



# >>> IMAGE PROCESSING AND COMPUTATIONAL PHOTOGRAPHY

## SESSION 1: DIGITAL IMAGE FUNDAMENTALS

Oriol Pujol

# PRELIMINARIES

What do you expect from this course?

# PRELIMINARIES

Name techniques you already know that are meaningful for this course.

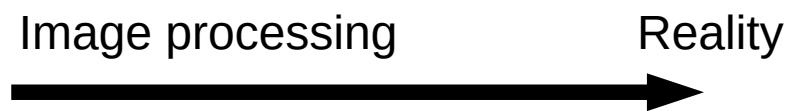
# PRELIMINARIES

Any wish list?

# Outline

- The quest for capturing reality
- Understanding computational photography
- But... I know about Computer Vision
- Images, images, ... images
- Sillabus

# The quest for capturing reality



# The quest for capturing reality: the beginning



# The quest for capturing reality: Middle Ages

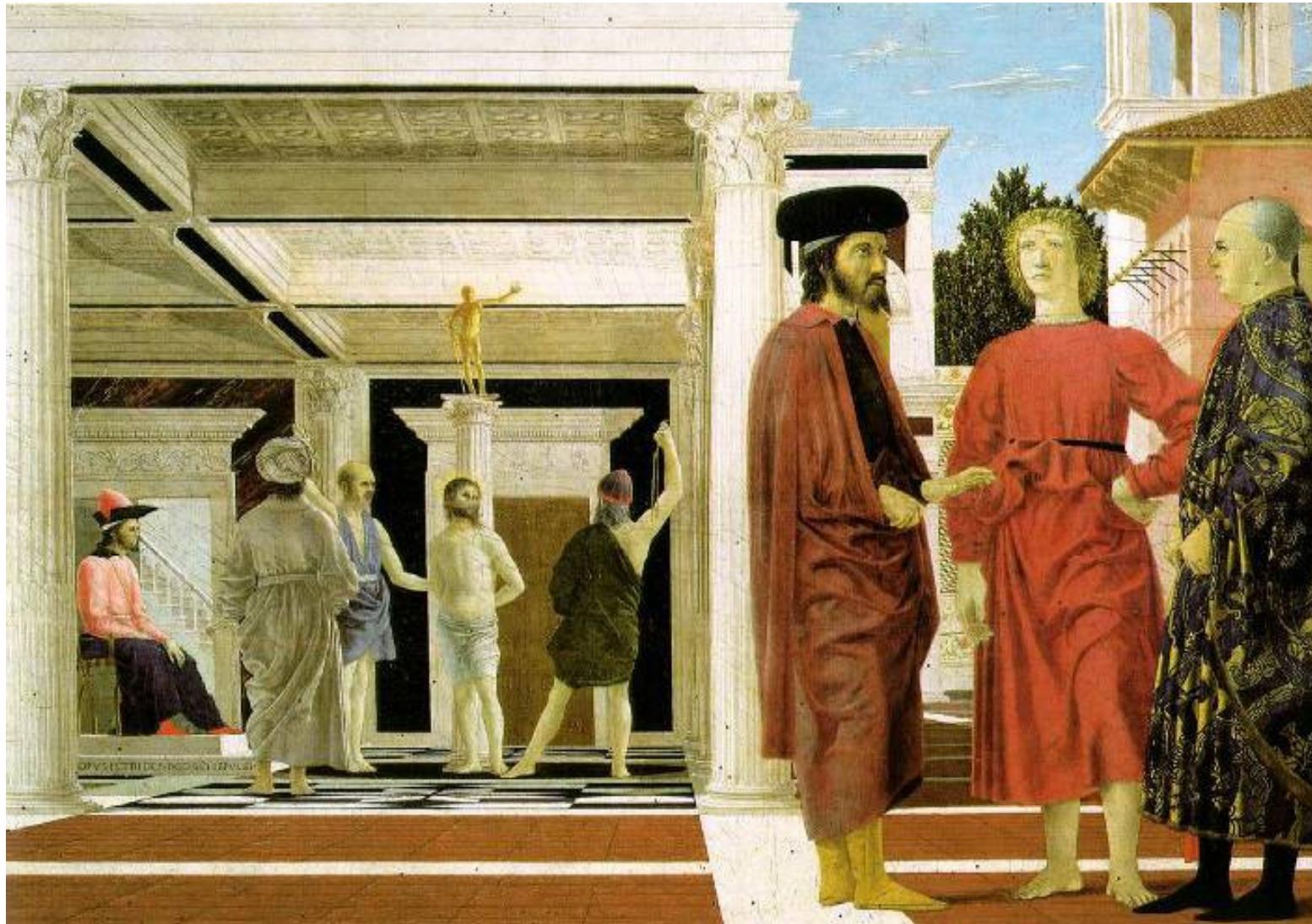


# The quest for capturing reality: Middle Ages



Nuns in Procession. French ms. ca. 1300.

# The quest for capturing reality: Renaissance



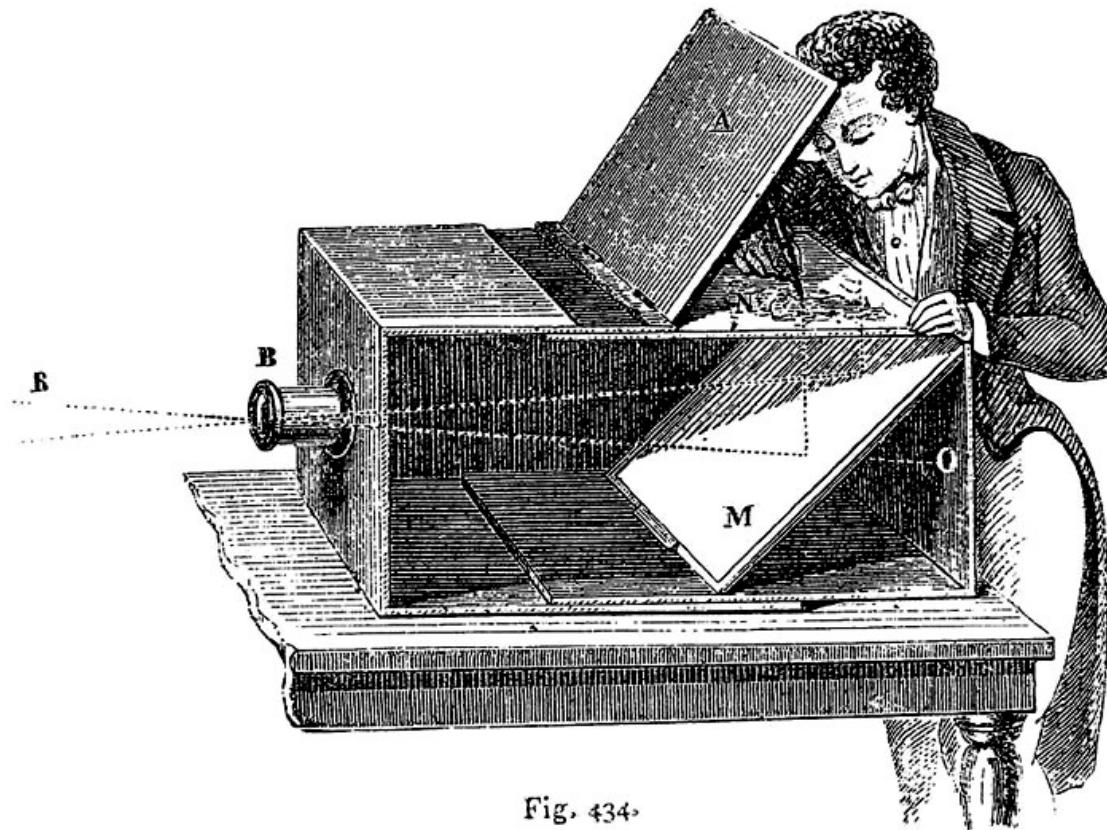
Piero della Francesca,  
*The Flagellation* (c.1469)

# The quest for capturing reality: Towards perfection



Jan van Eyck, *The Arnolfini Marriage* (c.1434)

