

**CS 663**  
**Digital Image Processing**

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PG Elective  
Slot 10, Tue + Fri, 2:00 - 3:25 pm

# Digital Image Processing

- Digital Images
  - Array of numbers (N dimensions)
- Algorithms
  - Input = image
    - e.g., black-and-white picture (2D), video (3D)
  - Output = image / measurement / high-level description
- Applications
  - Images are everywhere !

# Digital Image Processing

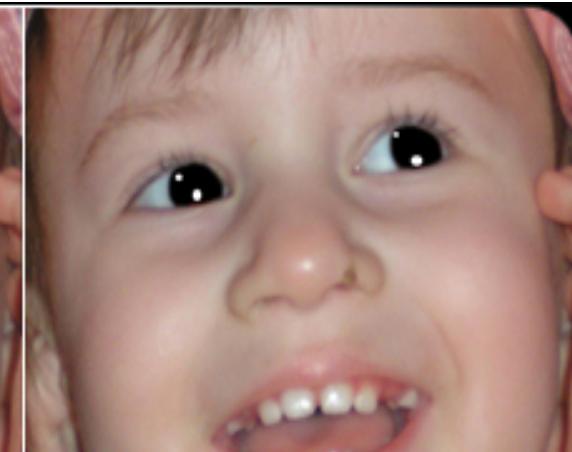
- Application domains
  - Images are everywhere
    - Pictures, videos: cameras, smartphones, webcam
  - Photography, Cinema (editing, special effects)
  - Medical image analysis
    - Microscopy, X-ray, CT, MRI
  - Remote sensing (weather prediction)
  - Biometrics, Forensics
  - Surveillance (military, urban)
  - Seismology
  - Sports
  - ...

# Digital Image Processing

- Why take this course ?
  - Research
    - Image processing and analysis
      - Required for CS 763 Computer Vision
      - Required for CS 736 Medical Image Processing
      - Required for advanced image processing
  - Learn powerful, cool mathematical concepts
    - Linear algebra, Statistics, Machine learning
  - Jobs in R&D
    - India
      - GE, Siemens, Philips, Samsung, Canon, Sun Pharma, Agilent (HP), Intel,, ...
      - DRDO (defense), ISRO (space), ICRISAT (agriculture)
    - Microsoft, nVidia, Facebook, Google, Pixar, Dreamworks, Toshiba, Medtronic, Hitachi, Pharma, Oil & Gas

# Digital Image Processing

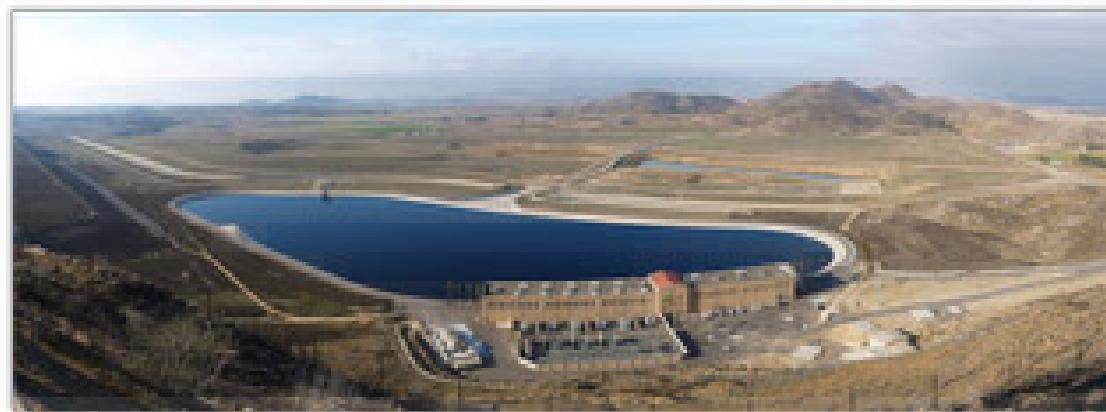
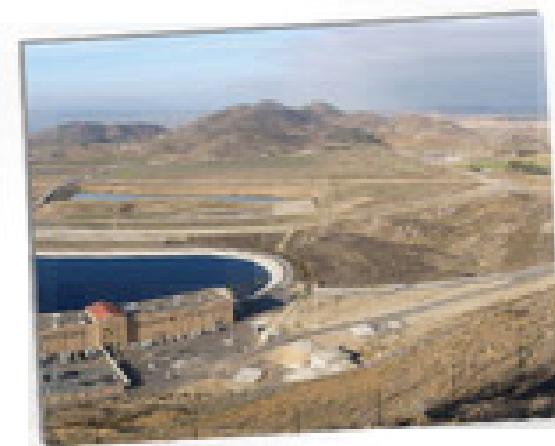
- Editing pictures, movies



+

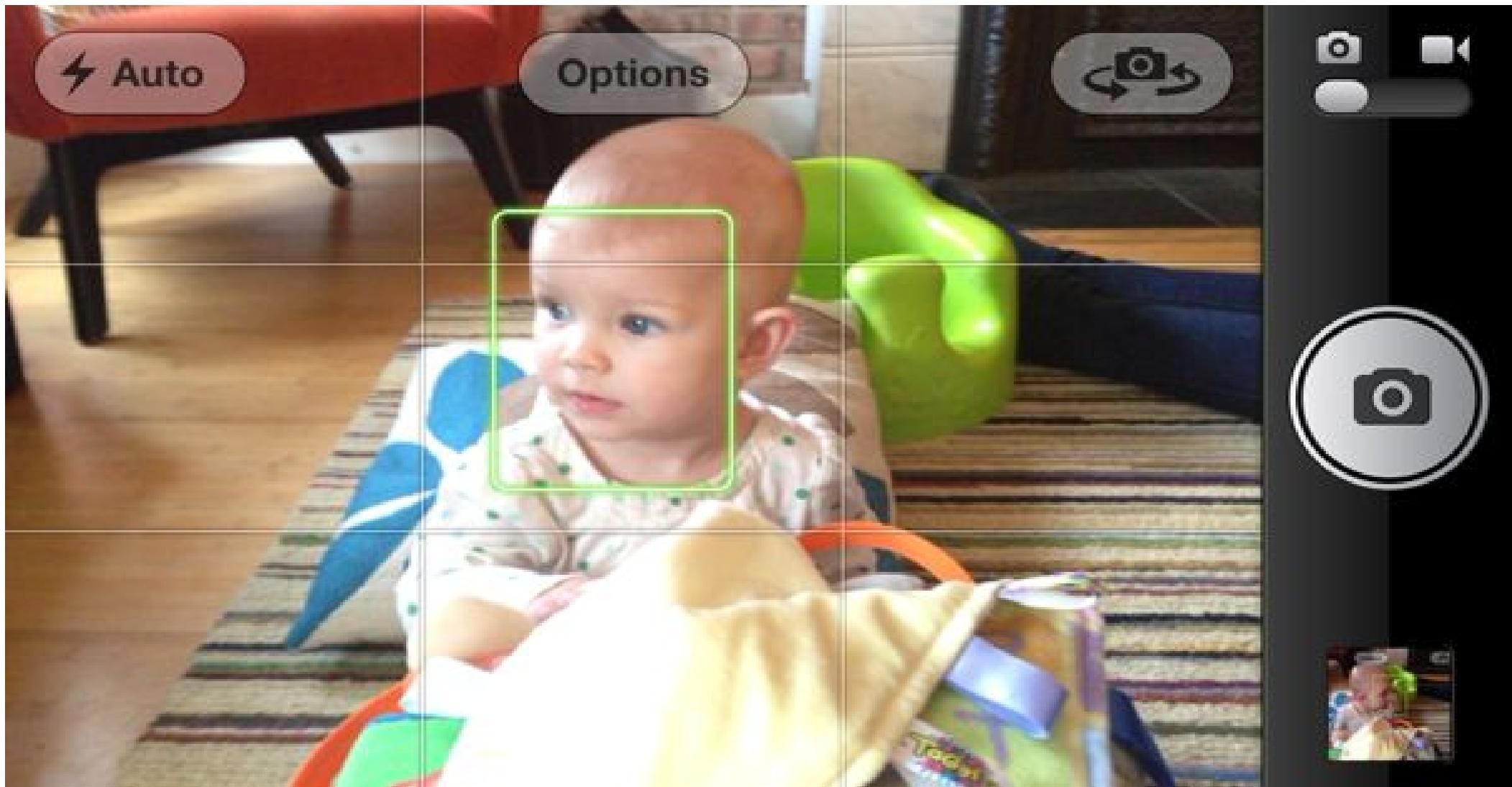


+



# Digital Image Processing

- Photography
  - Face detection for auto focus

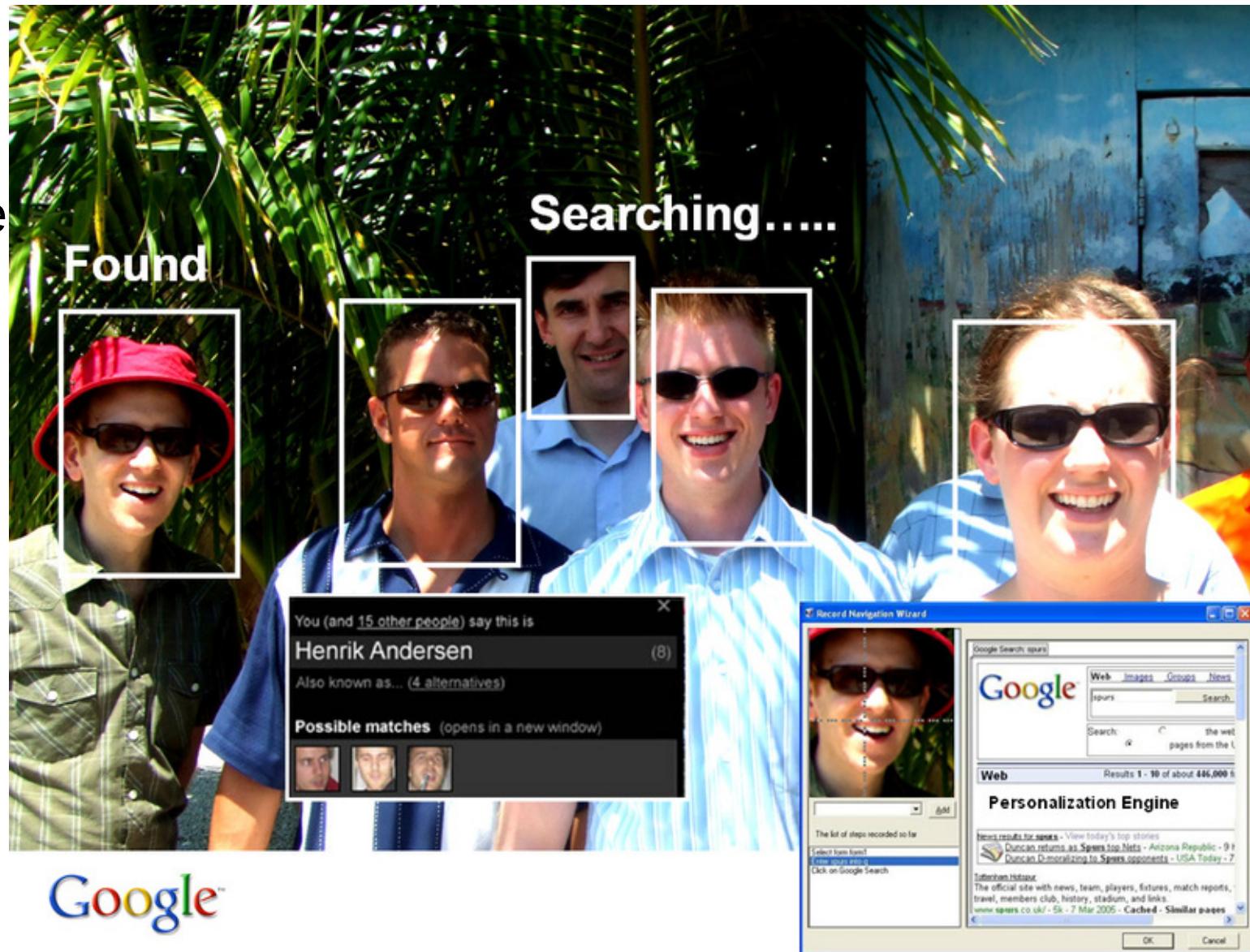


# Digital Image Processing

- Internet applications

- Tagging faces:

- Detect
    - Recognize



# Digital Image Processing

- Internet applications
  - Handwriting recognition



Google



Restaurants



Coffee



Bars



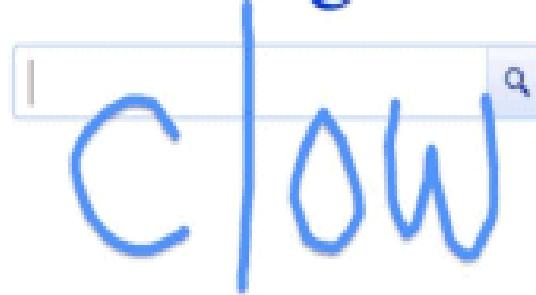
Fast Food



Shops



Google



Restaurants



Coffee



Bars



Fast Food

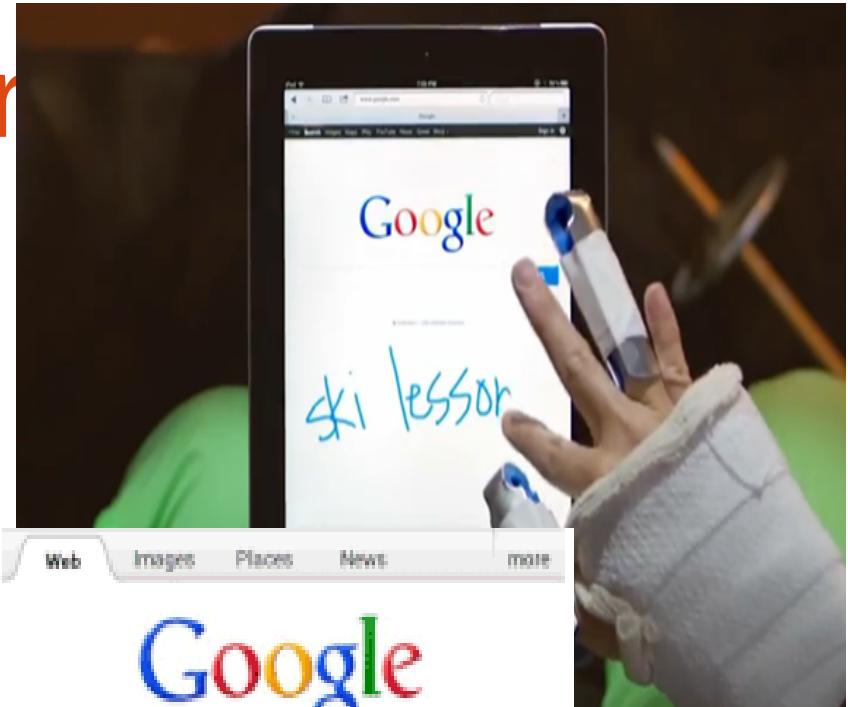


Shops

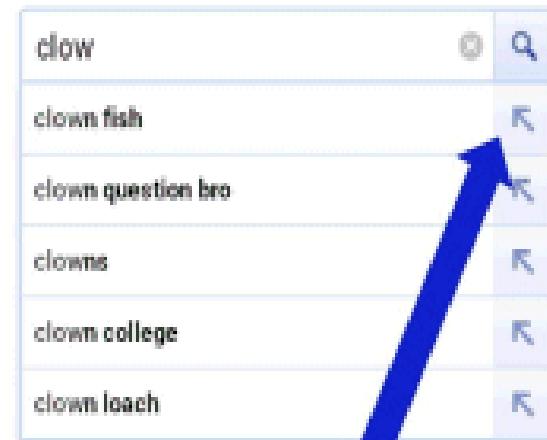
Sign in



Tap on the Handwrite icon



Google

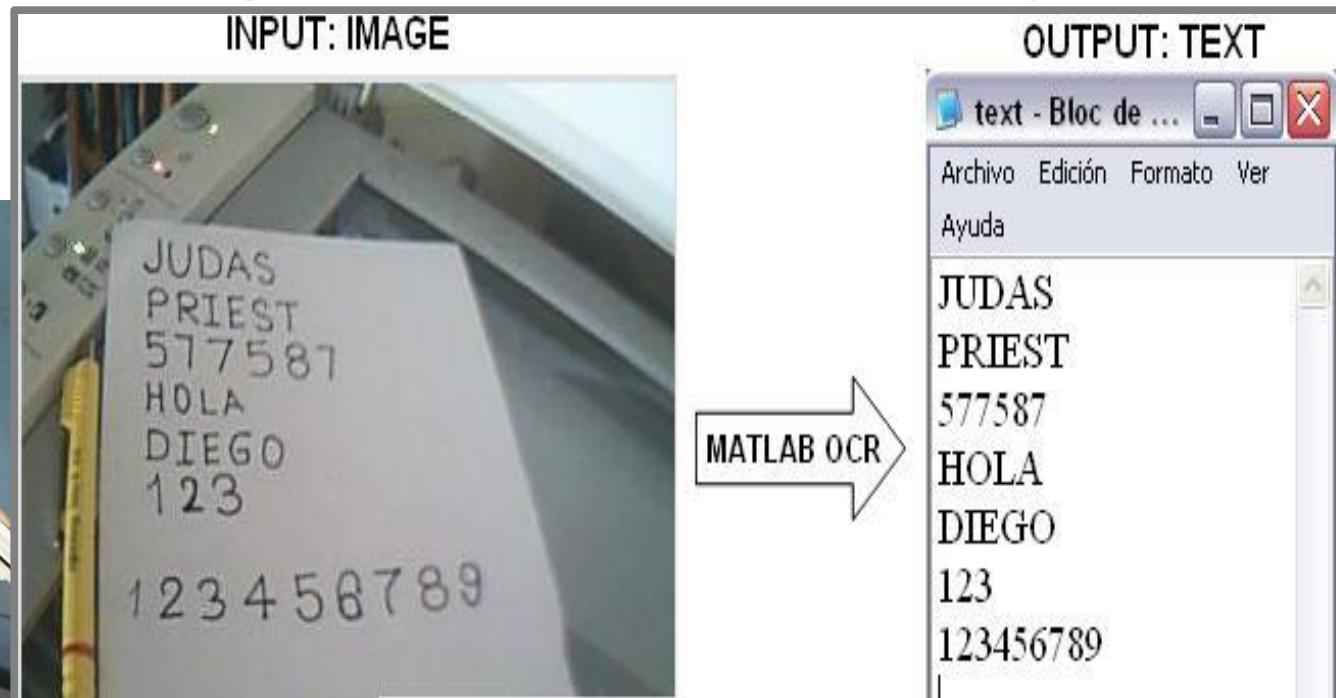
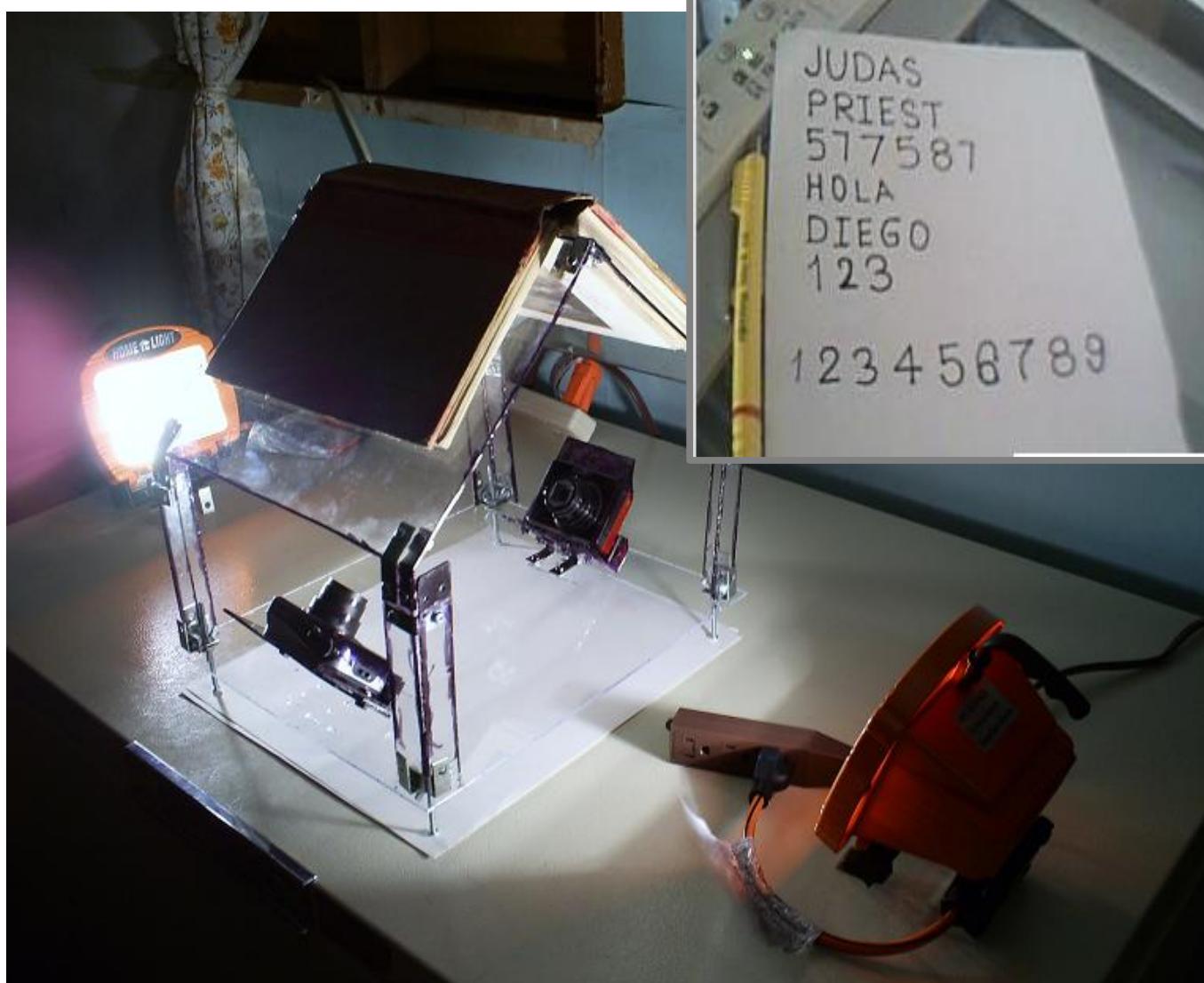


Write anywhere on the screen

Use autocomplete arrows for longer queries

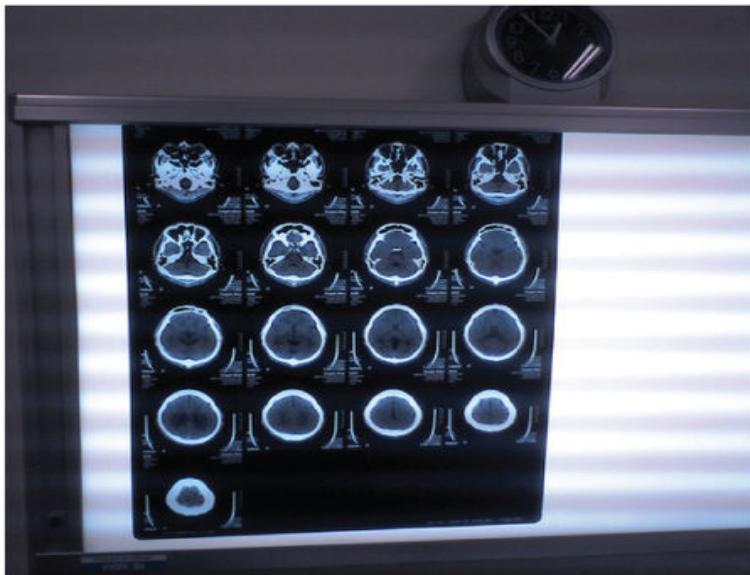
# Digital Image Processing

- Document digitization: optical character recognition



# Digital Image Processing

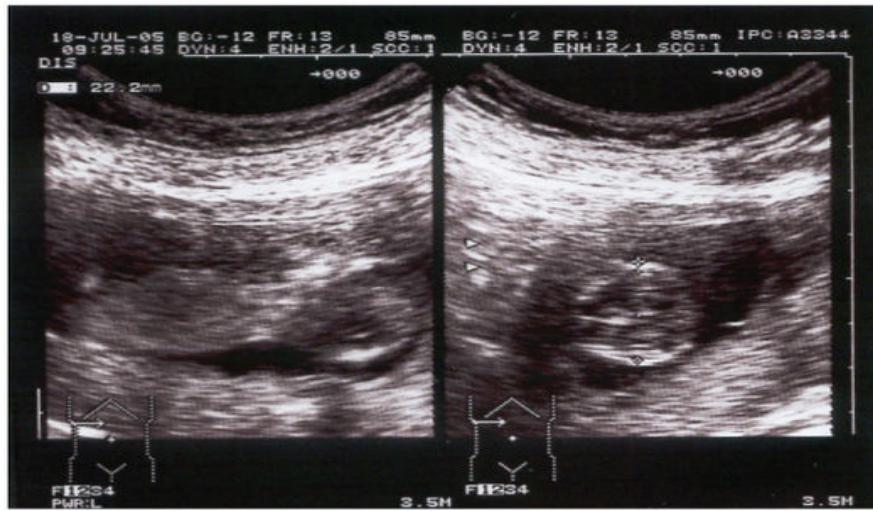
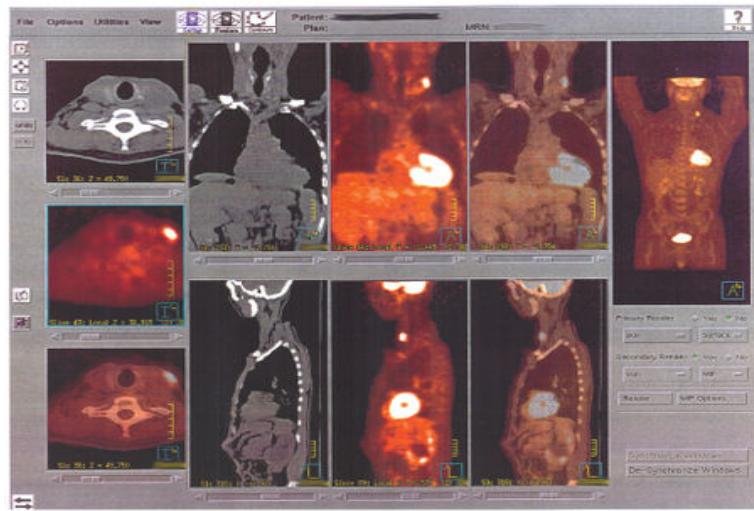
- Medical image analysis: MRI, CT, PET, Ultrasound, Microscopy, Laparoscopy



(a)

