Machine Vision Introduction
MCHE 470: Robotics

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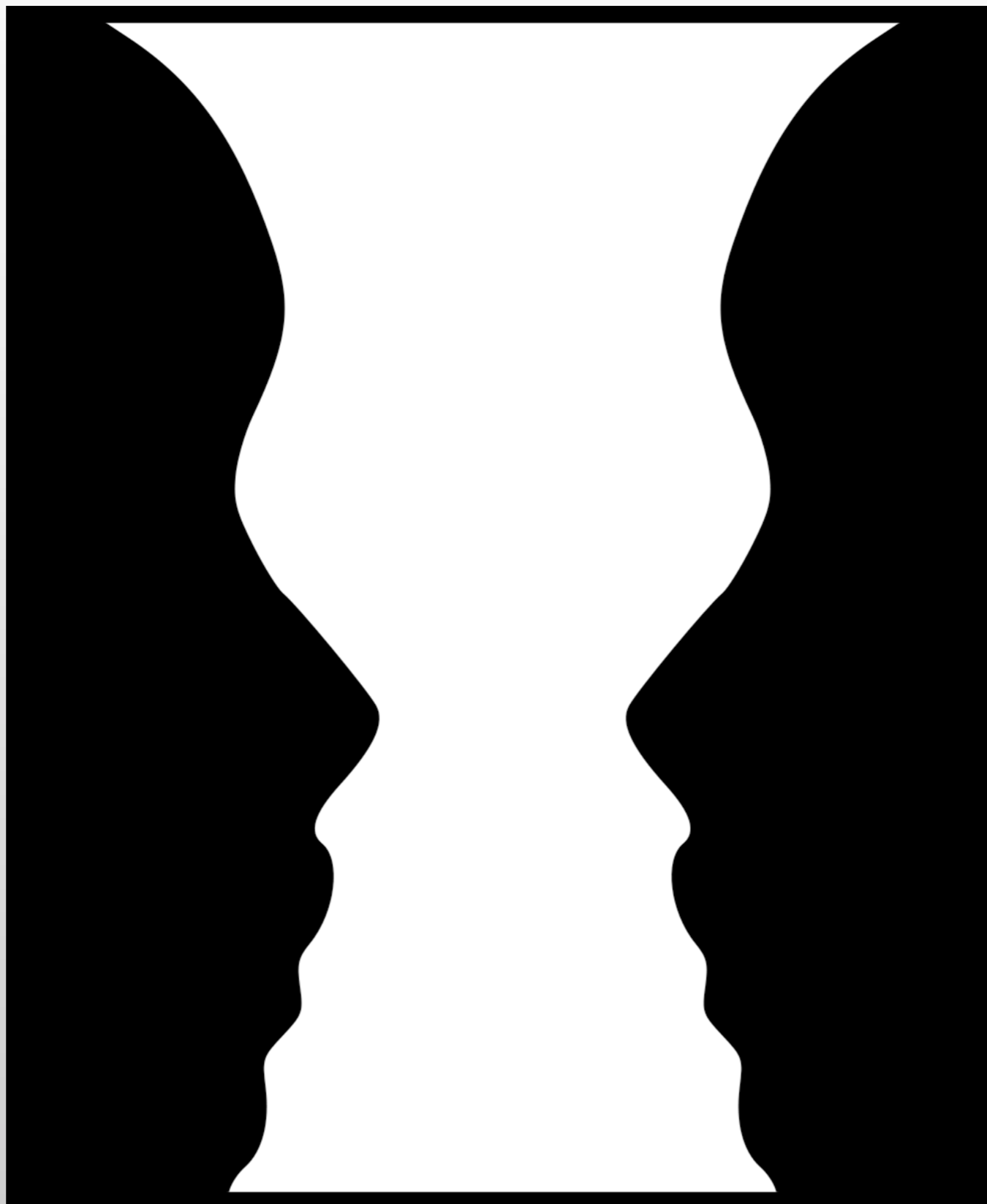@Doc_Vaughan

Why Machine Vision?

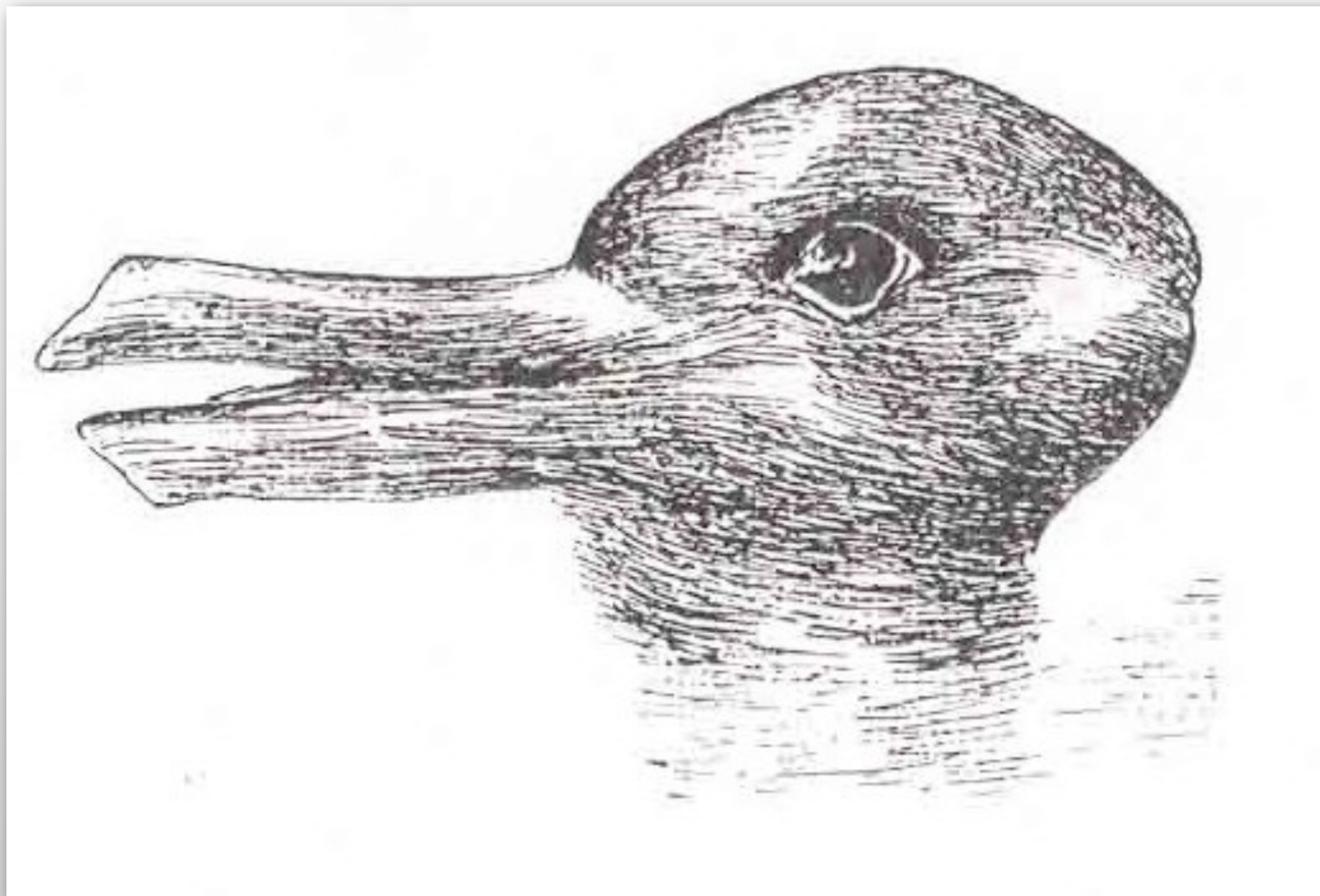- Or... what can machine vision do for us?

Extremely Multi-disciplinary

- Sensor Design
- Filter Design
- Optics
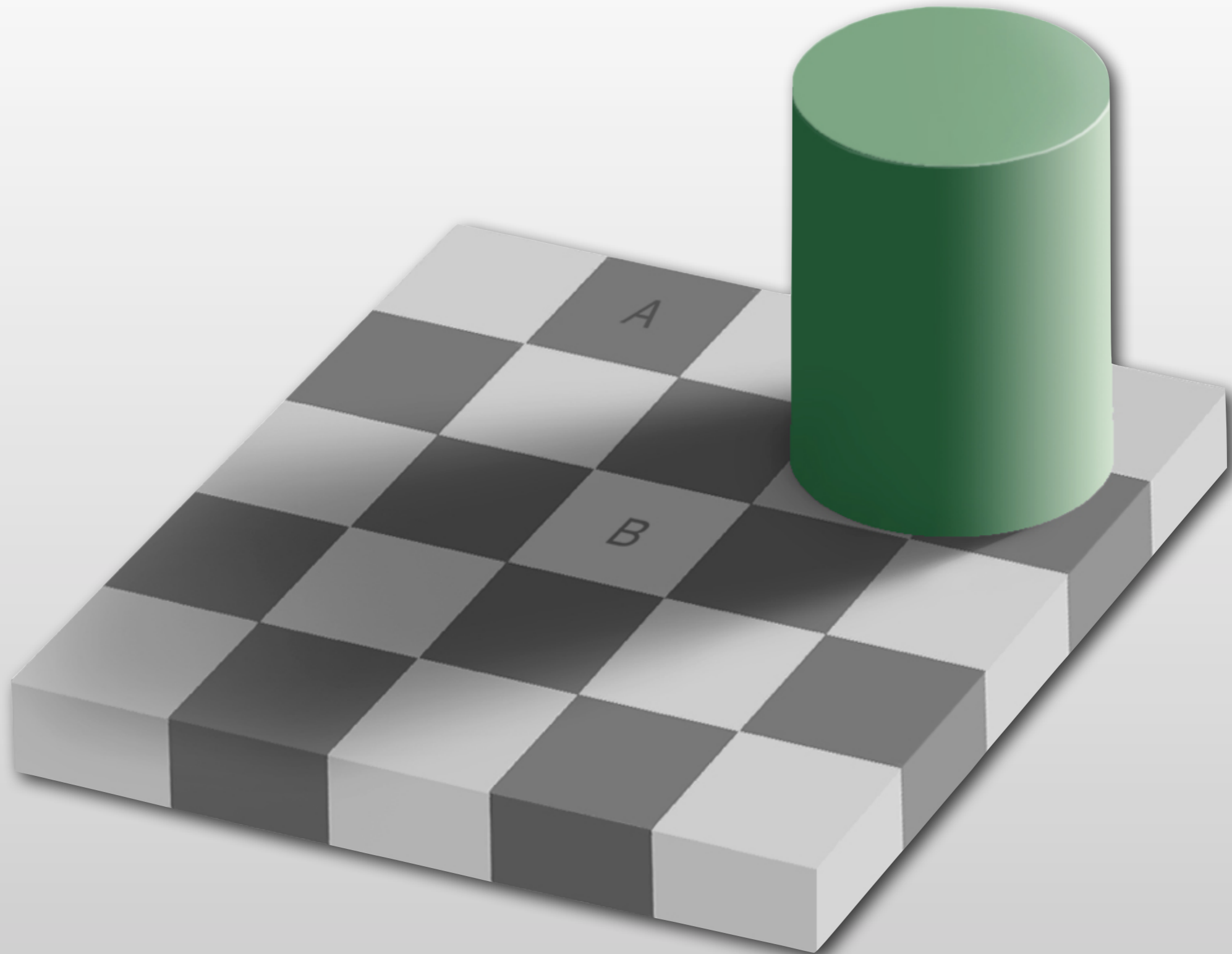- Artificial Intelligence
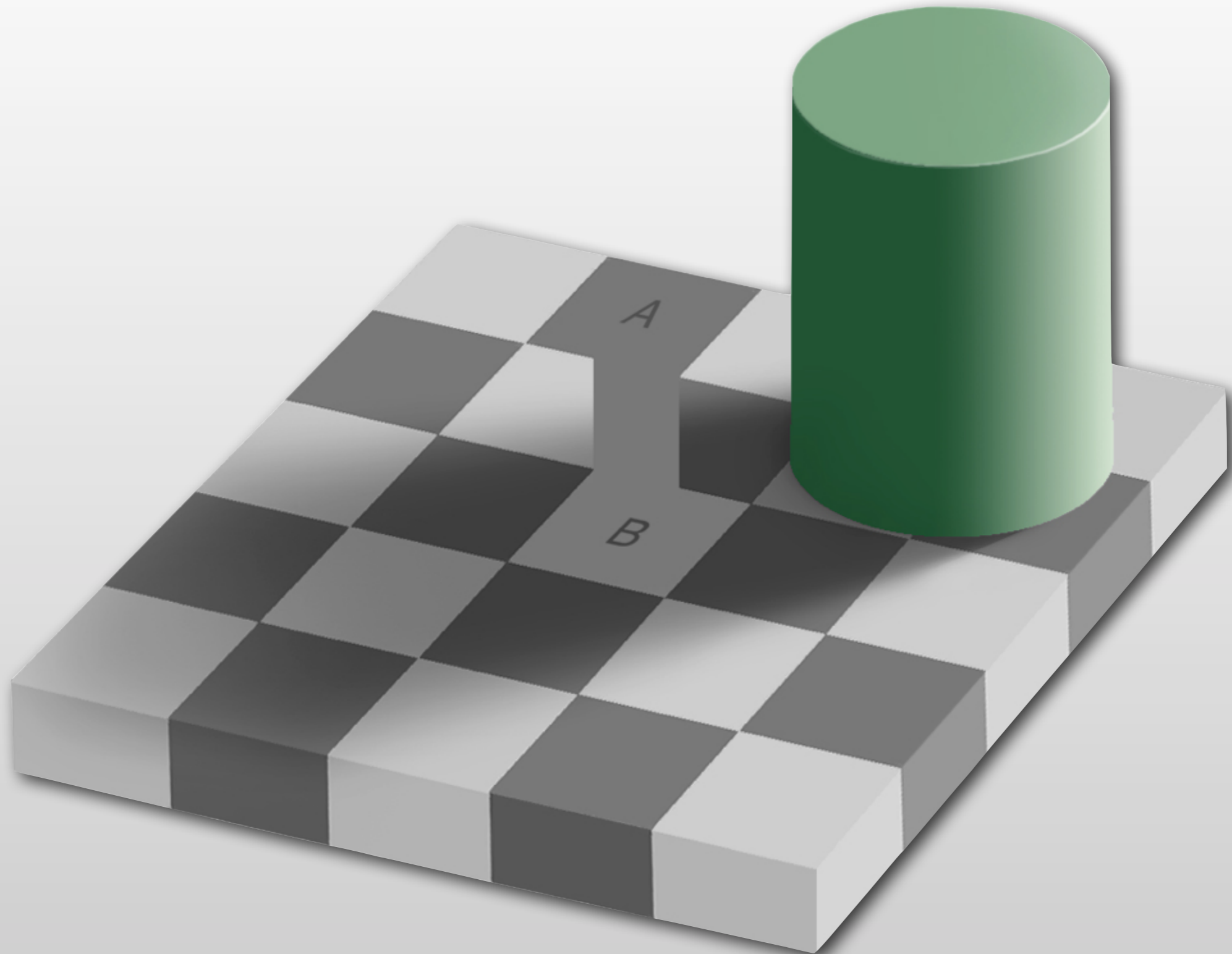- Linear Algebra
- ...

