Welcome to Computer Vision

Computer Vision

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Course Details

LECTURES: Monday & Wednesday

TIMINGS:

9:30 am – 11:00 am

MY OFFICE:

OFFICE HOURS:

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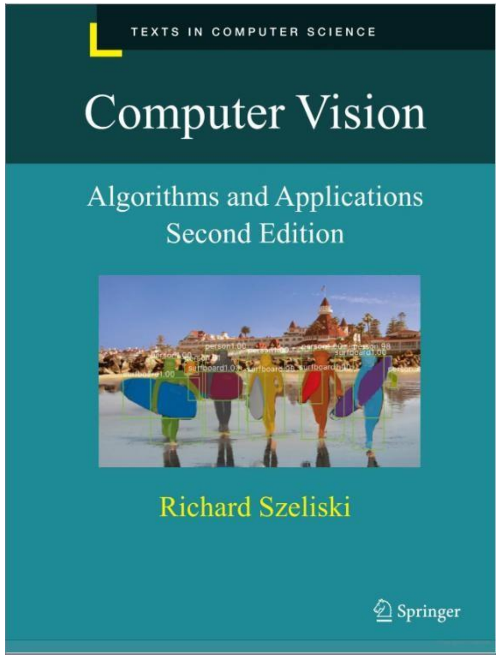
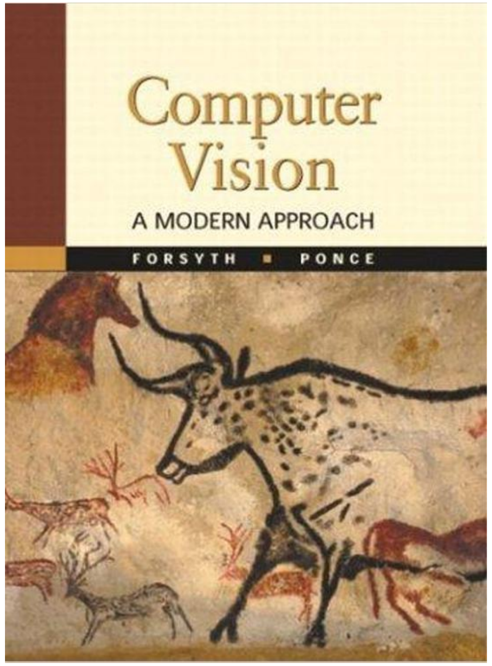