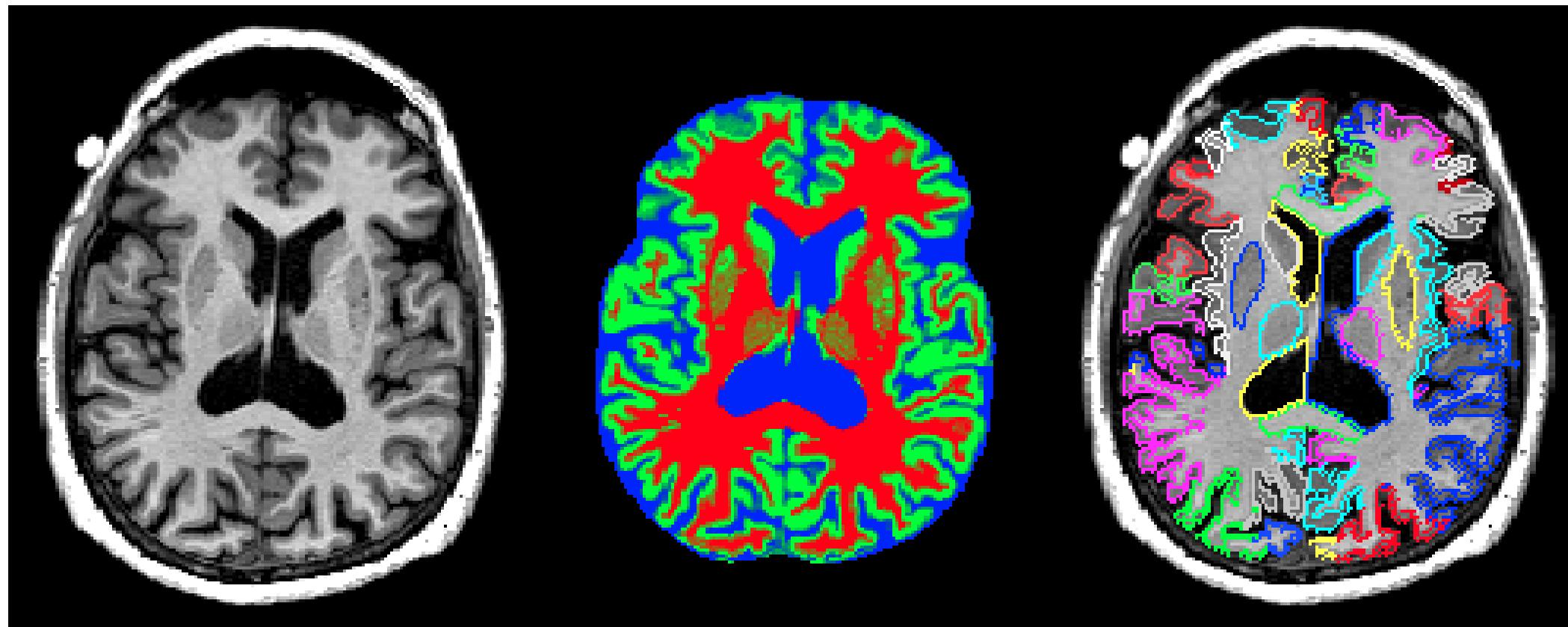


(b)



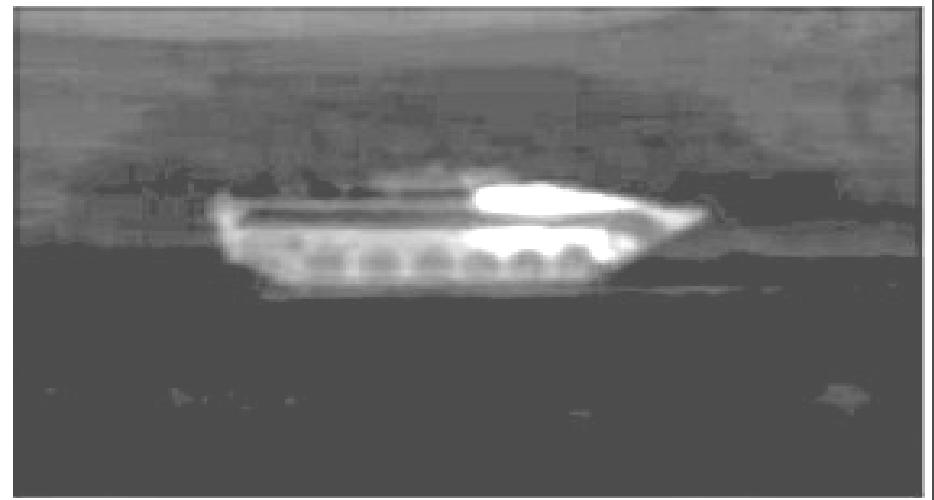
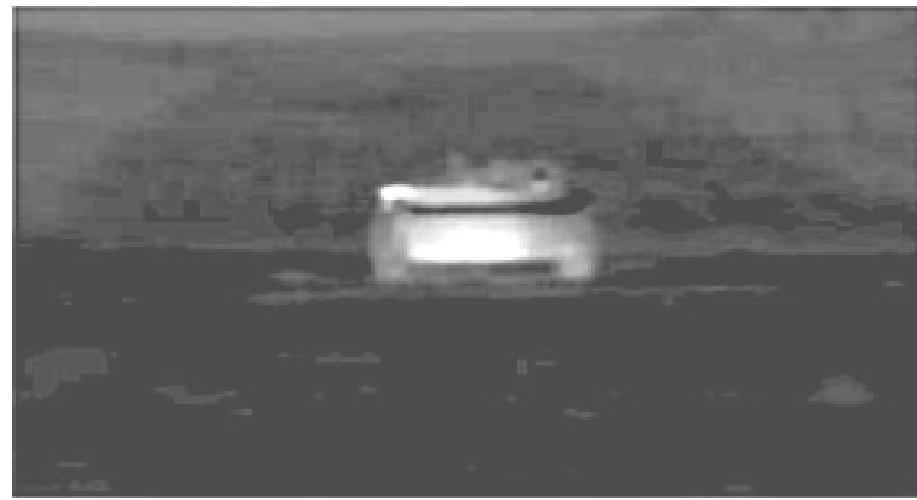
# Digital Image Processing

- Medical image analysis
  - Segmentation



# Digital Image Processing

- Segmentation



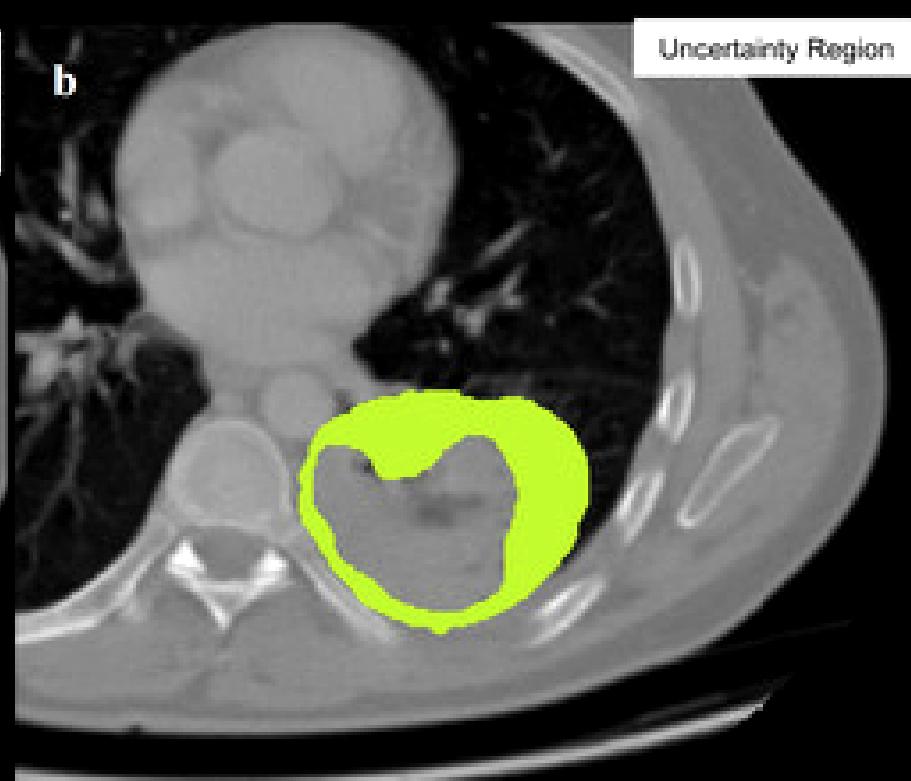
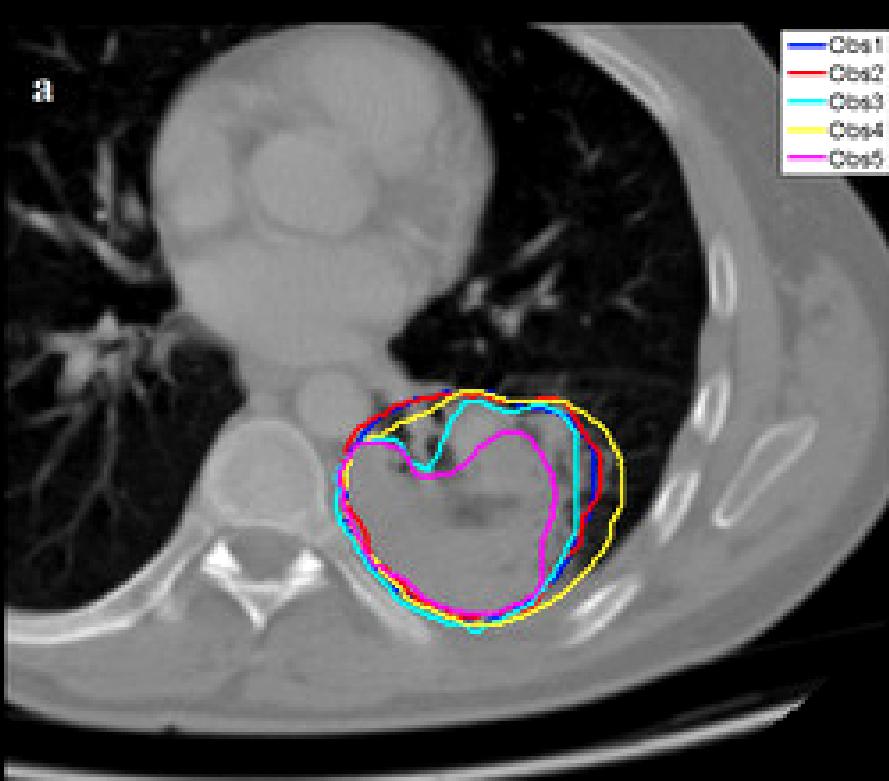
FRONTAL TARGETS

FLANK TARGETS

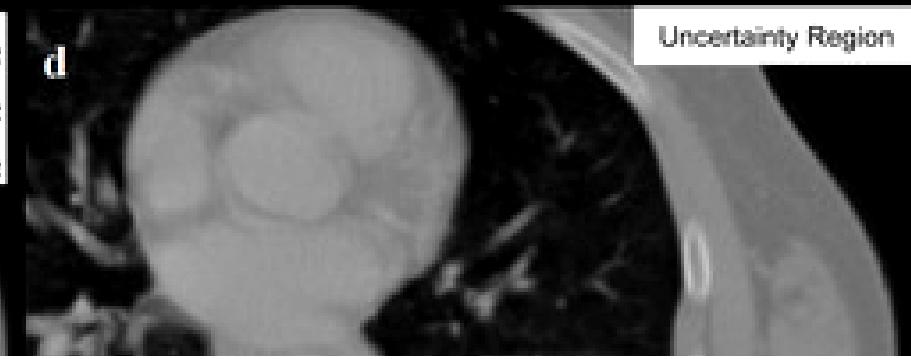
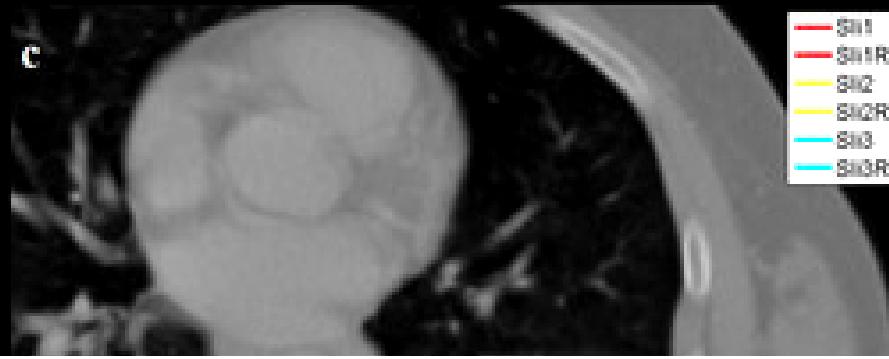
# Digital Image Processing