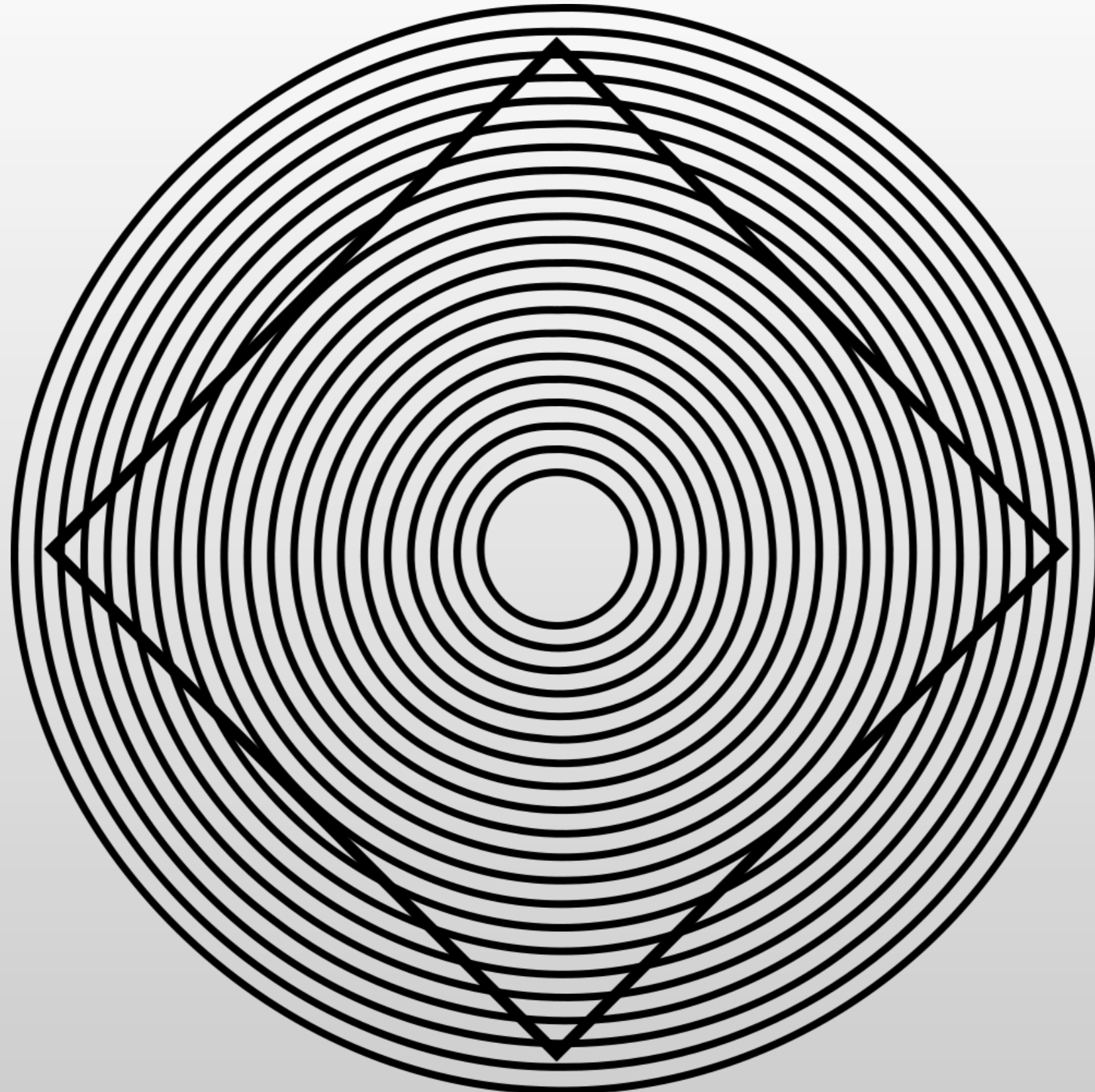# Doing all of that stuff is hard.
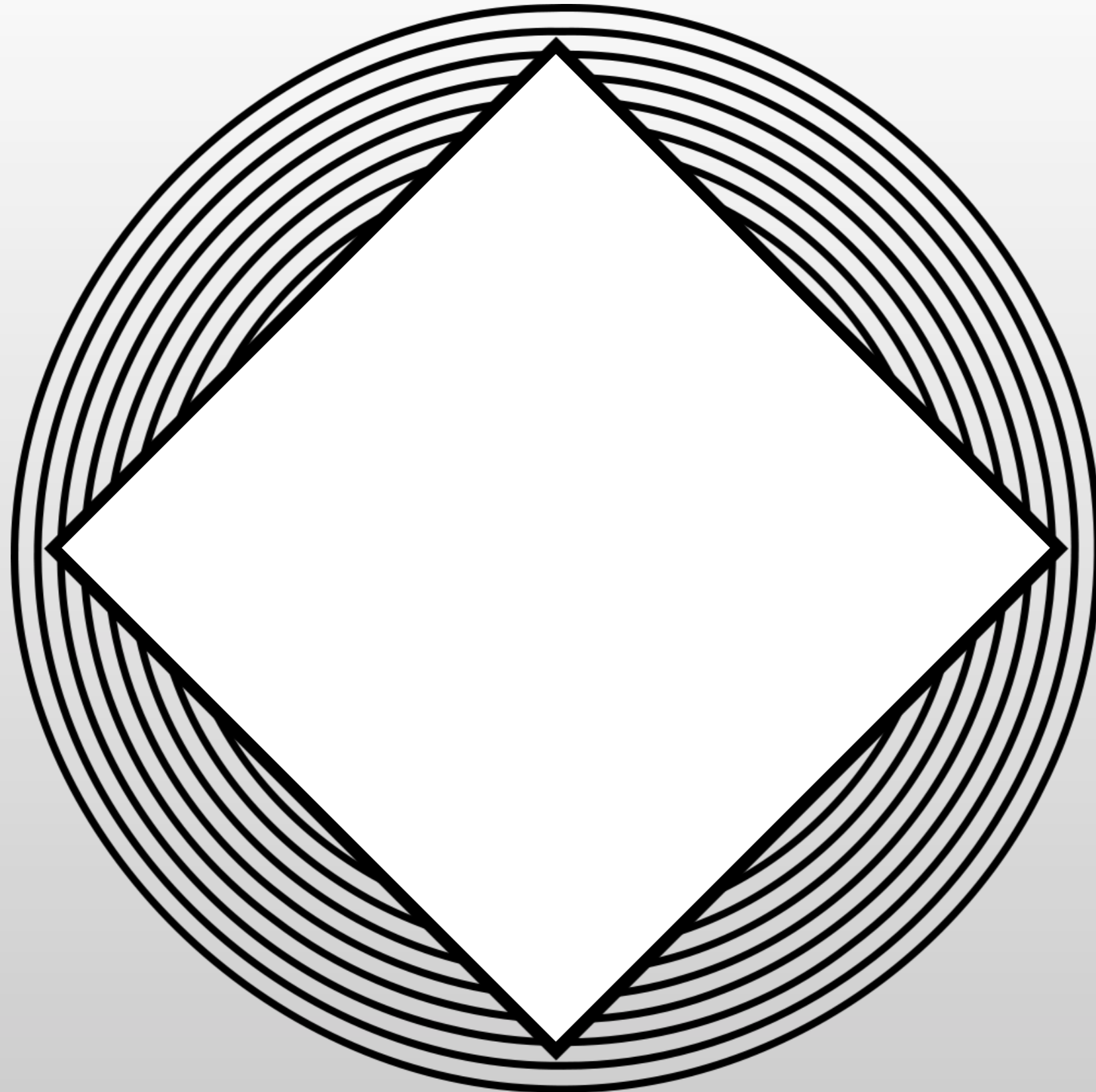
Doing all of that stuff is hard.

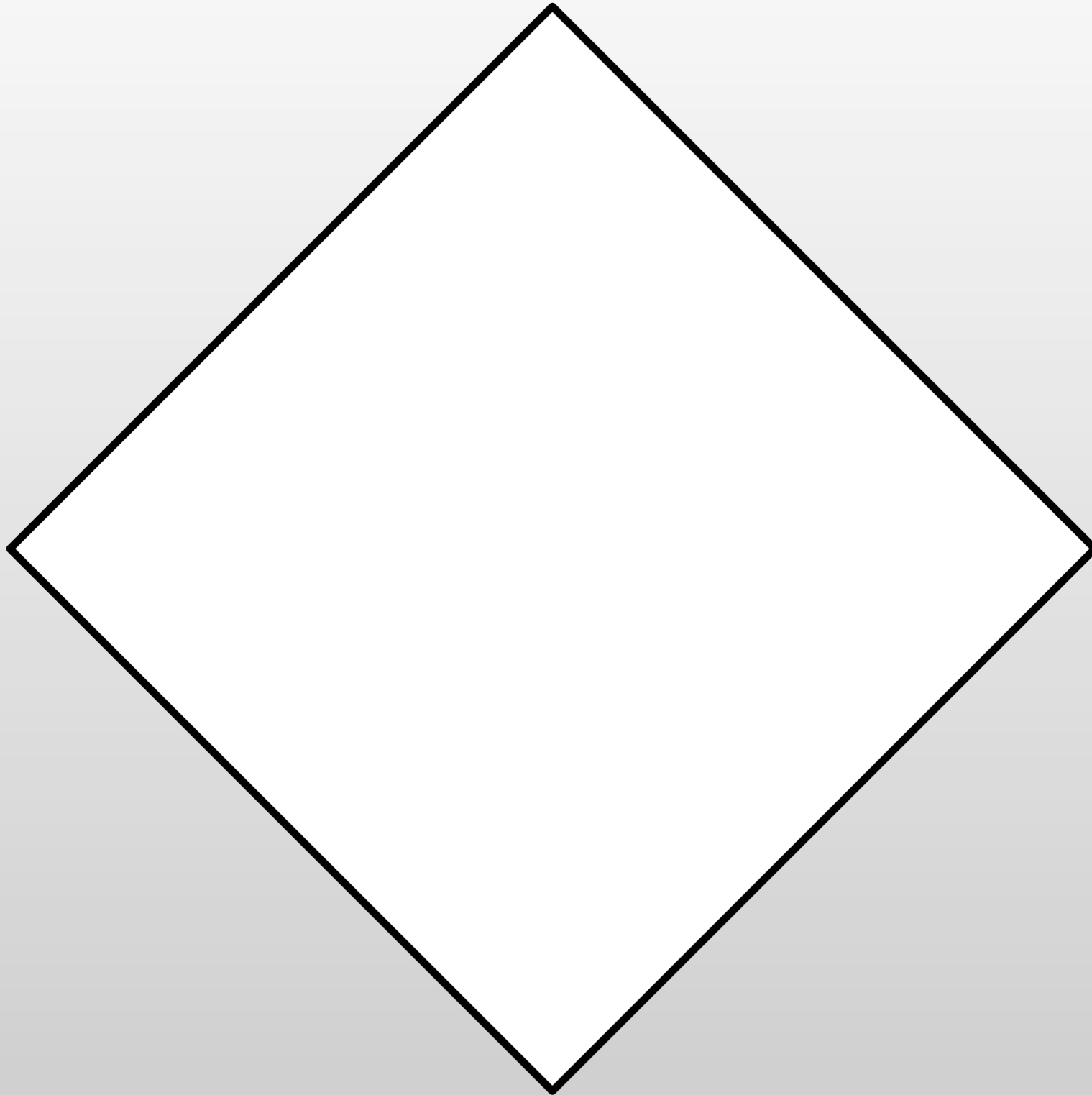# Are A & B the same?

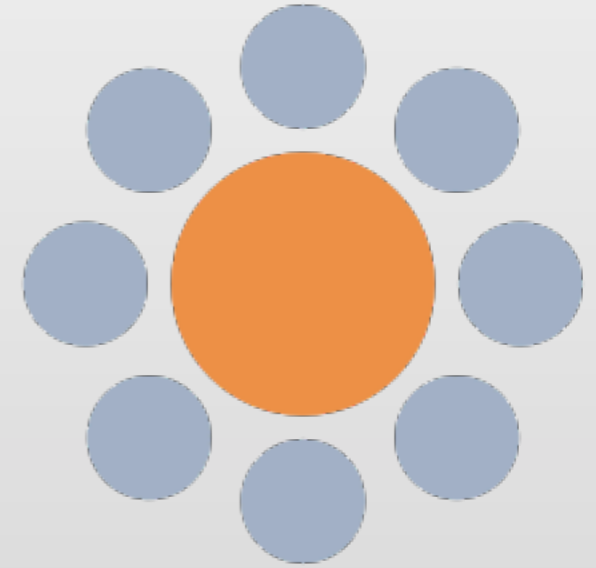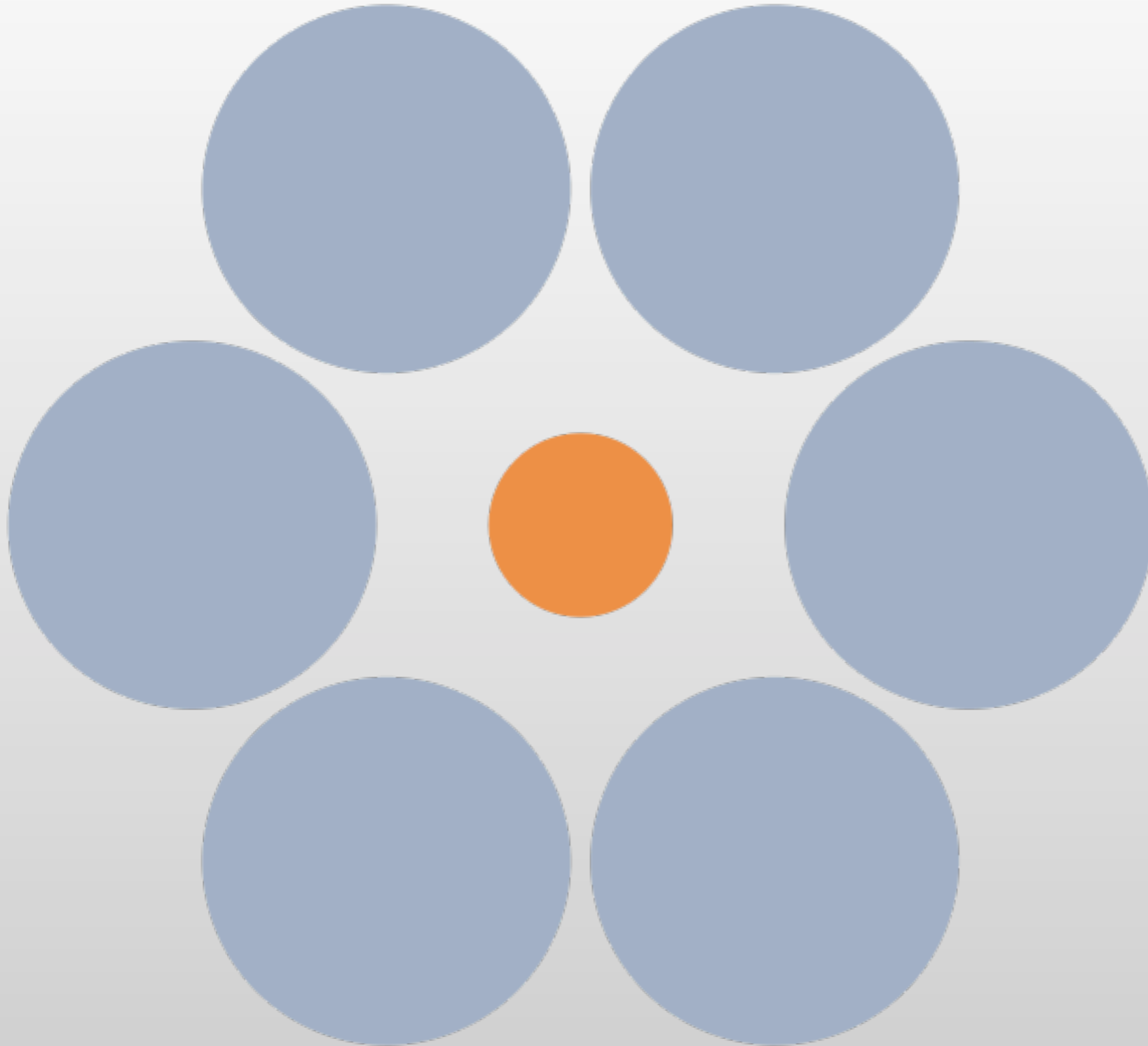# Are A & B the same?