# The quest for capturing reality: Towards perfection



Lens Based Camera Obscura, 1568

# The quest for capturing reality: Perfection



*Still Life*, Louis Jaques Mande Daguerre, 1837

# We don't really like reality ... much!

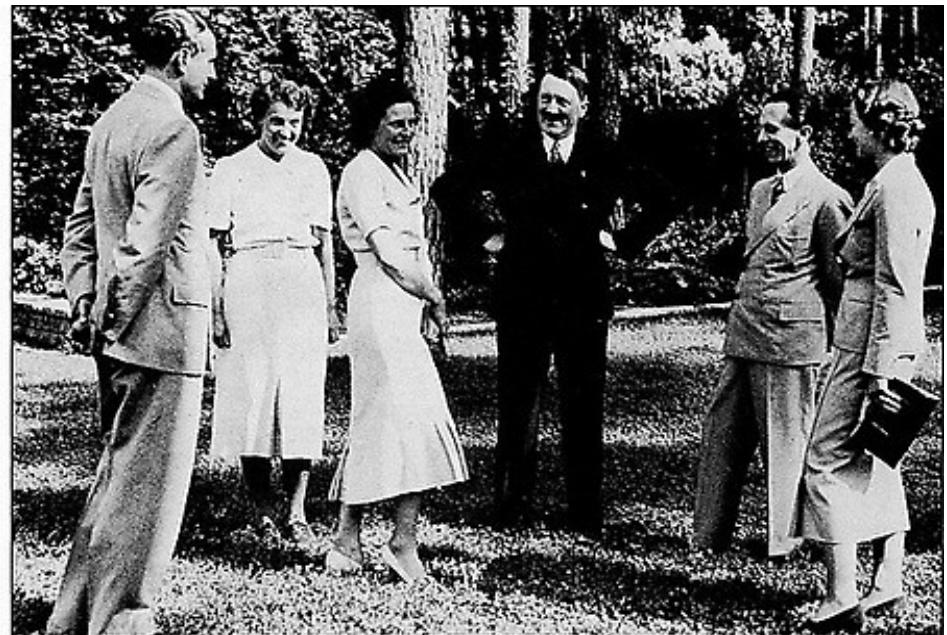


Abraham Lincoln's Head on John Calhoun's Body, circa 1860

# We don't really like reality ... much!



# We don't really like reality ... much!



We don't really like reality ... much!



The Star Issue

# Ni tro

No 146 ΔΕΚΕΜΒΡΙΟΣ 2007 € 4,40

Never In The Right Order

Ο ΛΟΥΑ  
ΛΟΥΑ ΜΙΛΑΕΙ  
(ΕΠΙΤΕΛΟΥΣ)

ΑΠΟ ΥΠΑΛΛΗΛΟΣ ΣΤΑ  
«McDONALD'S» ΠΑΙΚΤΗΣ-  
ΣΤΑΡ ΣΤΟ ΘΡΥΛΟ.  
ΑΠΟ ΤΟ ΘΑΝΑΤΟ ΤΟΥ ΓΙΟΥ  
ΤΟΥ ΣΤΑ ΣΧΕΔΙΑ ΓΙΑ  
ΤΟ ΓΑΜΟ ΤΟΥ

**51**  
ΠΡΑΓΜΑΤΑ ΠΟΥ  
ΑΛΛΑΞΑΝ  
ΤΗ ΖΩΗ ΤΟΥ  
ΕΛΛΗΝΑ  
ΑΝΤΡΑ

**KAI**  
Η HOT ΜΑΡΙΑ  
ΚΟΡΙΝΘΙΟΥ

ΔΕΣΠΟΙΝΑ  
**IS BACK!**

Η ΒΑΝΔΗ ΕΠΙΣΤΡΕΦΕΙ ΕΠΕΙΤΑ  
ΑΠΟ ΕΝΑ ΧΡΟΝΟ ΠΙΟ ΣΕΞΙ ΑΠΟ  
ΠΟΤΕ-ΟΙ 10 ΠΙΟ ΔΙΑΣΗΜΟΙ  
ΕΛΛΗΝΕΣ ΦΩΤΟΓΡΑΦΟΙ ΤΗΝ  
ΝΤΥΝΟΥΝ ΜΕ ΤΑ ΜΑΤΙΑ ΤΟΥΣ

9 771108583009 12

We don't really like reality ... much!



# A word of caution

R. Nash, K. Wade, R. Brewer, "Why do Doctored Images Distort Memory?", Consciousness and Cognition, 2010.

D. Sacchi, F. Agnoli, E. Loftus "Changing History: Doctored Photographs Affect Memory for Past Public Events" Applied Cognitive Phycology. 21: 1005–1022 (2007)

Is history as we think it is?  
Is reality as we see it is? Is it ethical?  
Which is the role of mass media?

PhD in Philosophy?  
– No? then forget the moral dilemma

We are “scientist” and engineers  
– What cool things we can do?  
– Is it publishable?

M. Brown

# Current status ...

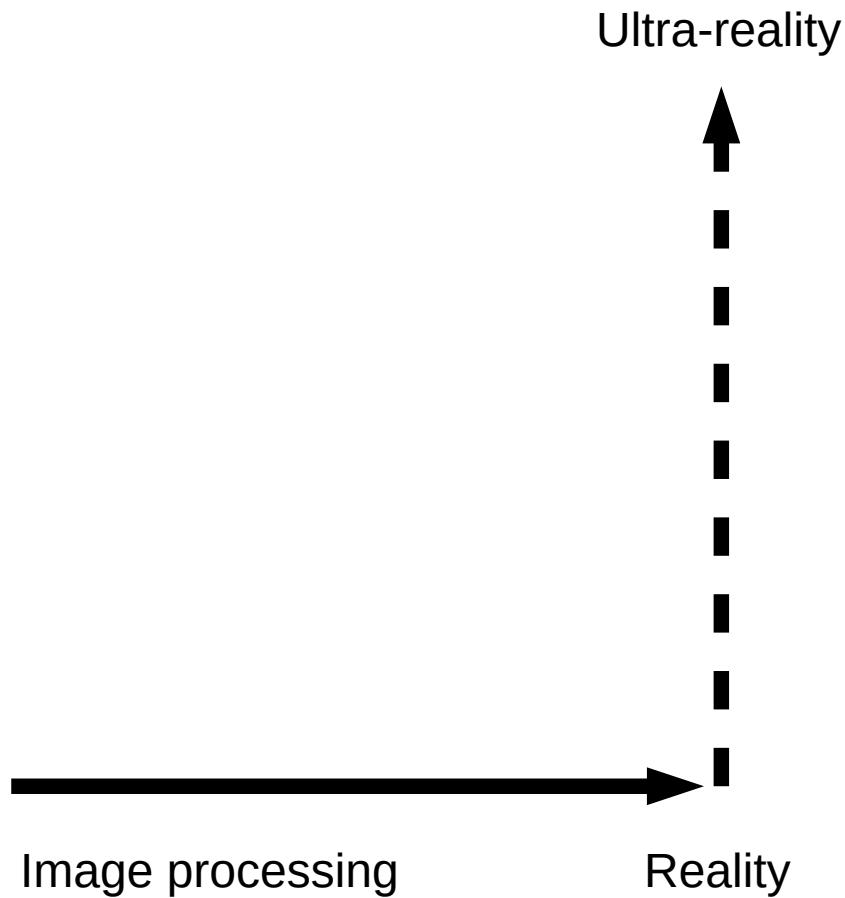


# Current status ...



- Modern photography is about obtaining “perceptually optimal” images
- Digital photography makes this more possible than ever before
- **Images are made to be processed**