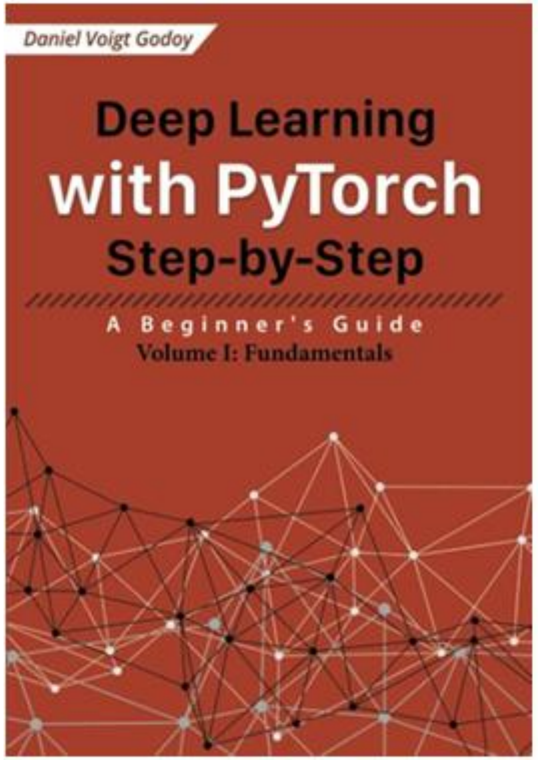
References

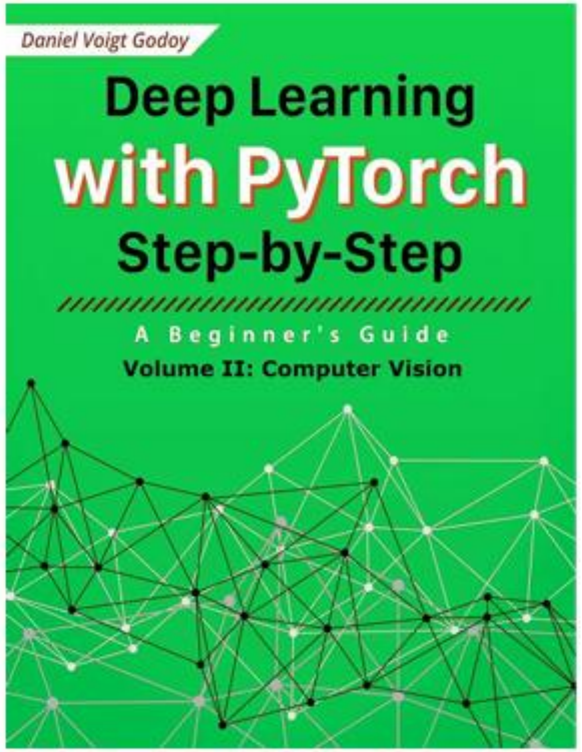
The material in these slides are based on:

1. Rick Szeliski's book: Computer Vision: Algorithms and Applications
2. Forsythe and Ponce: Computer Vision: A Modern Approach

Recommended Books

Deep Learning with PyTorch Step-by-Step by Daniel Voigt Godoy





Course Learning Outcomes

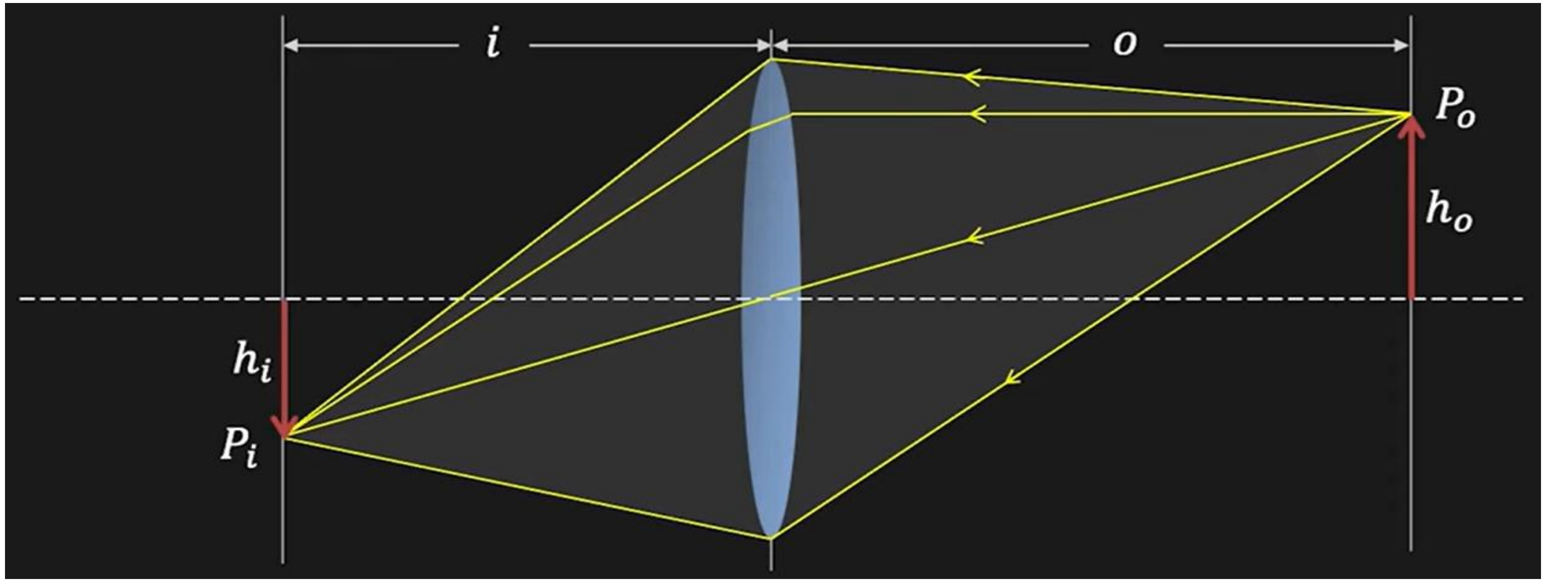
No	CLO (Tentative)	Domain	Taxonomy Level	PLO
1	Understanding basics of Computer Vision: algorithms, tools, and techniques	Cognitive	2	
2	Develop solutions for image/video understanding and recognition	Cognitive	3	
3	Design solutions to solve practical Computer Vision problems	Cognitive	3	