Square?

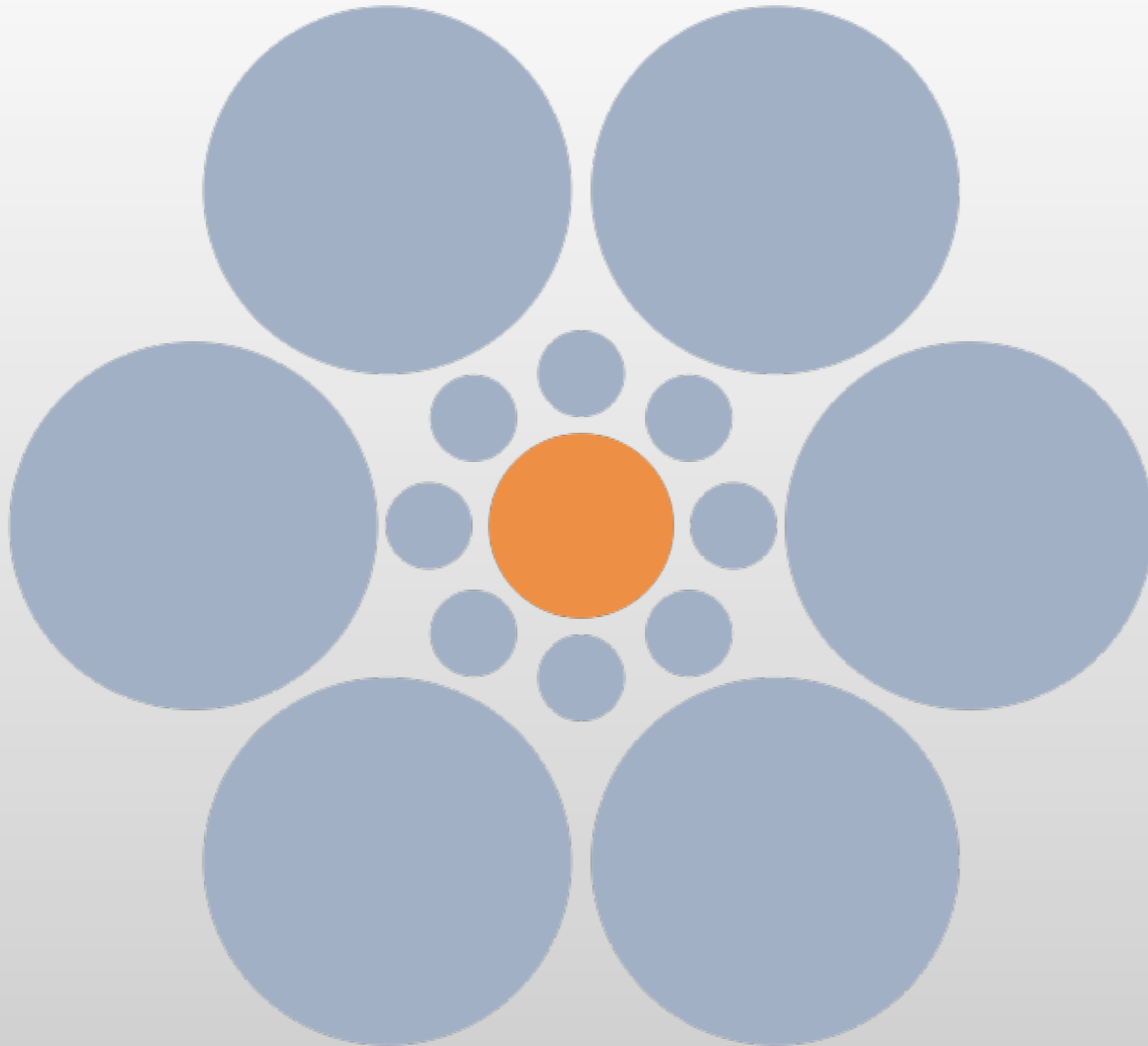# Square?

Square?

Which is longer?

Which is longer?

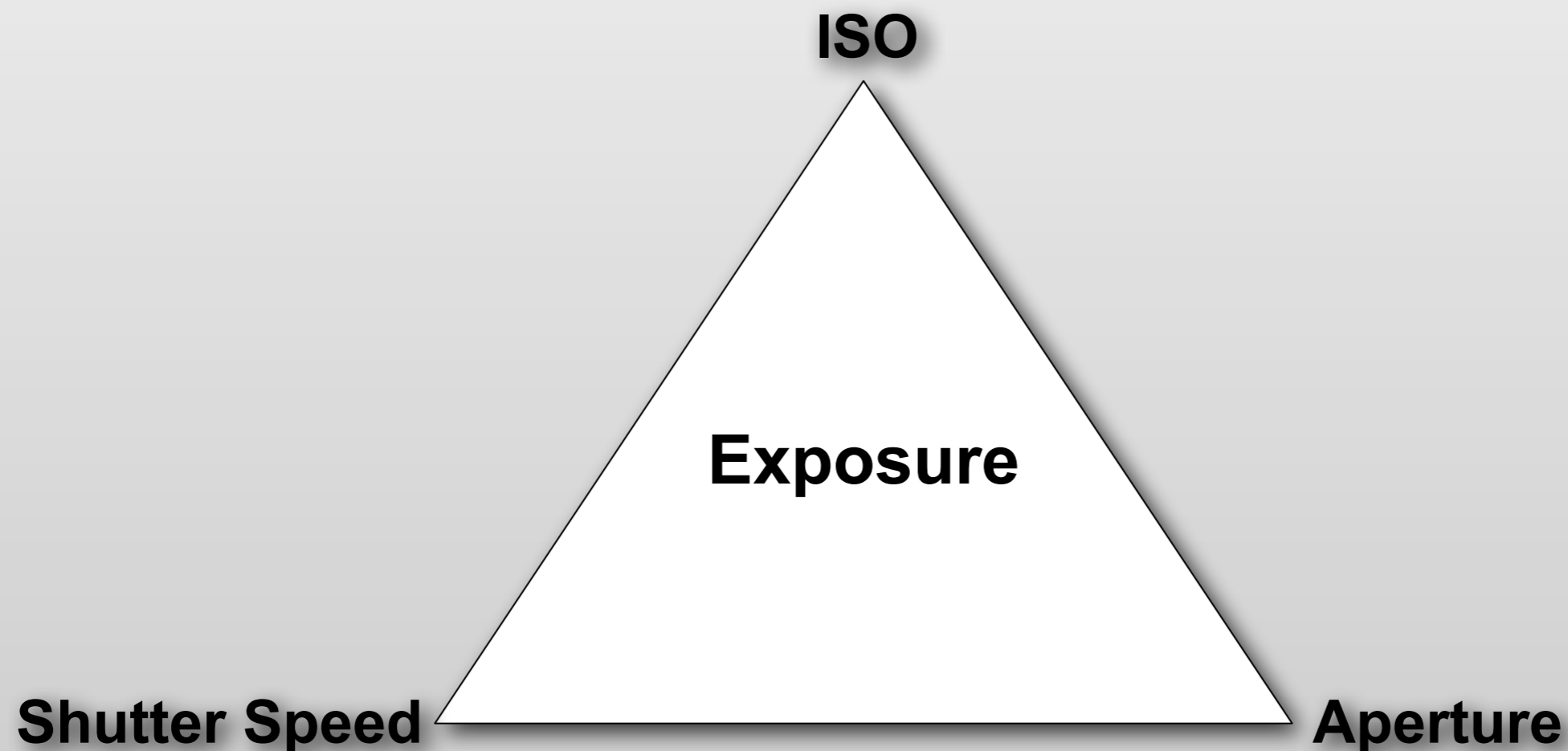# Which is bigger?

Which is bigger?

A Short Photography School

What affects exposure?

- ISO: How sensitive the sensor is to light
- Aperture: How big the lens opening is
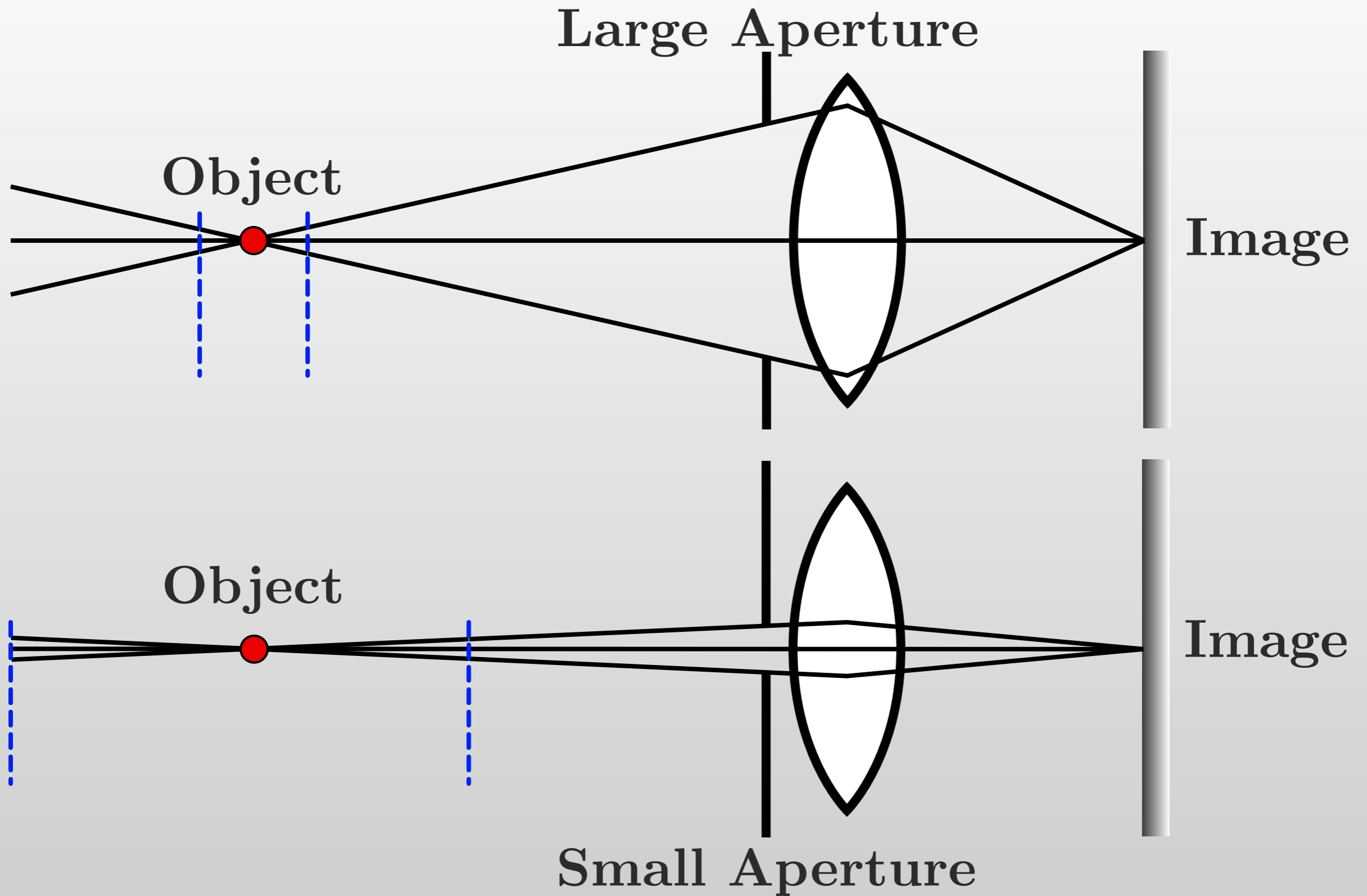- Shutter Speed: How long the shutter stays open

