KENTECH
Korea Institute of Energy Technology

Advanced Computer Vision
Week 02

Sep. 6, 2022

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Image Processing with Python

Anaconda – "Virtual Environment"

Purpose?

→ Package & environment management system [1]

Why?

→ **Various versions** of the package are required to run the code

→ To use multiple versions on a system, we have to **repeat** the process of installing and uninstalling.

→ Conda easily creates, saves, loads and **switches** between environments on your local system.

[1] https://docs.conda.io/en/latest/

Conda: Installation

Download Conda file

$ wget https://repo.anaconda.com/archive/Anaconda3-xxxx.xx-Linux-x86_64.sh

Install Conda

$ sh Anaconda3-xxxx.xx-Linux-x86_64.sh

Apply .bashrc

$ source ~/.bashrc

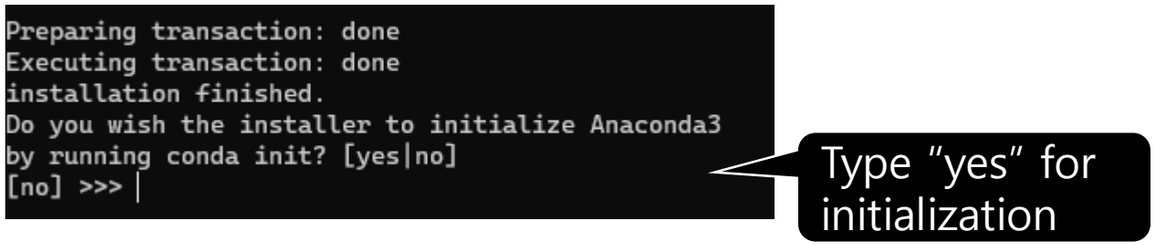
If you missed base initialization

$ conda config --set auto_activate_base true

How to turn on and off Conda?

$ conda activate

$ conda deactivate



Conda: Create Your Own Environment

Create a new Conda environment

$ conda create -n my_env python=3.7

Check available Conda environments

$ conda env list

Activate the environment

$ conda activate my_env

Check Python version

$ python –version

Remove environment

$ conda env remove –n my_env

→ Please activate your environment, whenever you open a new terminal!

→ For more efficient programming, please try tmux! [1]

[1] https://github.com/SeokjuLee/terminal-setup

Conda: Package Management

Install new packages on the Conda

$ conda install new_pkg

Install some basic packages as follows:

$ conda install numpy
$ conda install scikit-learn
$ conda install scipy
$ conda install scikit-image
$ conda install -c conda-forge opencv
$ conda install matplotlib
$ conda install tqdm

Check the list of installed packages in the current environment

$ conda list

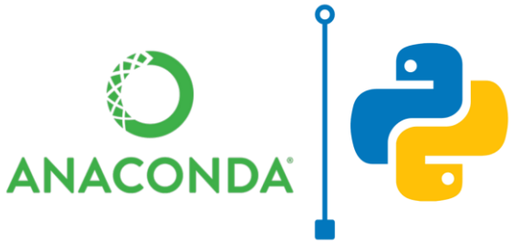
```
(test) slee@oem-System-Product-Name:/SSD1/slee$ python puzzle_1.py
Traceback (most recent call last):
  File "puzzle_1.py", line 6, in <module>
    import numpy as np
ModuleNotFoundError: No module named 'numpy'
```

Type "-c" option to specify the channel (package distributor)

Some packages are not available with Conda installation. Please try pip! [1]

First, install pip (package installer for Python)

$ conda install pip
$ pip install new_pkg

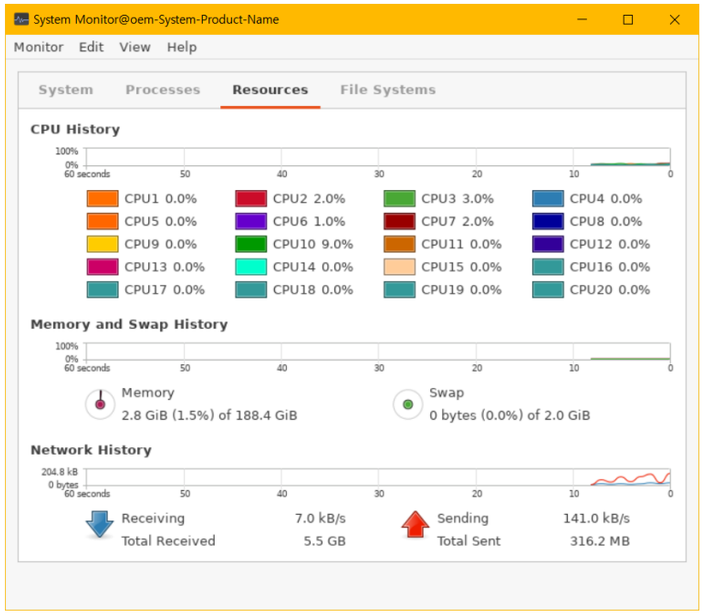


[1] https://daewonyoon.tistory.com/359

Install Useful Applications

System monitor

$ sudo apt-get install mate-system-monitor

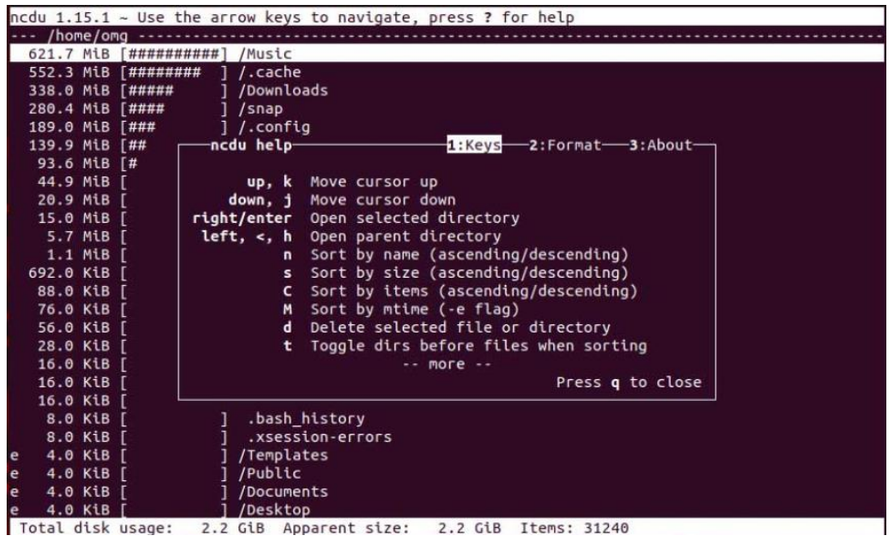


Vim (improved vi – text editor for terminal) [1]

$ sudo apt-get install vim

Check disk space

$ sudo apt-get install ncdu



Tmux

$ sudo apt-get install tmux

Sublime Text (link): code editor

[1] https://gmlwjd9405.github.io/2019/05/14/vim-shortkey.html

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Image Processing Puzzle

Summary of Previous Lesson

Basics of Python functions

→ How to define and use

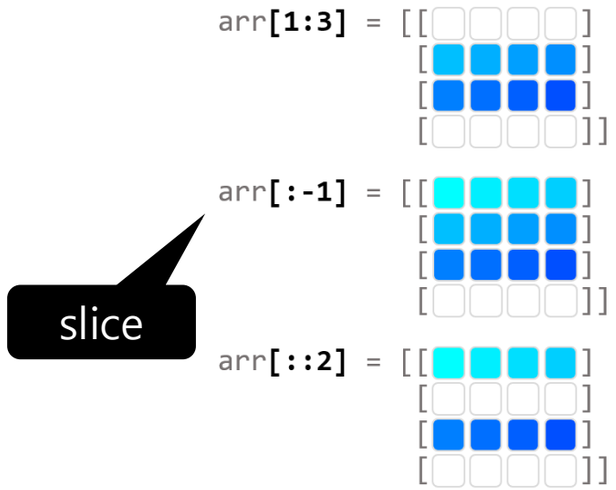
Basics of NumPy arrays

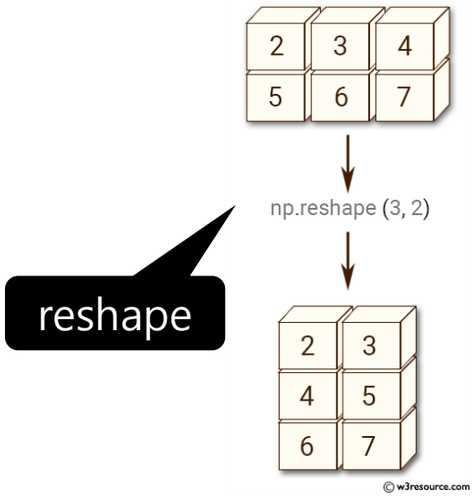
→ Many useful operations for multi-dimensional arrays

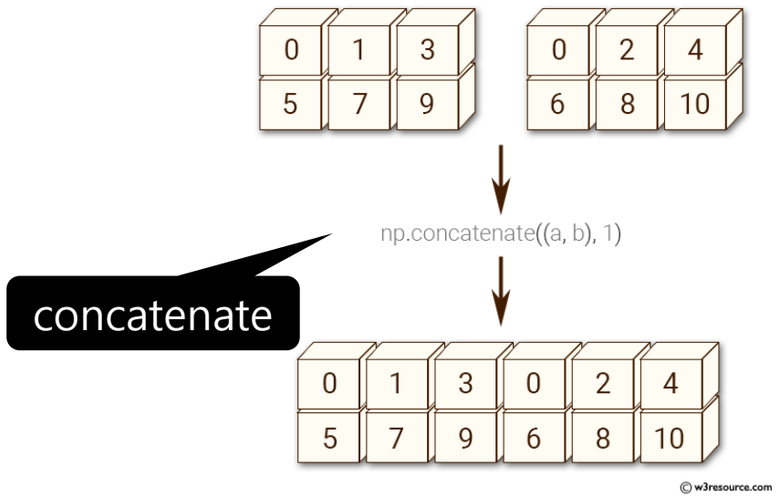
→ Please always check the current shape of arrays using the **shape** method!

→ Basic math operations: add, subtract, min, max, mean, etc. along different axis

→ Basic transformations: slicing, reshape, concatenate, stack, append, etc.







[1] w3resource.com

Now, Let's Play with Images!

Solve image processing puzzles.

→ Multiple image processing missions to make specific images.

→ If you need, please refer below pages.