Outline

Image Formation

Image Magnification due to Lens

Image Magnification due to Lens

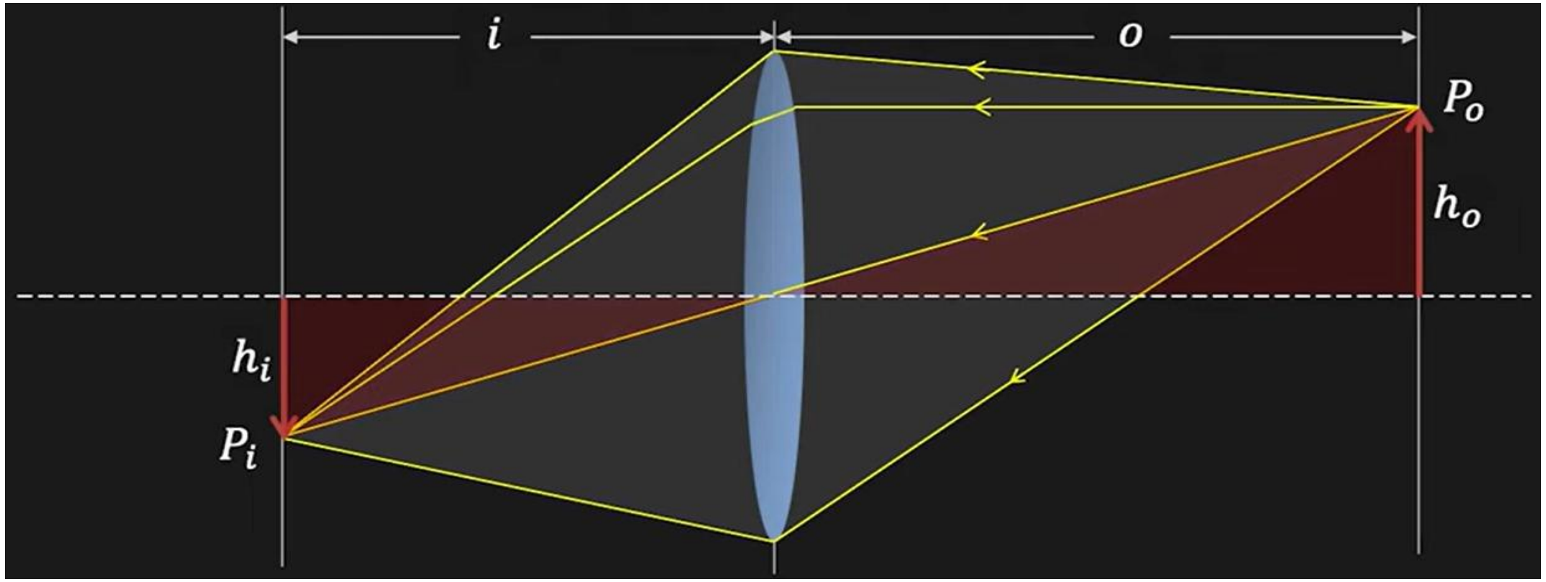


- The distance of the object from the lens is o
- The distance of the image from the lens is i
- The height of the object is h_o
- We want to know what is the height of the image h_i