ISO

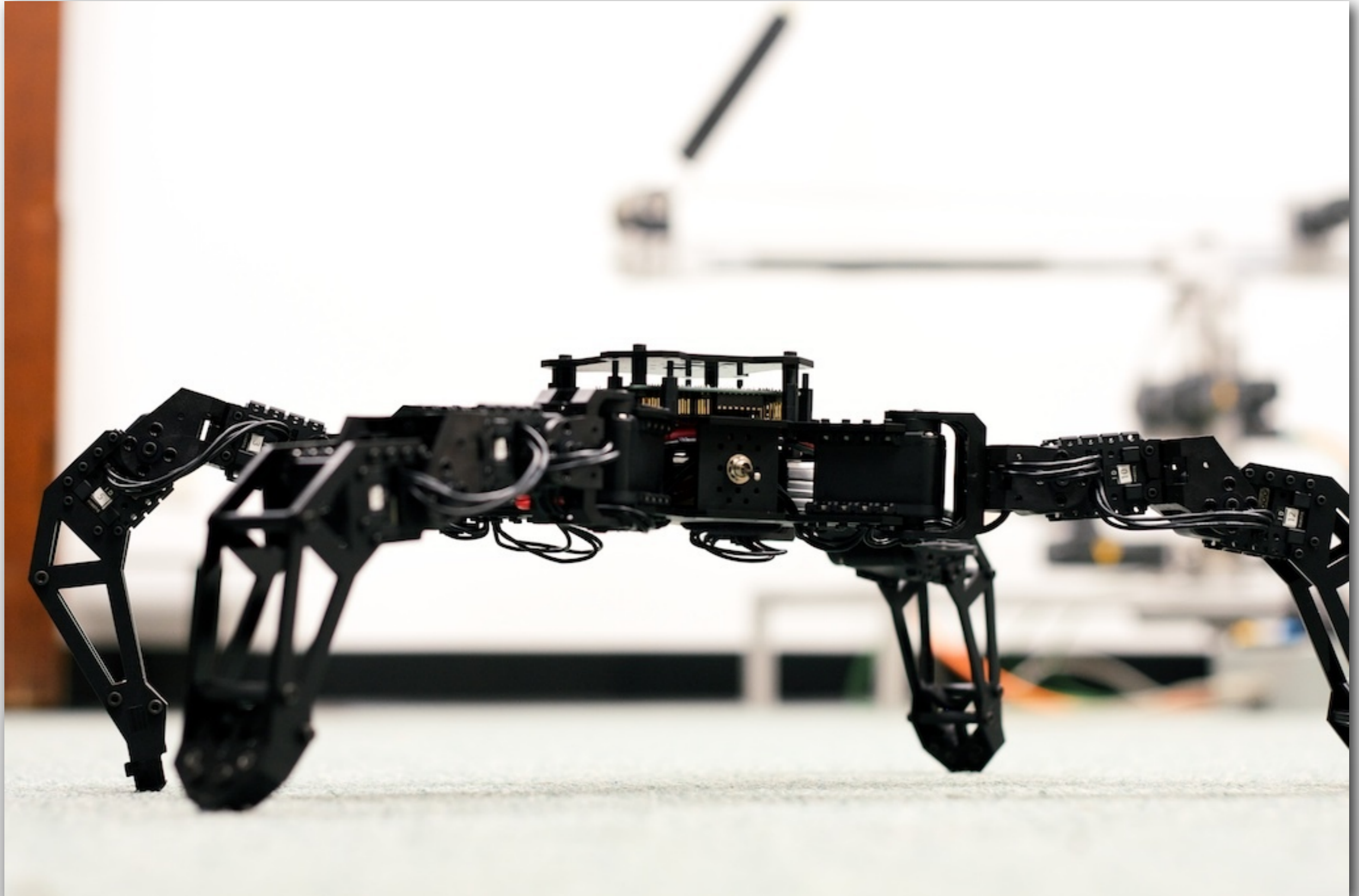**Exposure**

Shutter Speed   **Aperture**

Depth of Field

- How much of an image is in focus
  - Large Aperture ➔ Small Depth of Field
  - Small Aperture ➔ Large Depth of Field

  } **Why?**

Aperture Affect on DoF
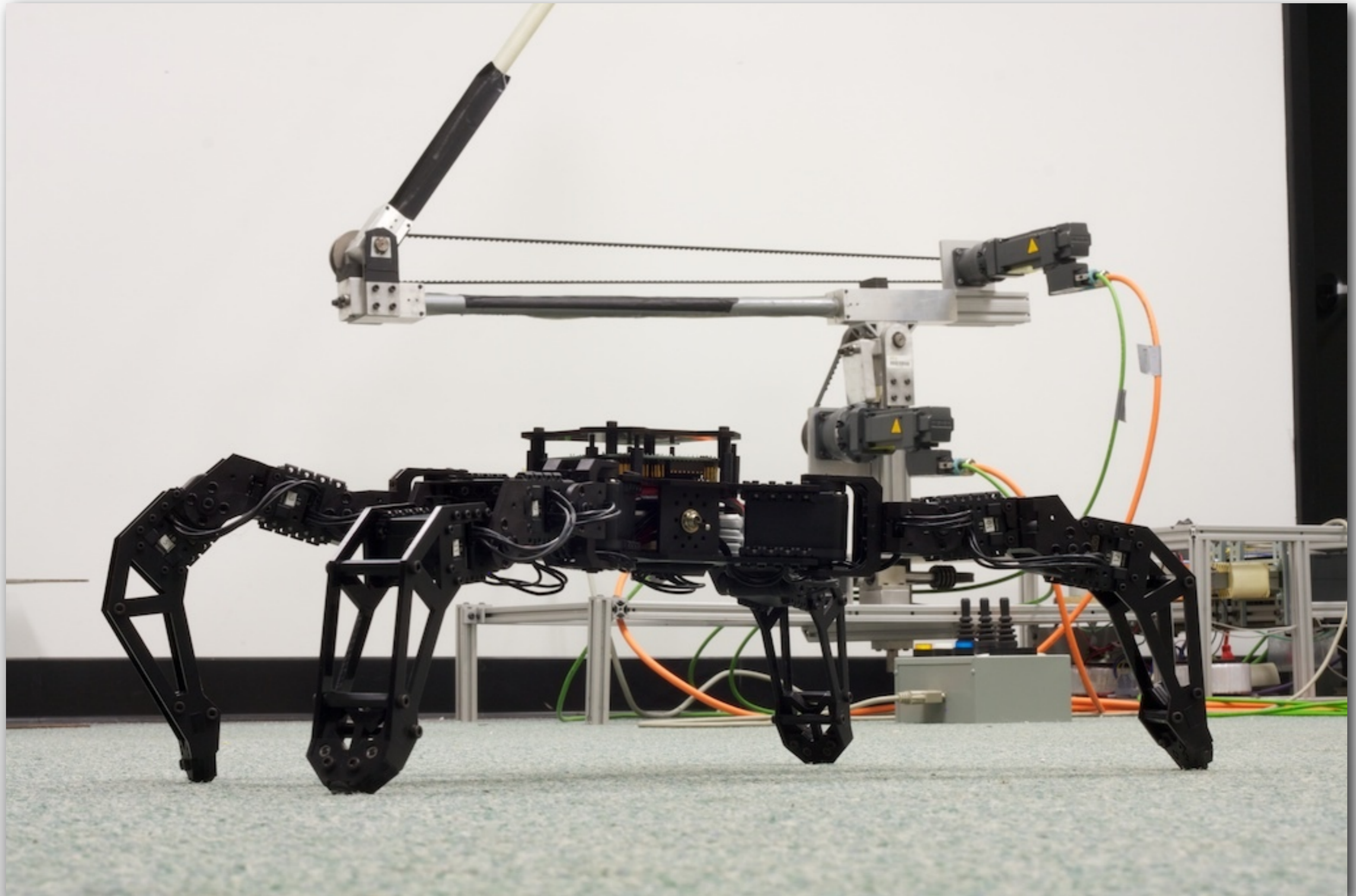

Large Aperture

Object

Image

Object

Image

Small Aperture

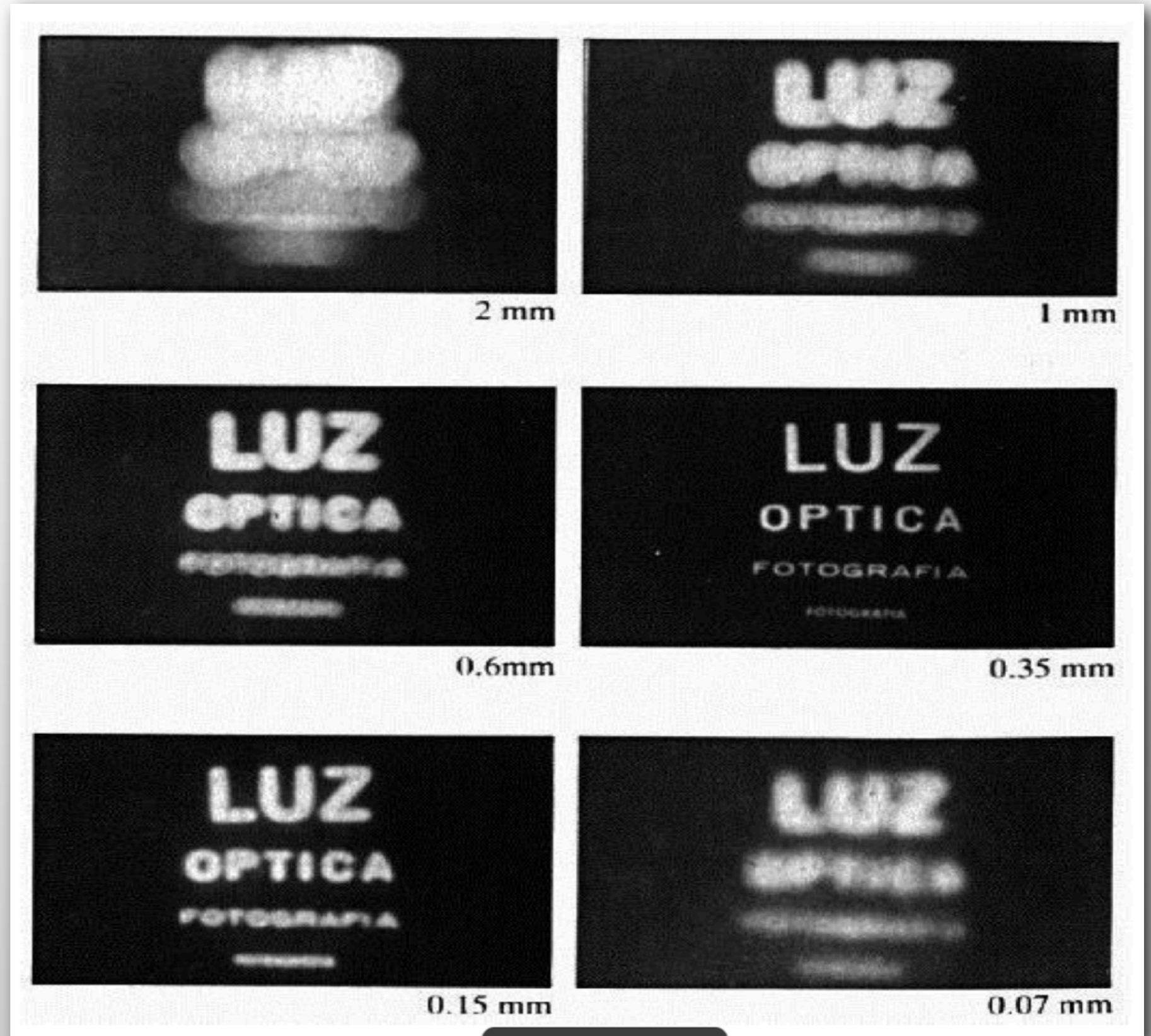# Shallow Depth of Field

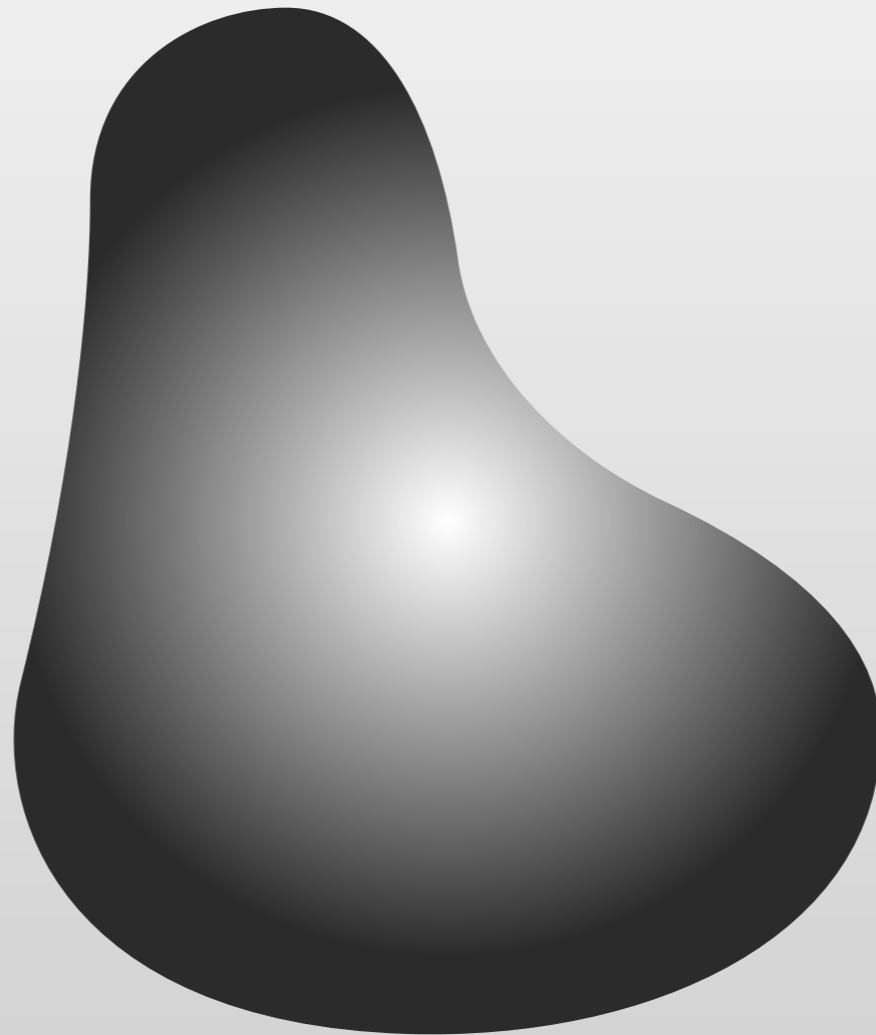# Large Depth of Field

Why not just minimize Aperture?

- Let's less light through
  - How does that affect exposure?

