Lecture-01

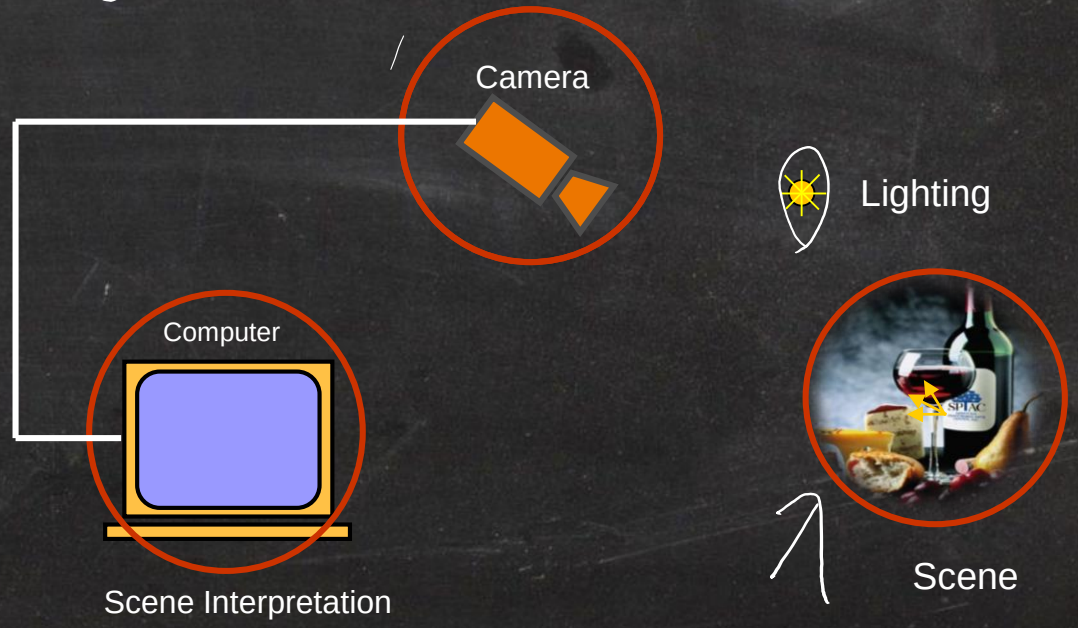
Introduction to Computer Vision

What is vision?

- Recognize objects
  - people we know
  - things we own
- Locate objects in space
  - to pick them up
- Track objects in motion
  - catching a baseball
  - avoiding collisions with cars on the road
- Recognize actions
  - walking, running, pushing

What is computer vision?

- CV is defined as a field of study that seeks to develop techniques to help computers "see" and understand the content of digital images



What is computer vision?

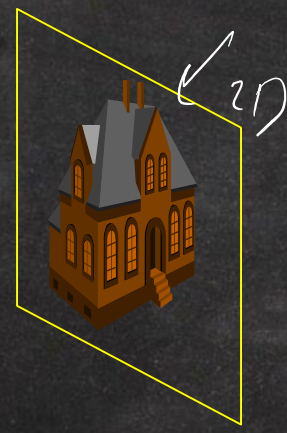
- Goal of computer vision is to write computer programs that can interpret images
- Also called
  - Image Understanding
  - Image Analysis
  - Machine Vision

Why is vision so difficult?

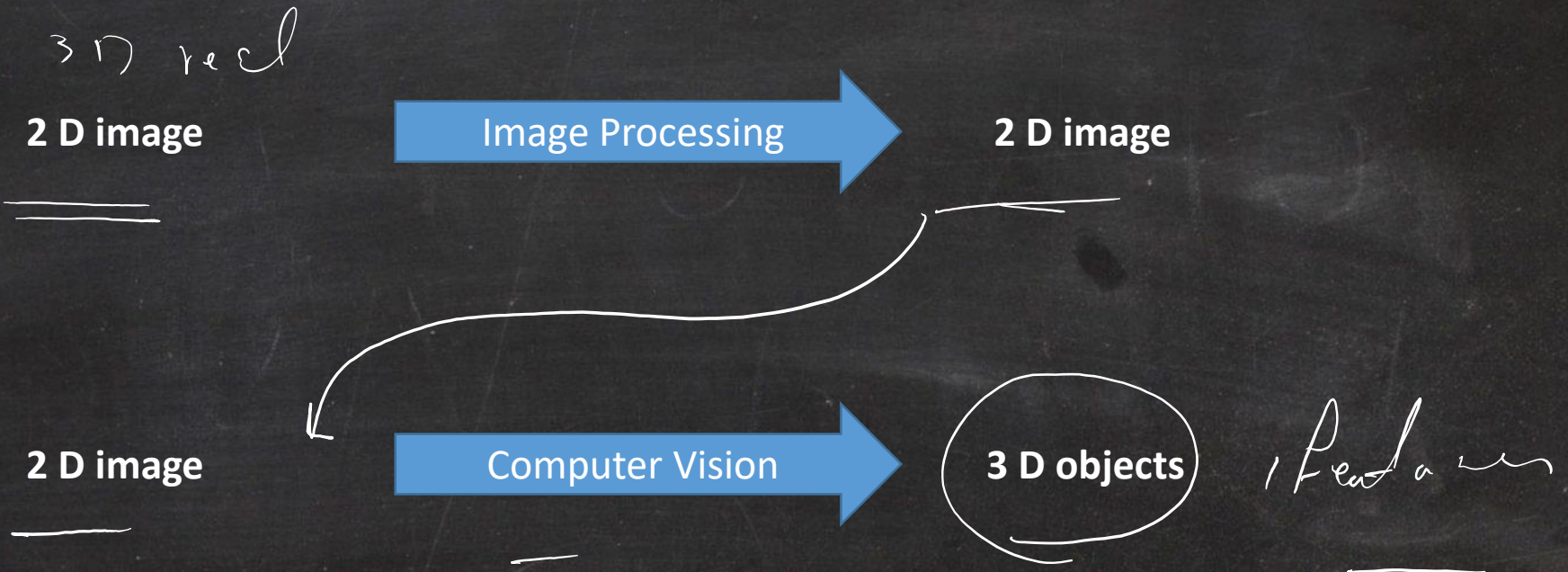
- because vision is an inverse problem.