So, magnification is defined as h_i divided by h_o

$$m = \frac{h_i}{h_o}$$

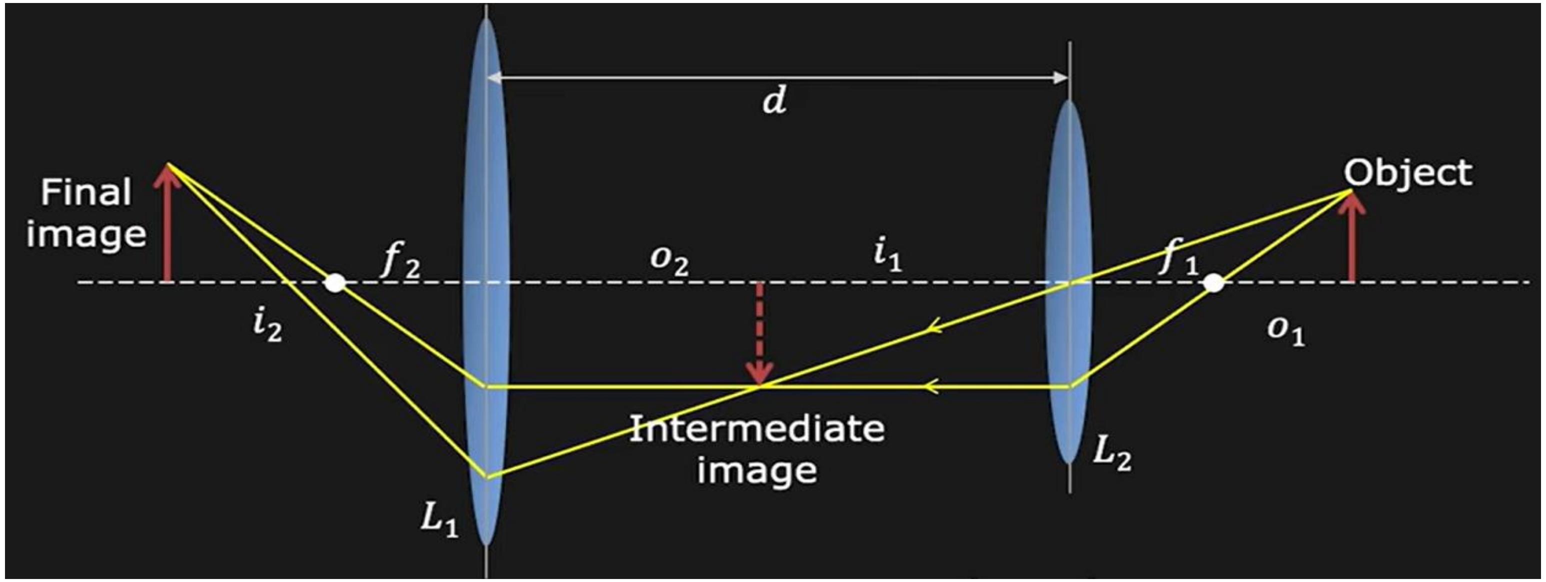
Image Magnification due to Lens



- Consider the two similar triangles, then $\frac{h_i}{h_o} = \frac{i}{o}$

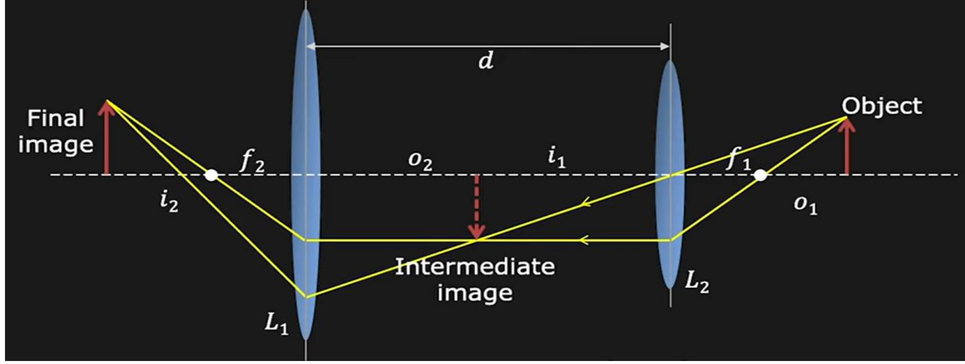
Two Lens System

Two Lens System



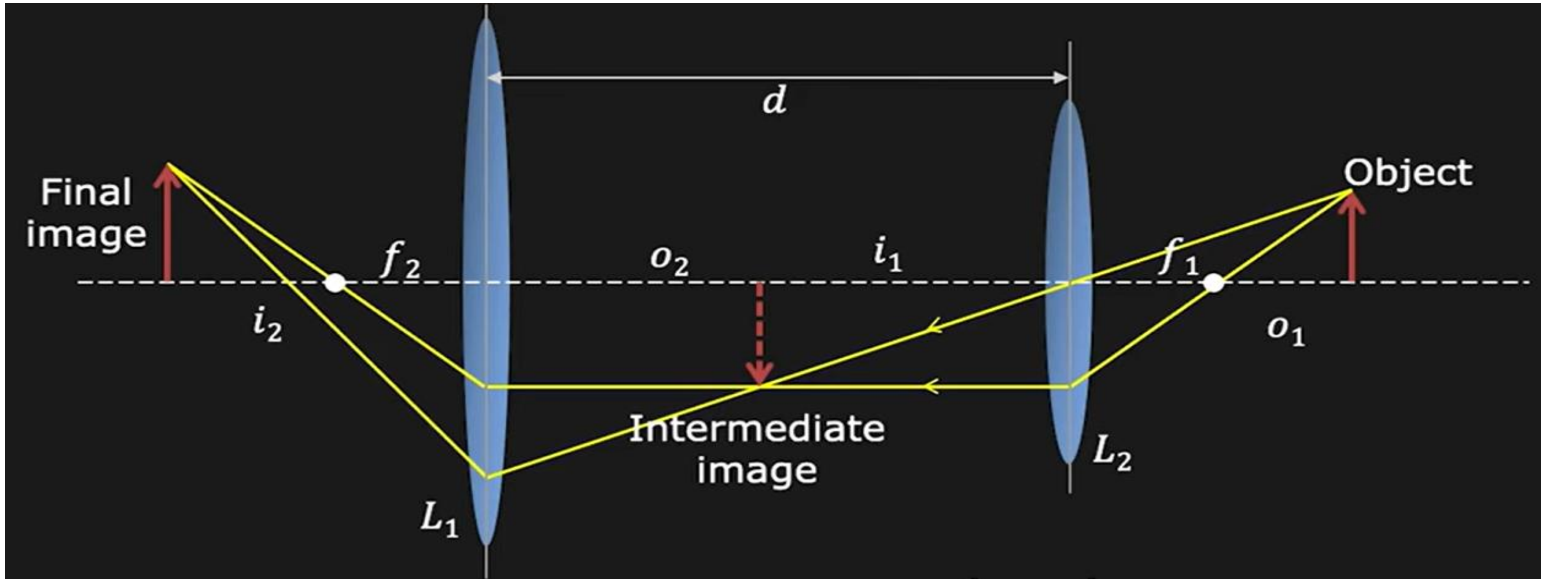
- The magnification of a lens system can be changed by using multiple lenses.