Numpy: https://numpy.org/doc/stable/reference/

Scikit-learn image: https://scikit-image.org/

PIL image: https://pillow.readthedocs.io/en/stable/reference/Image.html

Codes are available at:

https://view.kentech.ac.kr/a6fac1a2-7304-409e-85f0-78b1d527034f

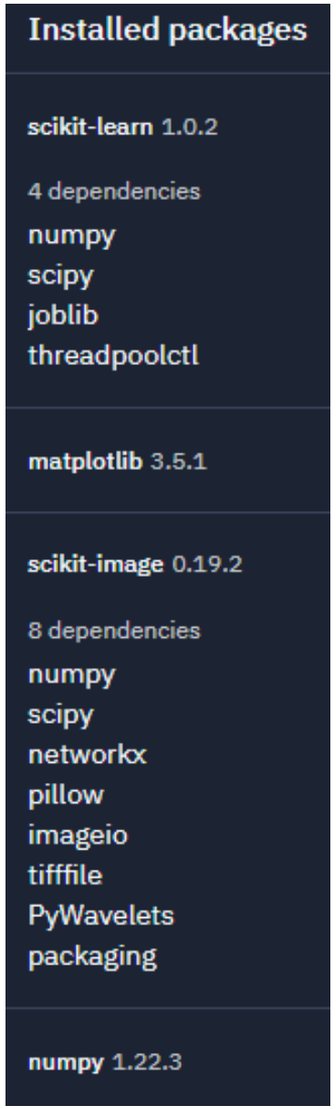


Image Processing Puzzle

Now we will try visualization

→ Enables image debugging

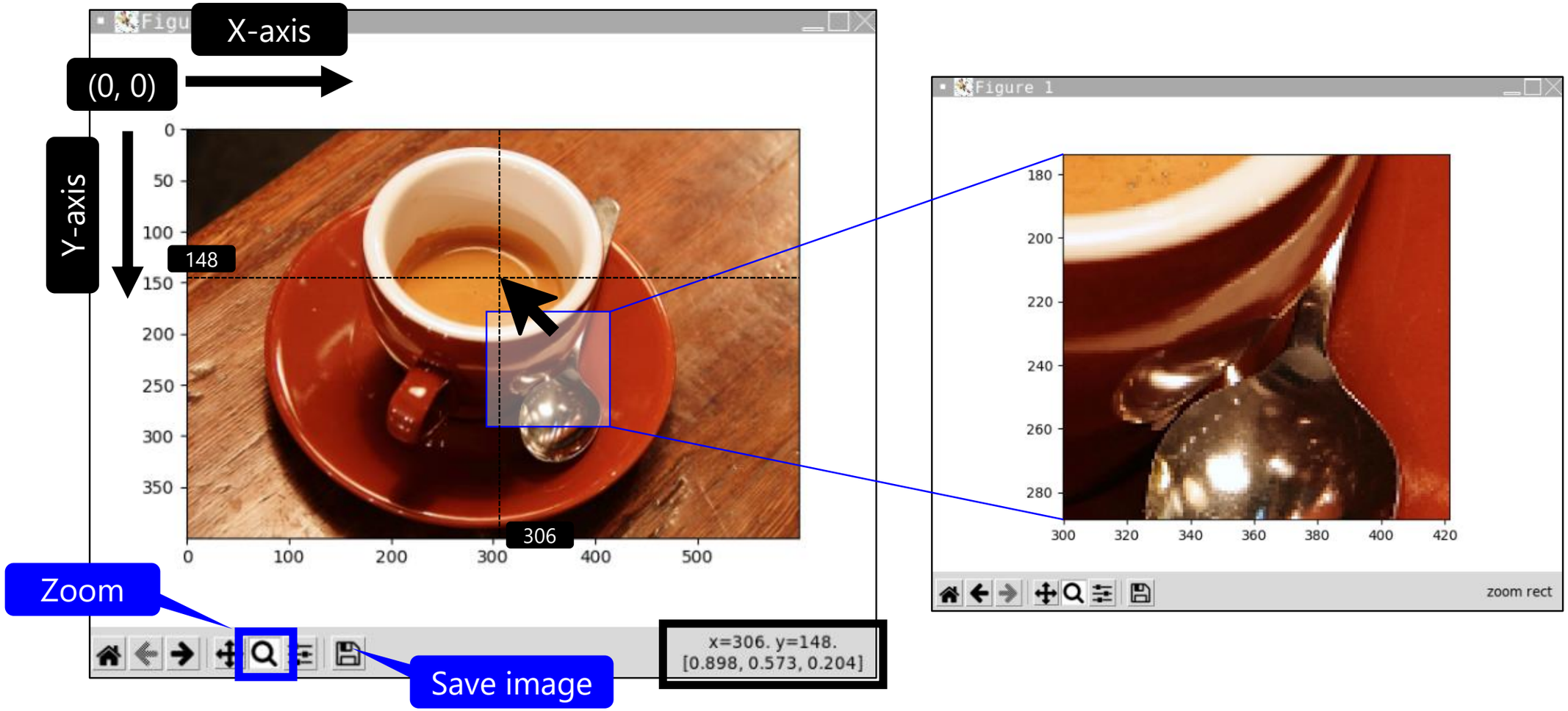
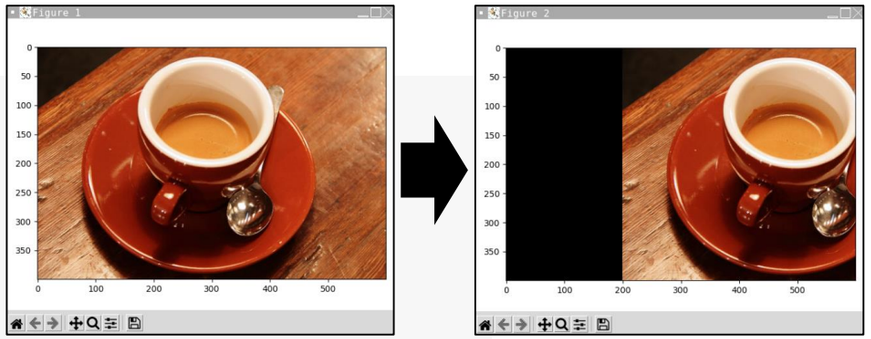


Image Processing Puzzle

Discussion 2: shifting image over x-axis

→ Use loop to generate the target image



```
hh, ww, ch = im.shape

for i in range(ww):
        print('index:', i)
        im1 = np.zeros(im.shape)
        im1[:, i:, :] = im[:, :ww-i, :]
        if (im1 == gt1).all():
                break;

check_same(gt1, im1)
```

Check the shape

Search space: maximum width

Initialize

Assign

Break the loop if the target is matched

Check if the output is correct

Image Processing Puzzle

Discussion 2-2: shifting over both x- and y-axis

→ Use loop to generate the target image → Too slow!

```
flag = False
hh, ww, ch = im.shape
for i in range(hh):
  for j in range(ww):
    print('index:', i, j)
    im1 = np.zeros(im.shape)
    im1[i:, j:, :] = im[:hh-i, :ww-j, :]
    error = np.abs(im1 - gt1).mean()
    if error == 0:
      flag = True
      break;
  if flag:
    break;
check_same(gt1, im1)
```

Search space: both maximum height + width
Use "**nested loop**"

You can check the processing time using the below code lines:

```
import time
start = time.time()
…
print(time.time() - start)
```

Image Processing Puzzle

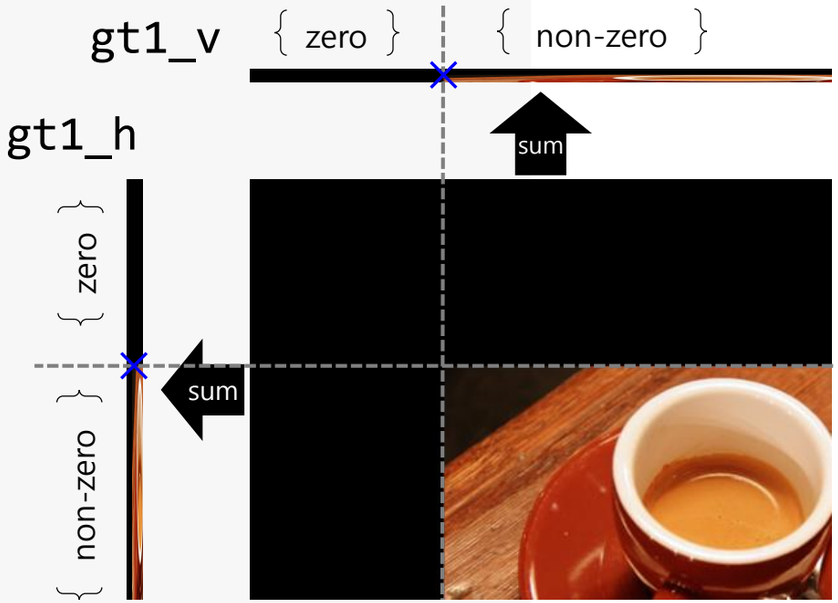
Discussion 2-2: shifting over both x- and y-axis

→ Dimension reduction. Please discuss this code in your report!

```
hh, ww, ch = im.shape

gt1_h = gt1.sum(axis=(0,2))
gt1_v = gt1.sum(axis=(1,2))

jj = (gt1_h == 0).sum()
ii = (gt1_v == 0).sum()

im1[ii:, jj:, :] = im[:hh-ii, :ww-jj, :]

check_same(gt1, im1)
```

Dimension reduction

Automatic binary sum
(= count the number of zeros)



→ Once you are familiar with the "for-loop" statement,

Try to implement your code **efficiently** through **dimension reduction!**

Image Processing Puzzle

Discussion 4: Image multiplication

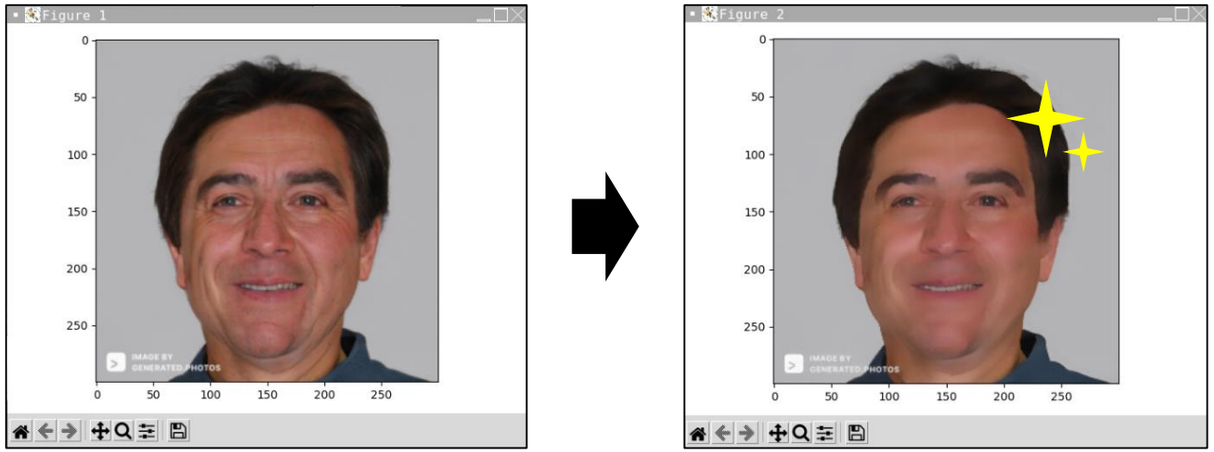
→ Multiply a binary mask to black out unnecessary parts.

