Camera obscura

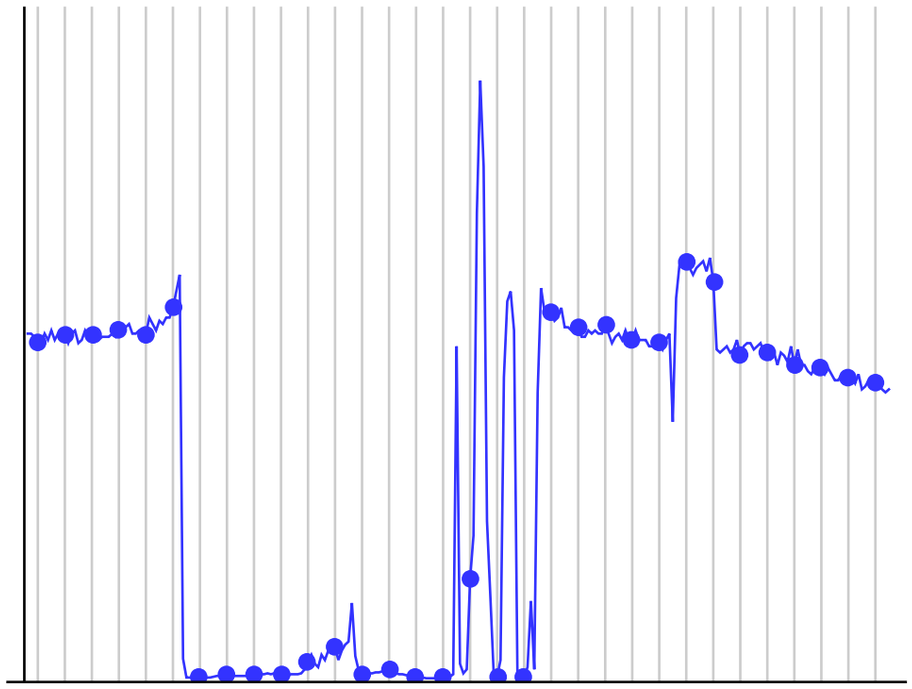
Digital images

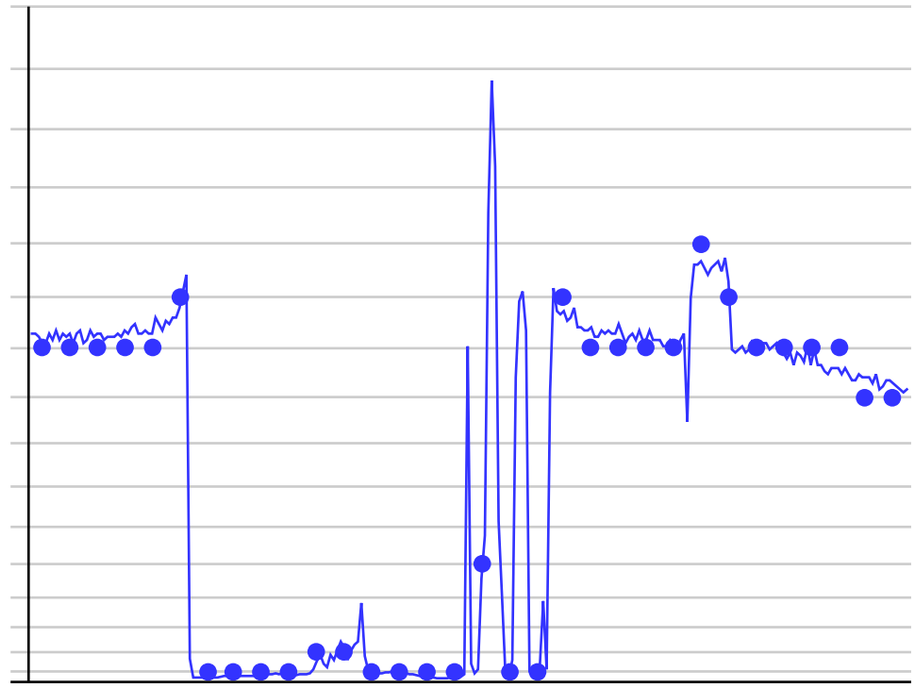


- Domain of *f* is **sampled** at discrete points
- Range of *f* is **quantized** into discrete values

f[*x*, *y*] becomes a 2D array containing finitely many elements: ***pic*ture *el*ements** or **pixels**