graphics

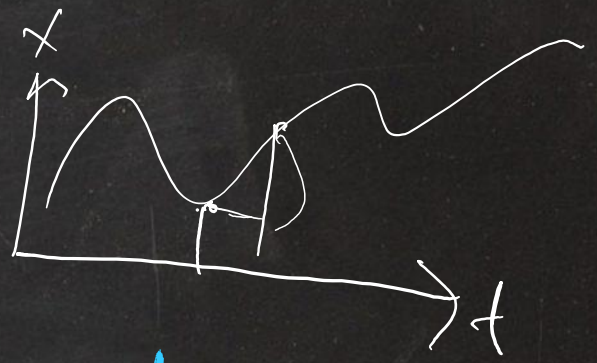
vision



Computer Vision and Image Processing



Mathematical tools



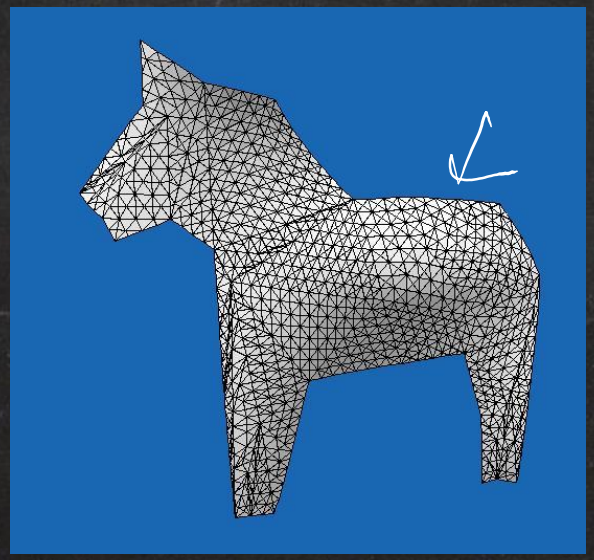
- Linear algebra → Matrix
- Vector calculus
- Euclidean geometry
- Projective geometry
- Differential geometry
- Differential equations
- Numerical analysis
- Probability and statistics

$y = f(x)$

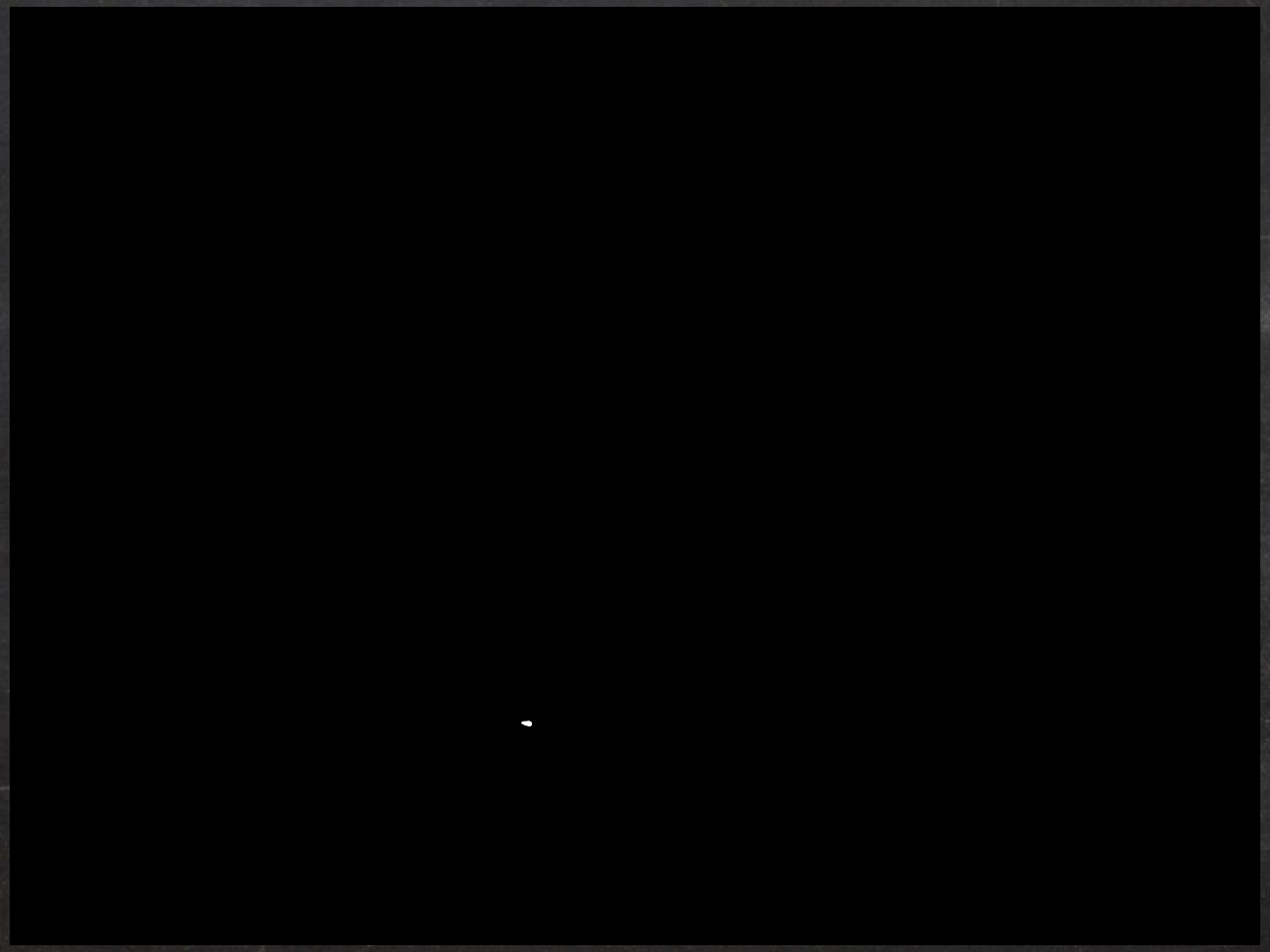
$\frac{dy}{dx}$

$z = f(x, y)$

Applications: 3D Reconstruction



Applications: Augmented Reality



Applications: Panoramic Mosaics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+ ... +