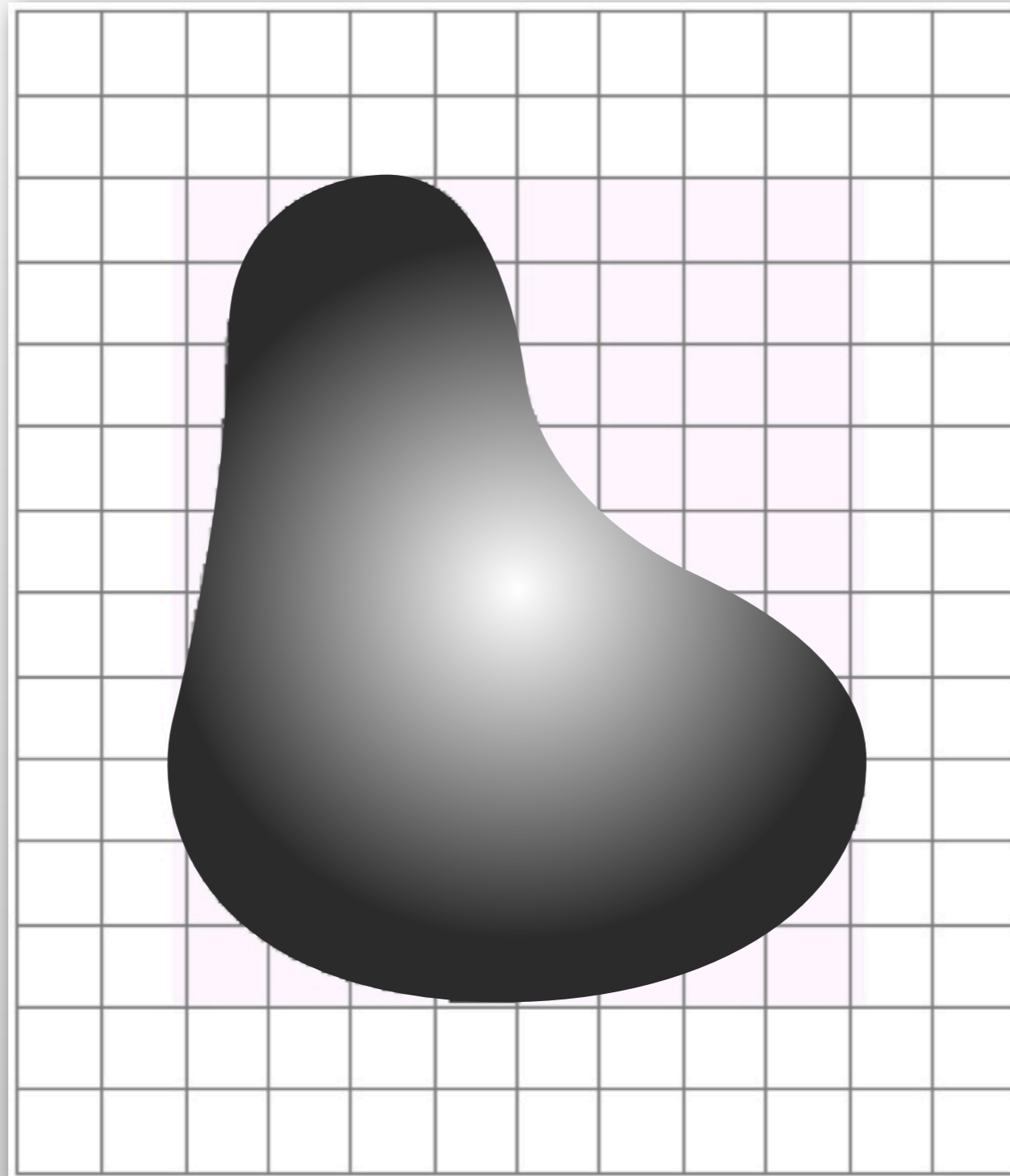- Diffraction

Digital Imaging

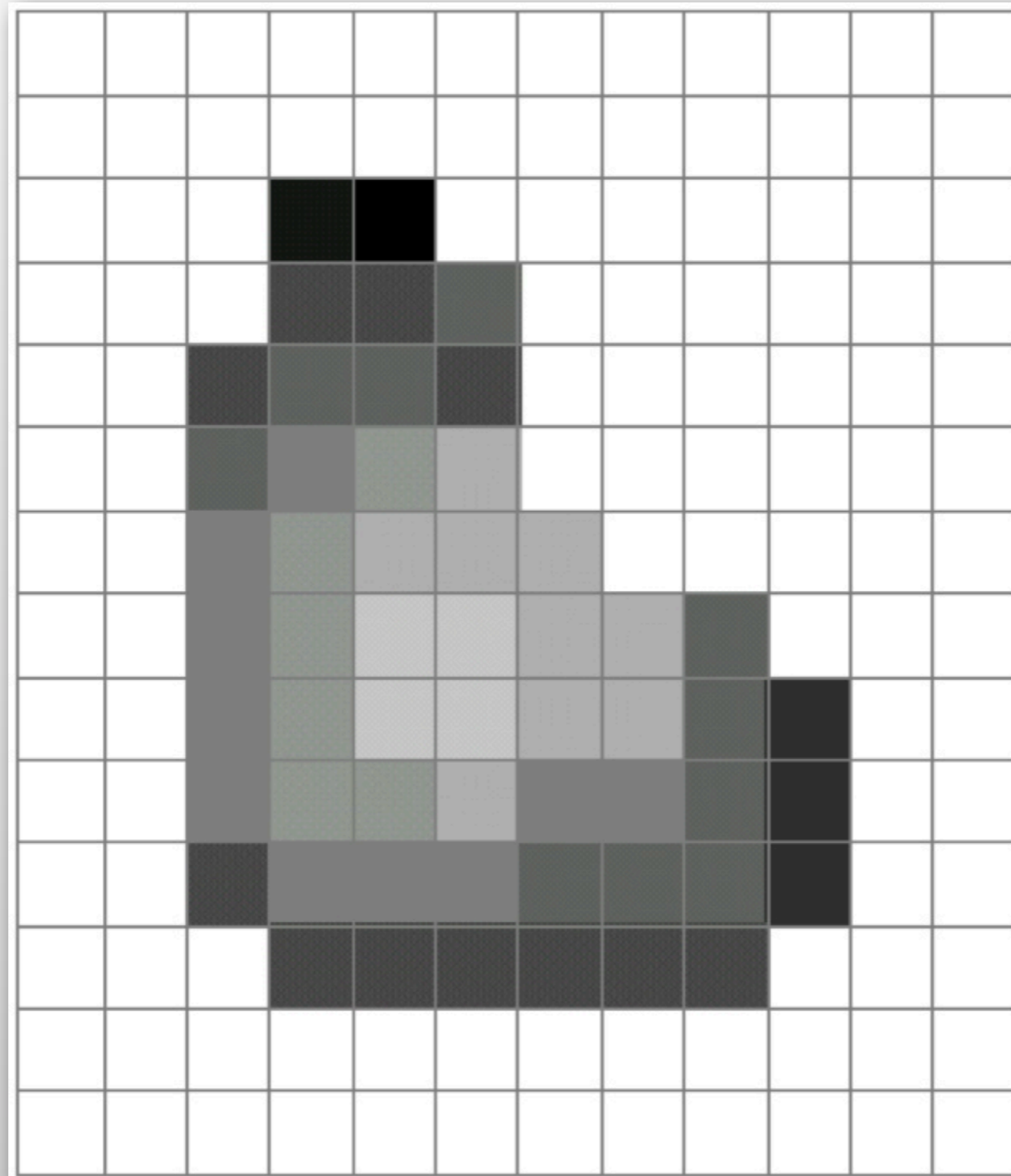- How does a digital sensor see this?

Digital Imaging

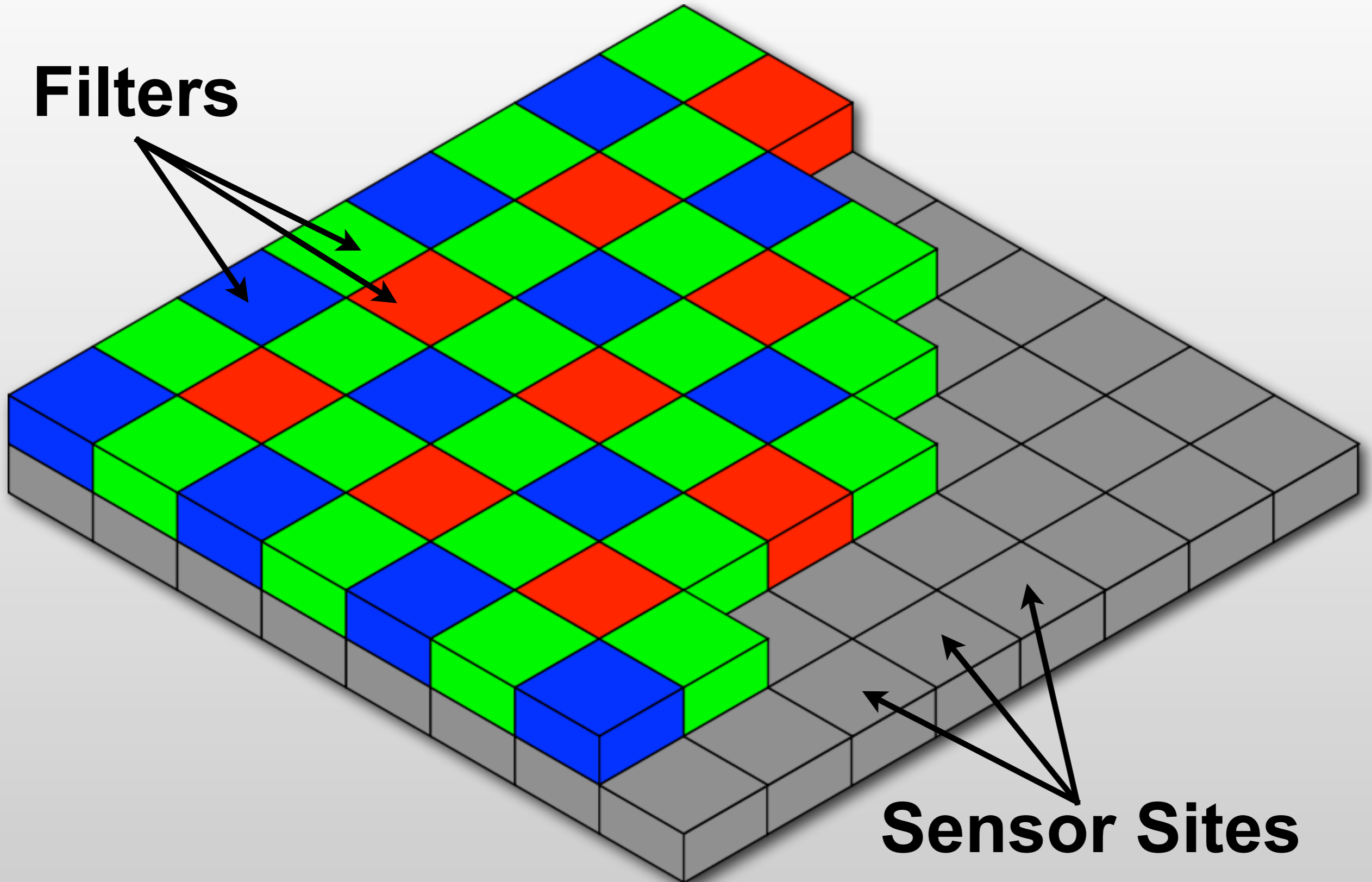- How does a digital sensor see this?

Digital Imaging

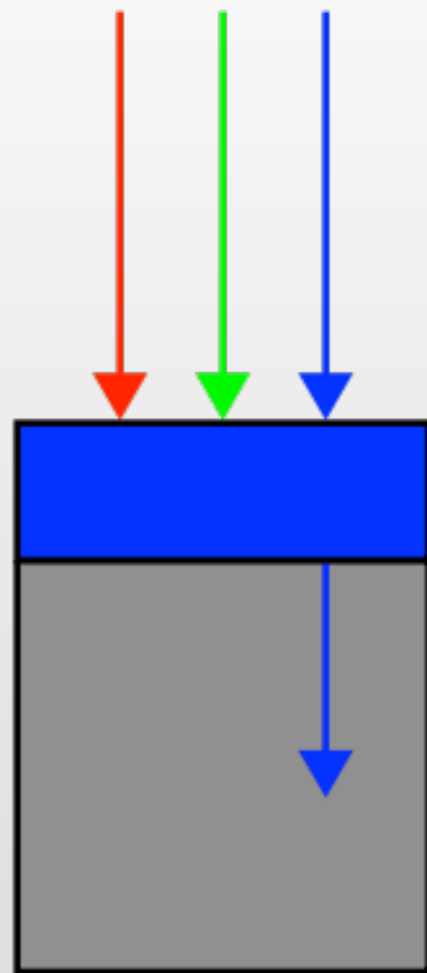• How does a digital sensor see this?

What about color?

Filters

Sensor Sites

From Another Angle
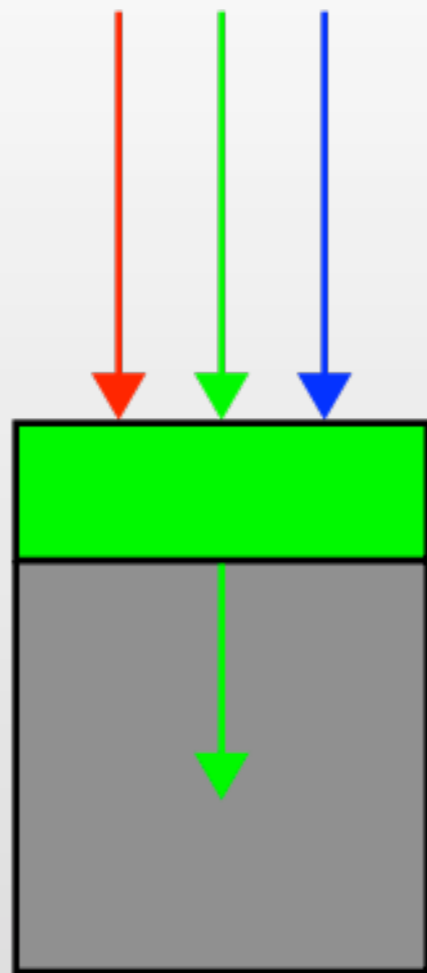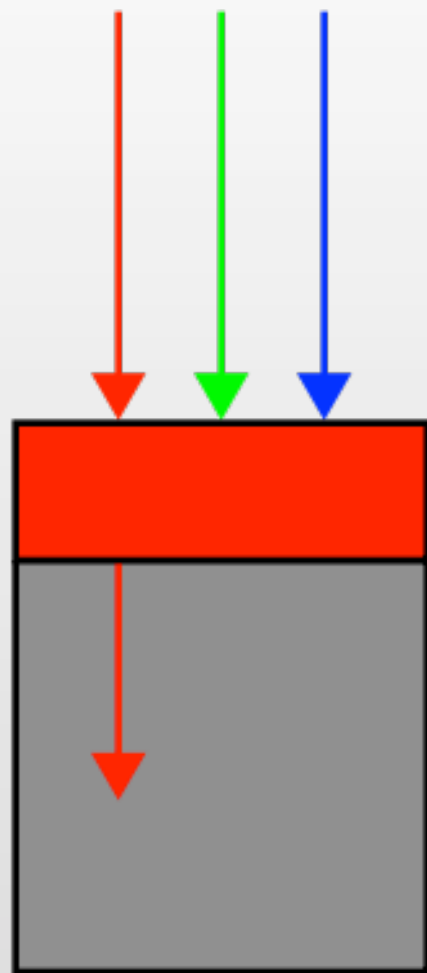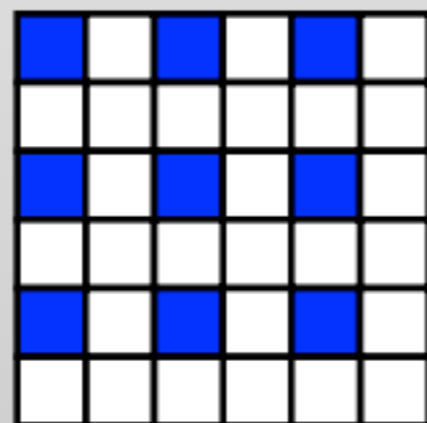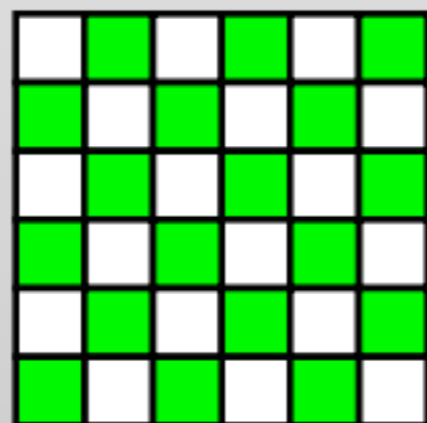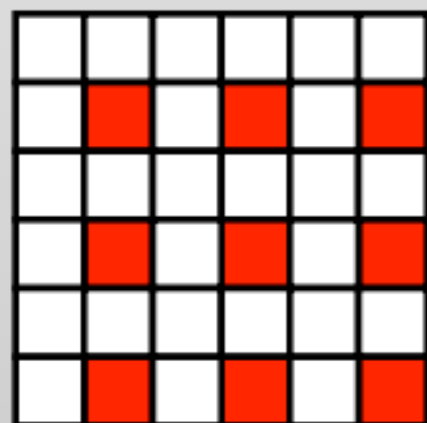
Incoming Light