Sampling

256×256

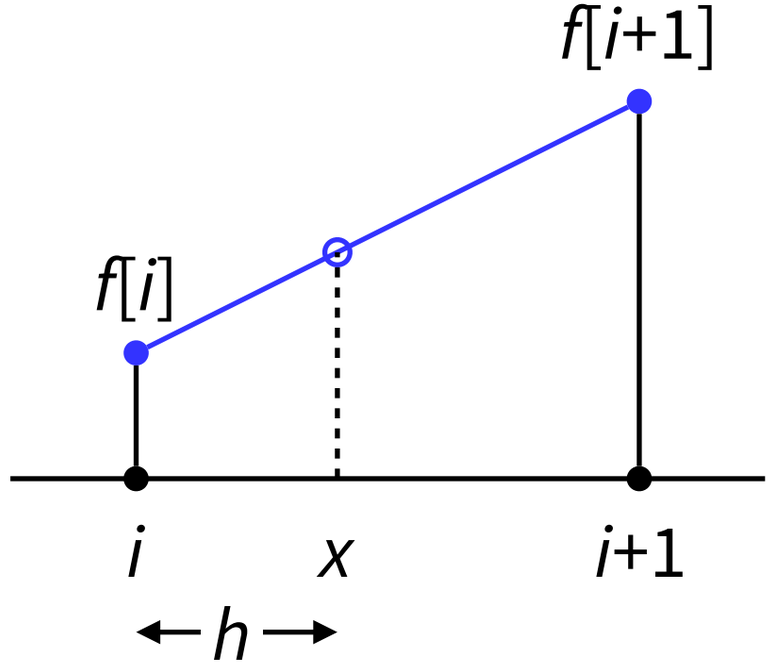
128×128

64×64

32×32

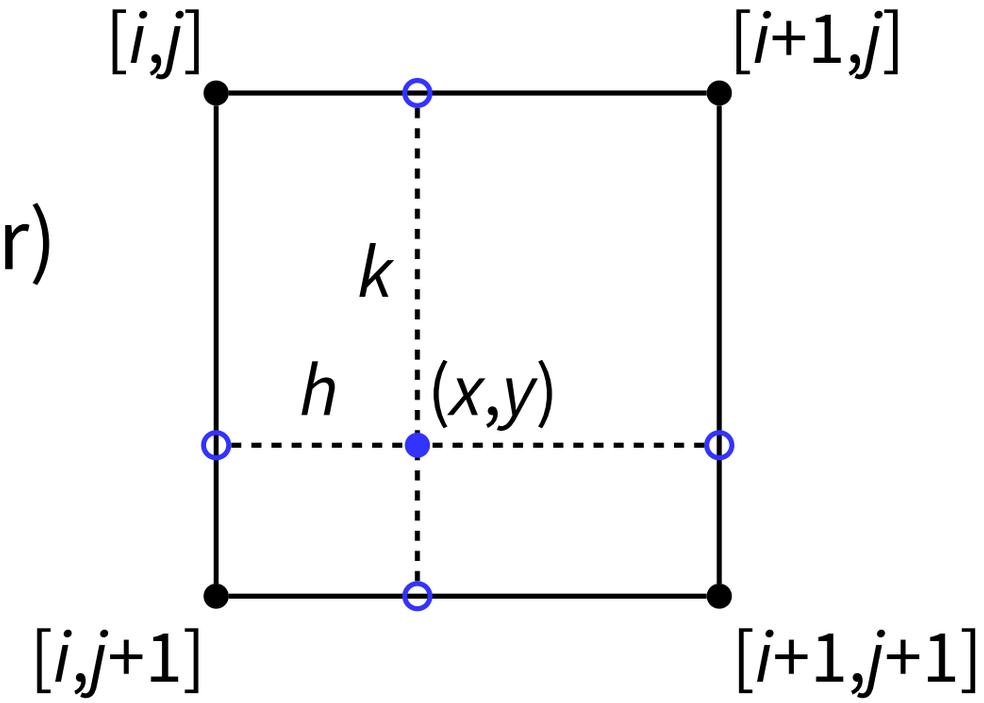
Interpolation

- **Linear interpolation:**
  $f(x) \approx (1 - h)\, f[i] + h\, f[i{+}1]$



- **Bilinear interpolation:**
  interpolate in *x* then in *y*
  (or vice versa, it doesn't matter)