# The quest for capturing ... beyond reality



# The Realism Spectrum

Computer Graphics



Realism  
Manipulation  
Ease of capture

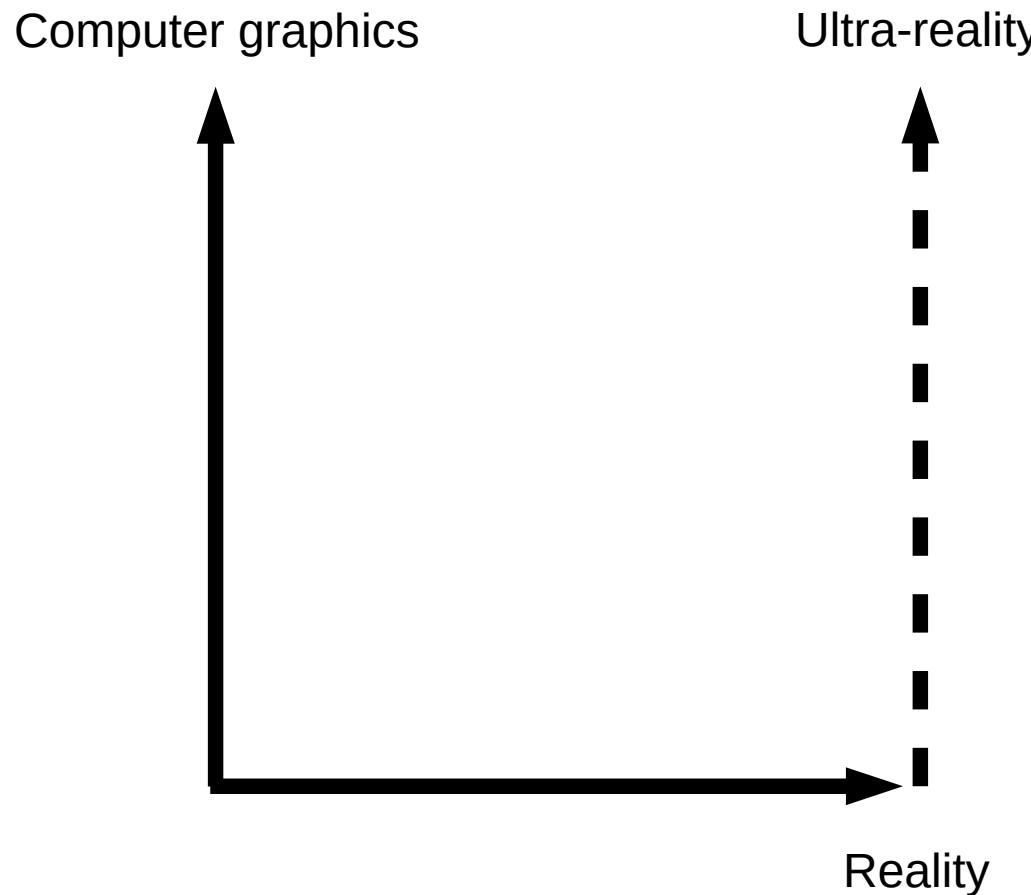
Photography



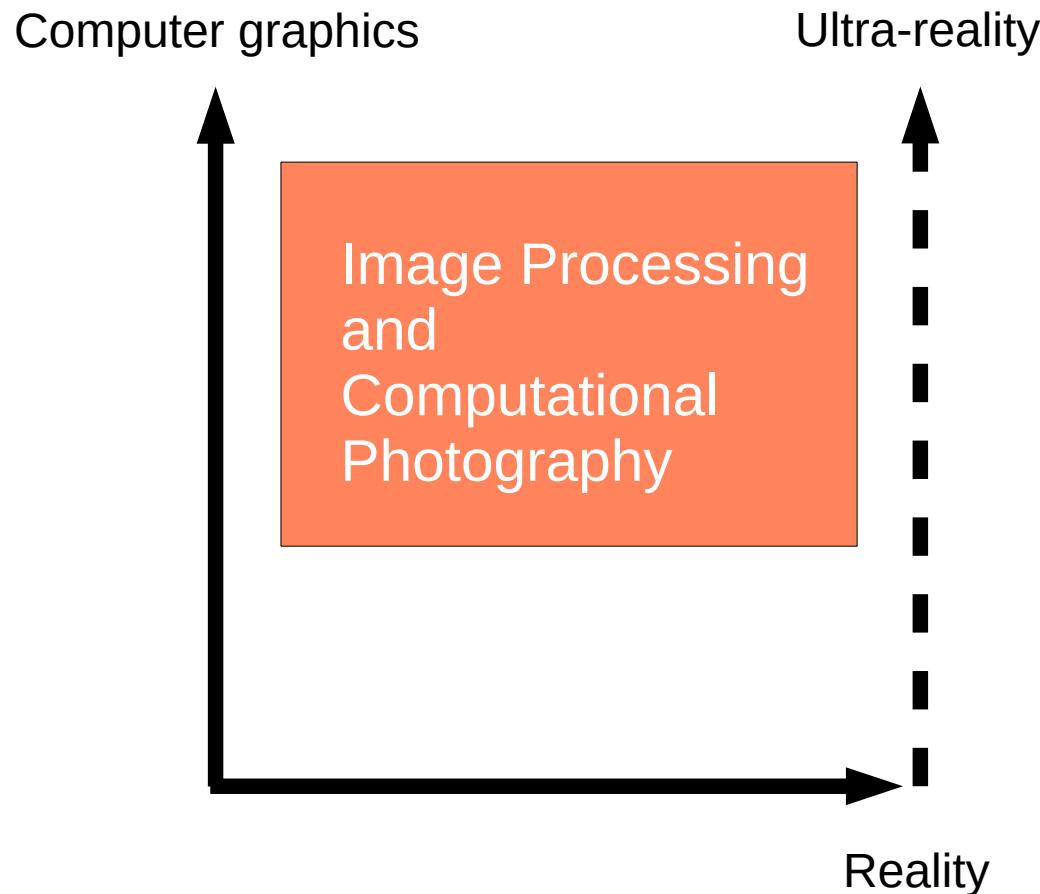
- + Easy to create new worlds
- + Easy to manipulate objects/viewpoints
- Very hard to look realistic

- + Instantly realistic
- + Easy to acquire
- Very hard to manipulate objects/viewpoints

# The quest for capturing ... beyond reality



# The quest for capturing ... beyond reality



# Computational Photography



How can I use computational techniques to capture light in new ways?

How can I use computational techniques to breathe new life into the photograph?

How can I use computational techniques to synthesize and organize photo collections?

# Conventional photography limitations



Image Blur/ Camera Shake



Limited Depth of Field



No or Bad Coloring



Limited Dynamic Range



Limited Resolution



Sensor Noise

Image Processing and Computational Photography  
provide answers ...

# Conventional photography solutions

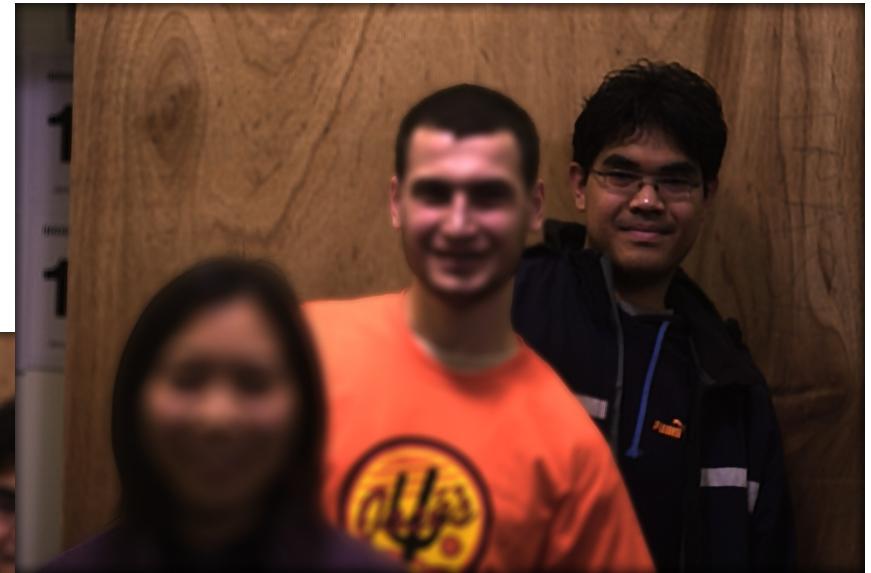


Image blur/ camera shake



Deblur / deconvolution

# Conventional photography solutions



Refocusing

# Conventional photography solutions



High dynamic range



Stormy Sunrise

© Royce Howland, 2006

# Conventional photography solutions



+



Color transference



# Conventional photography solutions



Low resolution



Super-resolution

Image Processing and Computational Photography  
provide answers ...  
**AND MORE !!!**