Two Lens System



- Consider the two-lens system where we have lens L_1 and L_2
- Object is placed at distance o_1 from L_2, which is imaged as an intermediate image between L_1 and L_2
- The intermediate image is a new object for the final image that is formed at distance i_2 from L_1
- So, the magnification of the complete system is a magnification due to lens L_2 times the magnification due to lens L_1
- So, $m = \frac{i_2}{o_2} \times \frac{i_1}{o_1}$

Two Lens System



- No need to change the distance between the object and the image plane.
- Instead, the effective magnification of the complete system is achieved by moving the lenses L_1 and L_2. That is the process of zooming.

Zooming: Move lenses to change magnification

Aperture of Lens

Aperture of Lens

- Aperture is the light receiving area of lens, indicated by lens diameter.

Aperture of Lens

- Aperture can be reduced / increased to control image brightness

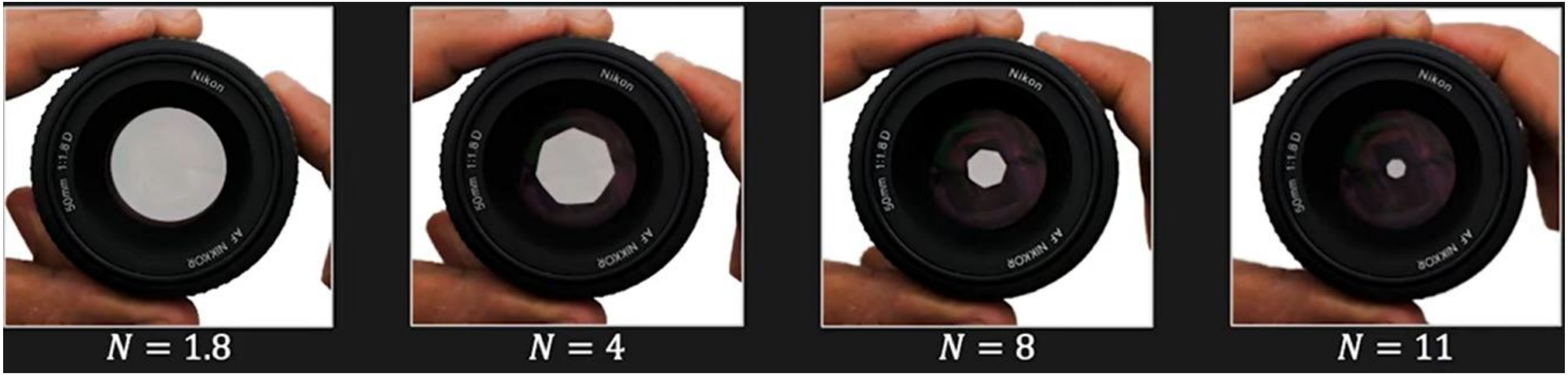
f-number (f-stop, f-ration) of Lens

- The aperture of a lens can be expressed as a fraction of focal length of the lens that is called the $f-number$ represented here by N.