Discussion 5: Image cropping and resizing

→ Crop a specific region with slicing, and resize the image.

Discussion 6: Photoshop - bilateral filter

→ Let's see how to do “photoshop” with a basic filtering algorithm.



Randomly generated face image (AI model) from https://generated.photos/face-generator/new

Discussion

<Image Processing Puzzle 2>
Please paste your result images (screenshot or save) in this report if needed.

Discussion 2-3: Shifting image
2.7. Try yourself! Please try to use “dimension reduction”.

2.8. Please visualize your output image.

Discussion 4 - Image multiplication
4.1. Please load a ground truth (GT) array from 'samples/puzzle2/gt1.npy'

4.2. Please convert 'im' to look like 'gt1' by multiplying the binary mask.

4.3. What is broadcasting?

4.4. What are the rules for allowing broadcasting?

Discussion 5: Image cropping and resizing
5.1. Crop the image (cat's eye) by array slicing.

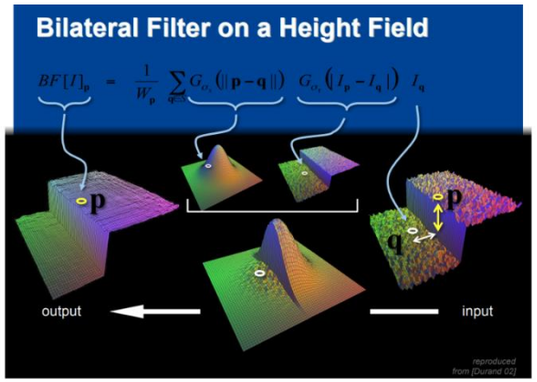
5.2. Increase the size of the "cat's eye" image to 400 x 400. Please discuss the difference between "rescale" and "resize".

Discussion 6: Photoshop - bilateral filter
6.1. Please capture random faces from "https://generated.photos/face-generator/new"

6.2. Please apply a "bilateral filter" on the image.

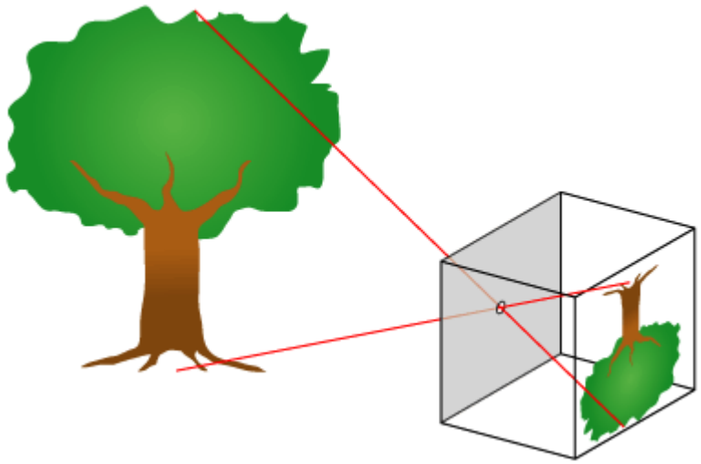
6.3. Please analyze the effect of the bilateral filter by changing the input parameters.

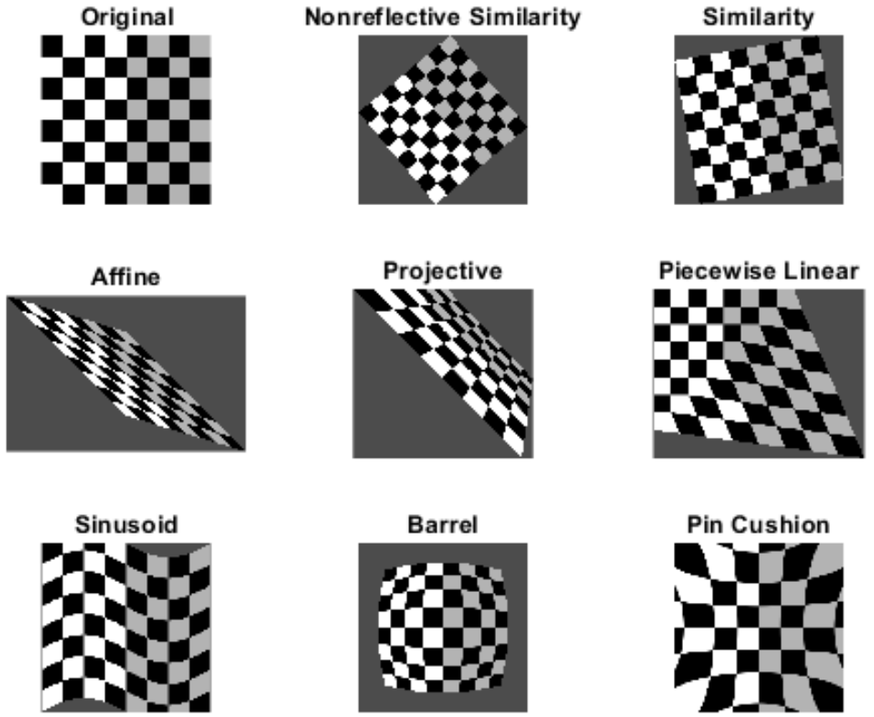
6.4. What are the pros and cons of filtering?



Next Contents

- Basic camera theory
  - Pinhole camera model
- Basic image transformation





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Brief Overview of Pinhole Camera Model

Camera Obscura – *Darken Room*

Camera (Latin) **= room or chamber**

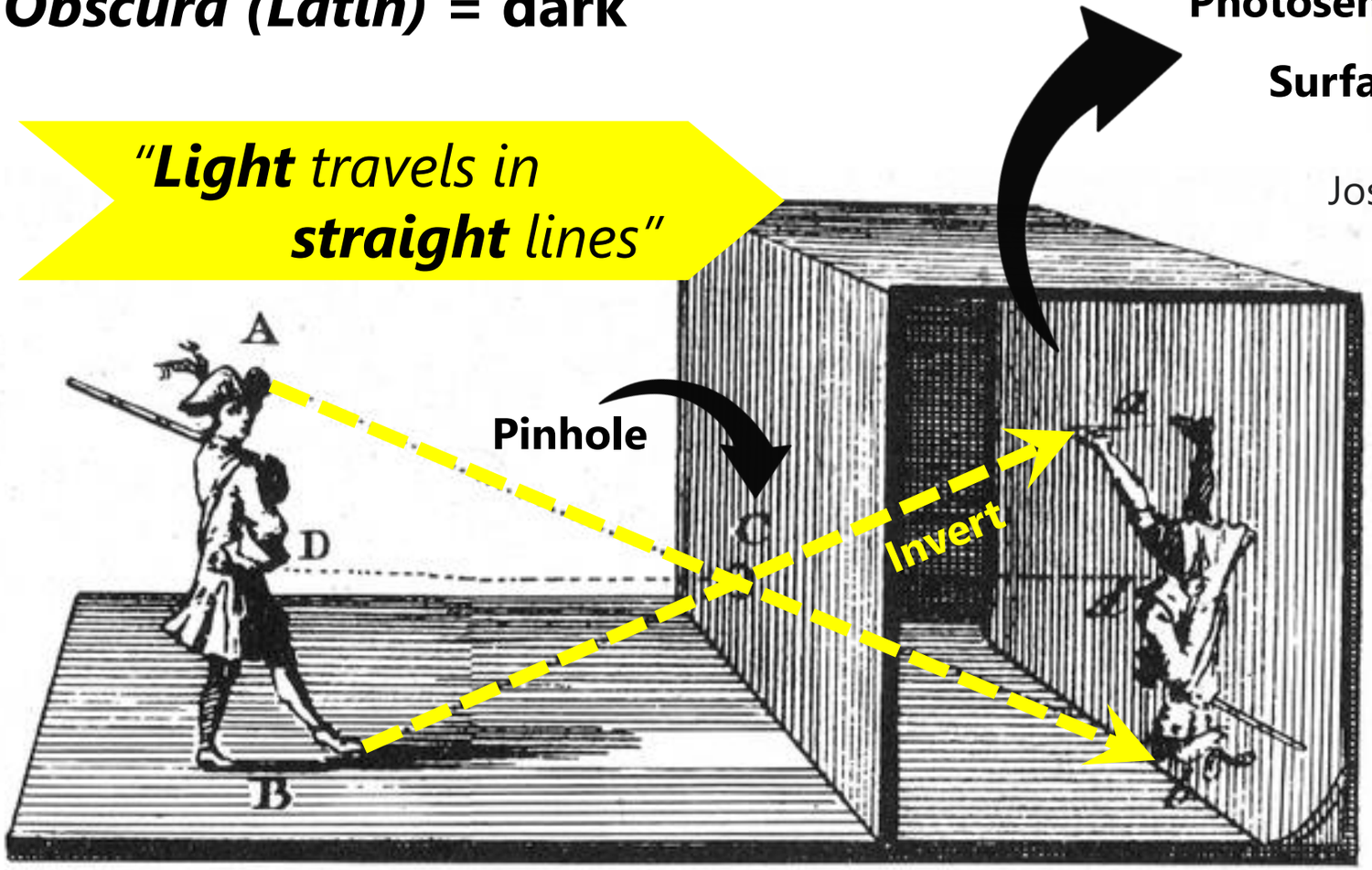
Obscura (Latin) **= dark**

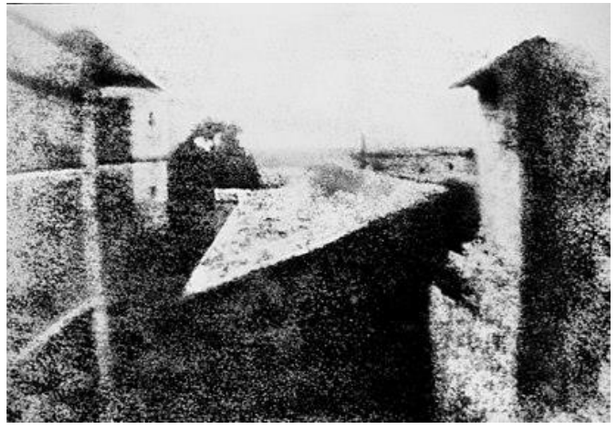
Photosensitive Surface

Joseph Nicéphore Niépce
(1765 – 1833)