Filter Array

Sensor

Resulting Pattern

Color Space/Models - RGB

- One way to describe an images
- How much Red, Green, and Blue exist
  - Any point is represented by the mix of RGB at that location

R = 1/5
G = 3/5
B = 4/5
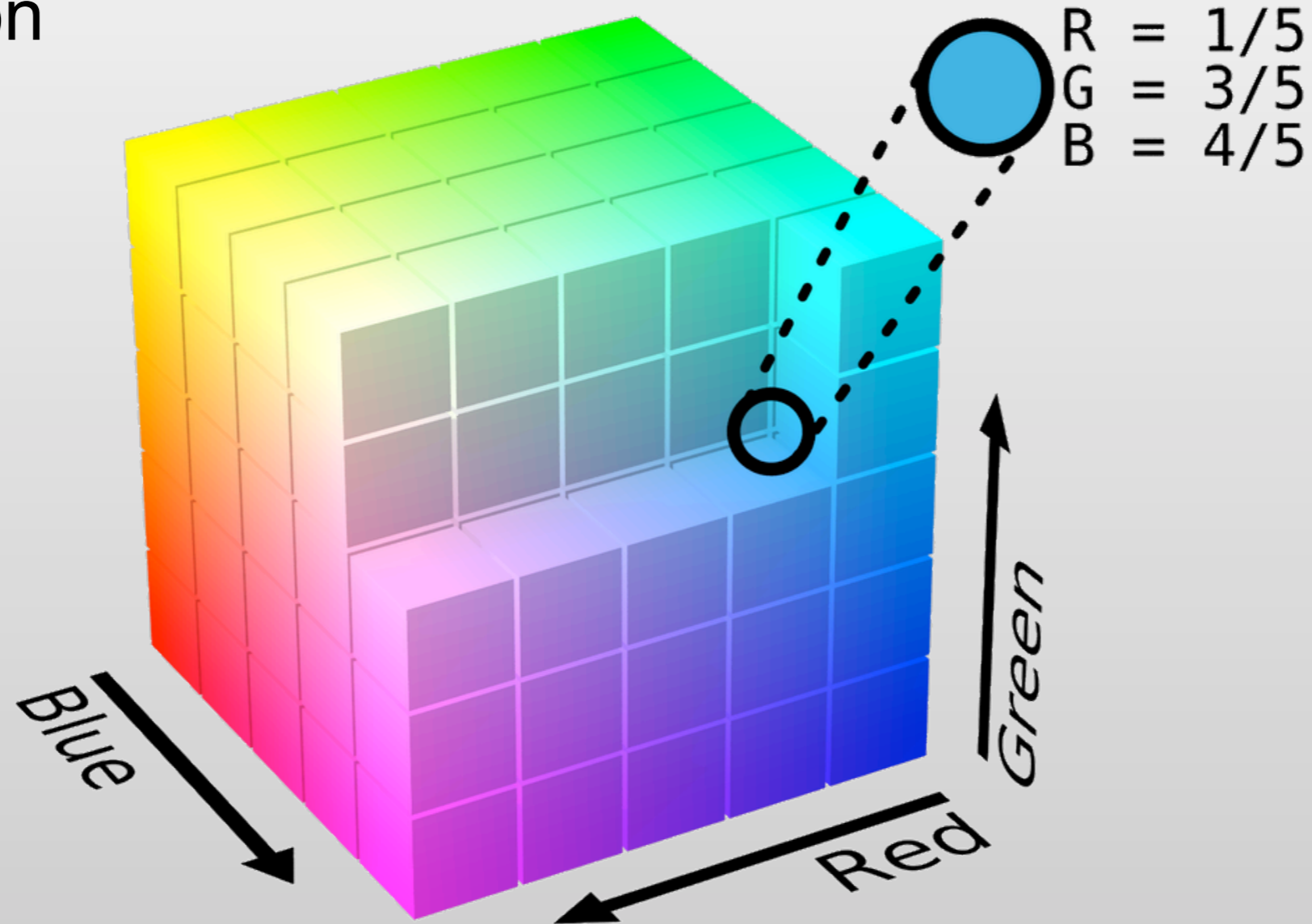
An Example
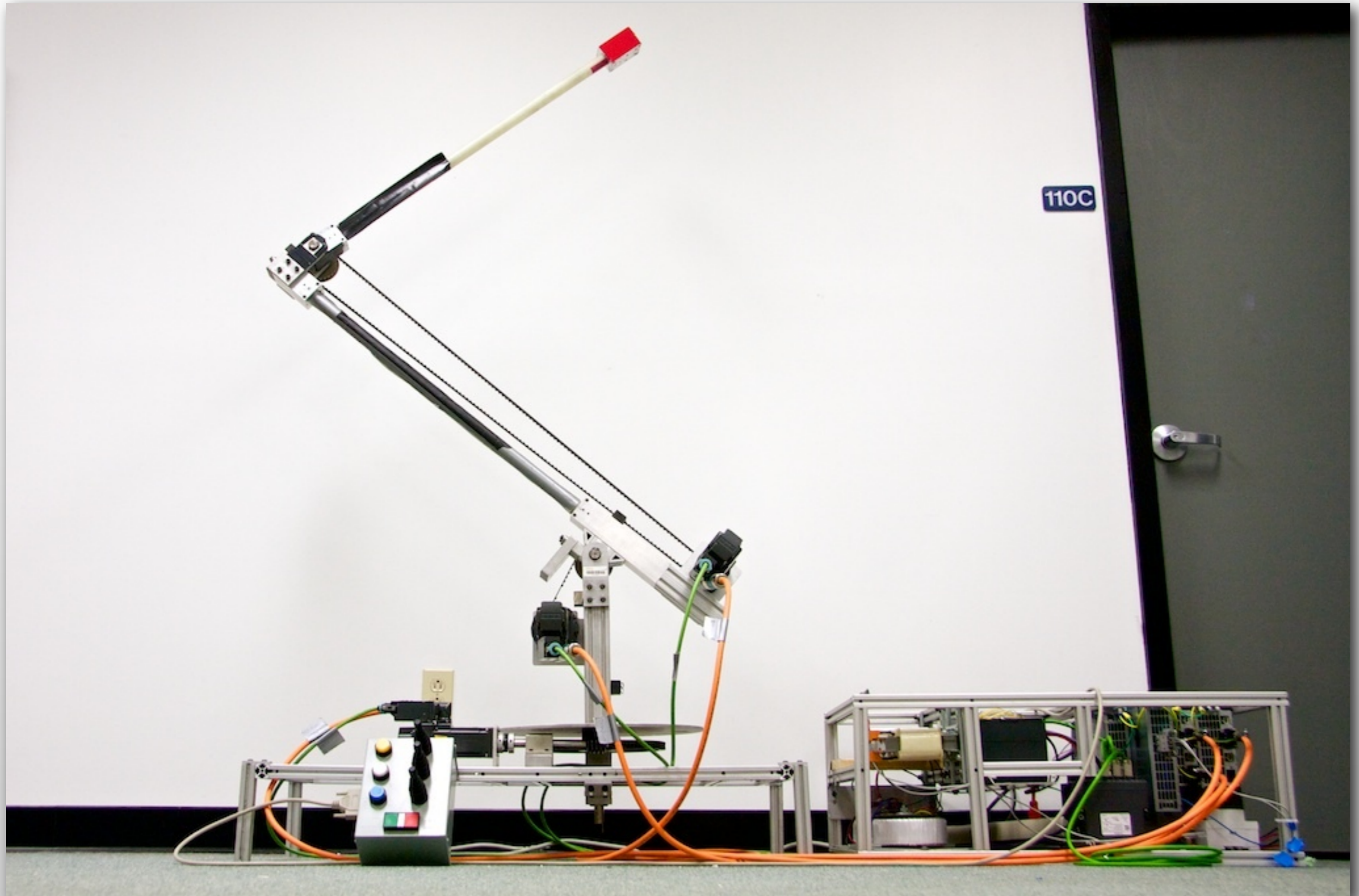
Red Channel
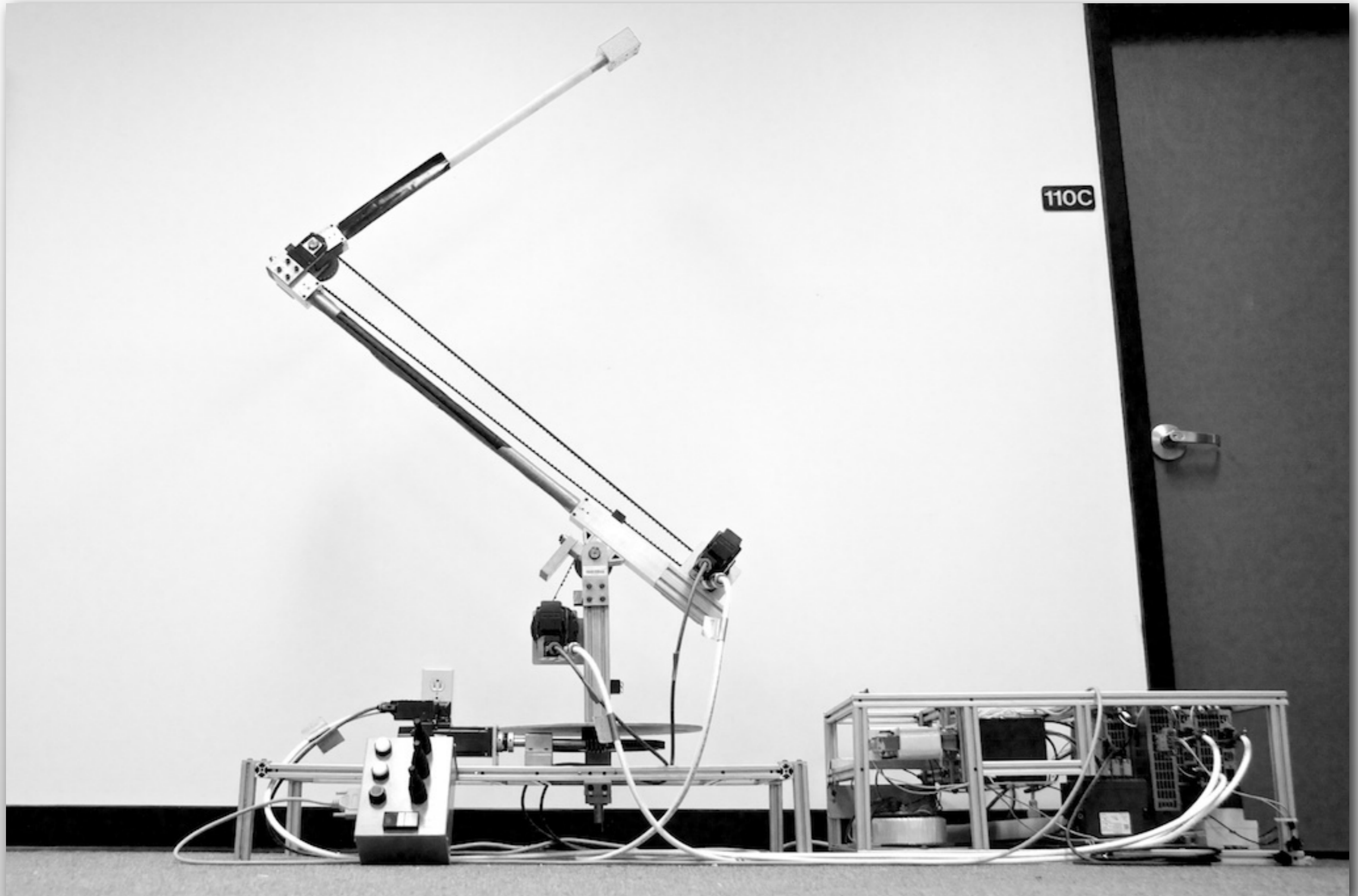
Blue Channel

Green Channel
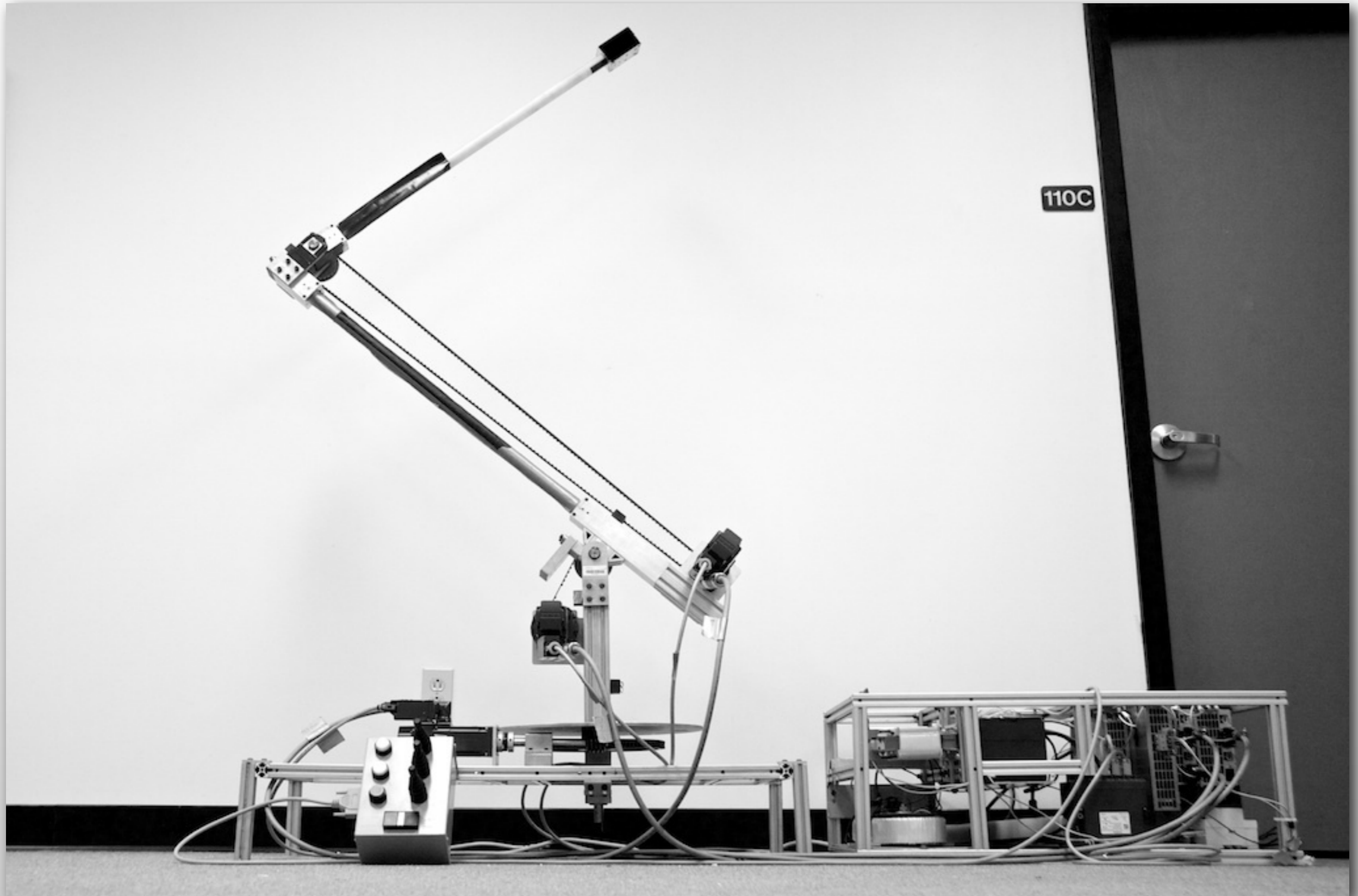
In the Computer

- RGB as an array, size H x W x 3

Often (0,0)