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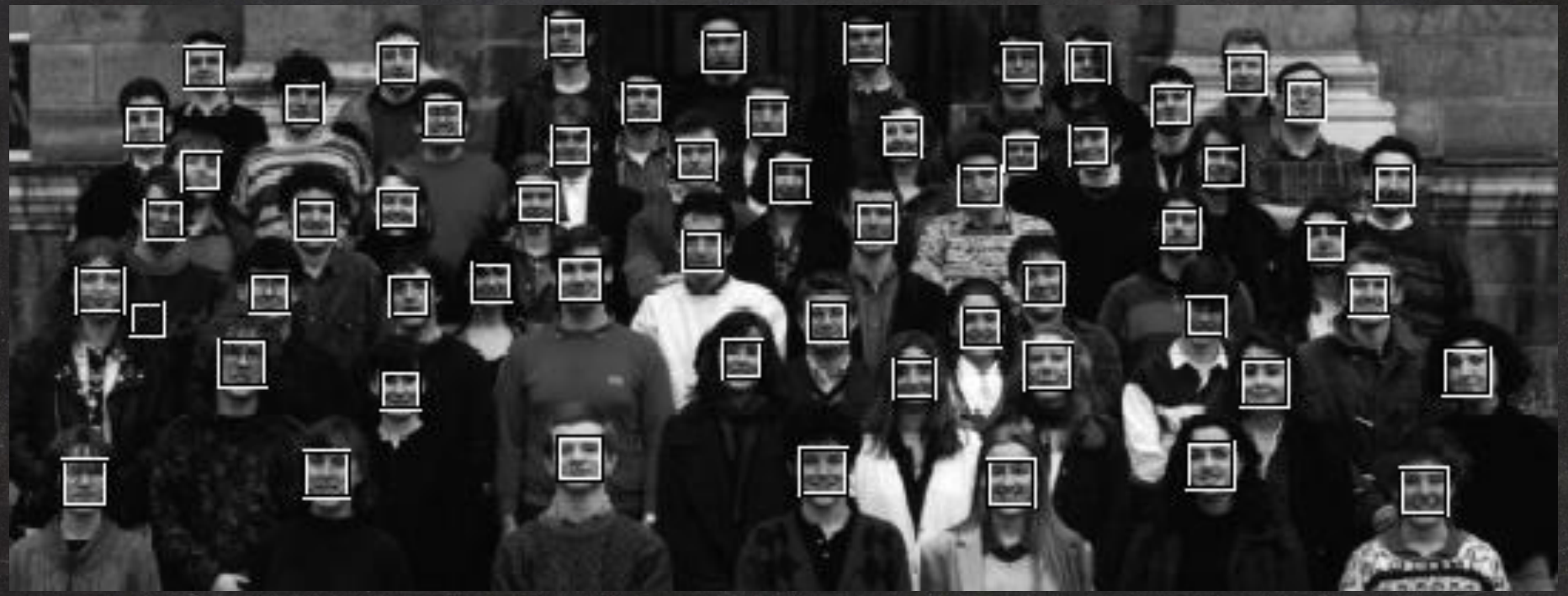
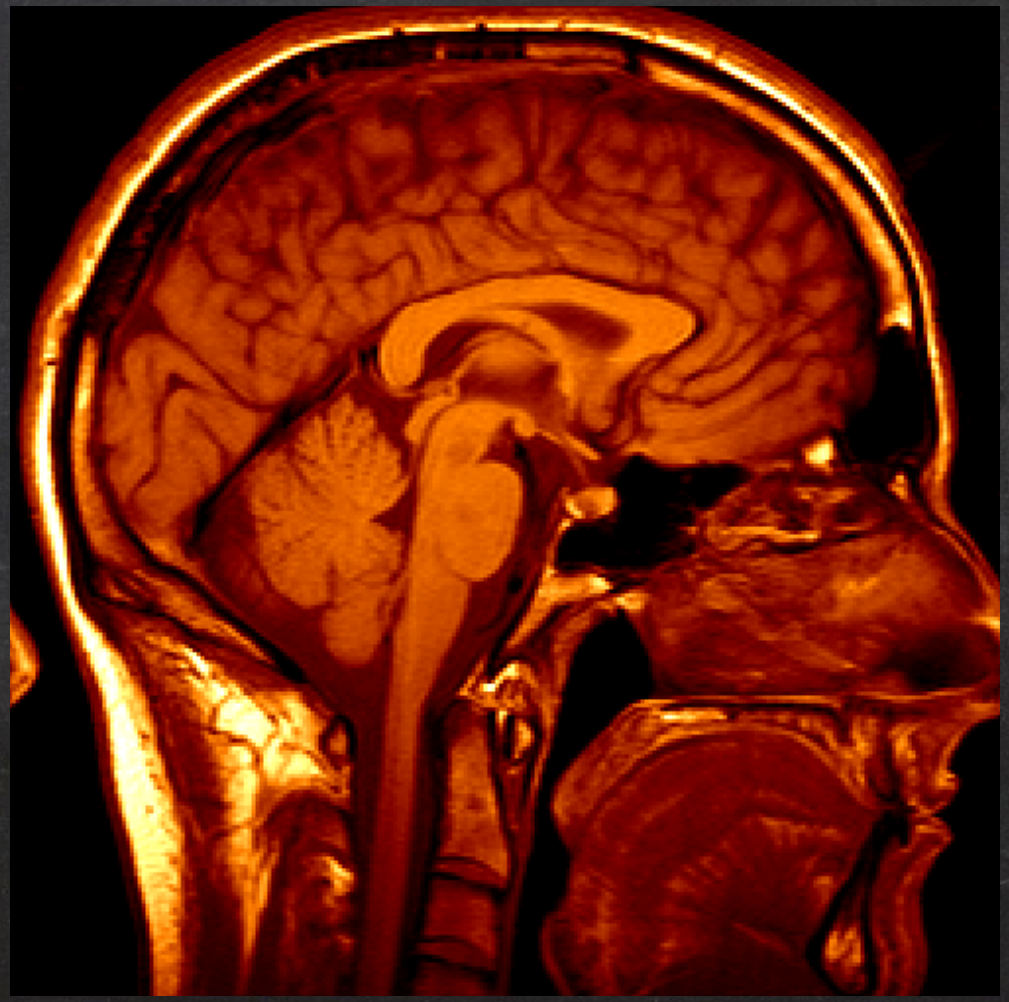
Applications: Recognition