- Segmentation

Manual

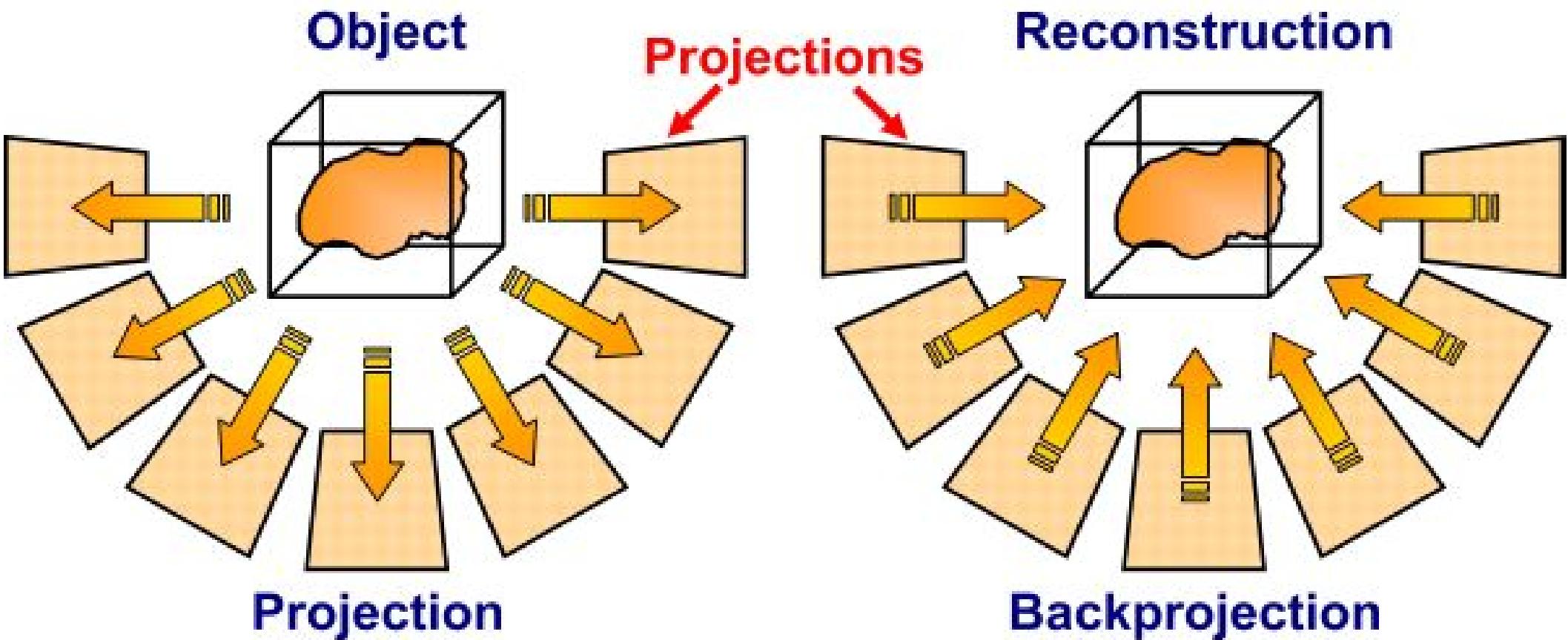


Slicer



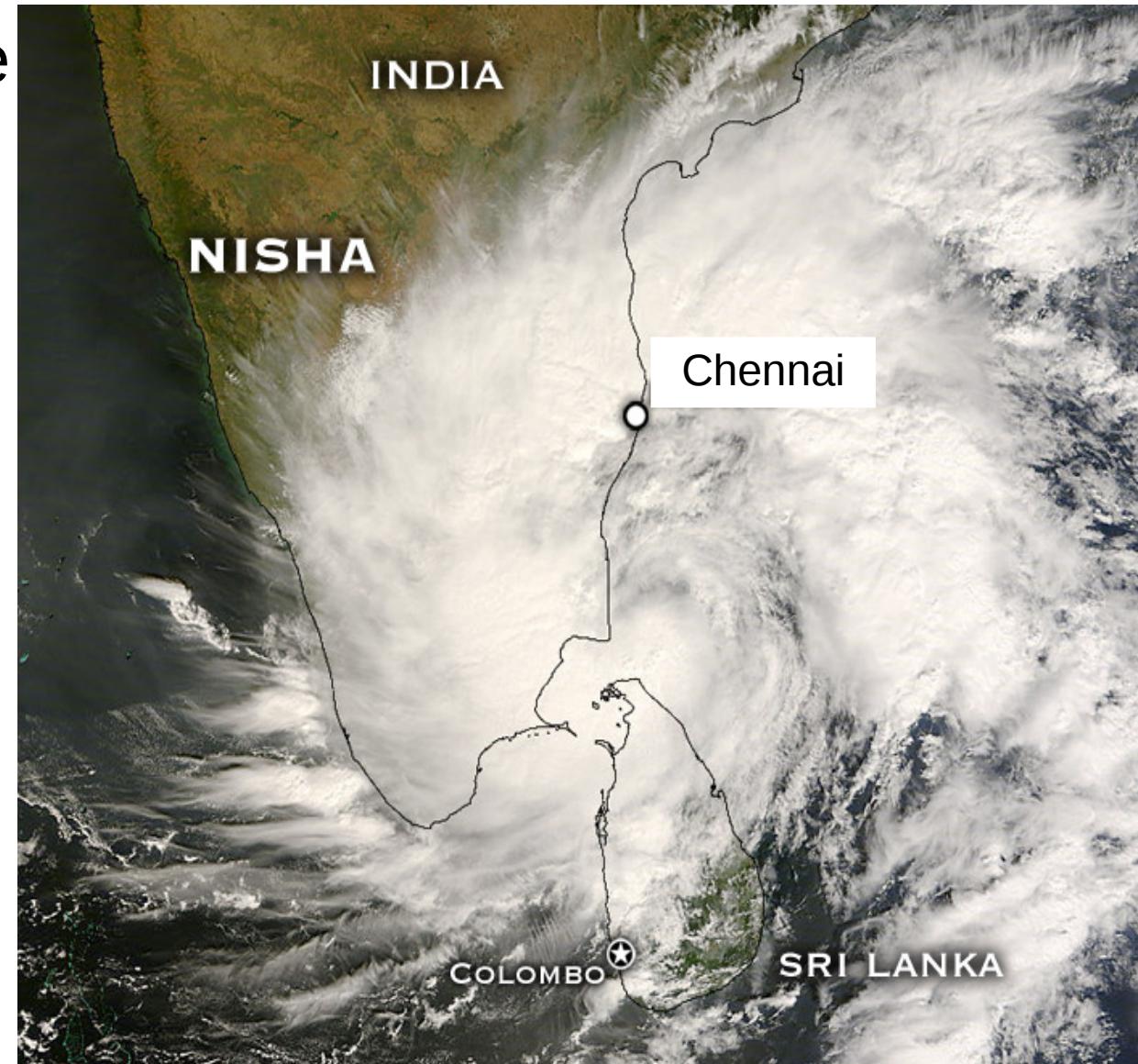
# Digital Image Processing

- Image reconstruction
  - Computer vision
  - Medical vision



# Digital Image Processing

- Remote sensing (weather prediction)
  - Tracking / predicting movement of cyclone
  - Locating center / eye



# Digital Image Processing

- Remote sensing



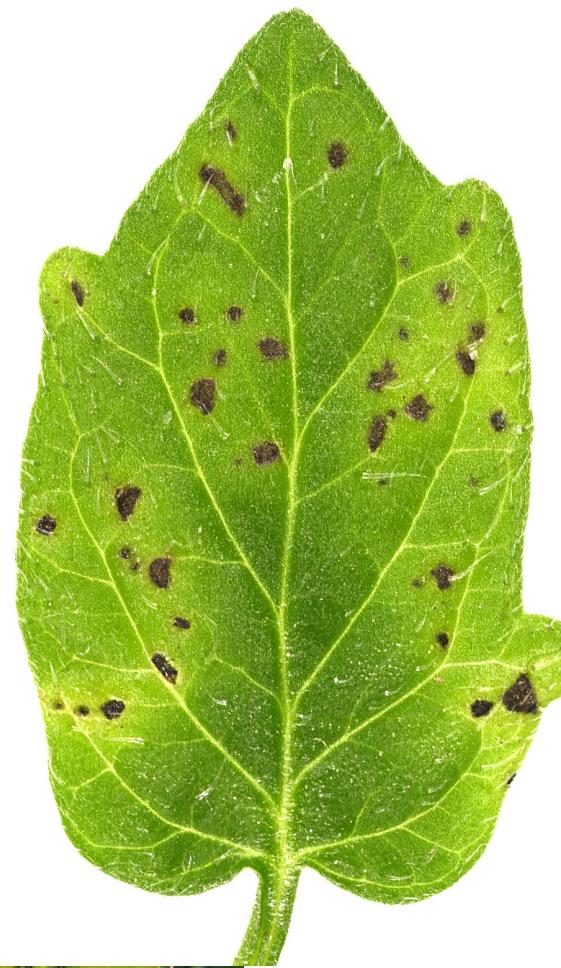
# Digital Image Processing

- Remote sensing (classify: water, forested, urban, ...)



# Digital Image Processing

- Agriculture : Classification of plant diseases



# Digital Image Processing

- Classification of leaves

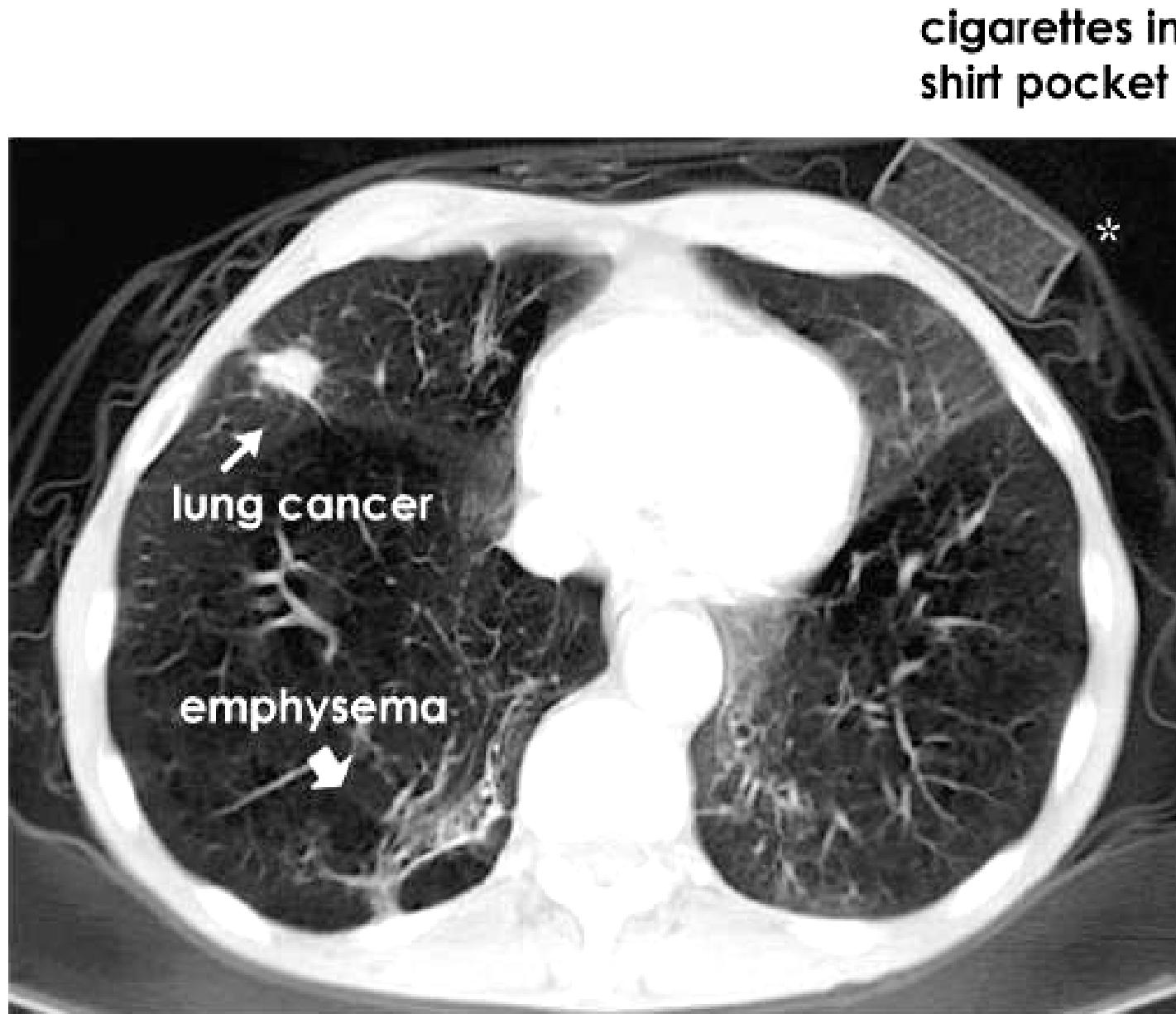


The image shows the classification results from the LeafSnap app. At the top, there are three buttons: "Back" (green), "Results" (yellow), and "Map" (brown). Below these are two images: a green oak leaf on the left and its corresponding binary mask on the right. The text "Snap It! Results" is displayed. The results are listed in a table:

Rank	Species Name	Scientific Name
1	English oak	<i>Quercus robur</i>
2	Sessile oak	<i>Quercus petraea</i>
3	Turkey oak	<i>Quercus cerris</i>