See also *bicubic interpolation*



Quantization

256 levels

32 levels

16 levels

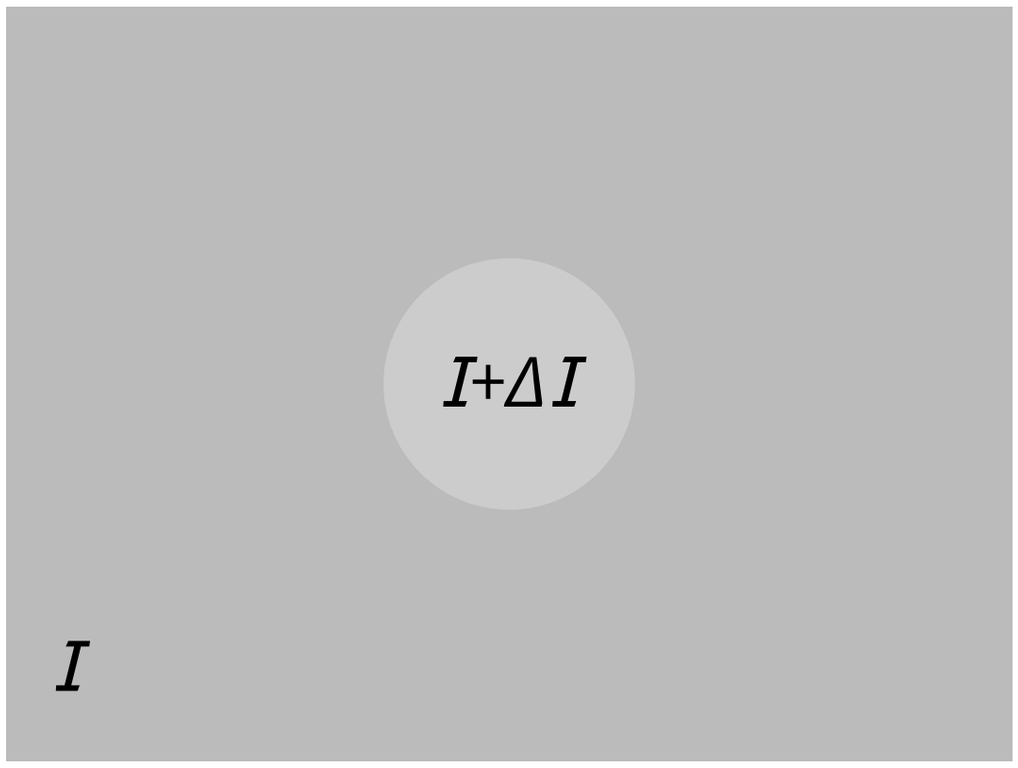
8 levels

How many levels to avoid visible banding?

How should they be distributed?

2 levels
(binary image)

Brightness discrimination



Weber fraction: $\Delta I / I \approx 1\ldots2\%$

Fechner's law: Perceived brightness is approximately proportional to the logarithm of physical intensity

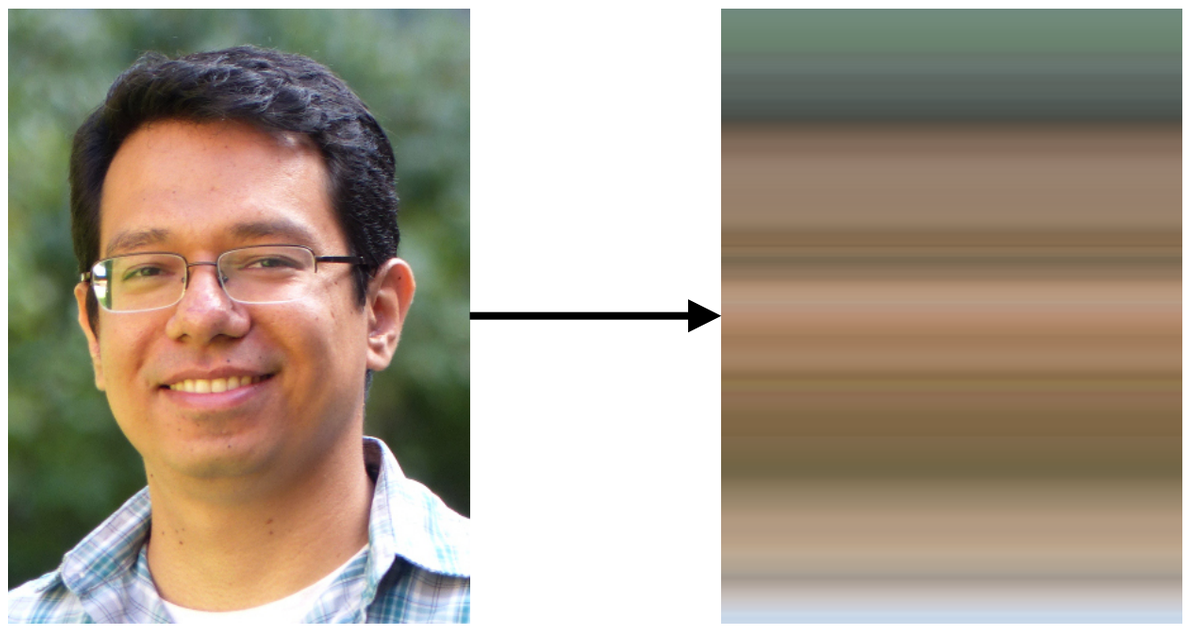
Quantization levels are not uniformly distributed in intensity!

After class

- Check the course webpage if you haven't already (linked from my homepage)
- Add the course on Piazza
- Obtain the textbook, *Digital Image Processing* (*DIP*)
- Read Chapter 2 of *DIP*
- Get prepared for working with images by doing Assignment 0

Assignment 0 (ungraded)

1. Read an RGB image
2. Modify its pixels by averaging each row
3. Write the image



Use any library/function that gives you direct access to the pixel array (e.g. Python: `matplotlib.image`, Matlab: built-in `imread`/`imwrite`, C++: CImg or OpenCV)

No marks, but must submit (partially) working code!
Penalty for next assignment if no submission

Next few classes

I will be away at a conference during 25 July—4 Aug

Prof. Kalra will cover next three classes

Topics:

- **Spatial domain filtering** (*DIP* Ch. 3)
- **Frequency domain filtering** (*DIP* Ch. 4)