HSV/HSL Color Space/Model

- **H**ue, **S**aturation, and **V**alue
- **H**ue, **S**aturation, and **L**ightness } **Slightly Different**
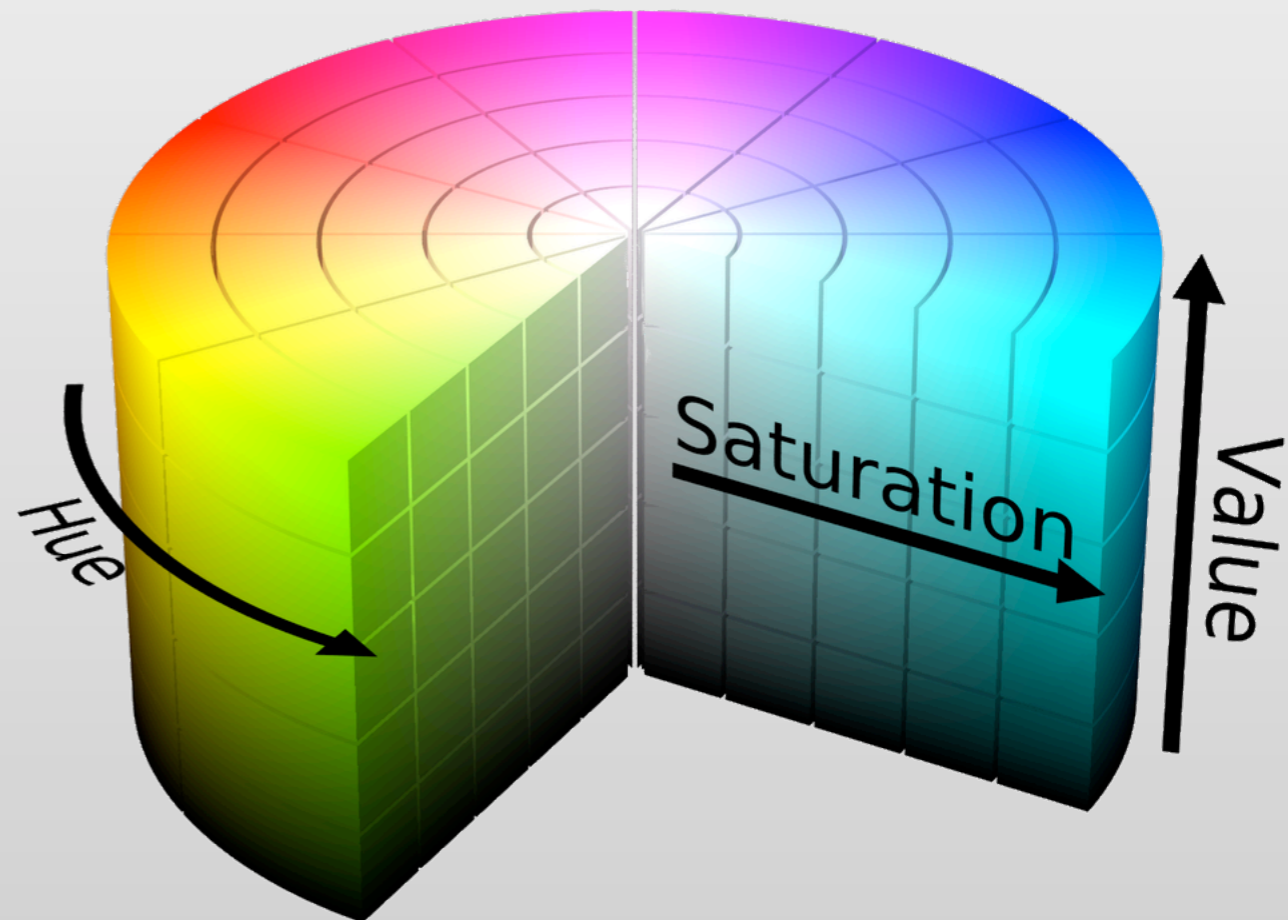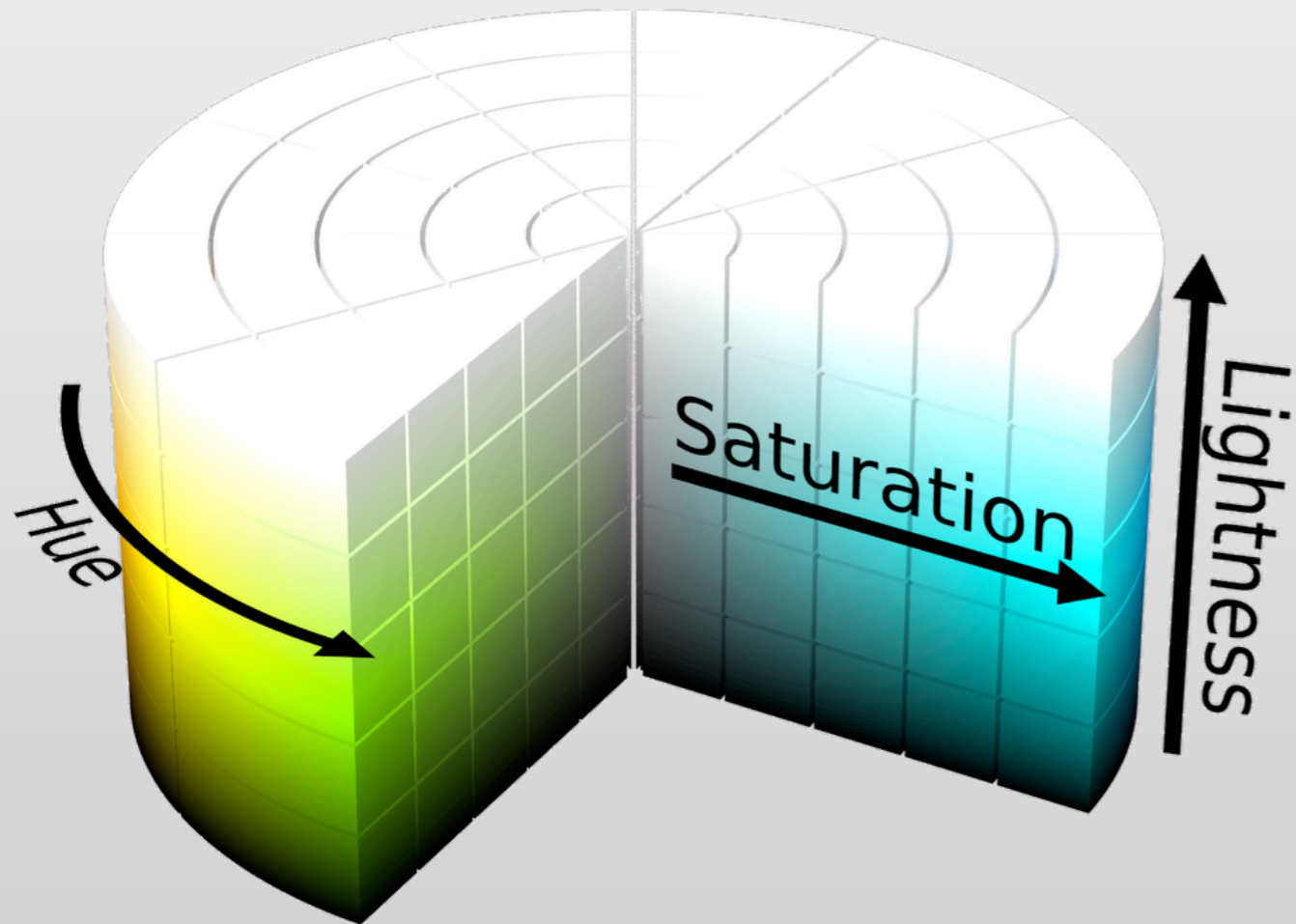
HSL

- Hue
  - Red - 0deg
  - Green - 120deg
  - Blue - 240deg
  - Red - 360deg
- Saturation
  - "Pure" Colors - 0.5
- Lightness
  - Black - 0
  - White - 1
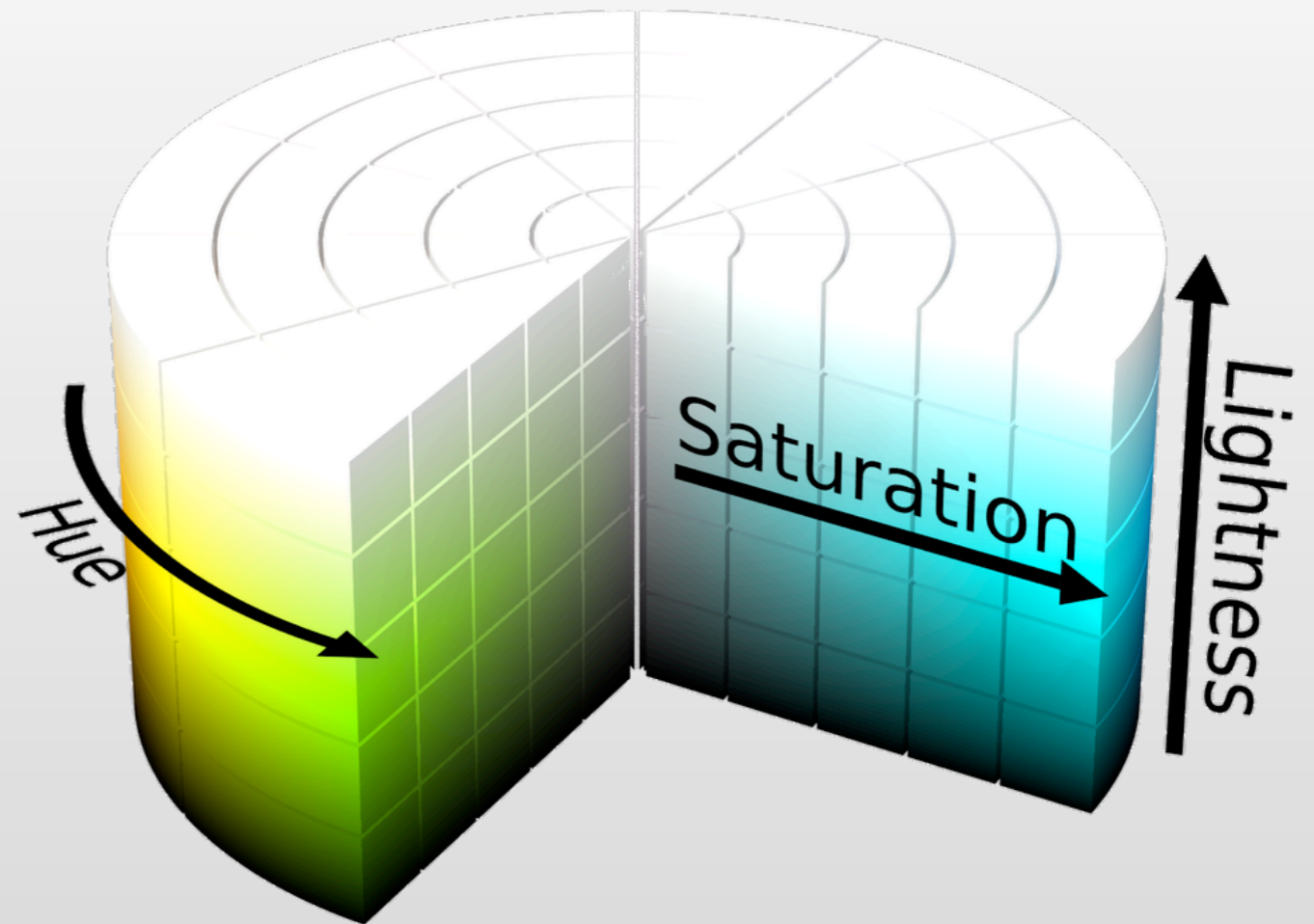
HSV