# Beyond conventional photography



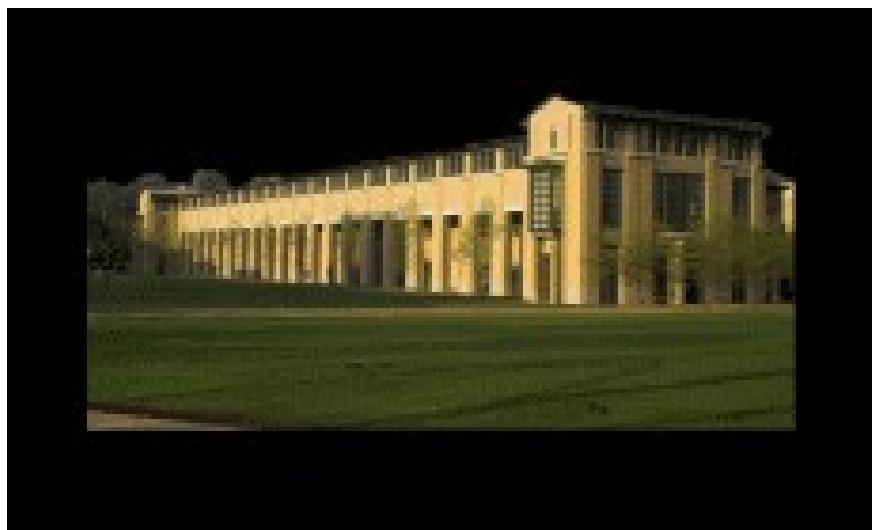
Non photo-realistic rendering

# Beyond conventional photography

Beyond static

(c) A. Efros, D. Hoiem and his students

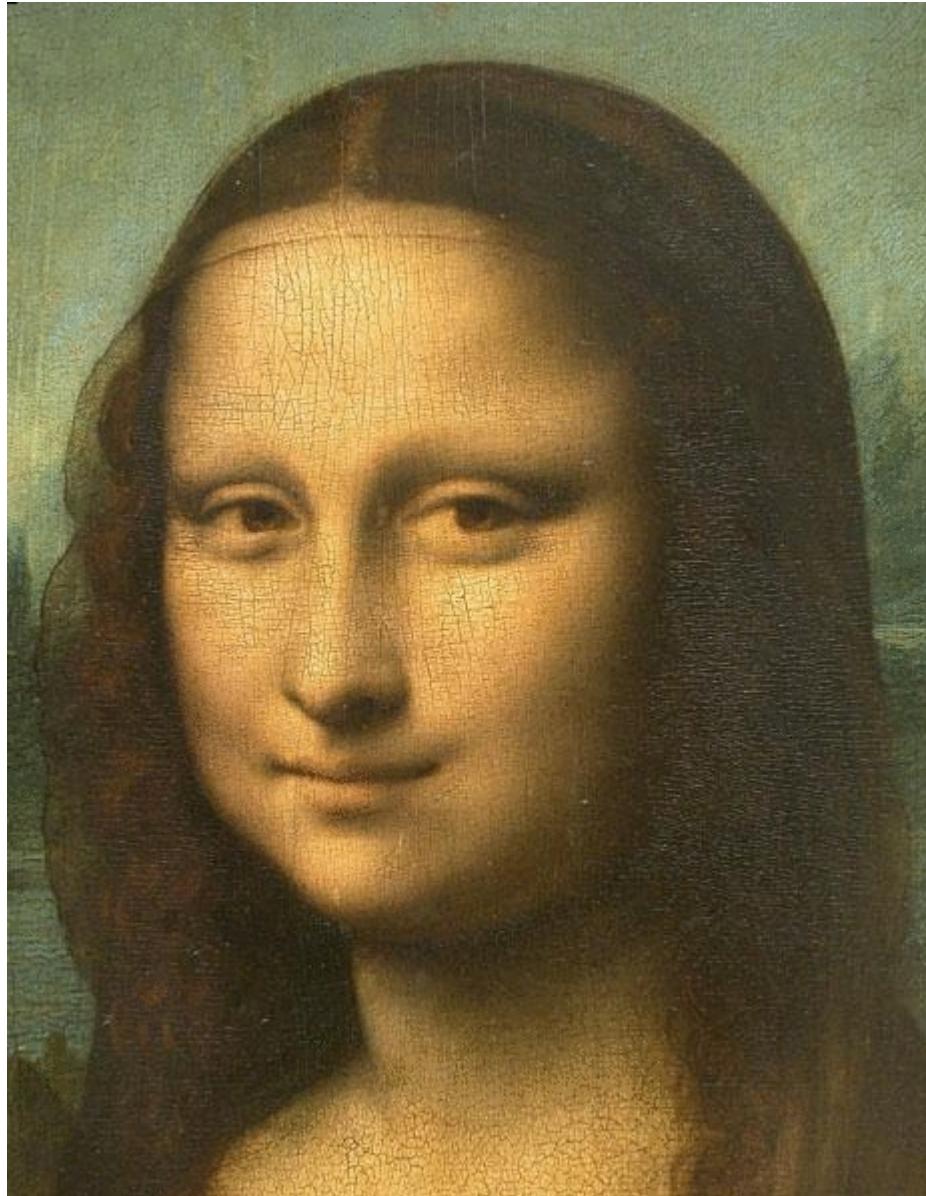
# Beyond conventional photography



Point of view re-rendering

(c) A. Efros, D. Hoiem and his students

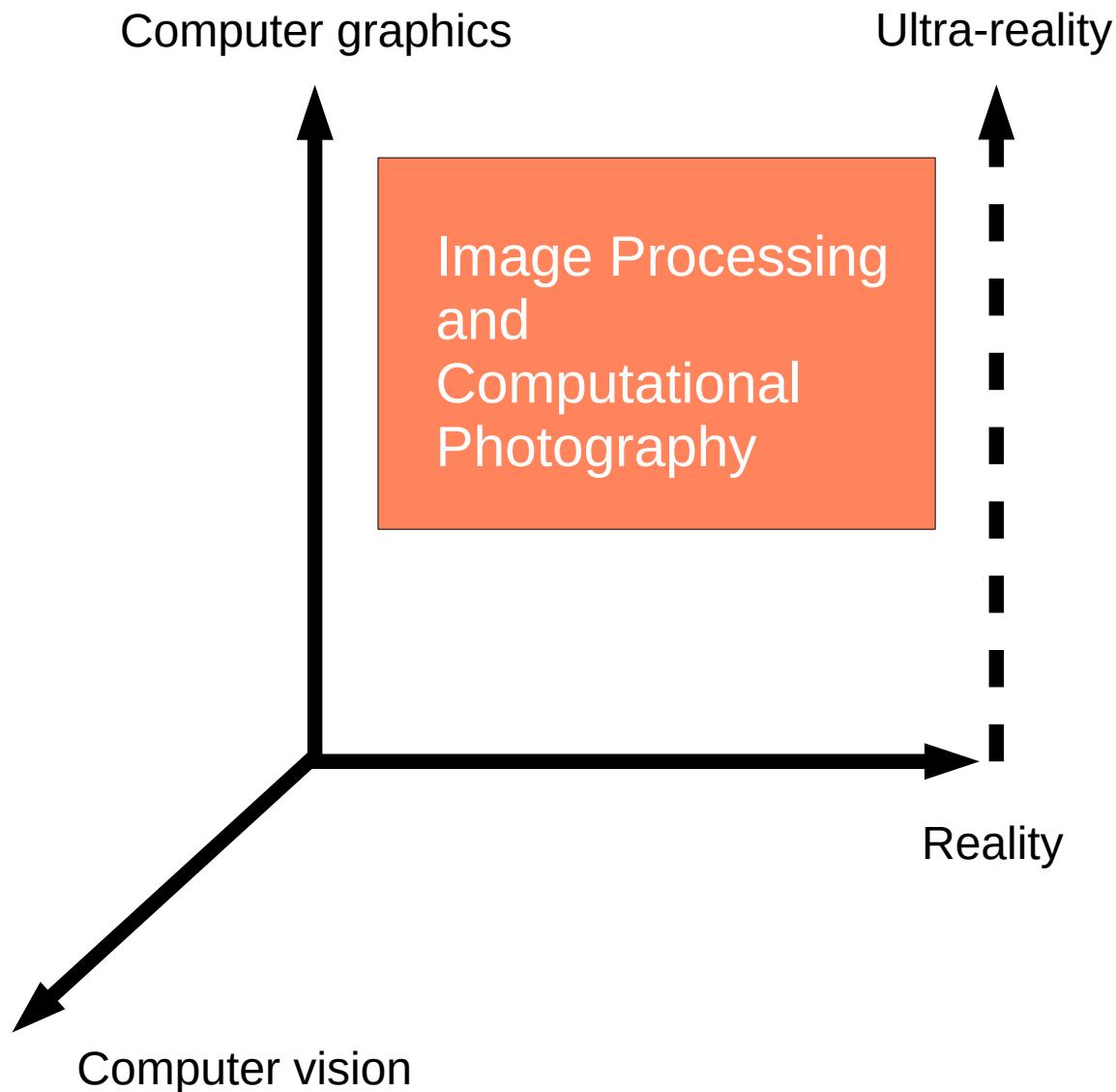
# Beyond conventional photography



Point of view re-rendering by morphing

(c) A. Efros, D. Hoiem and his students

# But ... I took the computer vision course?!



# Image processing, image analysis and computer vision

There are no clear boundaries among these concepts, but we may consider a three level paradigm:

**Low-level** processes involve primitive operations such as image preprocessing to reduce noise, contrast enhancement, and image sharpening. ***Input and outputs are images***

**Mid-level** processes involve tasks such as segmentation (partitioning an image into regions), description of these regions and classification or recognition of those. ***Input is an image, but outputs are attributes*** extracted from those images (e.g. edges, contours or identity)

**High-level** processes involves “**making sense**” of a collection of these objects (e.g. scene understanding).

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Image Processing

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Computer Vision

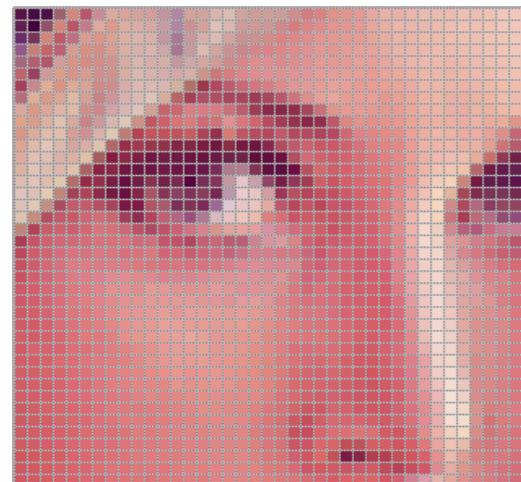
# The course main goals

Application areas:

- Improvement of pictorial information for human interpretation
- Processing of image data for storage and transmission
- Representation for autonomous machine perception



Cygnus Loop  
(Enhance human perception)

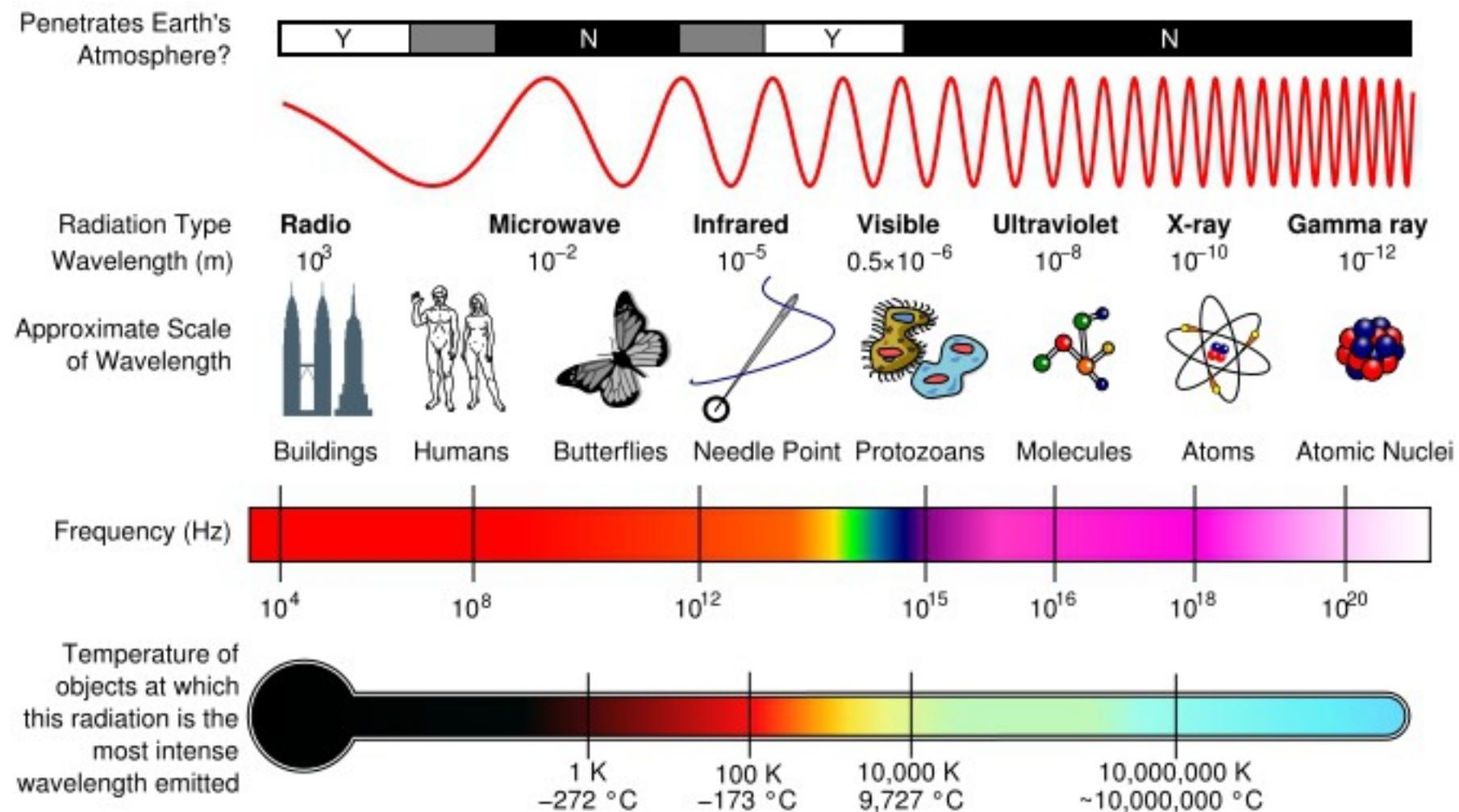


Compressing Lenna  
(A matrix interpretation)

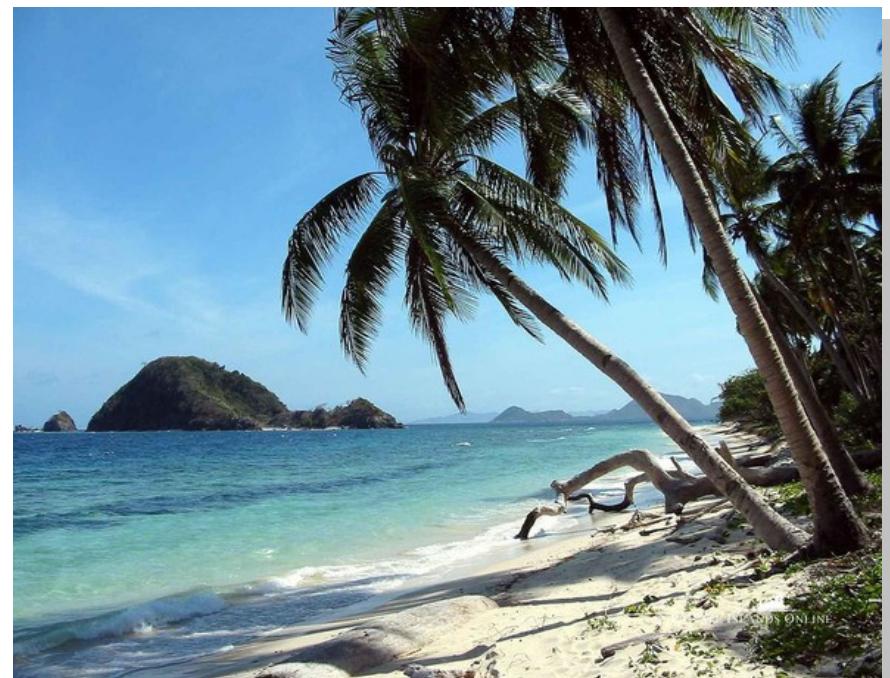
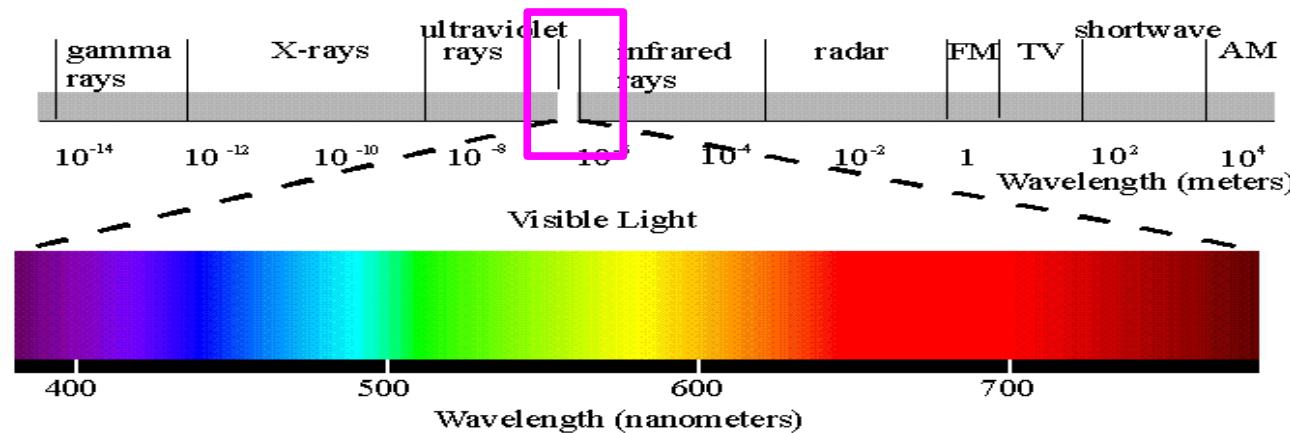