$$Aperture: D = \frac{f}{N} \qquad\qquad f - Number: N = \frac{f}{D}$$

- **Example:** A $50\ mm$ focal length, $\frac{f}{1.8}$ lens implies:
  - $N = 1.8\ (D = 27.8\ mm)$ when aperture is fully open

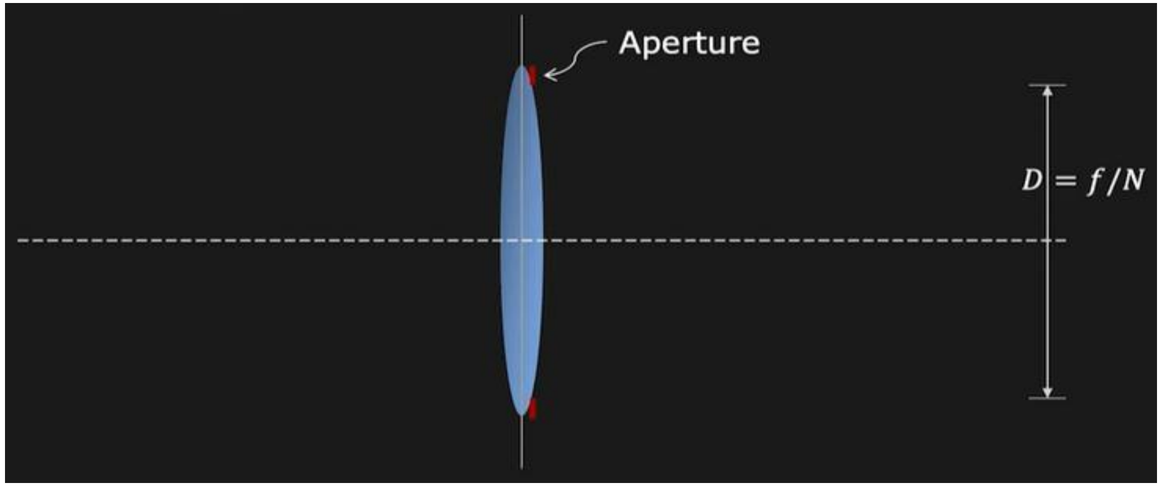
$f - number$ (f-stop, f-ration) of Lens



- $f - number$ goes up, the diameter goes down
- The $f - number$ tells you **how "open" or "closed"** the camera lens is.
  - A **small $\boldsymbol{f - number}$** $\rightarrow$ large aperture (wide opening) $\rightarrow$ more light enters.
  - A **large $\boldsymbol{f - number}$** $\rightarrow$ small aperture $\rightarrow$ less light enters.