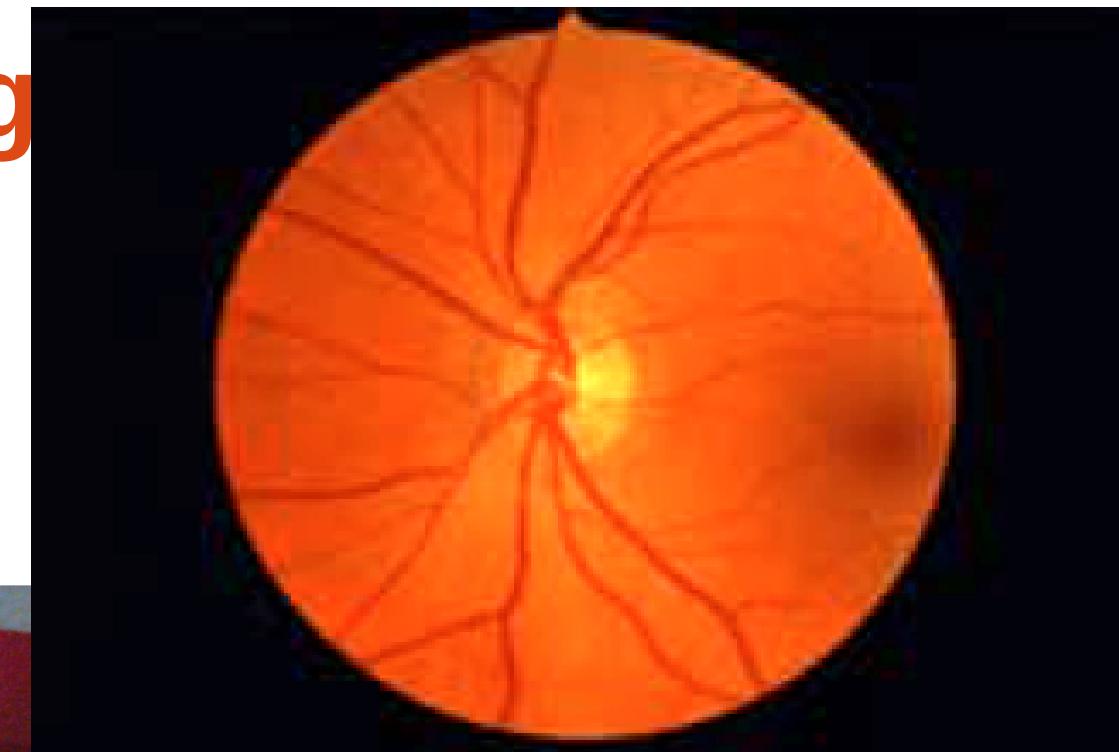
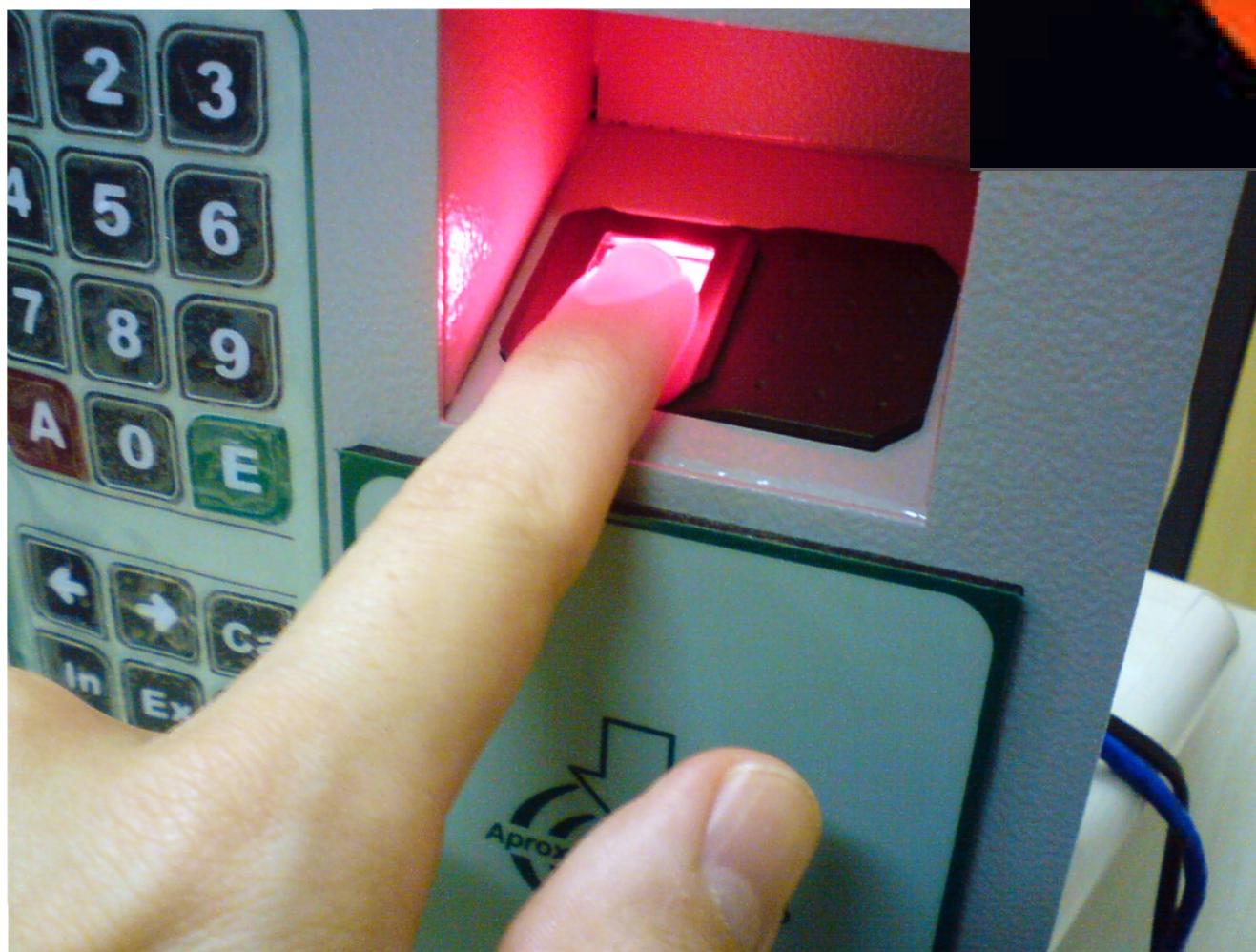
# Digital Image Processing

- Classification of tissue (cancer / normal)