Object recognition system  
(Gateway to AI)

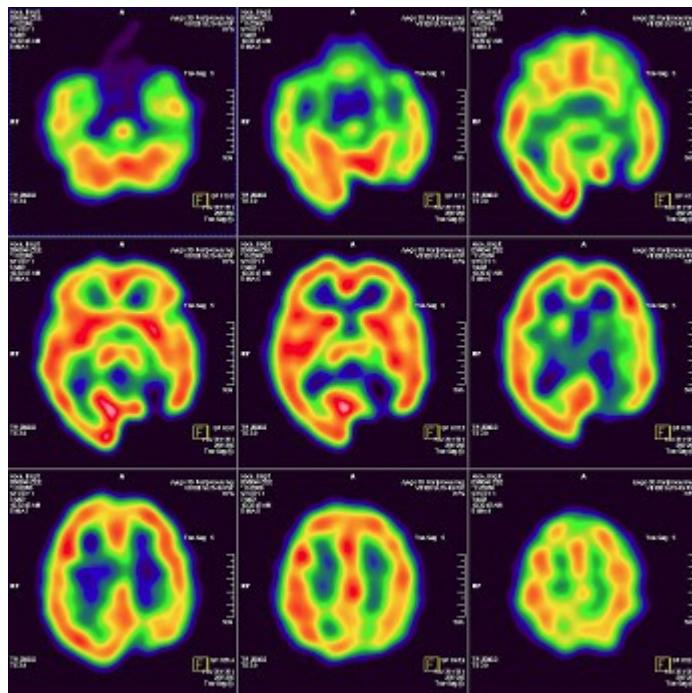
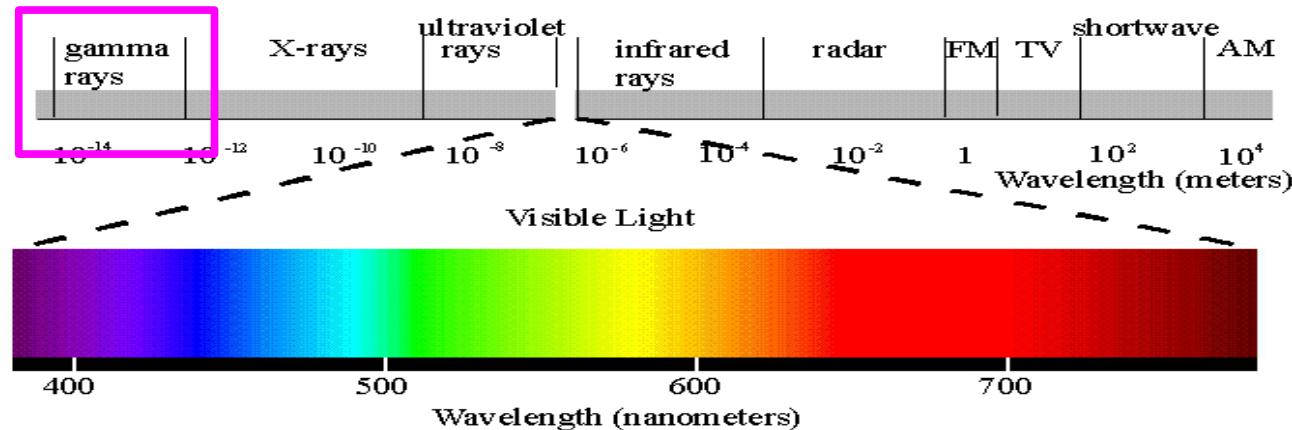
# Images, images and ... images !!!



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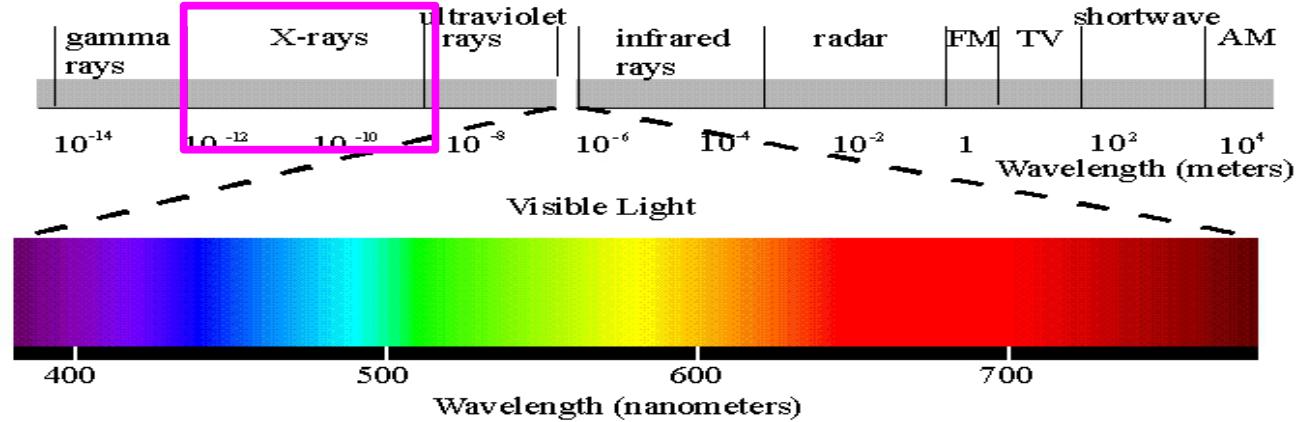


Gamma PET (Positron emission tomography)

SPECT imaging  
(single-photon emission computed tomography )

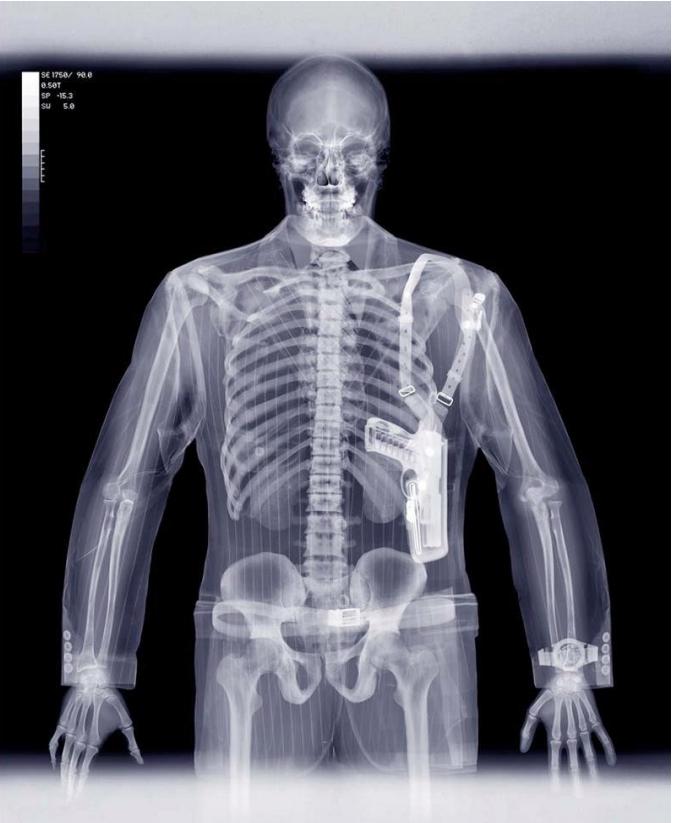
Associated to functionalities of the scanned areas. A gamma-ray emitting radiotracer is injected and monitored using a gamma camera.