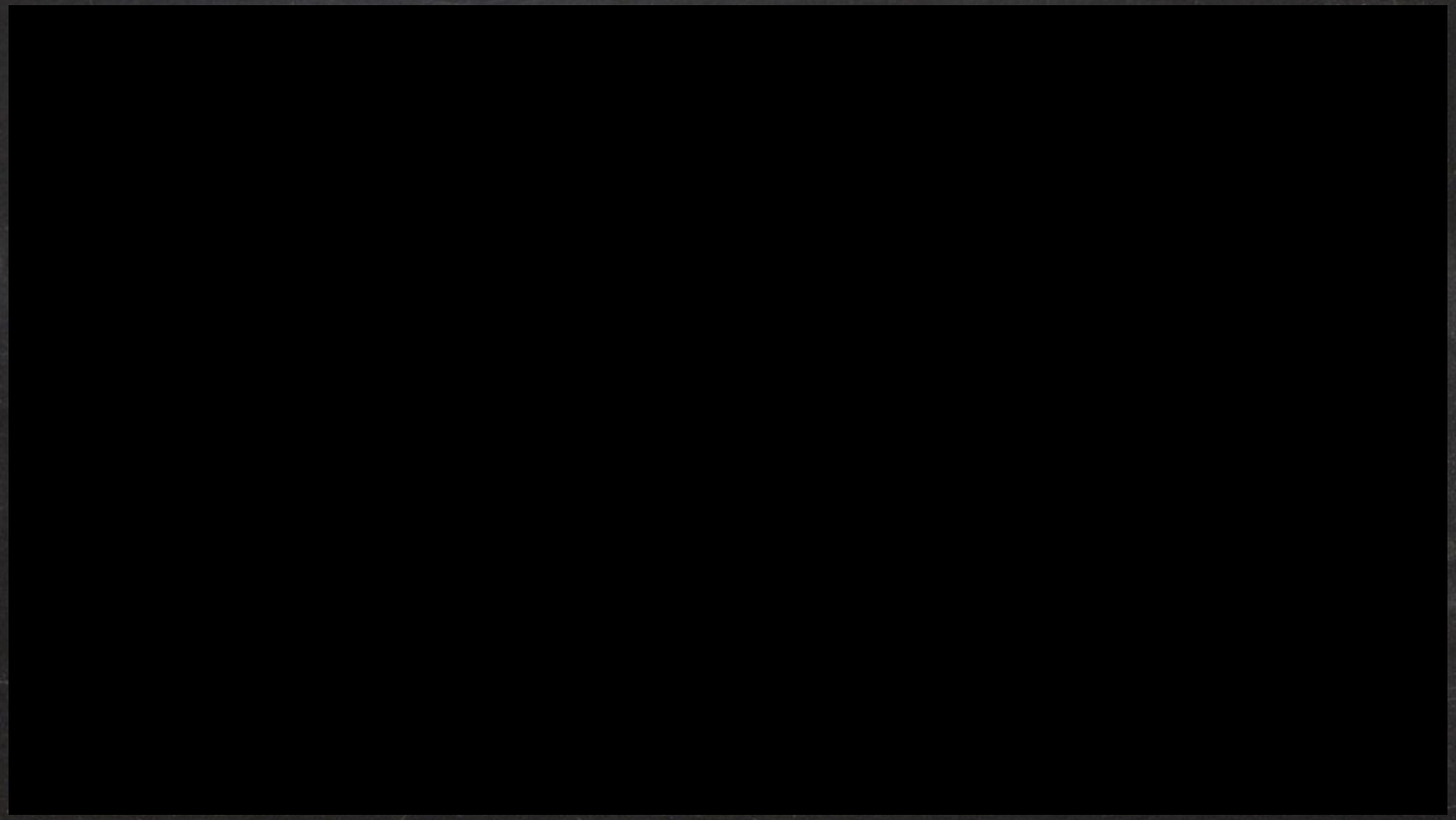
Applications: shape capture

Applications: motion capture

Applications: Medical Imaging

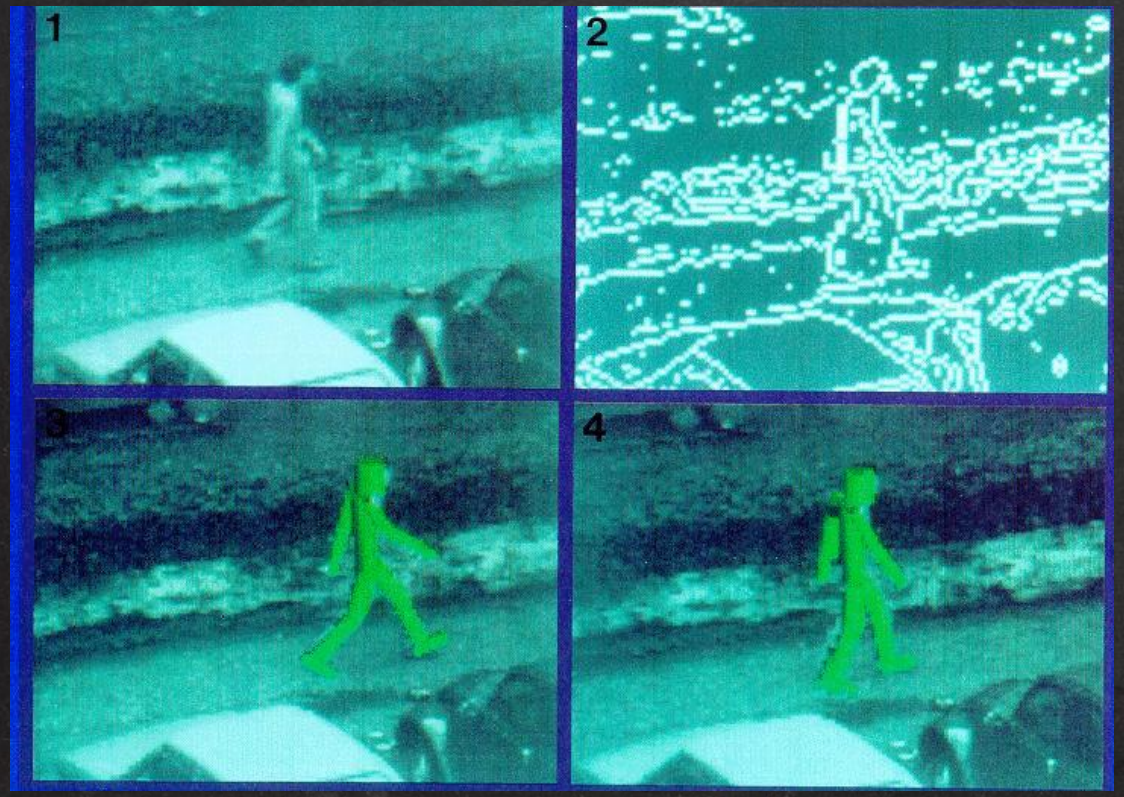


Autonomous Vehicle

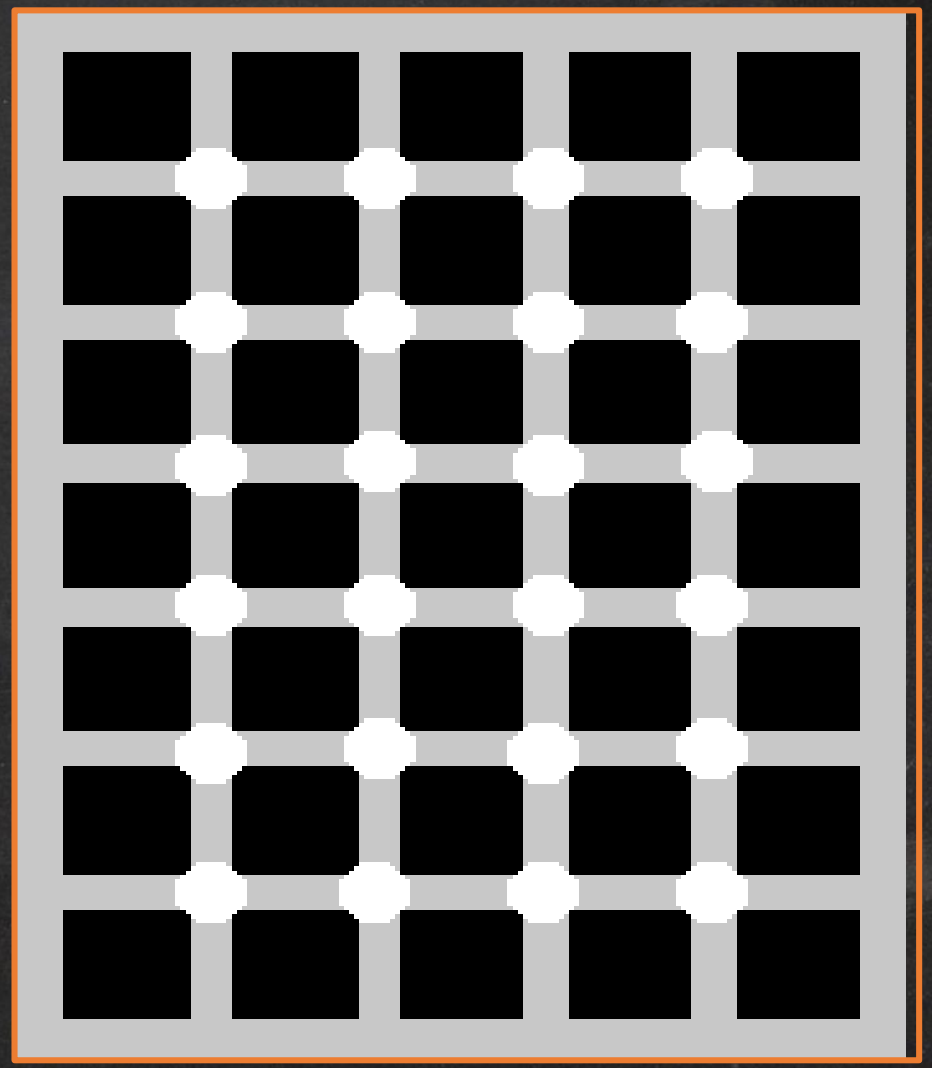


Applications: Robotics

Applications: Surveillance



Perceptual psychologists have spent decades trying to understand how the visual system works and, even though they can devise optical illusions to tease apart some of its principles