The inventor of photography

"***Light*** *travels in* ***straight*** *lines"*

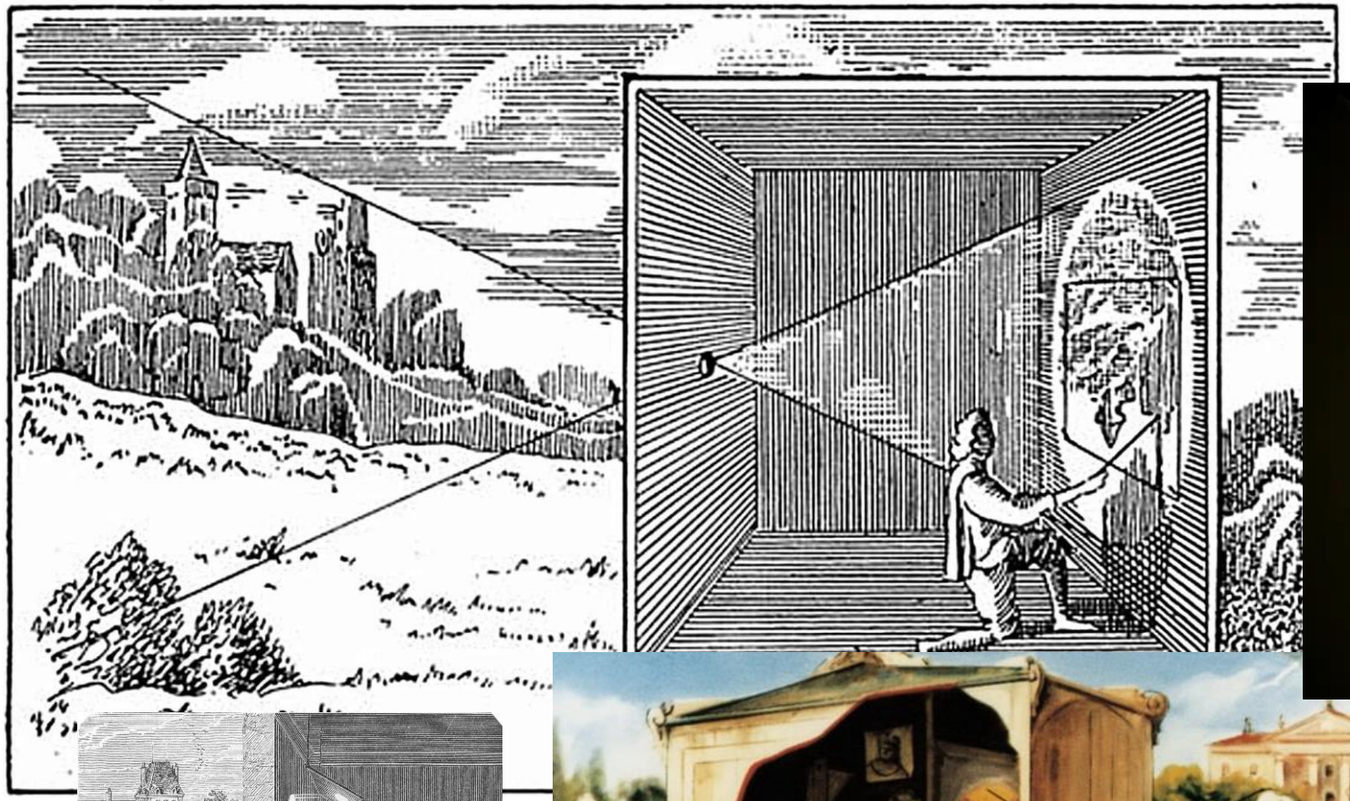


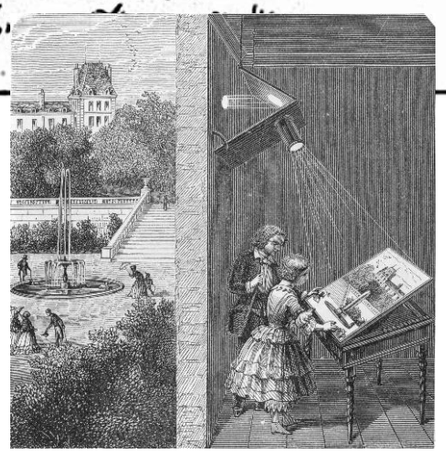


The first photograph

→ It took 8 hours

Camera Obscura – Based on *Art*





Amazing, cheap, fun way to experiment during COVID-19 quarantine

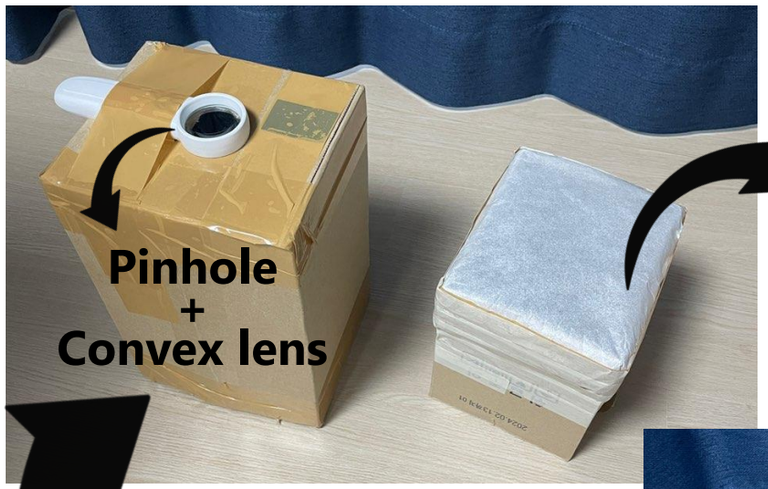
By Mathieu Stern

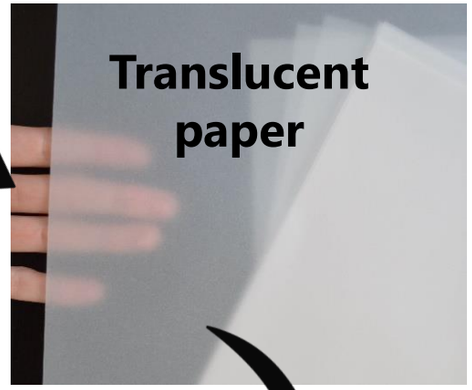
Inviting nature into your home!

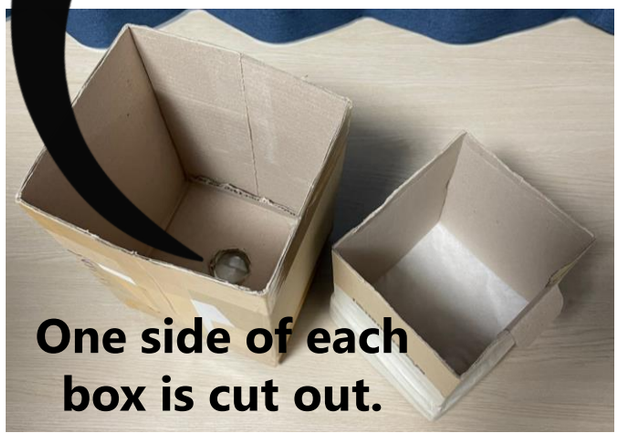
Agents of Change: Camera Obscura (Art Land Magazine)

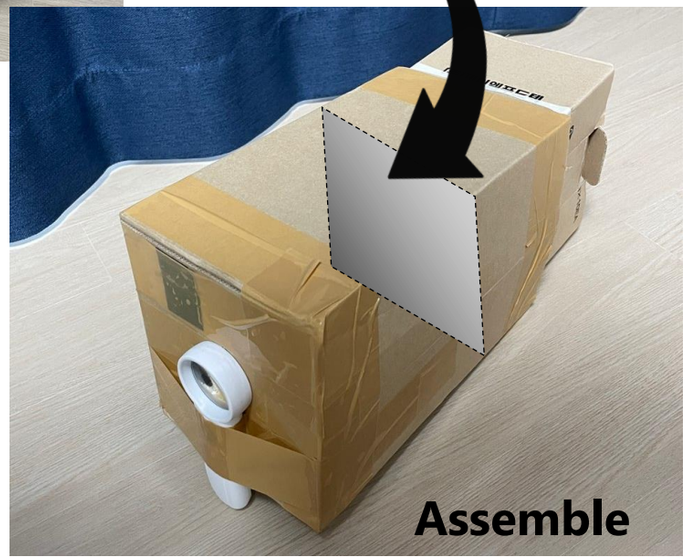
Camera Obscura – Making

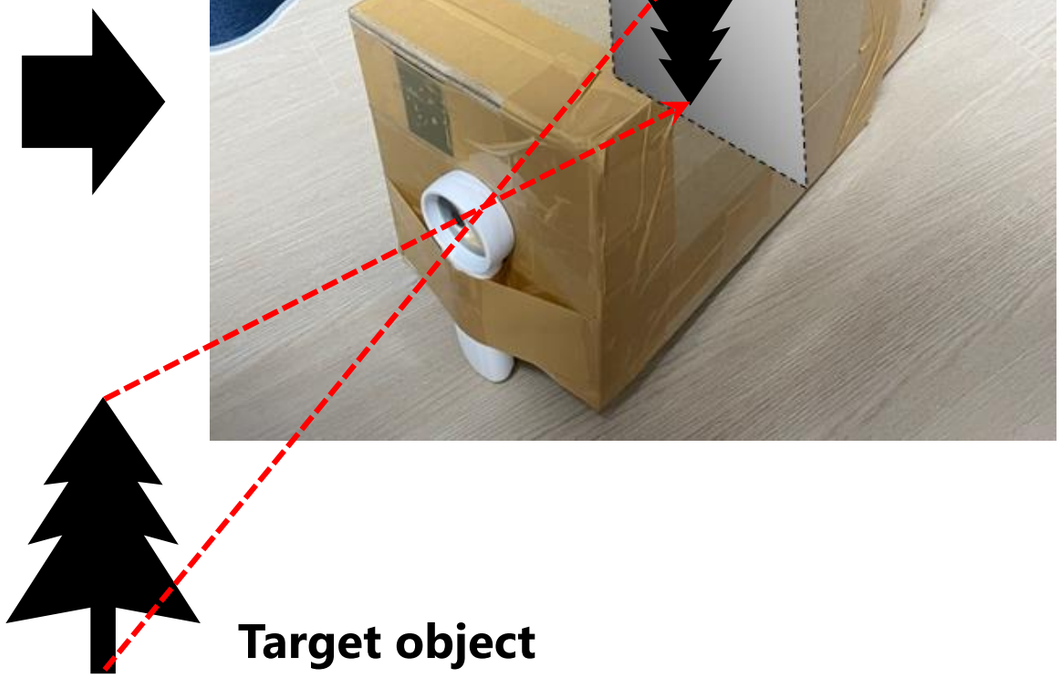
Preparation: two boxes, convex lens, translucent paper