# Images, images and ... images !!!



Airport Scanning

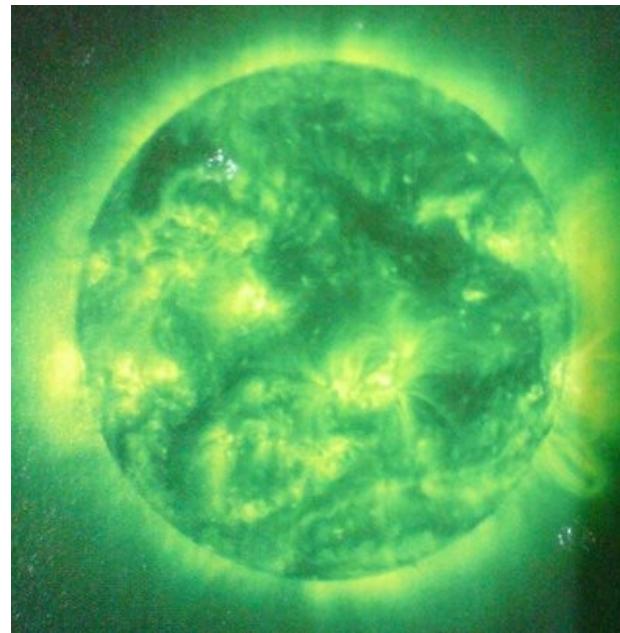
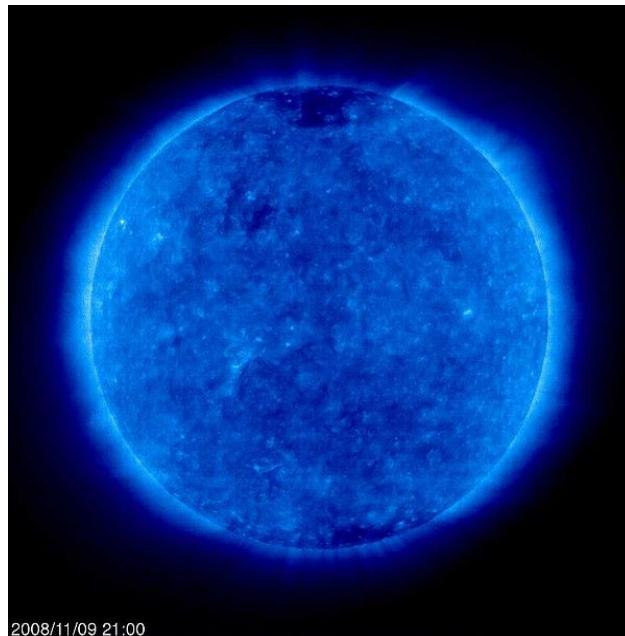
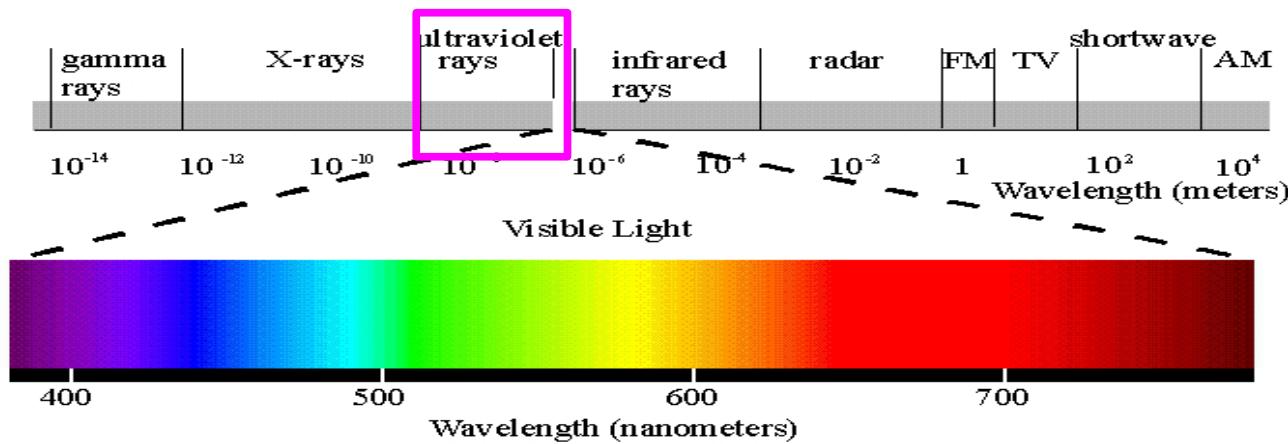
Traumatology



Fault detection in HW pieces

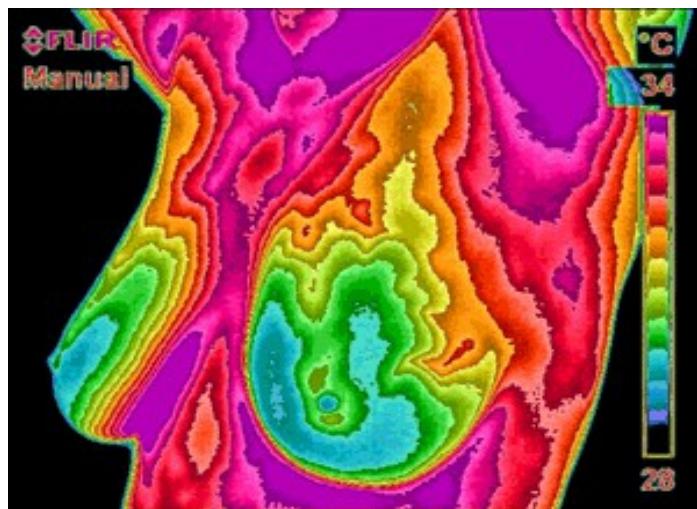
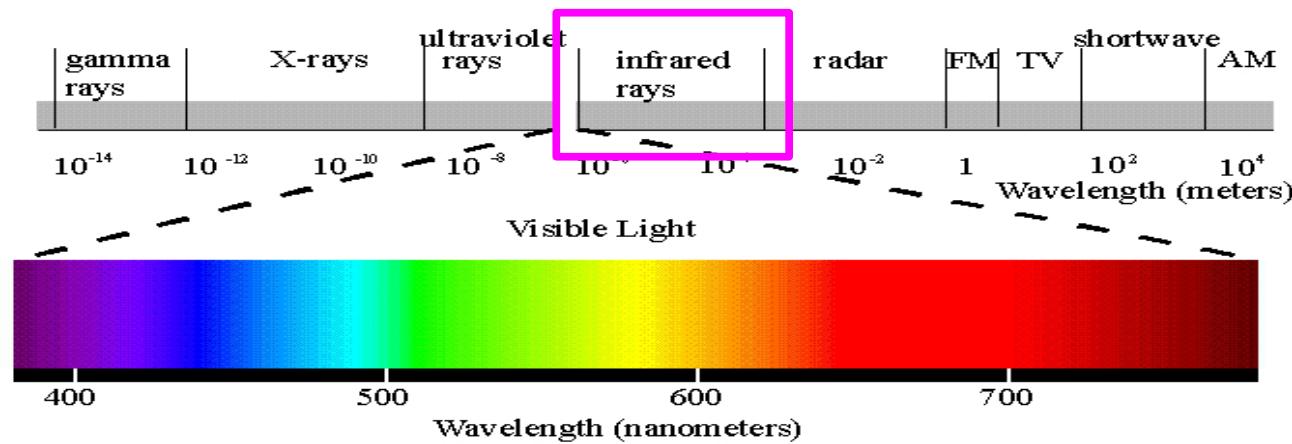


# Images, images and ... images !!!



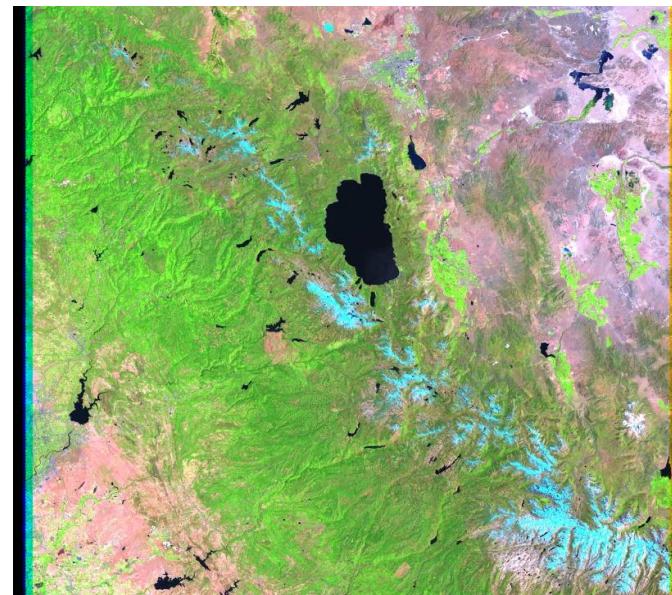
Solar flare studies  
Extreme Ultraviolet Imaging Telescope (EIT)