# Digital Imaging

- Biometrics
  - Recognition



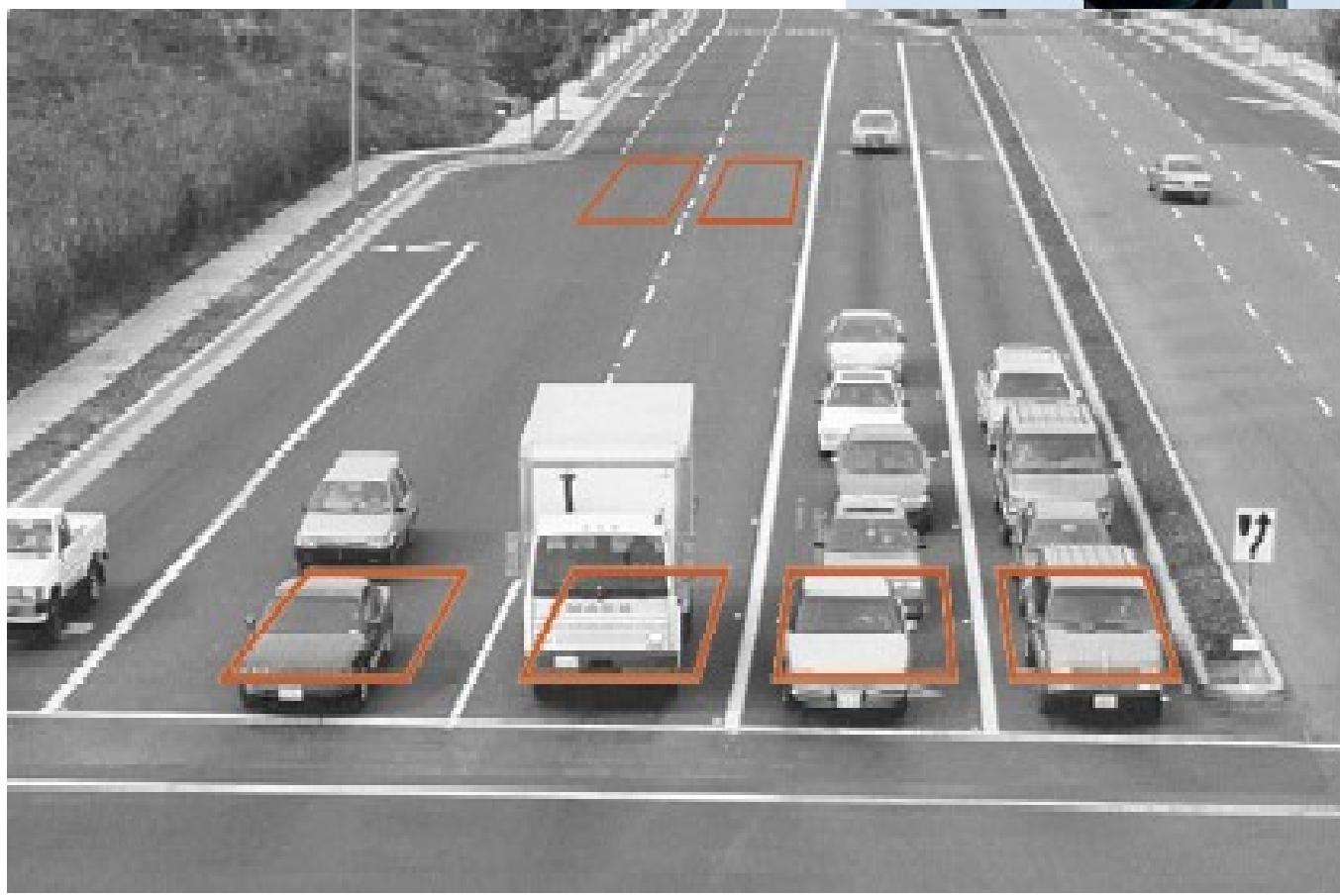
# Digital Image Processing

- Surveillance



# Digital Image Processing

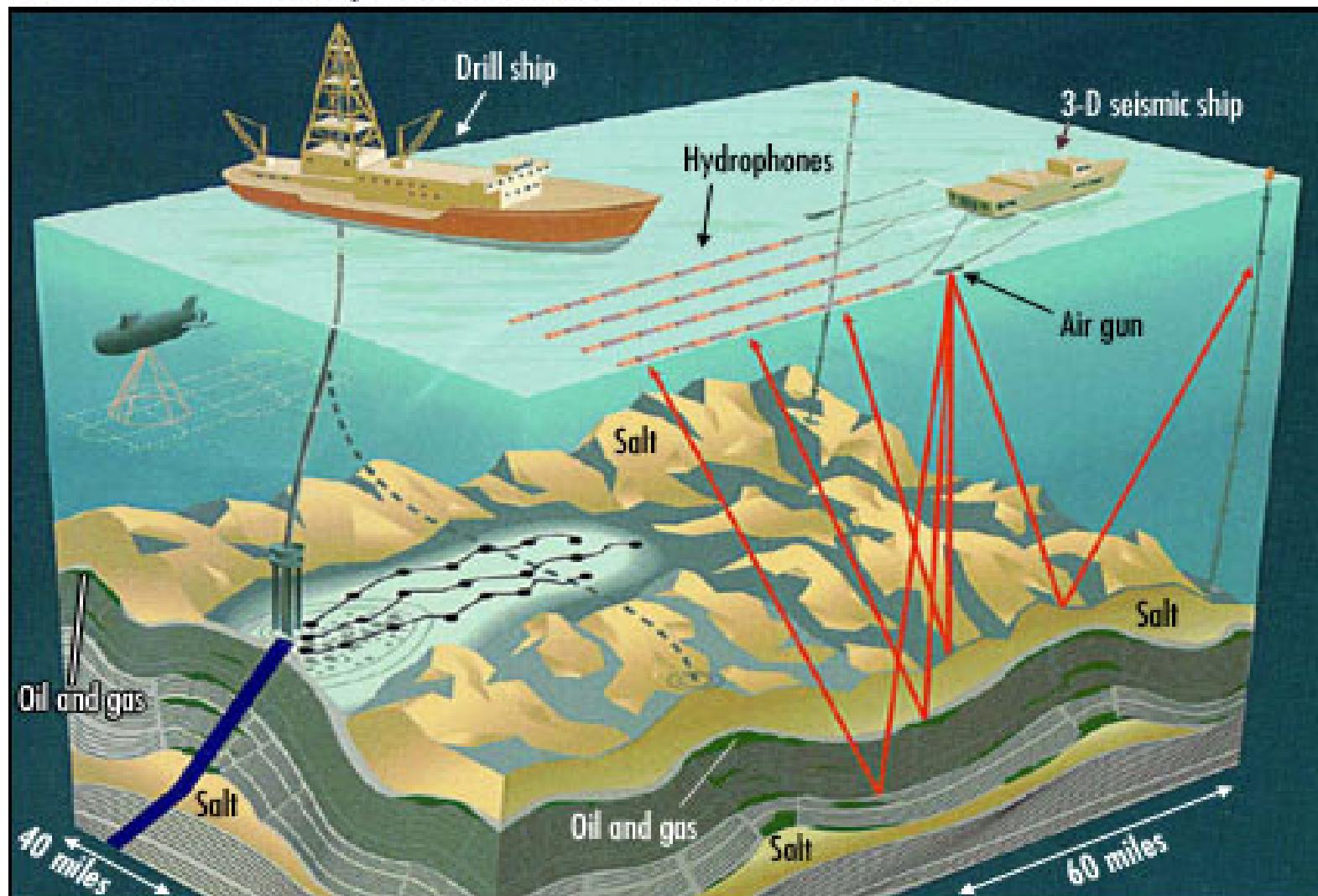
- Surveillance



# Digital Image Processing

- Seismology 3-D Seismic Imaging At Work

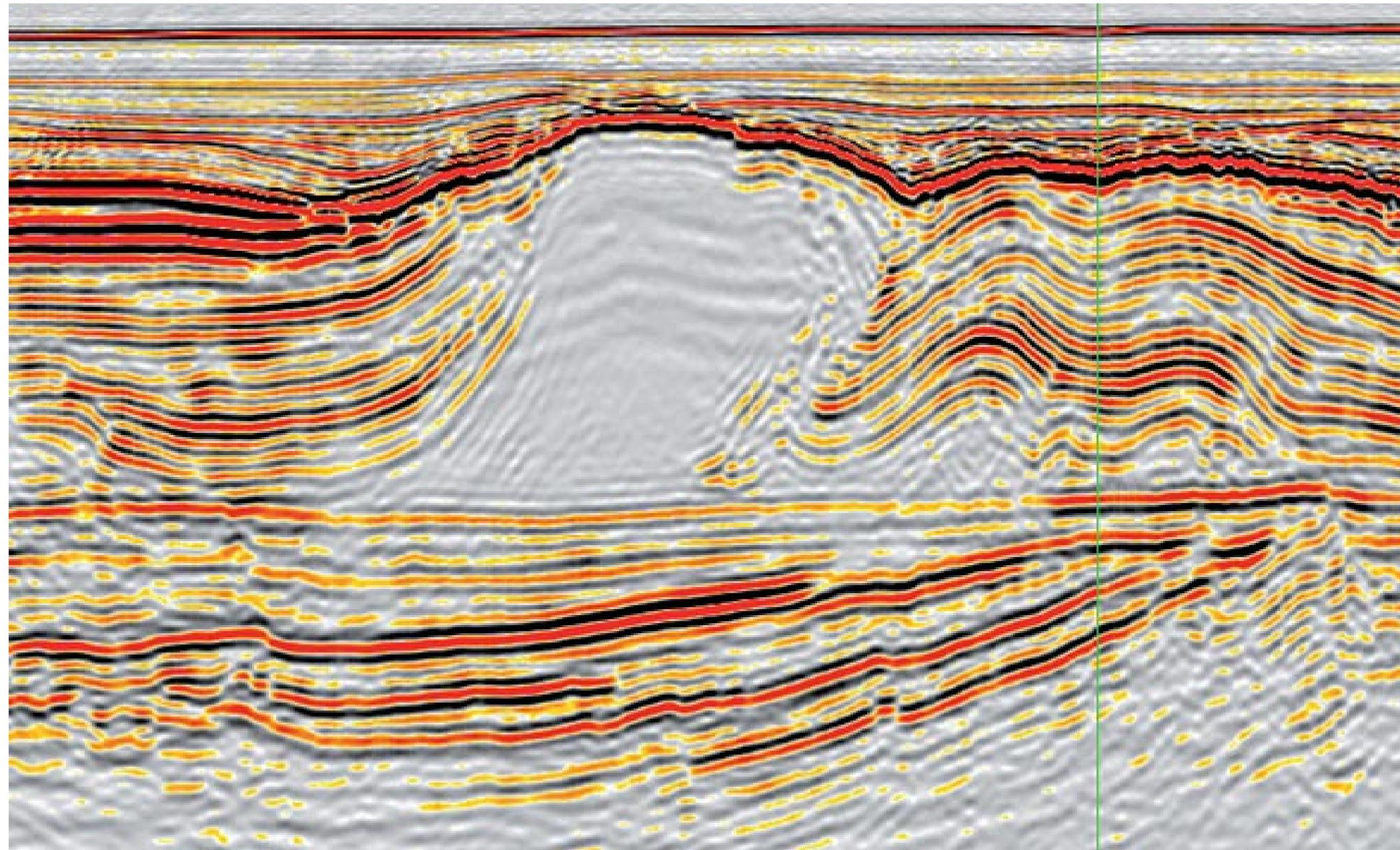
Hydrophones streaming from a 3-D seismic ship record the reflection of sound waves as they bounce back from subsalt surfaces.



Credit: Hutchins, A.E. and Anderson, R.N. (Eds.), World Oil's 4-D Seismic Handbook, Gulf Publishing, 1997.

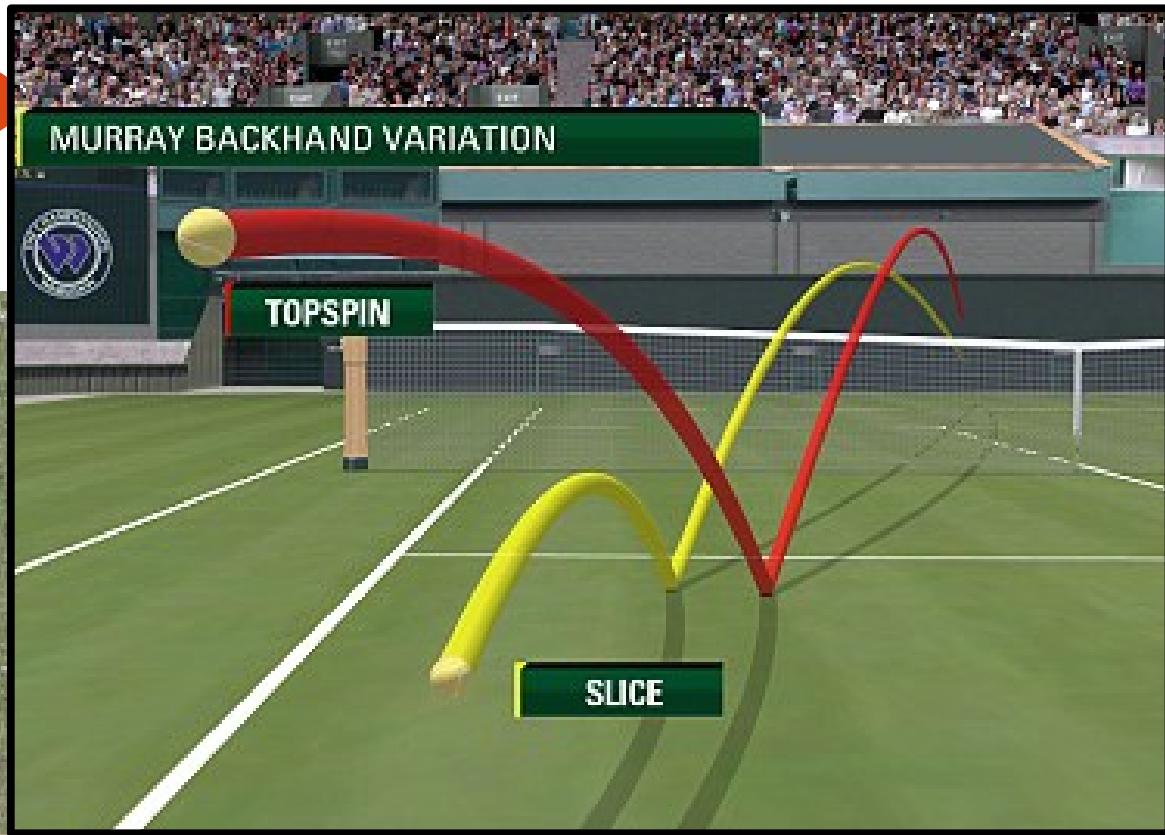
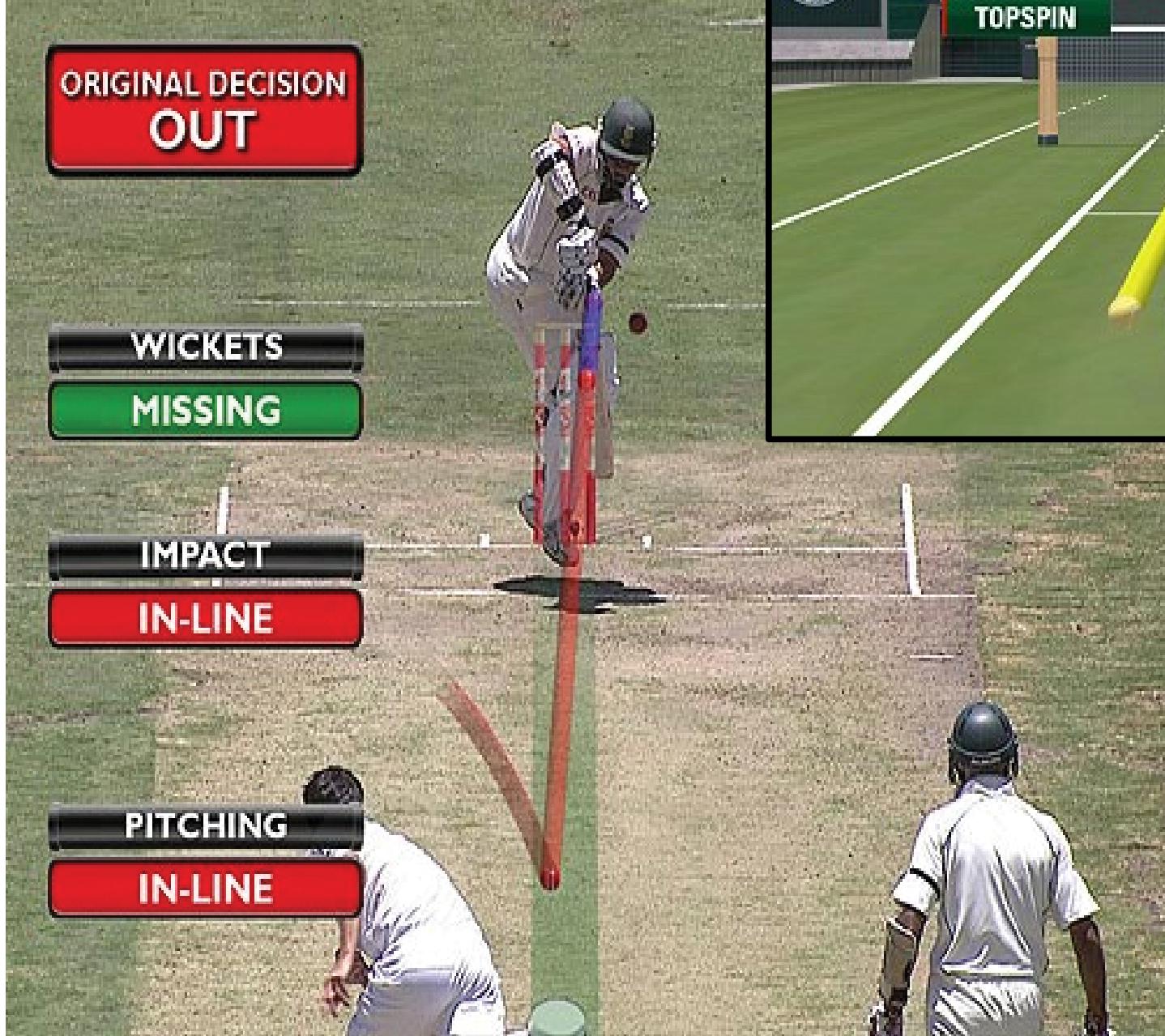
# Digital Image Processing

- Seismology



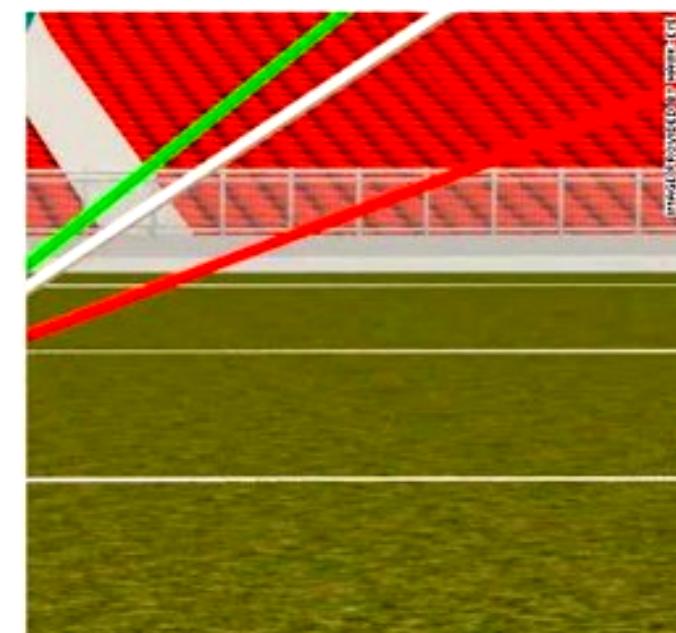
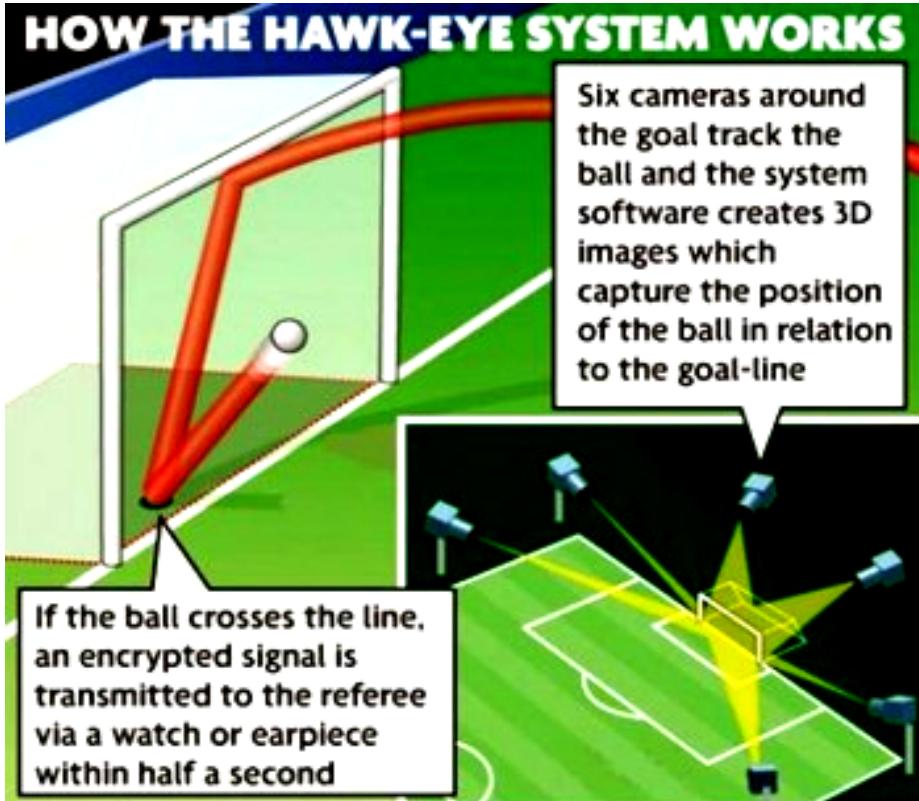
# Digital Image Pro

- Sports



# Digital Image Processing

- Sports



# Digital Image Processing

- Assignments (~45%)
  - How many ? 5-6
  - Implement algorithms
    - Experiment with real / simulated image data
  - Groups of 3 or less
- Tests etc.
  - Mid-sem exam (~20%)
  - End-sem exam (~20%)
- Course project (~15%)
  - Groups of 3 or less
  - Presentation + viva voce examination

# Digital Image Processing

- Attendance policy
  - <http://www.iitb.ac.in/newacadhome/rules/newugrules.html>
    - “Attendance in classes is compulsory and will be monitored.”
    - “A student not having 80 per cent attendance may be debarred from appearing in the semester-end examination and given XX grade and such student has to re-register for the same course.”
    - “In general, the institute expects 100% attendance.”
    - “The 80% attendance is permitted only for health or other emergency situation.”
    - “A medical certificate from IITB hospital or Government hospital is necessary for getting leave on health grounds.”