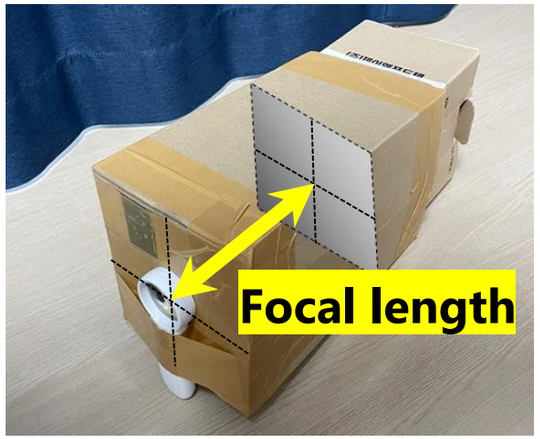




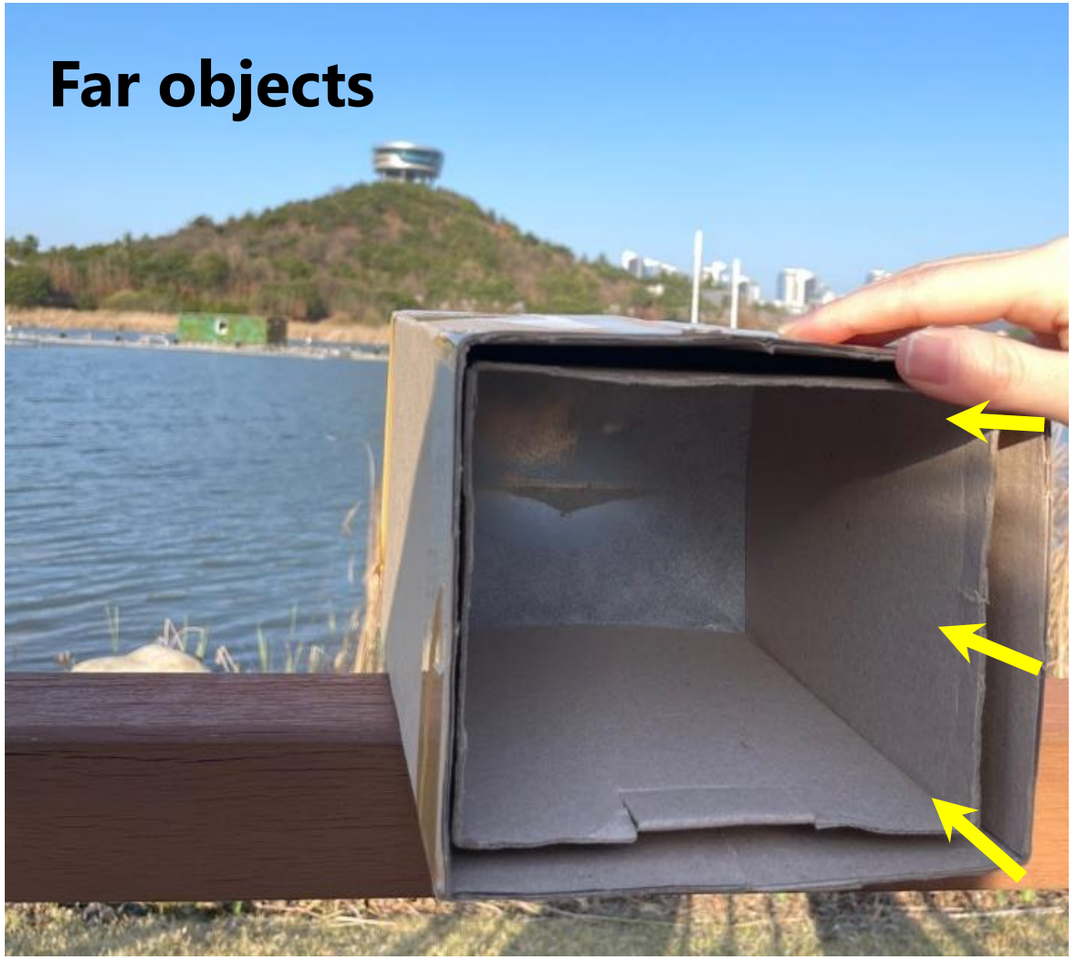
Camera Obscura – Experiments

Camera Obscura – About Focal Length

Near objects



Far objects

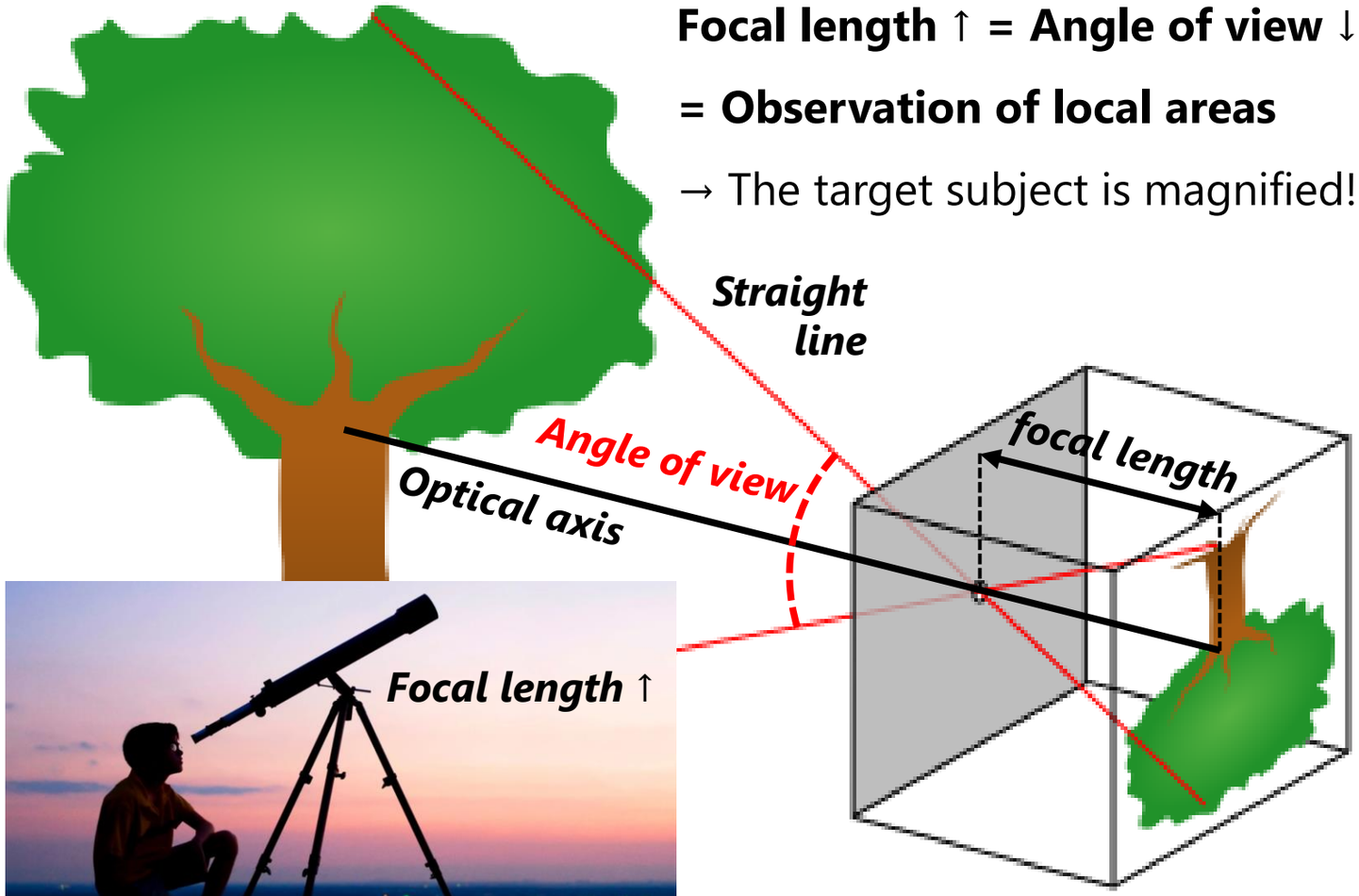


→ **Near** objects: focal length ↑

→ **Far** objects: focal length ↓

Pinhole Camera Model

Simplified example of ray optics



Focal length ↑ = Angle of view ↓

= Observation of local areas

→ The target subject is magnified!

We will make it!