# Images, images and ... images !!!



Heat due to blood flow  
for cancer detection

Landsat projects

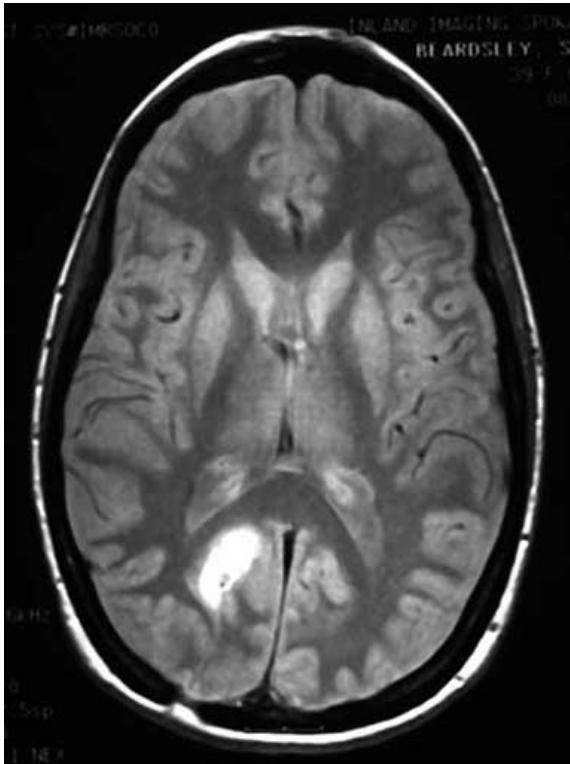


# Images, images and ... more!!!

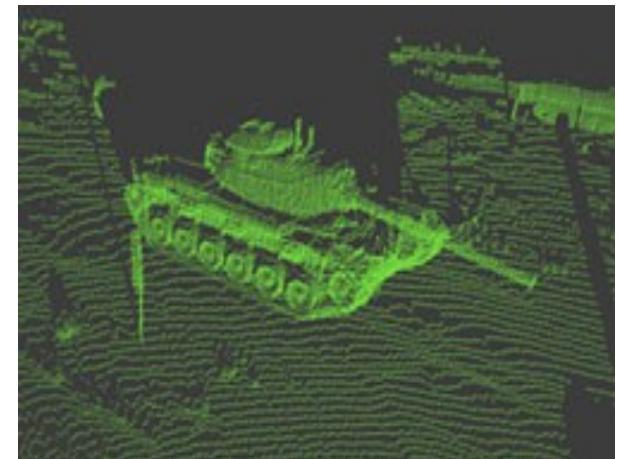
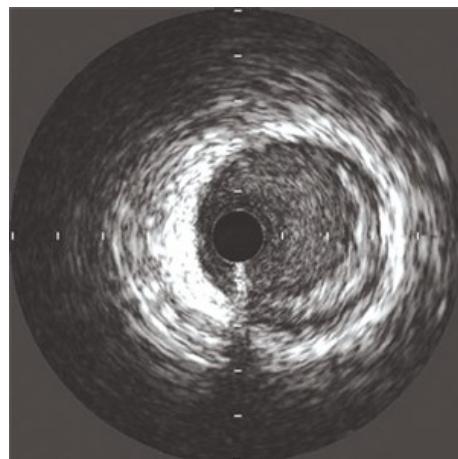
But not restricted to electromagnetic waves ...

... in general any bidimensional scanning producing some magnitude value associated to a measure of a quantity of interest can be interpreted as an image.

MRI (magnetic resonance)



Ultrasounds (acoustic waves reflection)



LADAR (Laser depth)

What do you expect from this course?

Name techniques you already know that are meaningful for this course.

Any wish list?

# Course outline

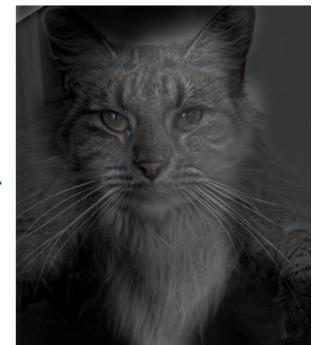
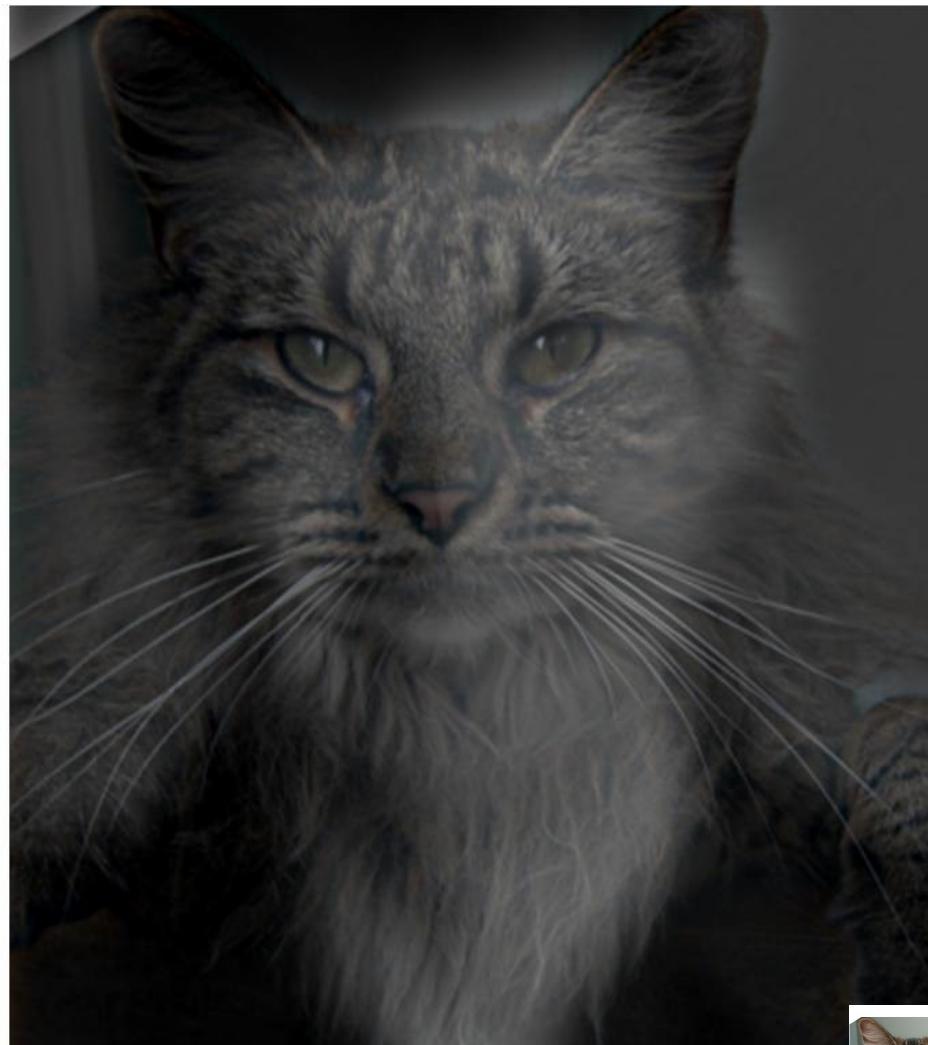
Basics of working with images  
Filtering  
Fourier  
Templates and pyramids

Color  
Light and colour  
Color adjustment  
Tone mapping and HDR

The digital canvas: Cut and paste  
  
Cutting  
Synthesizing  
Composites and blending

Domain  
  
Warping  
Morphing  
Stitching and mosaicing  
3D from 2D

# Assignments: Prac 1: Hybrid Images



# Assignments: Prac 2: Colorizing Prokudin-Gorskii photo collection



# Assignments: Prac 2: Seam carving



# Assignments: Project: Something cool

Propose something cool ...  
or talk to Simone for some ideas ...

# Grading

Final Grade = 0.2\*T1+0.2\*T2+0.3\*PRAC+0.3\*PROJECT

Cheating policy: Do not embarrass yourself!