- Hue
  - Red - 0deg
  - Green - 120deg
  - Blue - 240deg
  - Red - 360deg
- Saturation
  - "Pure" Colors - 1
- Value
  - Black - 0
  - White - 1
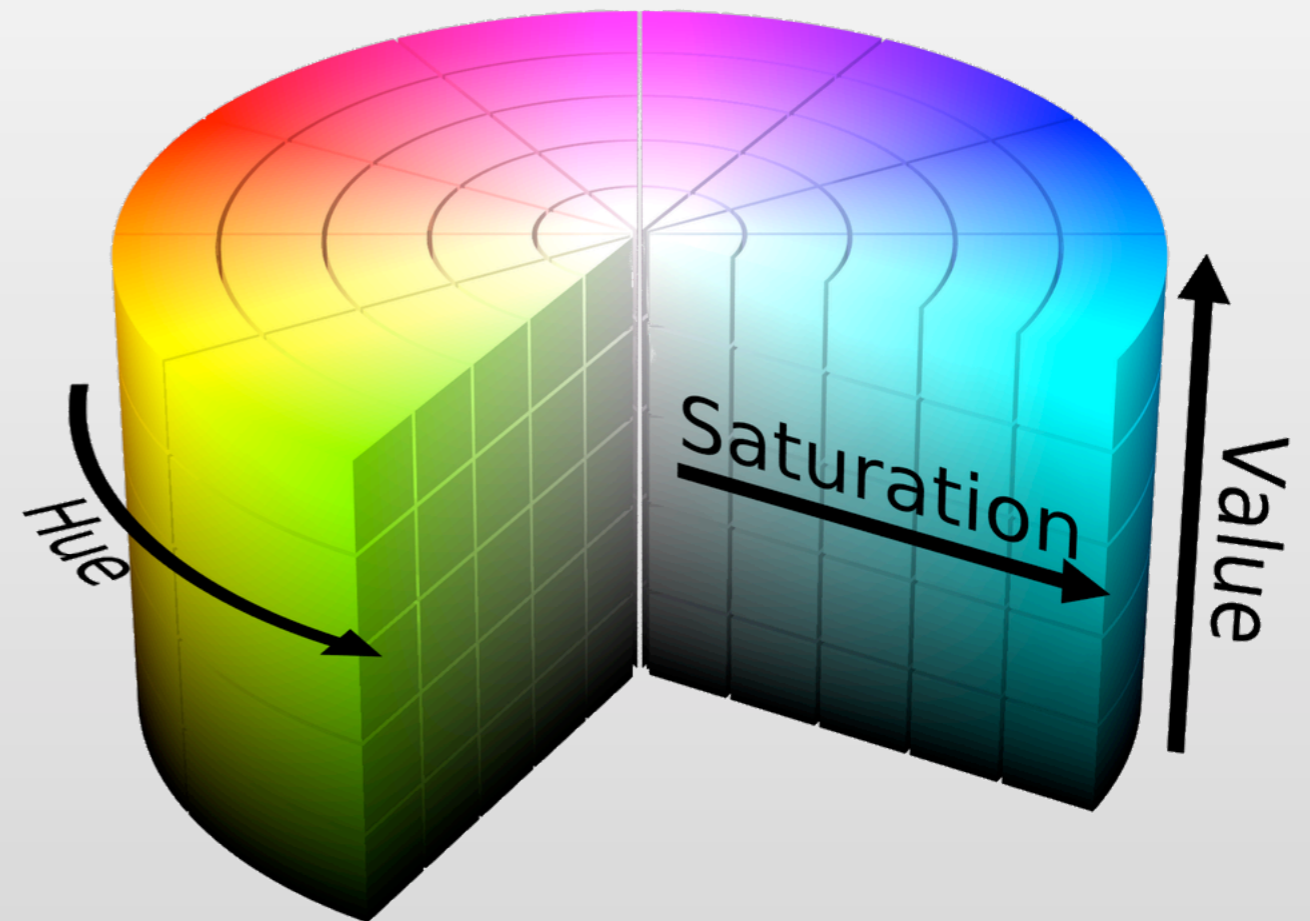
Other Color Spaces/Models

- CMYK
  - Cyan, Magenta, Yellow, Black
  - Most often used in printing

- YCbCr
  - Luminance, Blue-Difference Chroma, Red-Difference-Chroma
  - Used for TV

- Many others...

Filtering

- In machine vision: used to make the image easier to process

- In Instagram: used to make your boring picture more interesting

Blurring Makes the Image Clearer?

Blurring Makes the Image Clearer?

Once Masked for White

No Blur

Once Masked for White

Thresholded Image

After Blurring
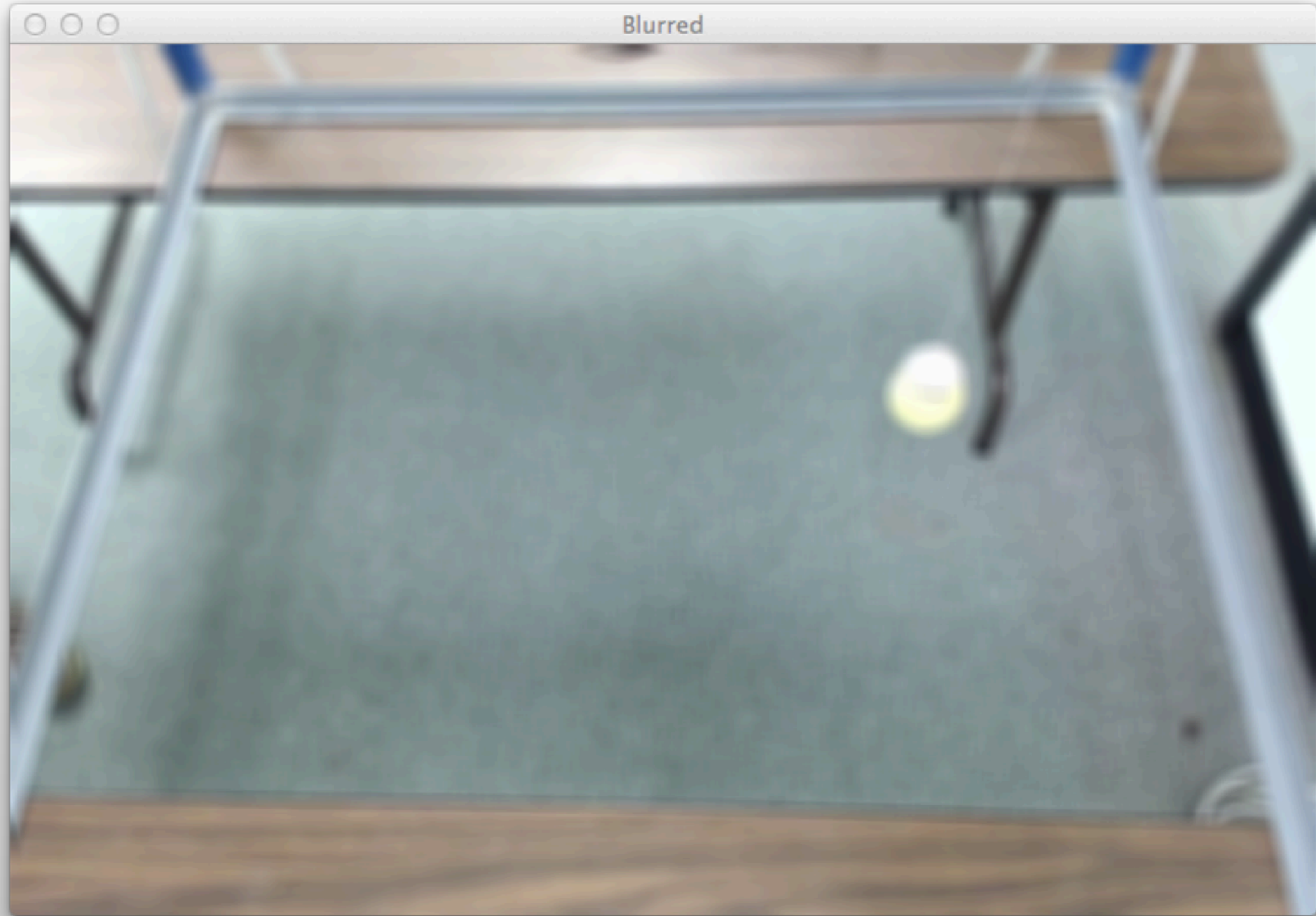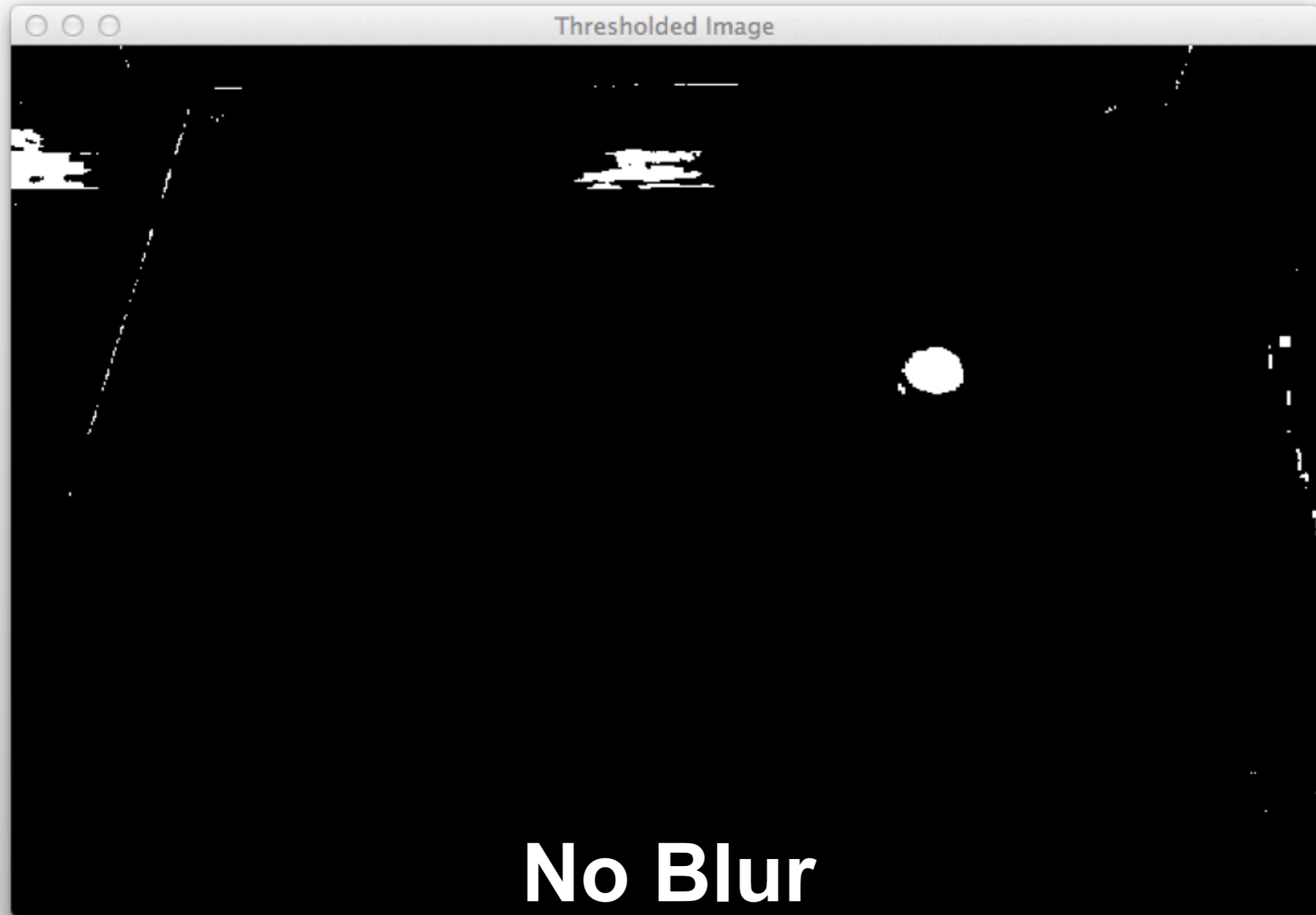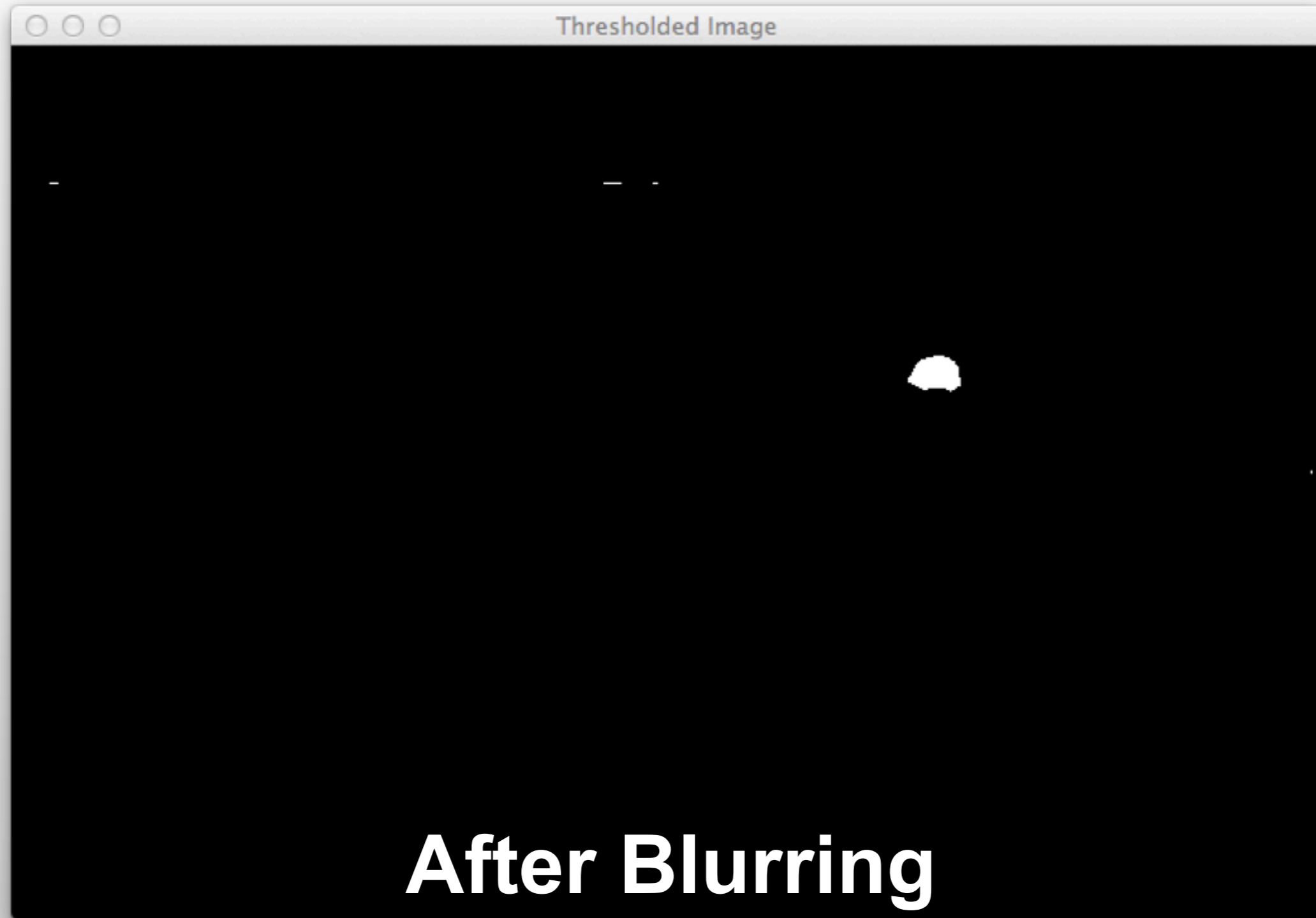
How to Blur?

- Box Filter (a type of linear filter)
    - Make every pixel the average of itself and those around it
    - Removes "sharp" features
    - Form:

$$\frac{1}{9} \begin{array}{|c|c|c|} \hline 1 & 1 & 1 \\ \hline 1 & 1 & 1 \\ \hline 1 & 1 & 1 \\ \hline \end{array}$$

Example Box Filter Process

33	68	47	44	96	78	46	63	10	66
88	34	84	67	54	55	56	1	65	83
56	98	65	72	80	11	30	17	43	82
46	89	24	50	52	37	0	5	48	67
85	49	82	17	6	93	98	39	62	92
89	35	58	81	34	84	36	29	60	70
45	81	6	88	32	16	65	75	86	22
98	16	49	33	33	35	48	55	47	37
14	39	20	97	36	11	23	77	66	51
7	94	22	28	91	21	48	11	46	11

$$1/9 * (73+50+66+19+73+27+22+56+9) = 44$$

Aside: How could we sharpen?

0	0	0
0	2	0
0	0	0

- 1/9

1	1	1
1	1	1
1	1	1

- Sharpening makes differences from local average *more* apparent