# Digital Image Processing

- Plagiarism policy
  - <http://www1.iitb.ac.in/newacadhome/punishments201521July.pdf>
    - “A student found copying in an assignment/laboratory project is given a zero in the assignment/project and is further given a one grade penalty.”
    - “The same disciplinary action is taken against both the person copying and the person from whom the material was copied.”

# Digital Image Processing

- Audit
  - Meet instructor(s)
  - Need to submit all assignments
  - 100% attendance required, unless valid reasons

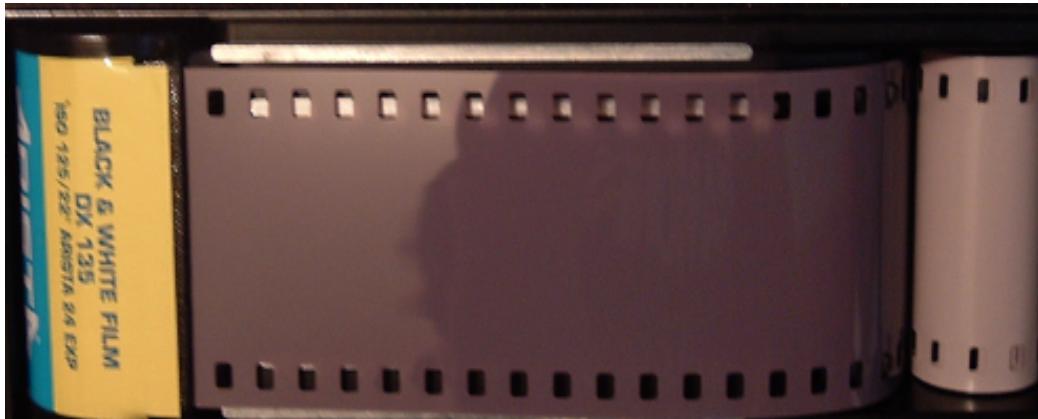
# Signals

- Function

- Types of domains :
  - Time : Stock-market index
  - **Space : Image**
  - **Space + Time : Video** (no sound)
- Types of ranges :
  - Integer, real
- Dimensions
  - $1 \rightarrow 1$  : Stock-market index
  - $2 \rightarrow 1$  : Photograph (black and white)
  - $3 \rightarrow 3$  : Video (color; no sound)

# Image

- “Analog” Image
  - Continuous function
    - No discretization, infinite “resolution”
  - Data acquired on photographic film (“negative”)



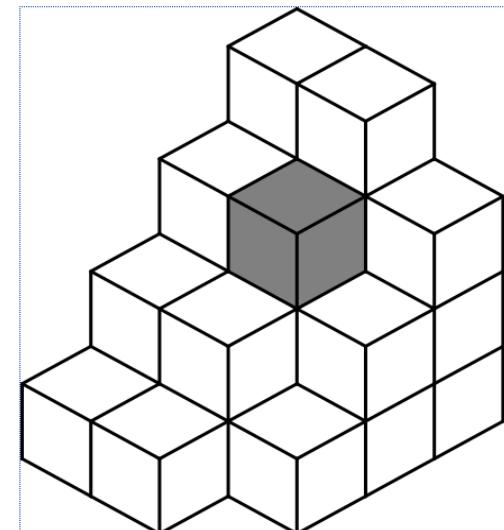
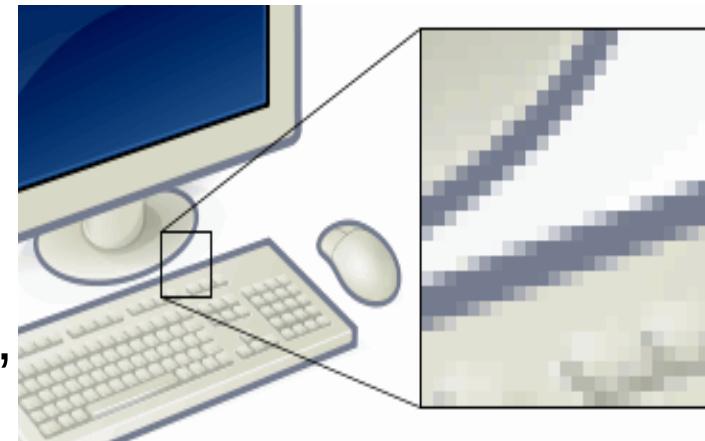
- This course **isn't** about analog images/signals

# Image

- Digital (Discrete) Image
  - **Array / grid** of numbers
    - Integers, Real
    - Signed, Unsigned (non negative)
    - Many dimensions
  - What makes data discrete ?
    - Acquisition
      - e.g., charge-coupled device (CCD) array in camera
    - Representation
      - e.g., digitization : analog print → scanned digital copy
- This course **is about digital images**

# Digital Image

- Digital image
  - For 2D domain
    - “picture element” = “pixel”
    - “pix” (pictures) + “el” (element) = “pixel”
    - Each pixel assigned a value / intensity
  - For 3D domain
    - “volume element” = voxel
    - Each voxel assigned a value / intensity



# Imaging

- Imaging = Process of acquiring the image
  - Taking a digital photograph
  - Taking an X-ray / CT / MRI scan
- 1) Imaging Hardware / Instrumentation
  - Camera lens system, SLR, ...
  - X-ray machine, MRI machine, ...
- 2) Imaging Physics
  - Camera → Optics
  - Ultrasound → Acoustics
  - MRI → Electromagnetism

# Imaging vs. Image Processing

- This course **isn't** about **imaging**
- This course **is** about **image processing**
  - Image data is given
  - Scanner is a black box
    - Don't know hardware details
      - e.g., what is inside photographic camera
    - Don't know physics details
      - -e.g., optics
    - Only know a high-level system specification
      - Transformation from physical quantity → data
      - e.g., objects and colors in scene → acquired image

# Programming

- Matlab ([www.mathworks.com](http://www.mathworks.com))
  - “Matrix Laboratory”
  - Matrix ~ multi-dimensional arrays
  - See [moodle.iitb.ac.in](http://moodle.iitb.ac.in) for useful information
    - Matlab license with IITB
    - Tutorials, Tips / Tricks
- OpenCV [www.opencv.org](http://www.opencv.org)
- Insight Toolkit (ITK) [www.itk.org](http://www.itk.org)

# Programming

- Matlab
  - A single environment for :
    - Coding
    - Visualization → plots, surfaces, images
    - Debugging
    - Profiling
  - Highly optimized for operations on / using matrices
  - Support for linear algebra, statistics, image processing
    - Toolboxes, ...

# Programming

- Matlab : Writing fast code
  - “profile” code
  - Use fewer loops (vectorize instead)
    - e.g., for matrix-vector multiplication
    - Replace loops by operations on arrays
  - Use built-in functions

# Programming

- Matlab : Writing fast code
  - examples

[www.mathworks.in/help/matlab/matlab\\_prog/vectorization.html](http://www.mathworks.in/help/matlab/matlab_prog/vectorization.html)

This code computes the sine of 1,001 values ranging from 0 to 10:

```
i = 0;  
for t = 0:.01:10  
    i = i + 1;  
    y(i) = sin(t);  
end
```

This is a vectorized version of the same code:

```
t = 0:.01:10;  
y = sin(t);
```

```
function d = minDistance(x,y,z)  
    % Find the min distance between a set of points and the origin  
  
    d = sqrt(x.^2 + y.^2 + z.^2);      % Compute distance for every point  
    d = min(d);                        % Get the minimum distance
```

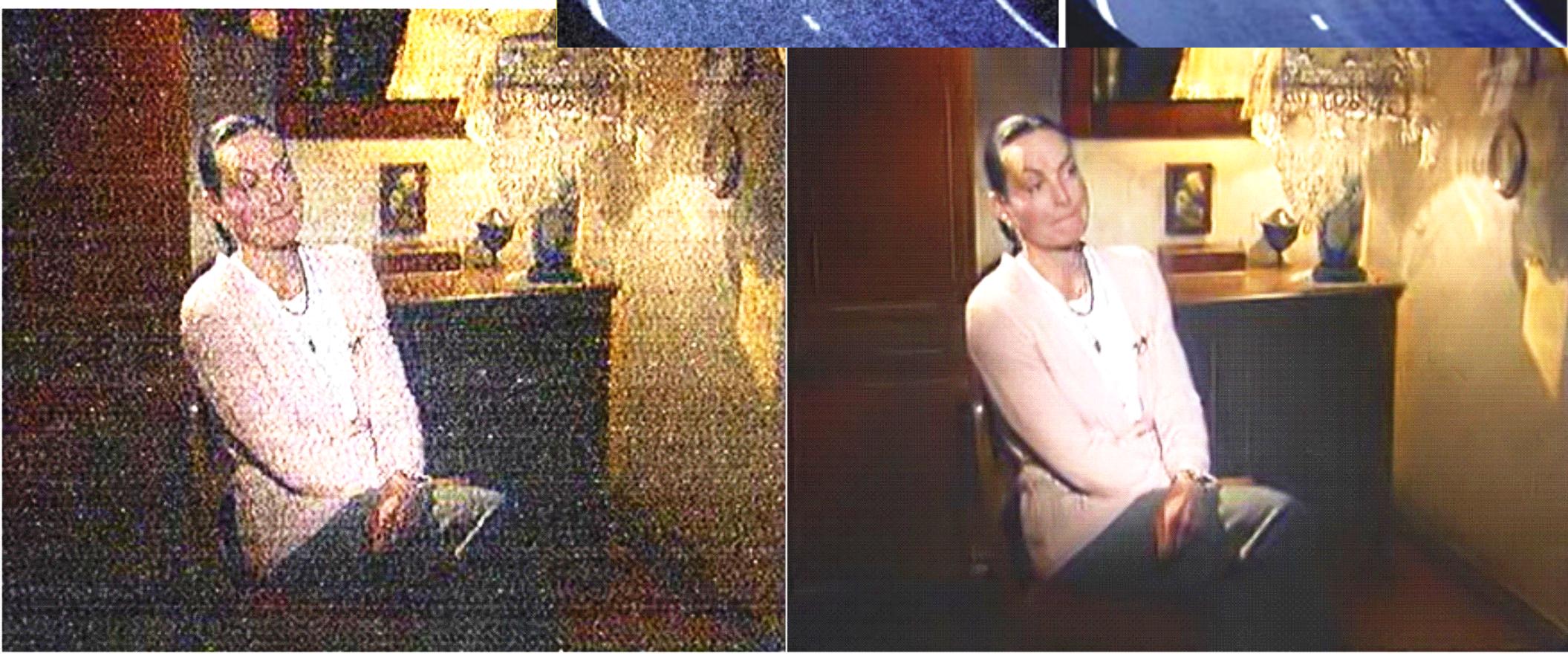
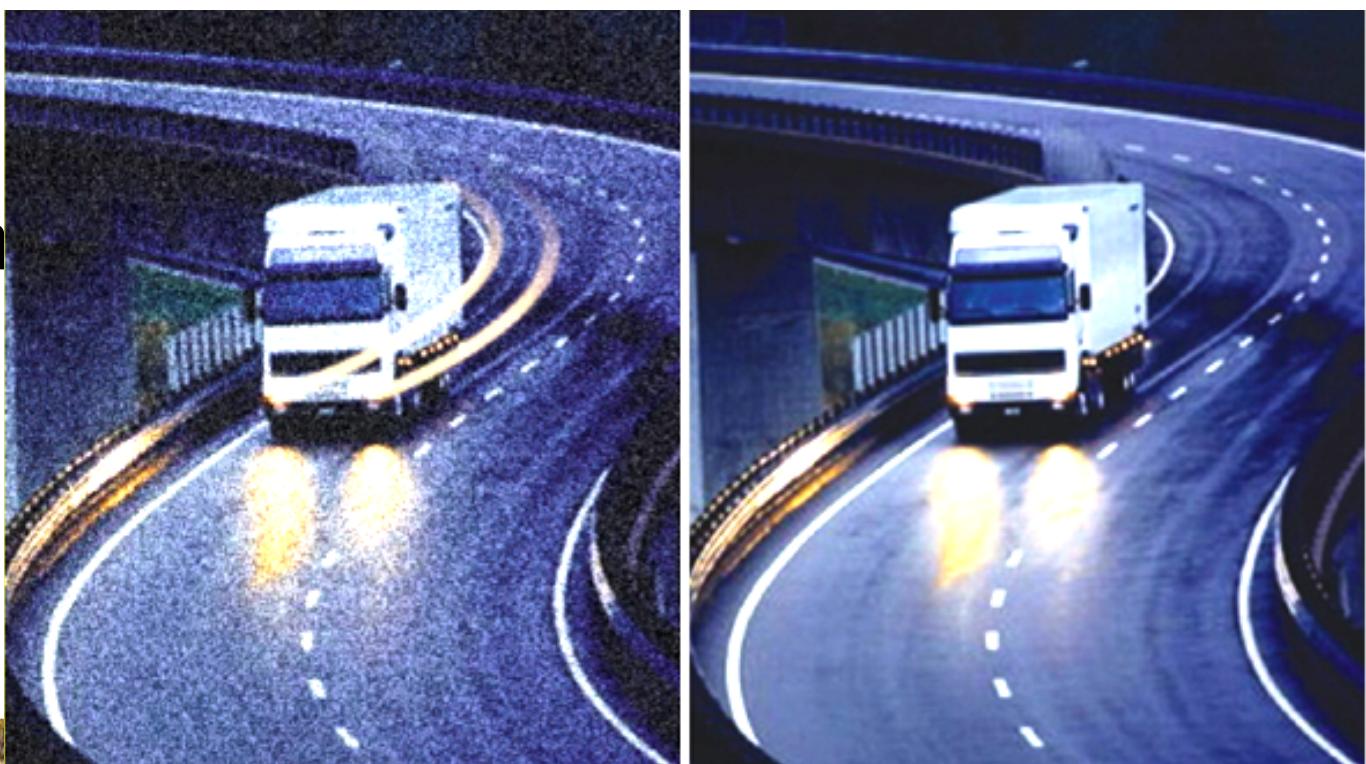
# Applications