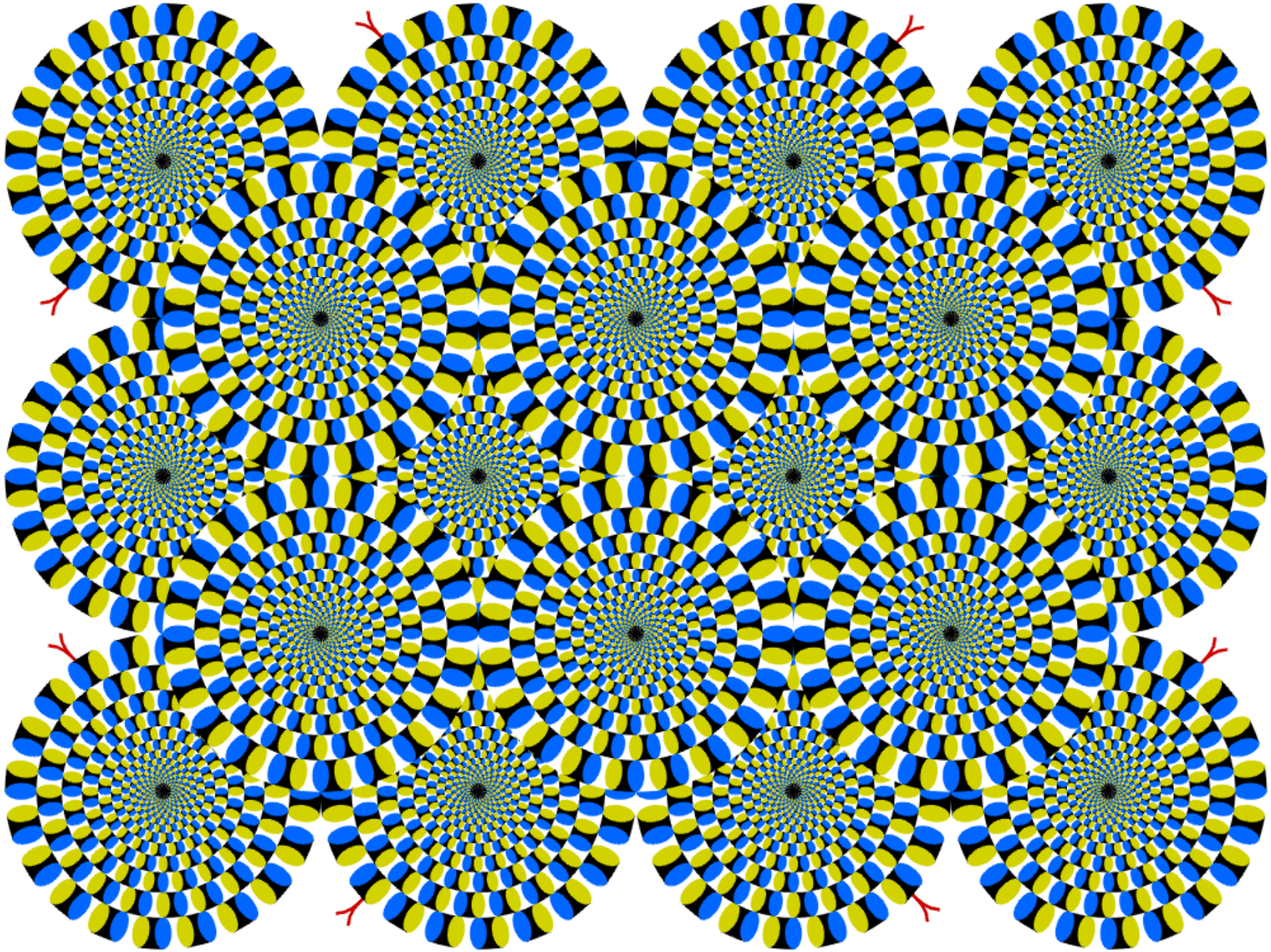


Image formation

- In modeling the image formation process, images are made up of discrete color or intensity values.

  Where do these values come from? How do they relate to the lighting in the environment, surface properties and geometry, camera optics, and sensor properties?