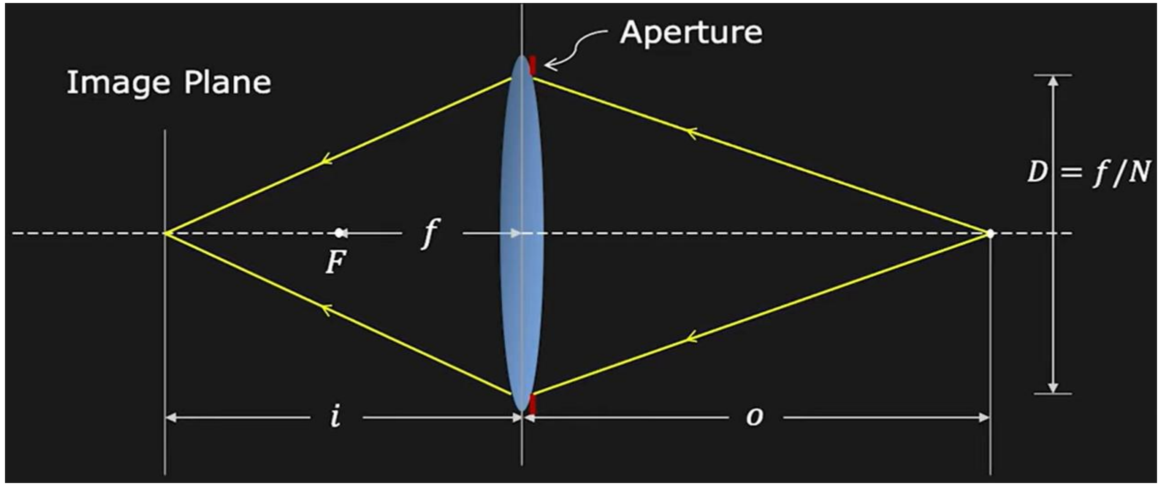
Lens Defocus

Lens Defocus



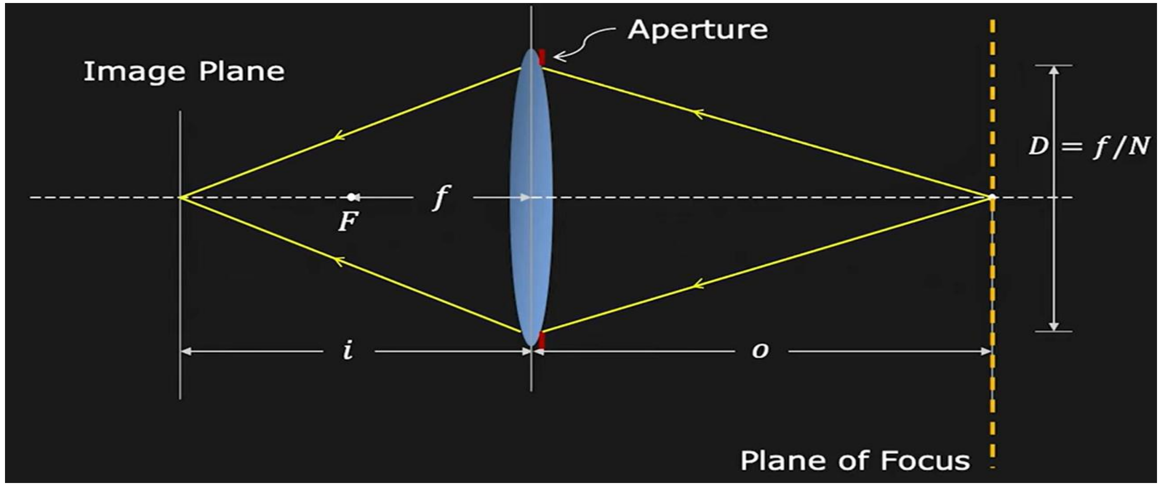
- **Lens defocus** occurs when a point in the scene **is not in perfect focus** on the image sensor.
- Lens gathers more light compared to a pinhole camera
- However, there is only one plane in the scene that is perfectly focused onto the image plane by lens

Lens Defocus



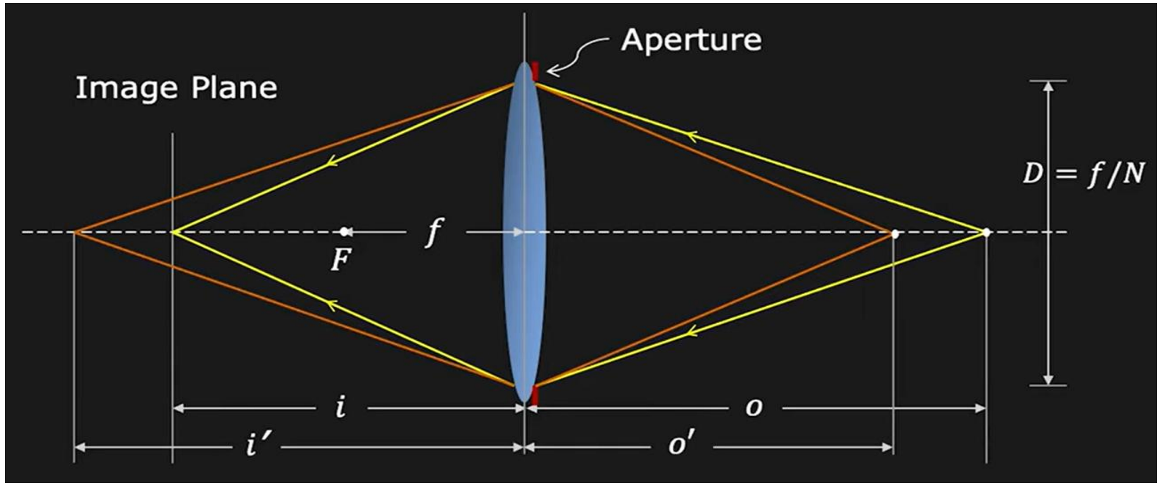
- The point at the distance o will be focused on the distance i
- The image plane is placed exactly at that location