- Image enhancement
  - e.g., contrast increase
  - e.g., sharpen



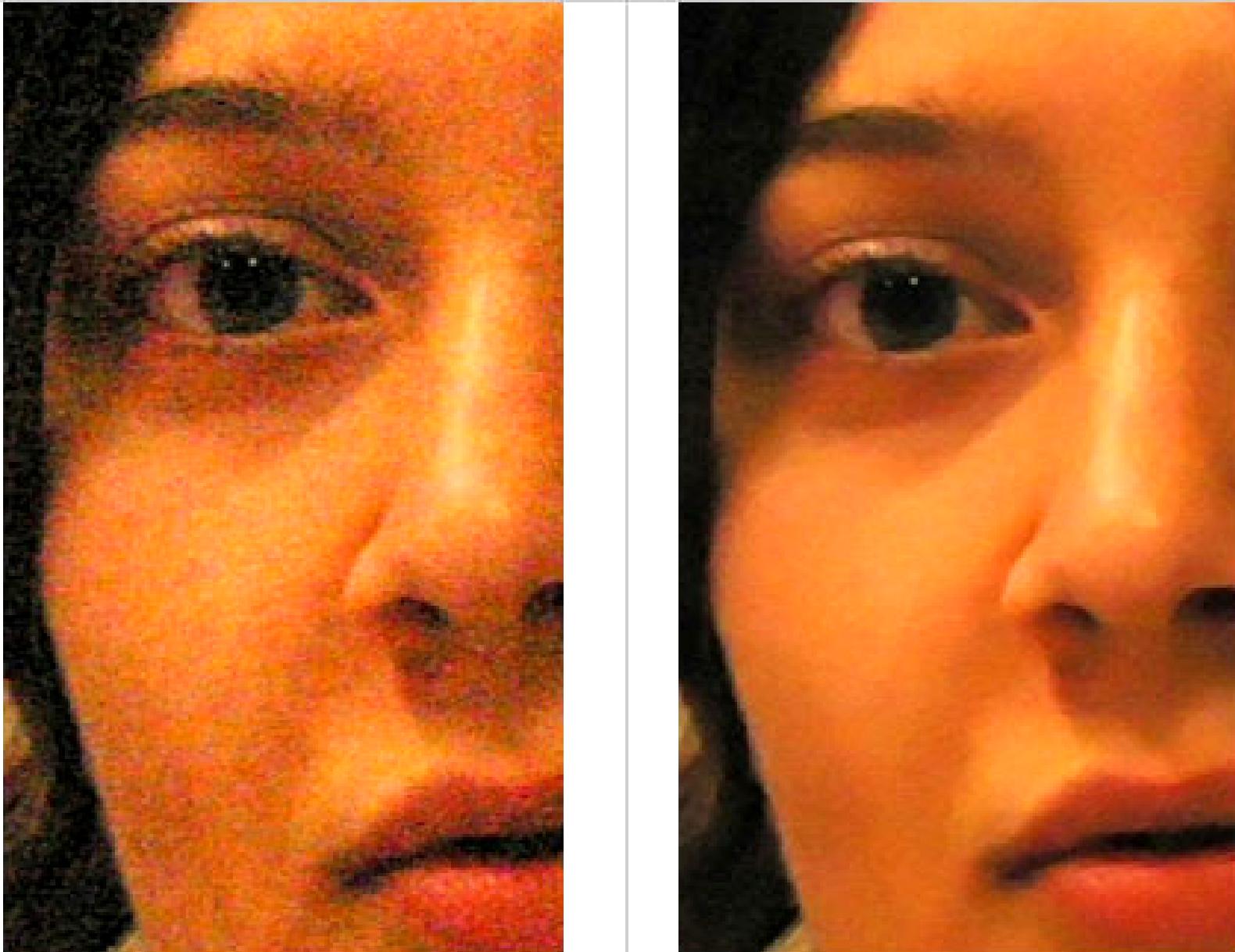
# Applications

- Image restoration
  - Denoising



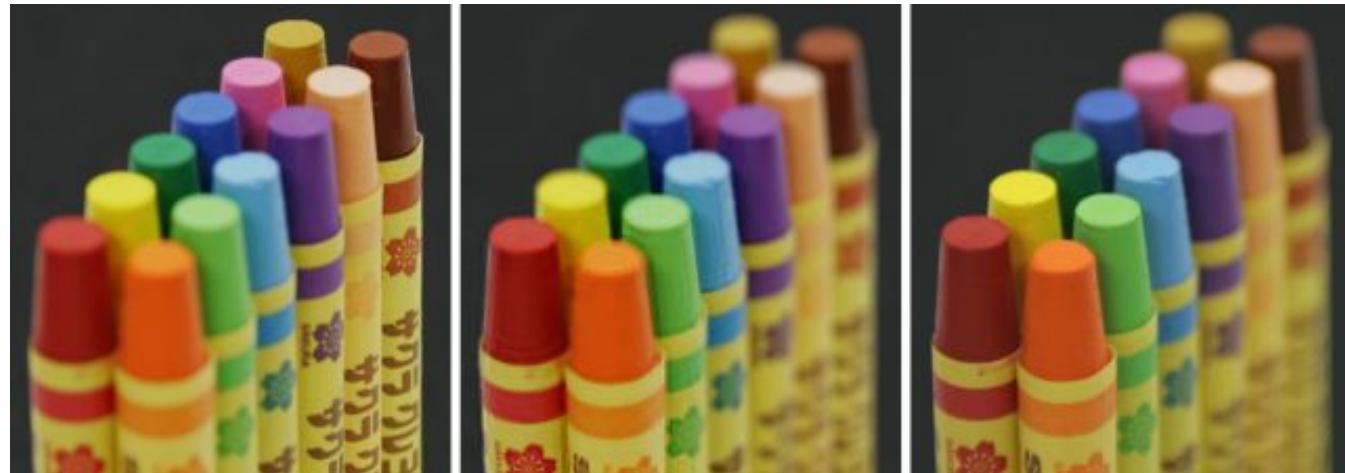
# Applications

- Image restoration
  - Denoising



# Applications

- Image restoration
  - Deblurring
  - Refocusing



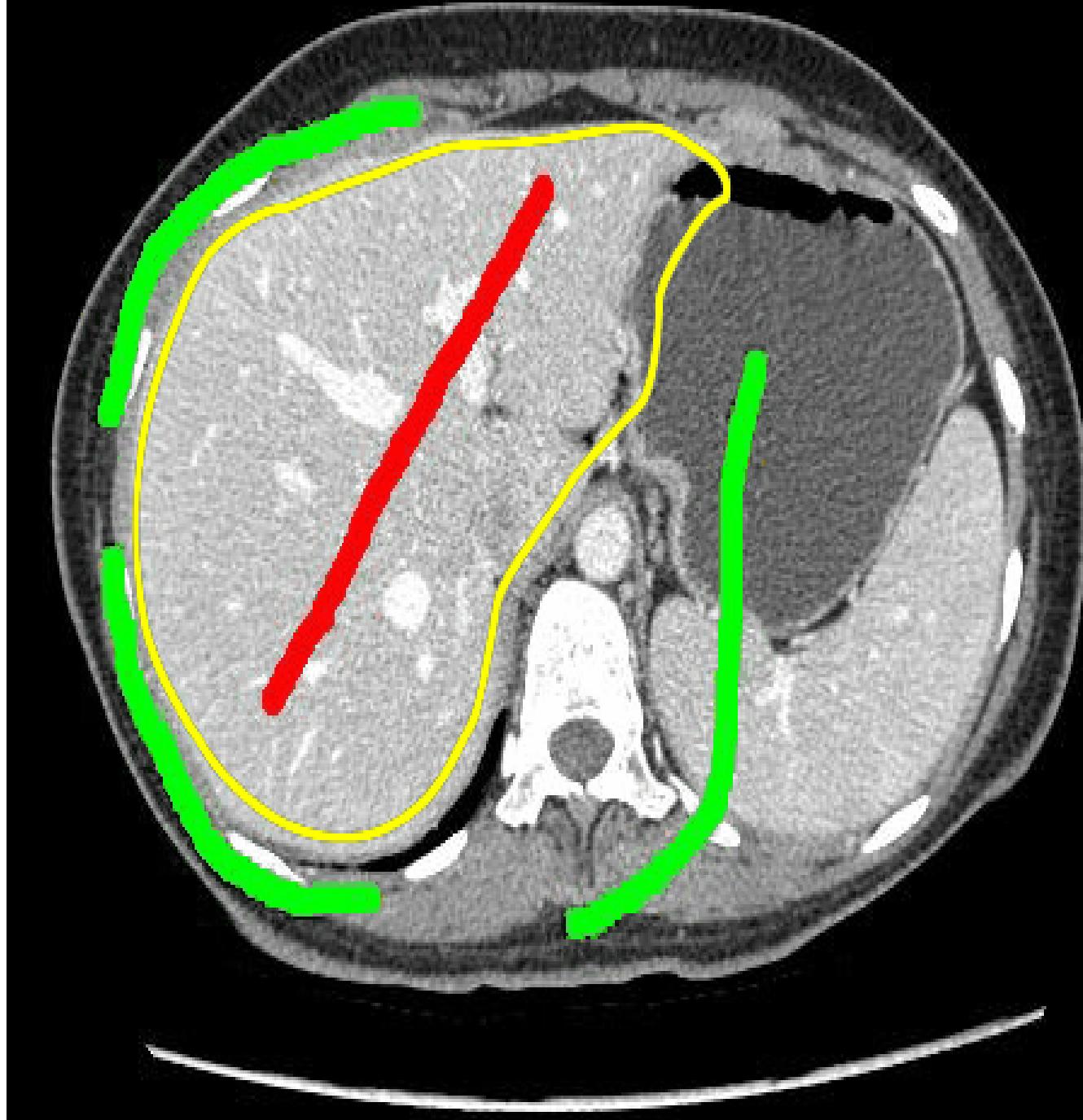
# Application

- Image segmentation



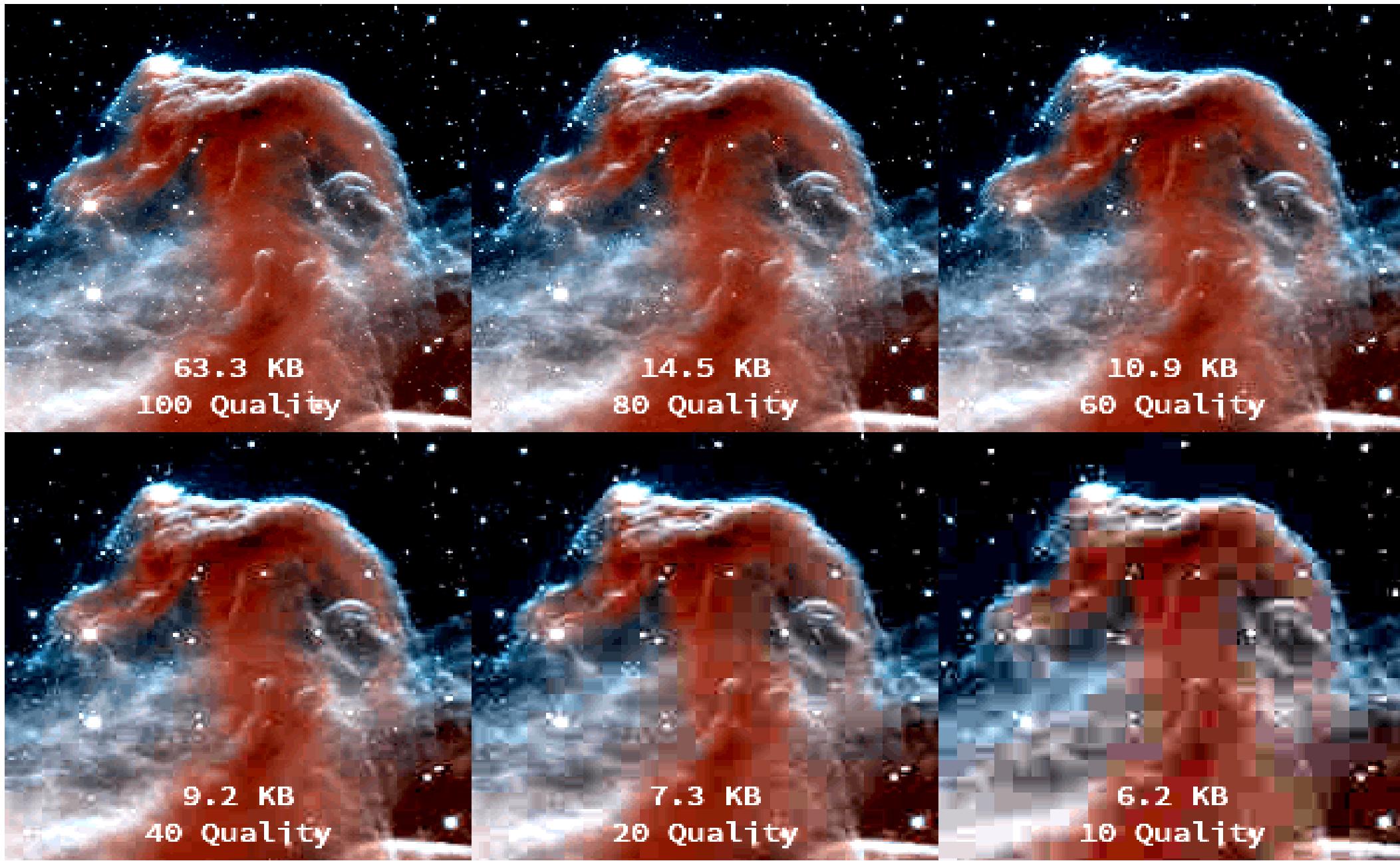
# Applications

- Image segmentation



# Applications

- Image and video compression



# Applications

- Face recognition