Image formation

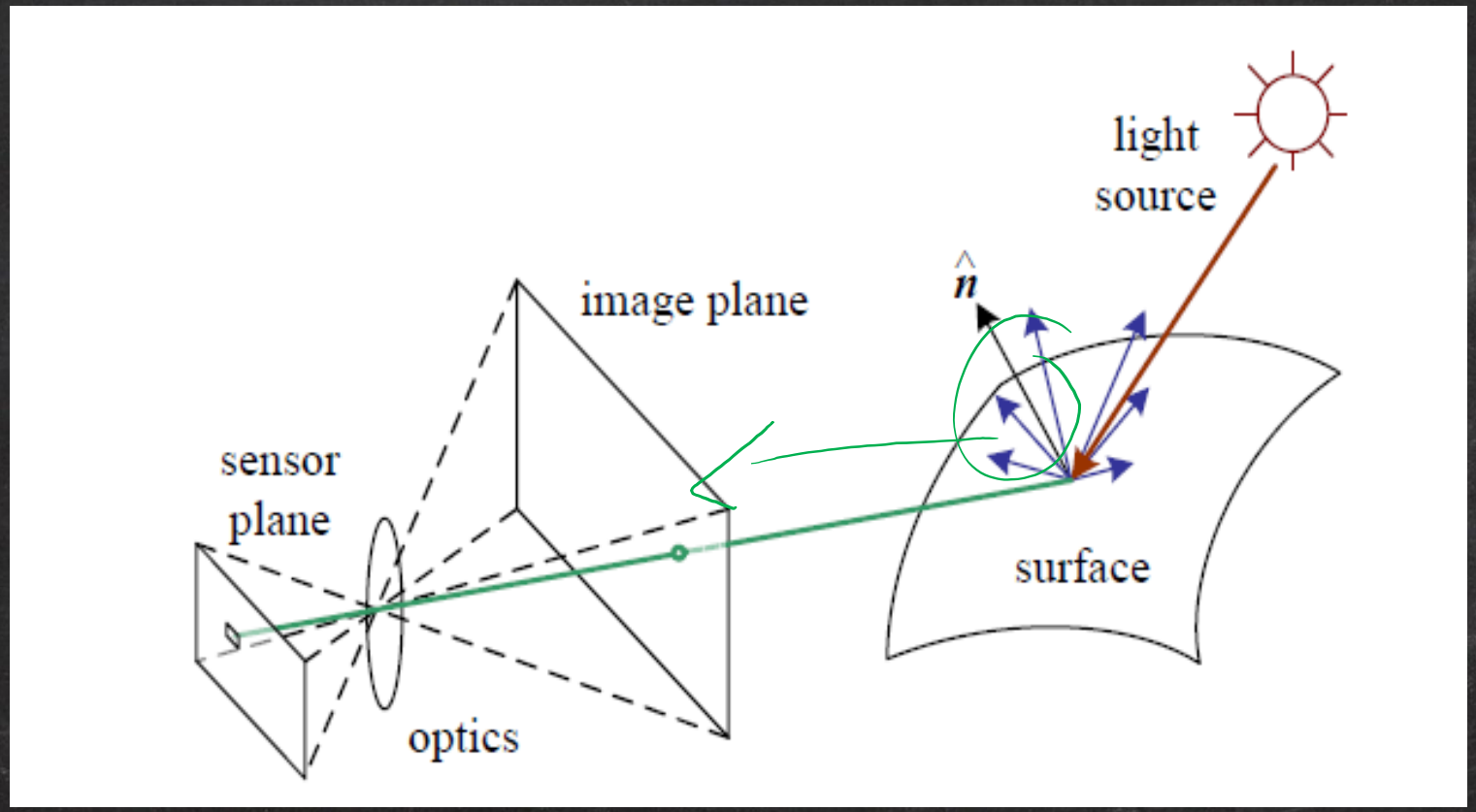


Image formation - Lighting

- Images cannot exist without light.
- To produce an image, the scene must be illuminated with one or more light sources.
- A point light source originates at a single location in space.
- In addition to its location, a point light source has an intensity and a color spectrum, i.e., a distribution over wavelengths

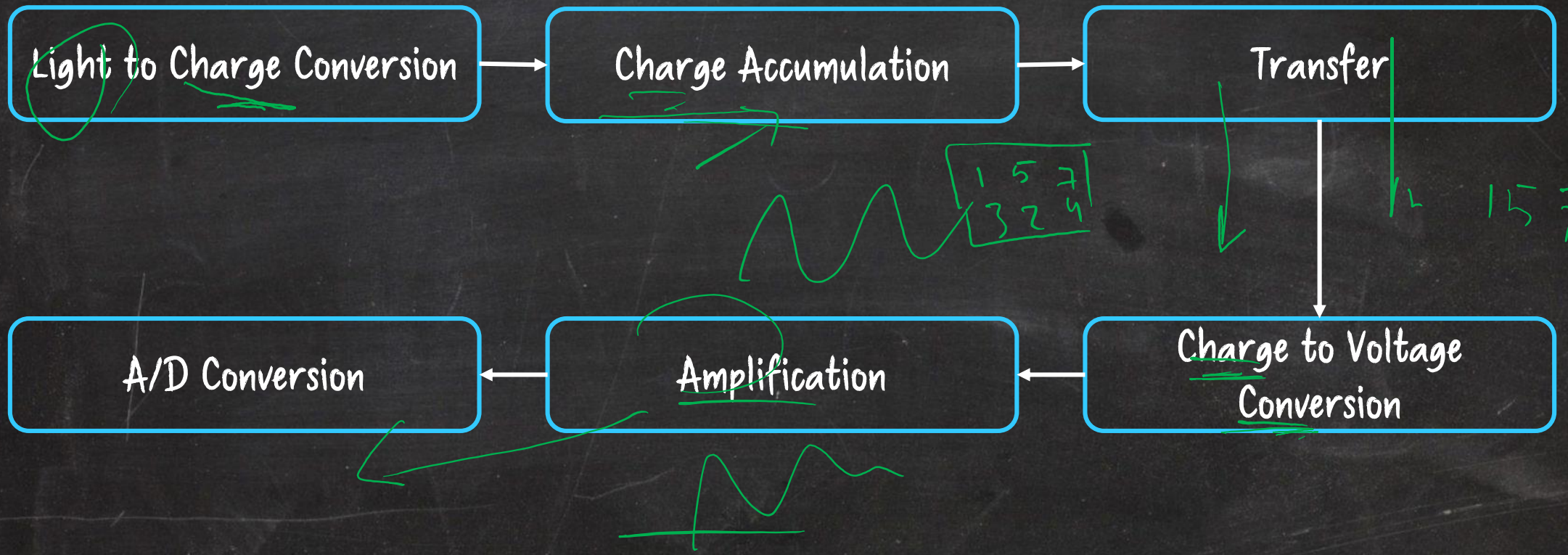
Image formation - Lighting

- The intensity of a light source falls off with the square of the distance between the source and the object being lit

The digital camera

- After starting from one or more light sources, reflecting off one or more surfaces in the world, and passing through the camera's optics (lenses), light finally reaches the imaging sensor.