***Resolution** (for image, “spatial”)

→ The number of pixels in each dimension

***Frame rate** (for video, “temporal”)

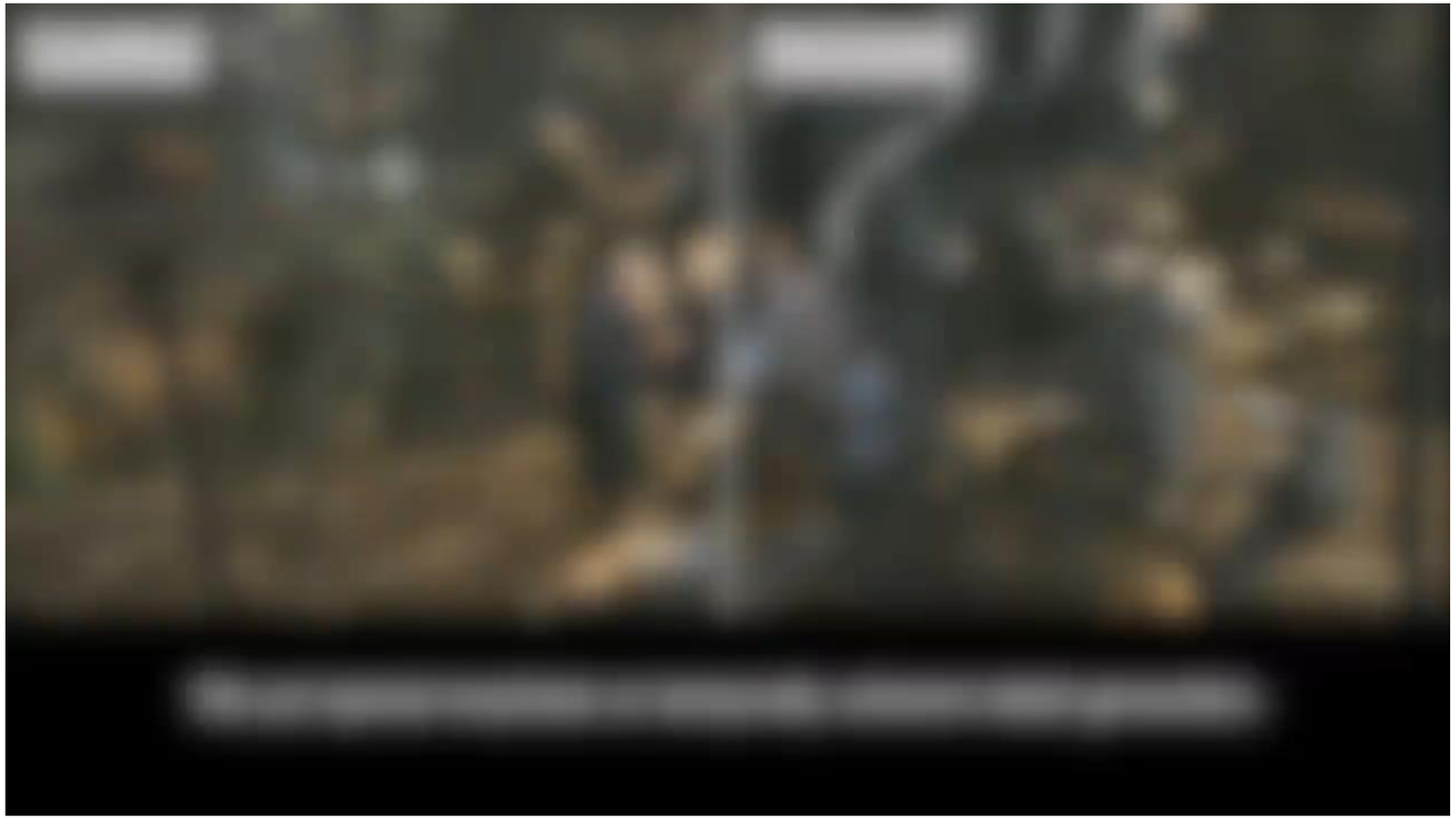
→ The number of image frames per second

Screen = Photographic film = CCD sensor

About Resolution

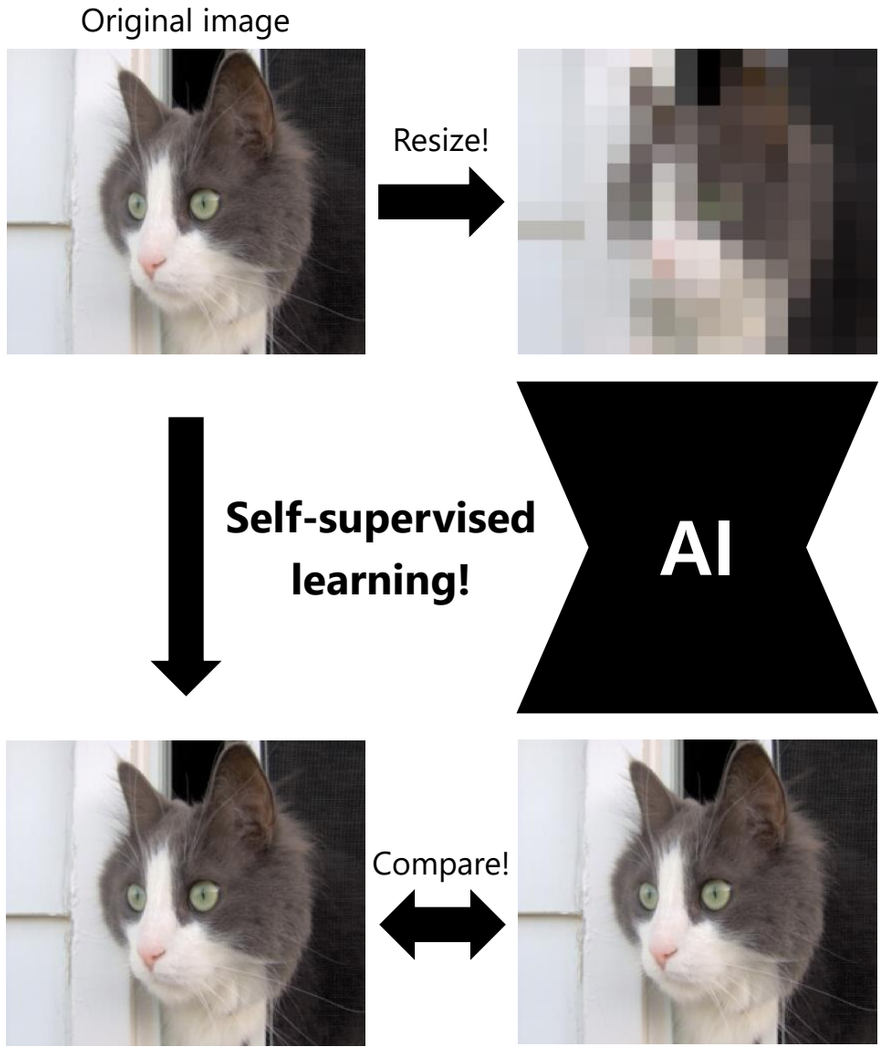
Example of deep learning application:

→ Image super resolution, "**spatial** processing"



TecoGAN (*SIGGRAPH'19*)

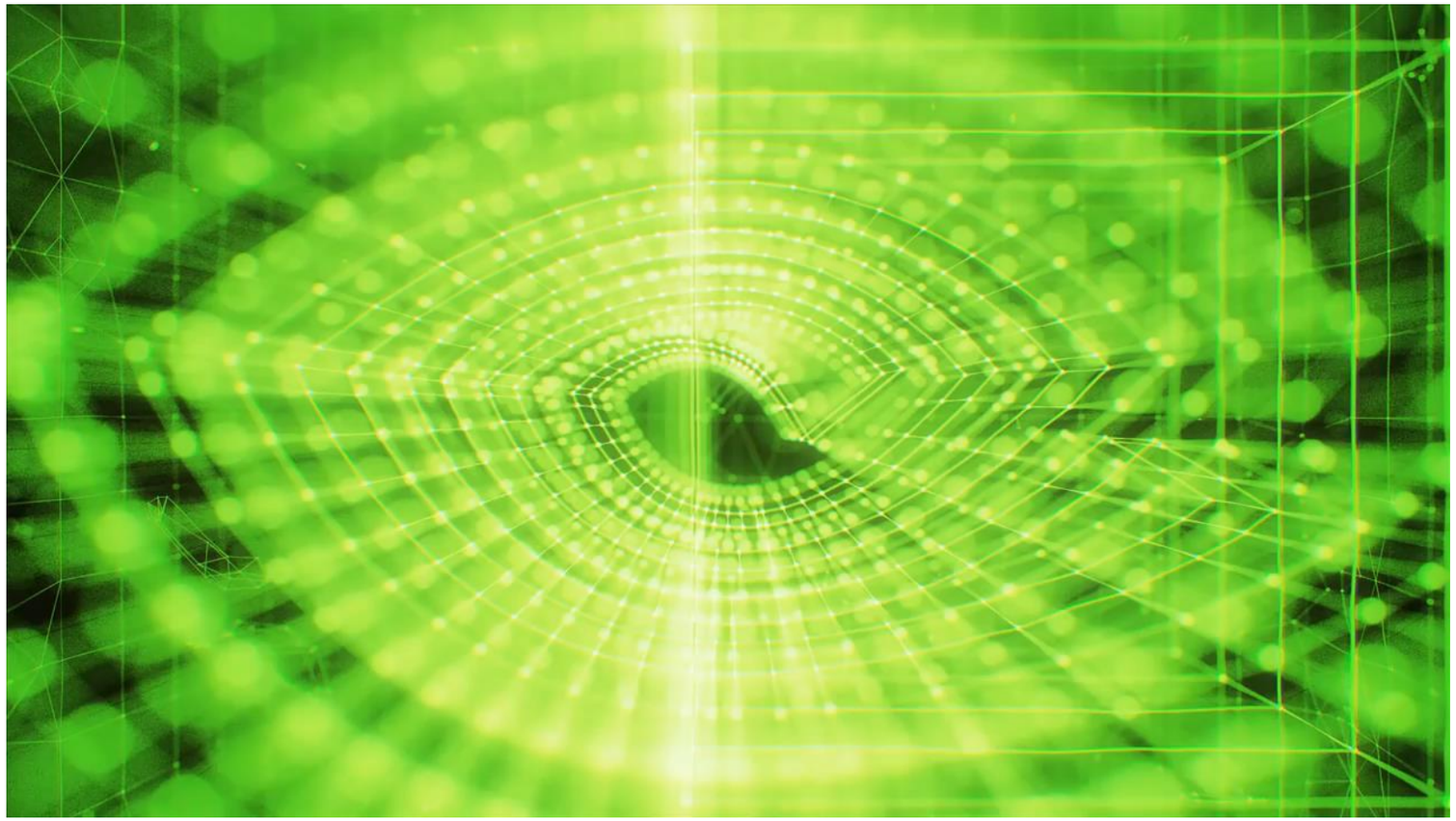
How to train?



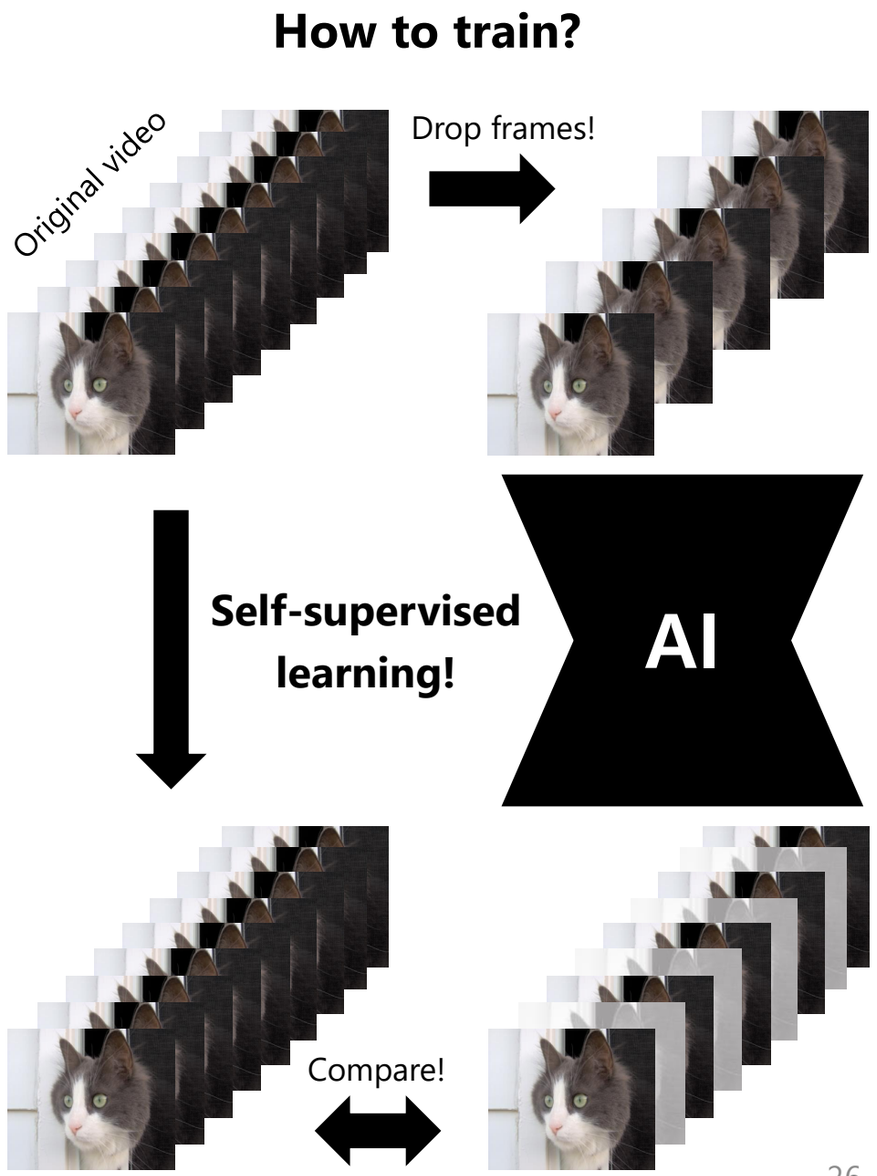
About Frame Rate

Example of deep learning application:

→ Video frame interpolation, "**temporal** processing"



Transforming Standard Video Into Slow Motion with AI
(Research at NVIDIA, 2018)



About Shutter Speed

A.k.a., exposure time:

The length of time that the digital sensor inside the camera is exposed to light

→ **How shutter speed affects motion.**

"The faster your shutter speed,
the sharper your image will be."

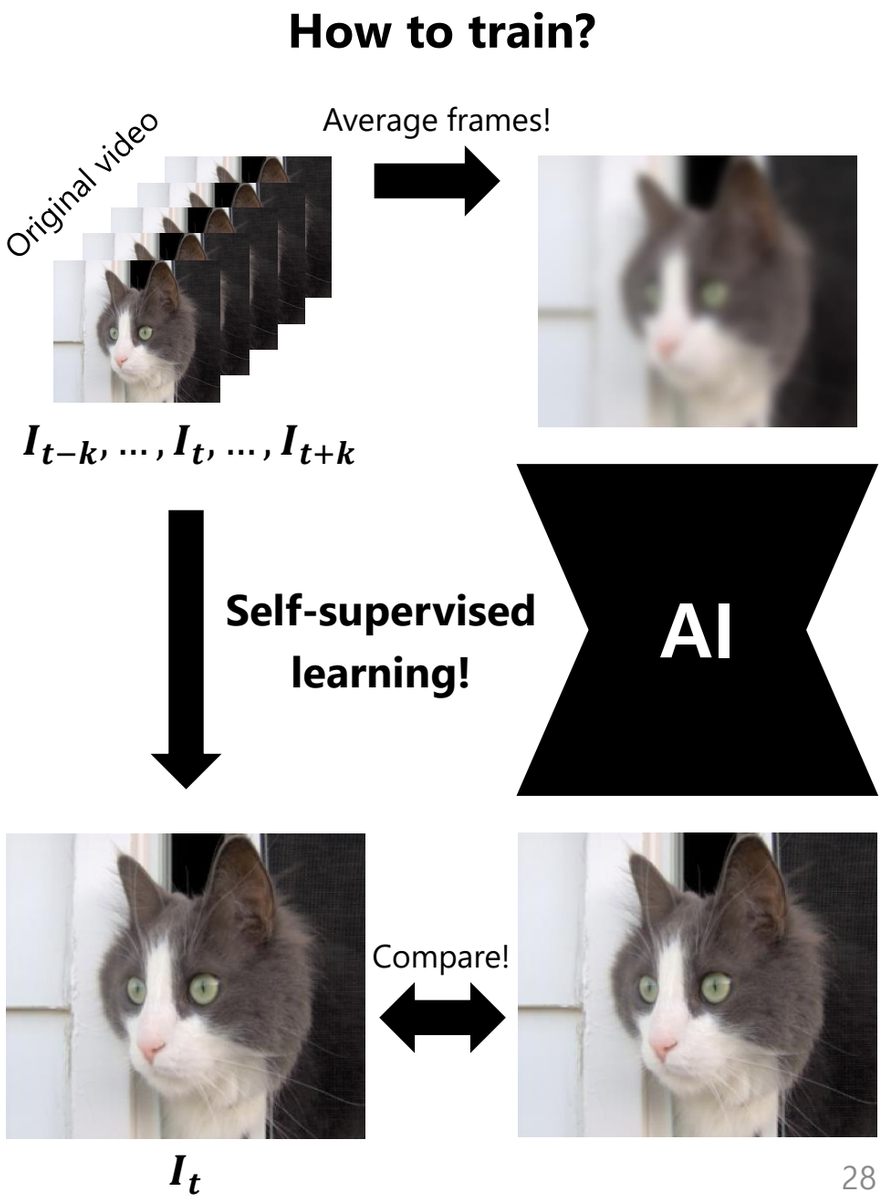
mrs-cook.weebly.com

About Shutter Speed

Example of deep learning application:

→ Motion deblurring

Fix Blurry Photos with Motion Deblur AI (by AKVIS, 2021)

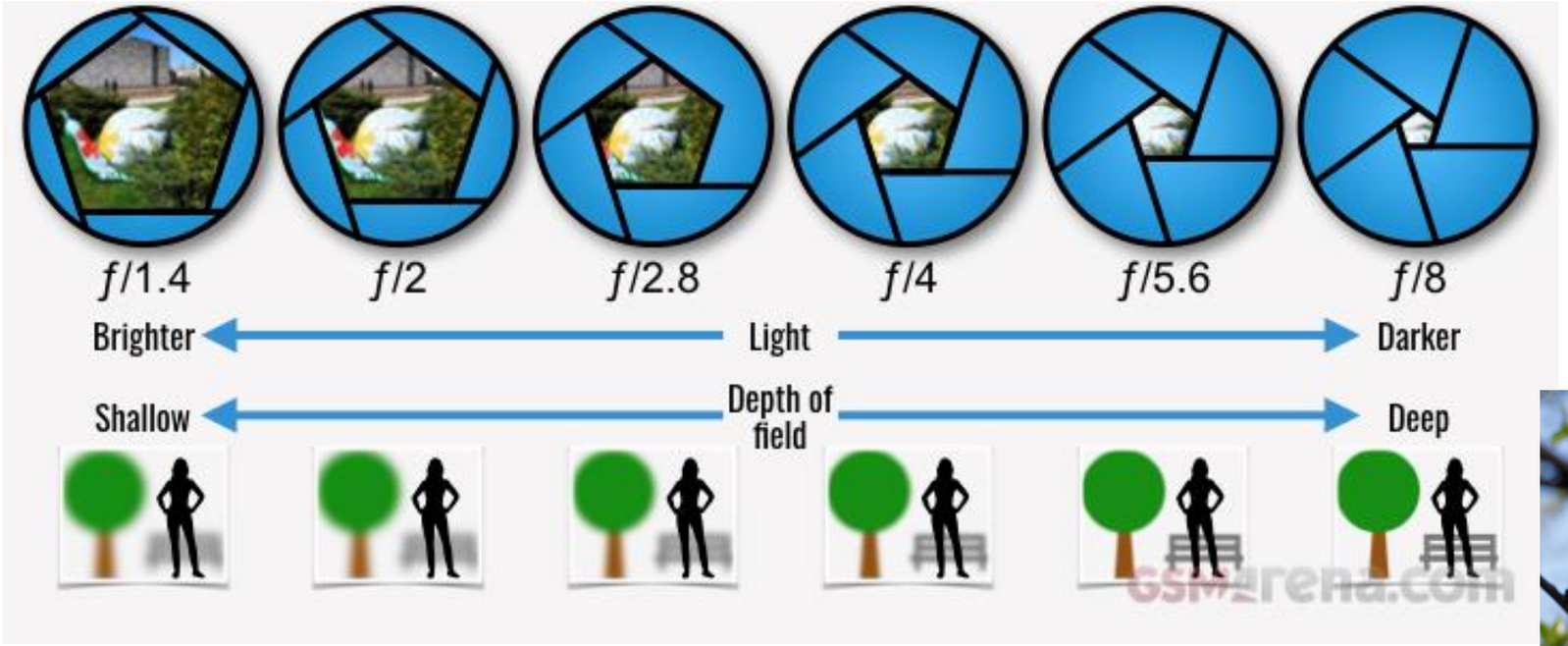


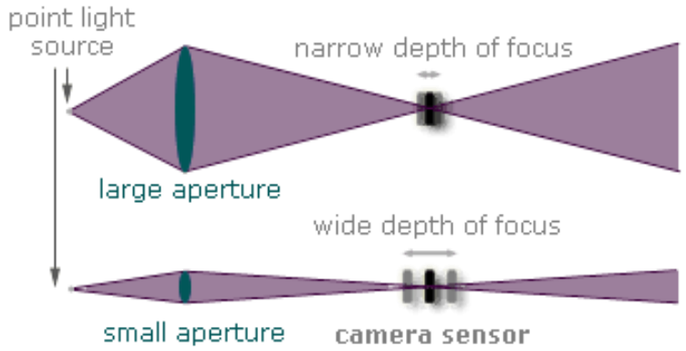
Aperture

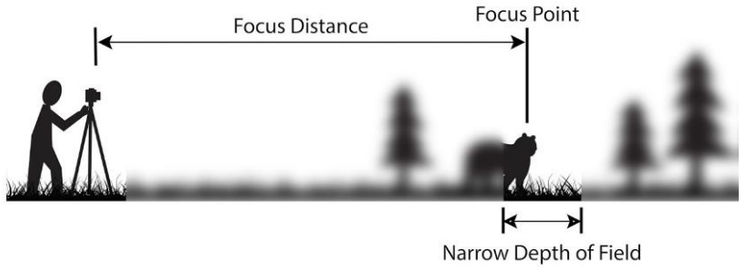
A hole through which light travels

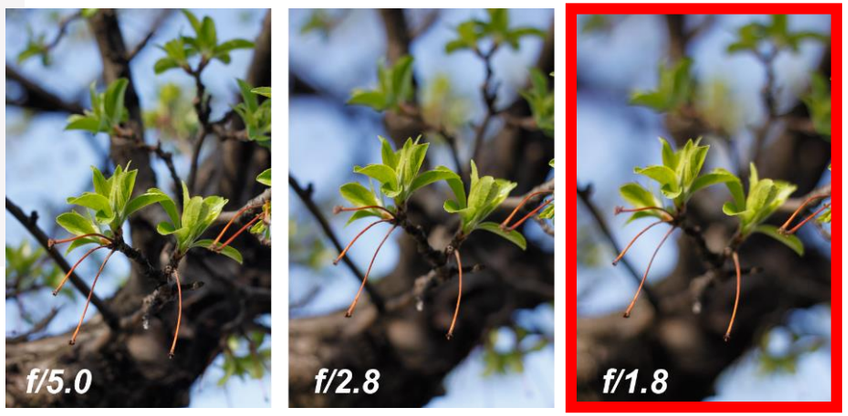
→ Controls the amount of the light

→ Controls depth-of-field (DoF)