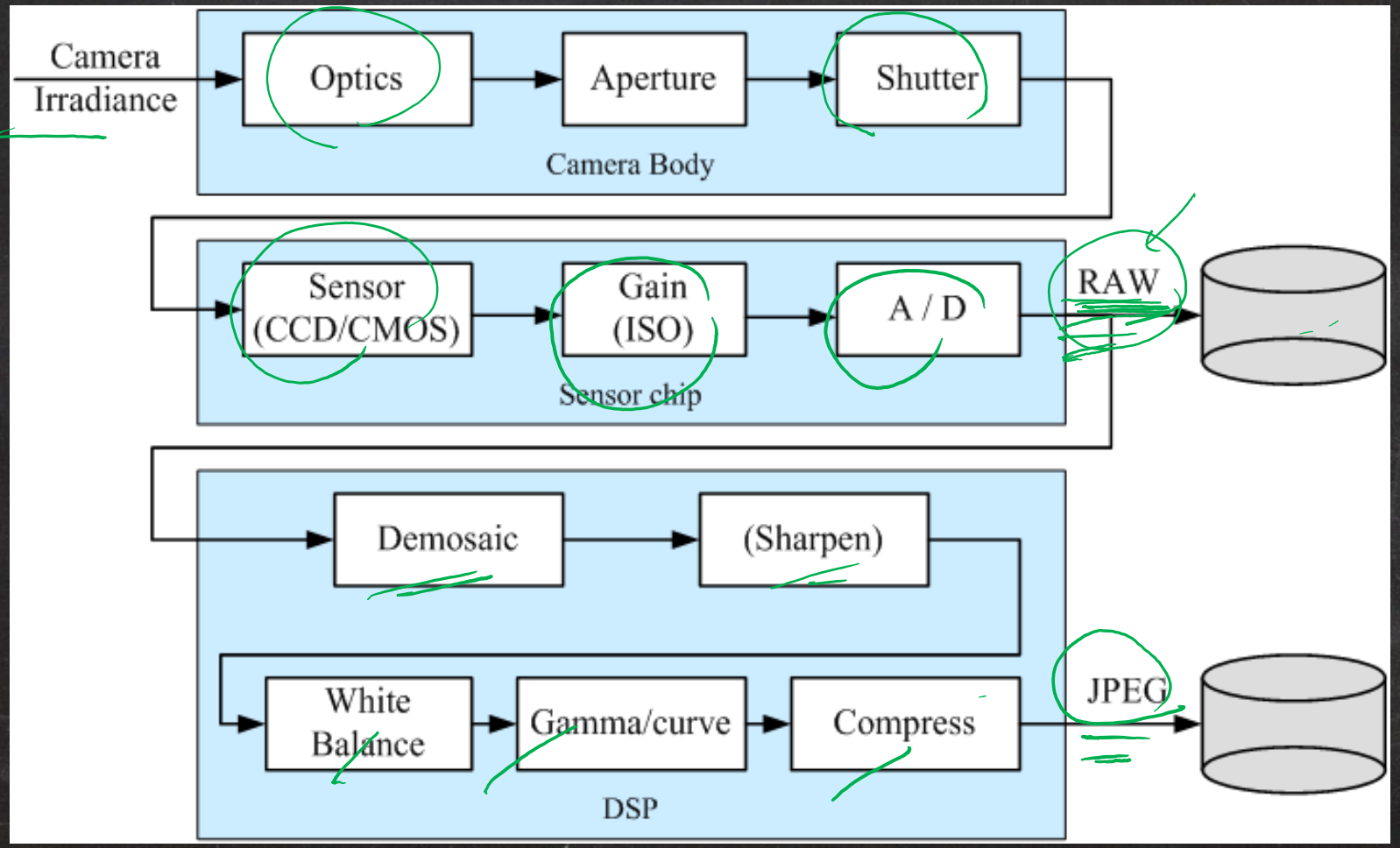
The digital camera sensor



The digital camera

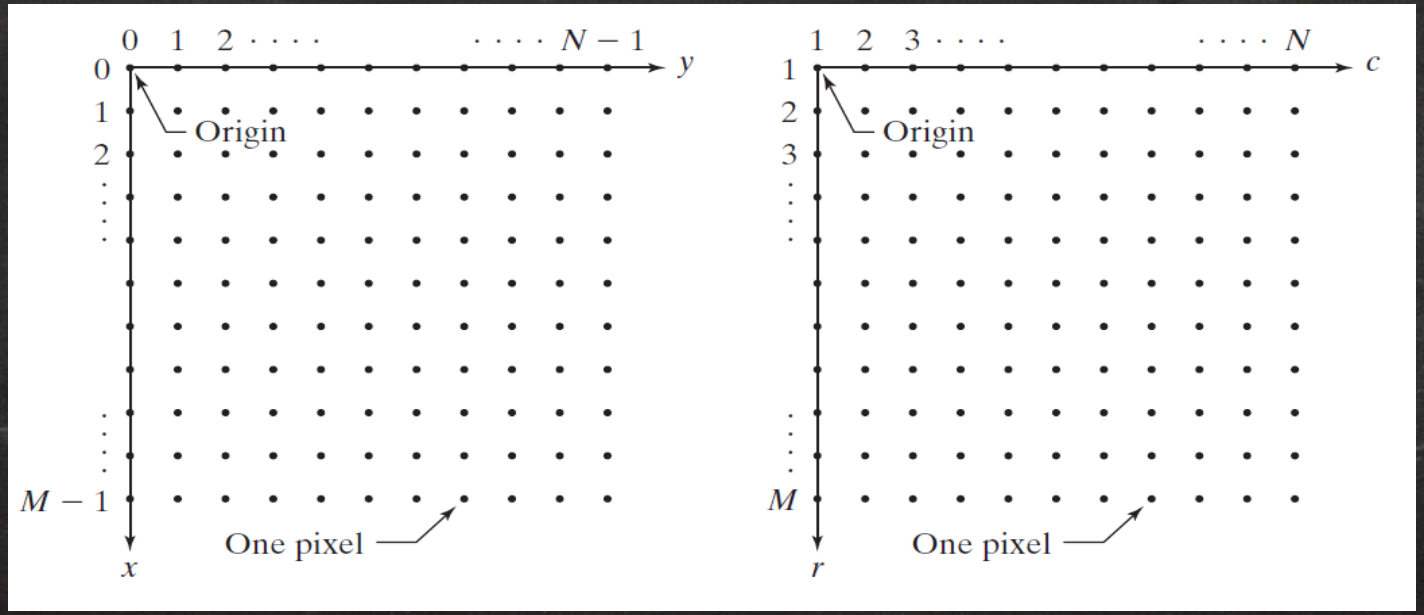
- The two main kinds of sensor used in digital still and video cameras.
  - Charge-Coupled Device (CCD)
  - Complementary Metal Oxide on Silicon (CMOS).
- Report
  - What are differences between CCD and CMOS camera sensors?

Image sensing pipeline



Images as function

- Assume that an image $f(x, y)$ is sampled so that the resulting image has M rows and N columns



Images as function

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,N-1) \\ f(1,0) & f(1,1) & \cdots & f(1,N-1) \\ \vdots & \vdots & \vdots & \vdots \\ f(M-1,0) & f(M-1,1) & f(0,0) & f(M,N-1) \end{bmatrix}$$

- the values of the coordinates x, y are discrete quantities
- the amplitude of f at any pair of coordinates is called the intensity of the image at that point.
- Each element of this array is called an image element, picture element or pixel.