Out focus
= **shallow** depth of field

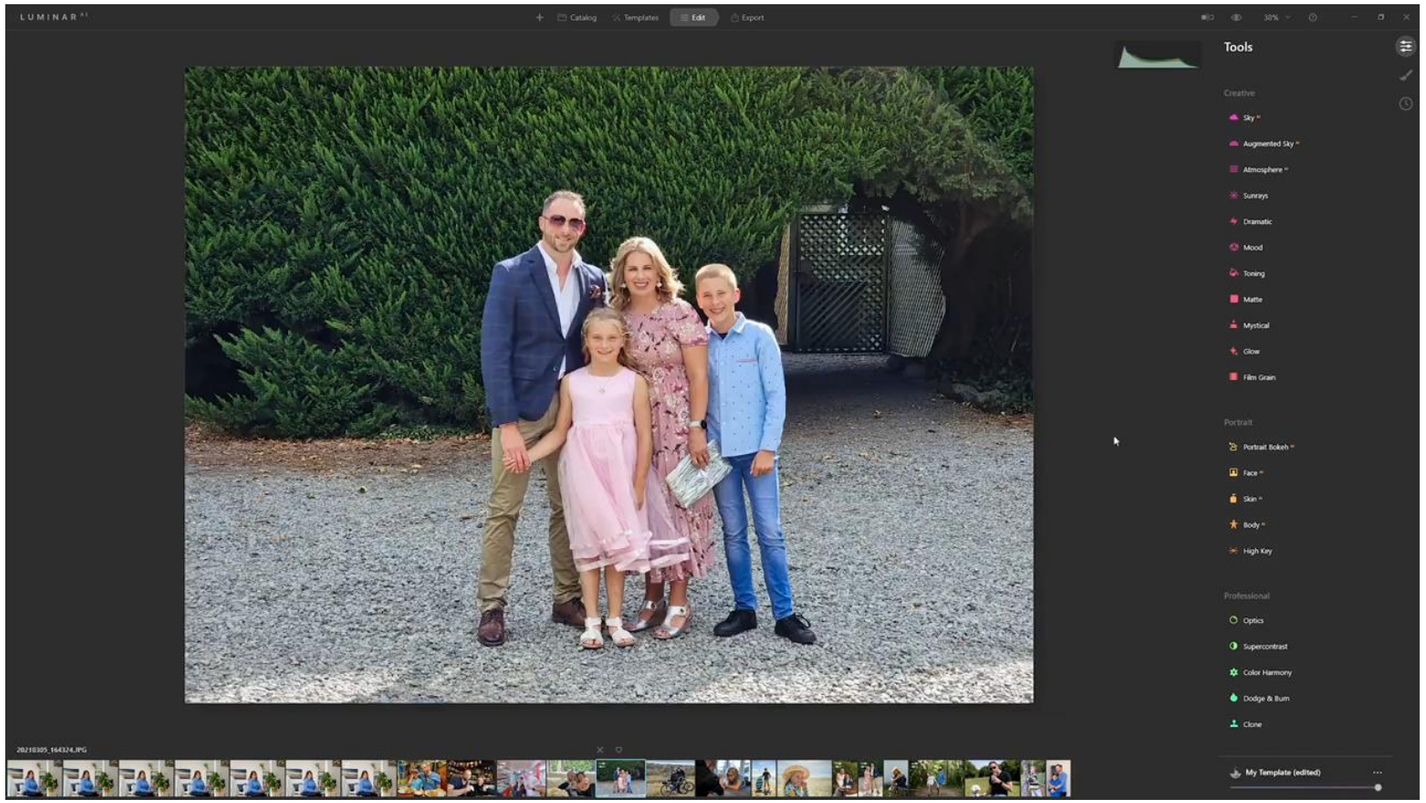
→ Helps concentrate on the subject!

[1] gsmarena.com [2] boostyourphotography.com [3] cambridgeincolour.com

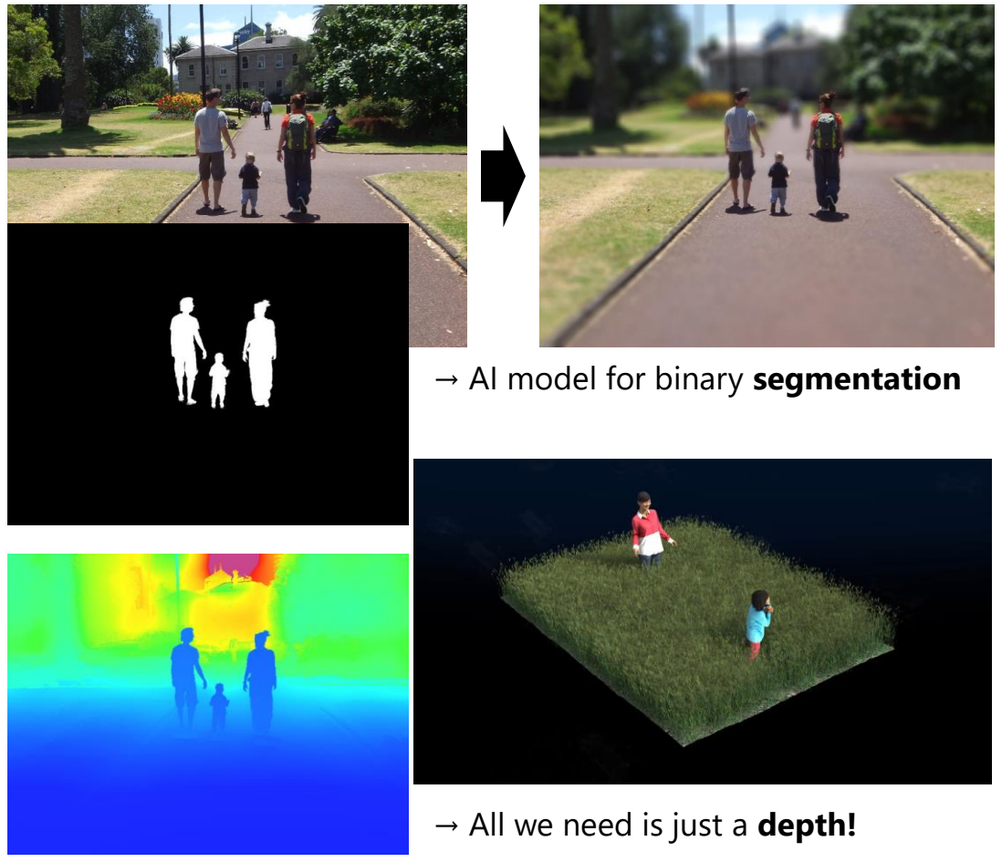
Out Focusing

Technically difficult for smartphone cameras 🤔

→ Computer vision & AI make this possible!



Automatic bokeh by Luminar AI (2021)



→ AI model for binary **segmentation**

→ All we need is just a **depth!**

[1] Liu, et al., “Bokeh Effects Based on Stereo Vision” (2015)

Summary of a Basic Camera Model

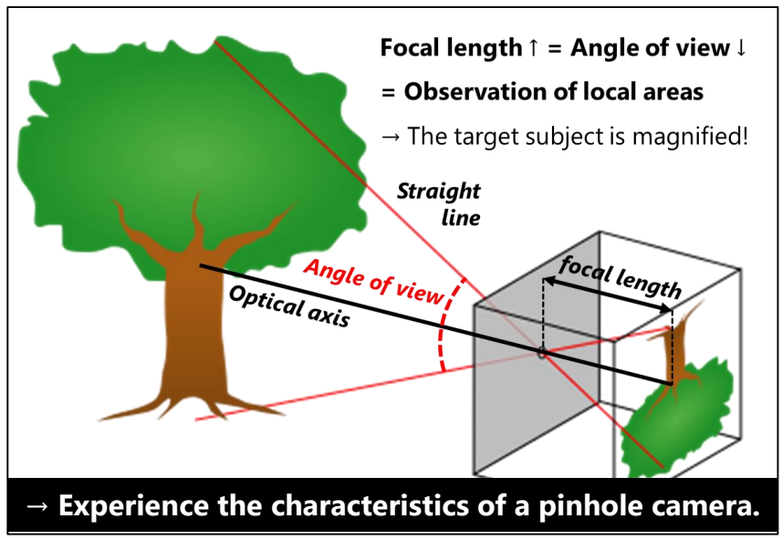
Characteristics of a pinhole camera

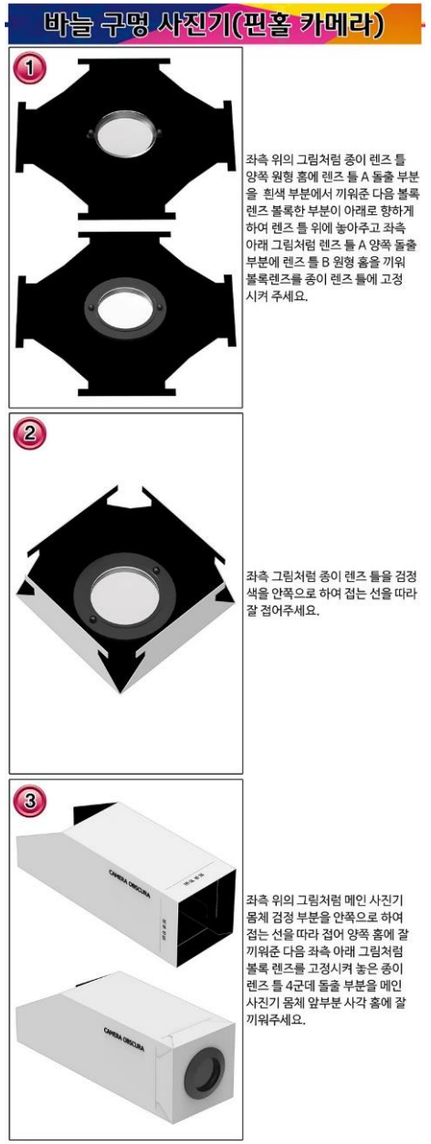
- Camera obscura
- Focal length
- Aperture & depth of field
- Shutter speed & exposure time

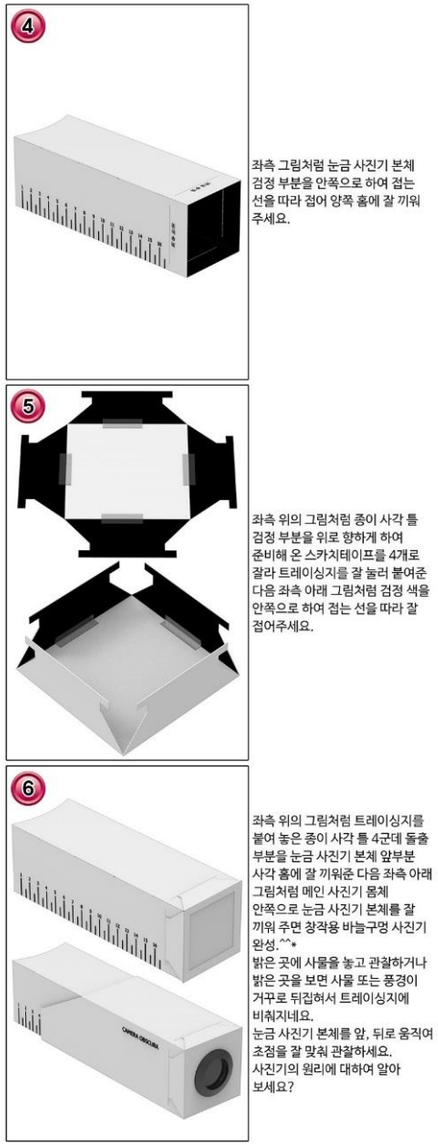
What AI can enhance images and videos

- Self-supervised learning
  - Image super resolution
  - Video frame interpolation
  - Motion deblurring
- Segmentation and depth
- 3D photography

Let's Make a Pinhole Camera







Discussion

<Pinhole Camera Quiz>
True or False?

Q1. Decreasing the focal length makes the object smaller. [True / False]

Q2. Increasing the focal length makes the field-of-view smaller. [True / False]

Q3. Increasing the size of aperture makes the photo darker. [True / False]

Q4. Increasing the size of aperture makes the depth-of-field shallower. [True / False]

Q5. Decreasing the shutter speed makes the photo sharper. [True / False]

Q6. Increasing the exposure time makes the photo brighter. [True / False]