Lens Defocus



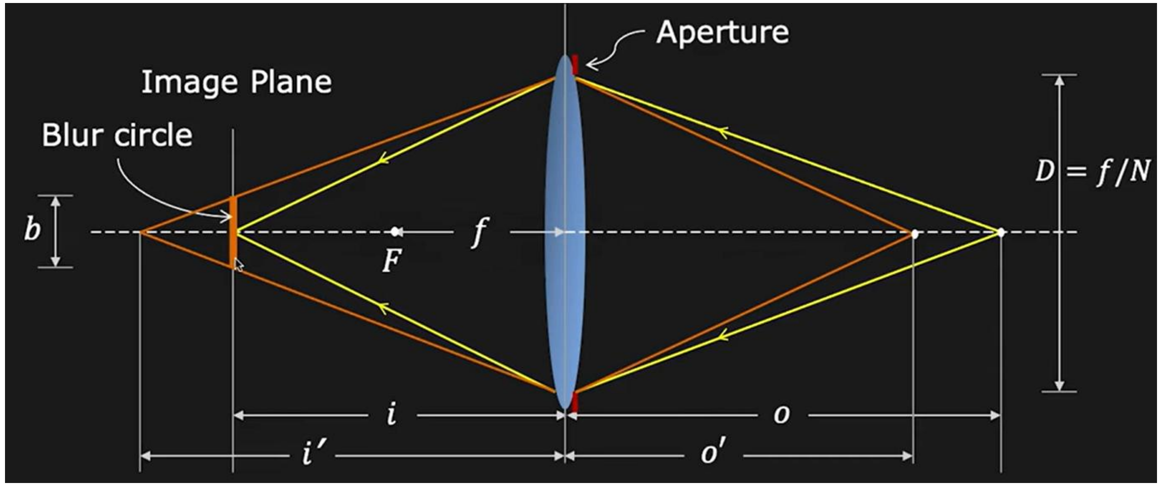
- For this particular position of the image plane, there is exactly one plane which is going to be completely in focus.
- This is called the plane of focus corresponding to the lens system

Lens Defocus



- If a point lies out of this plane of focus, For example the point at distance $\acute{o}$ from the lens
- Since it is closer to the lens, its image is going to be formed at a distance $\acute{i}$ that is behind the image plane

Lens Defocus



- The light that the lens receives from this point is not going to end as a single point on the image plane but rather distributed over a circular disk on the image plane
- It is going to be blurred that is called the blur circle with a diameter b.

Lens Defocus

- For any given position of the object in the scene, the diameter b can be calculated
- From similar triangles:

$$\frac{b}{D} = \frac{|\acute{\imath} - i|}{\acute{\imath}}$$

- So, the blur circle diameter:

$$b = \frac{D}{\acute{\imath}}|\acute{\imath} - i|$$

$$b \propto D \propto \frac{1}{N}$$

Blur Circle (Defocus)

Focused Point

$$\frac{1}{i}+\frac{1}{o}=\frac{1}{f}$$

$$i=\frac{of}{o-f}$$

Defocused Point

$$\frac{1}{\acute{i}}+\frac{1}{\acute{o}}=\frac{1}{f}$$

$$\acute{i}=\frac{\acute{o}\,f}{\acute{o}-f}$$

Gaussian Lens Law

$$\acute{i}-i=\frac{f}{(\acute{o}-f)}\times\frac{f}{(o-f)}\times(o-\acute{o})$$

$$b=Df\left|\frac{o-\acute{o}}{\acute{o}\,(o-f)}\right|$$

$$b=\frac{f^2}{N}\left|\frac{o-\acute{o}}{\acute{o}\,(o-f)}\right|$$

Focusing

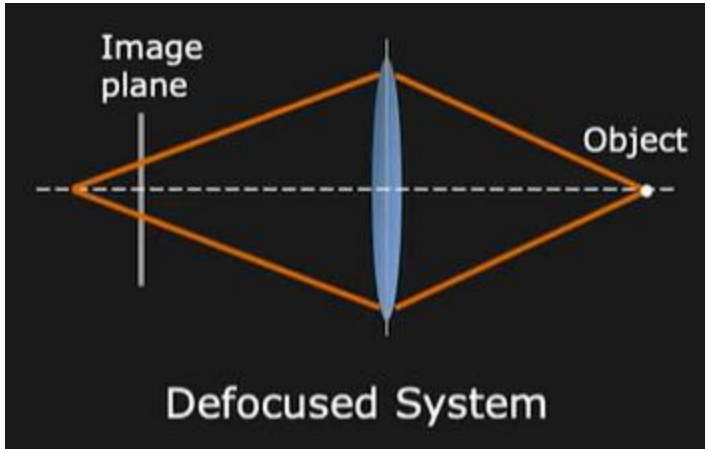


Image
plane
Object
Defocused System

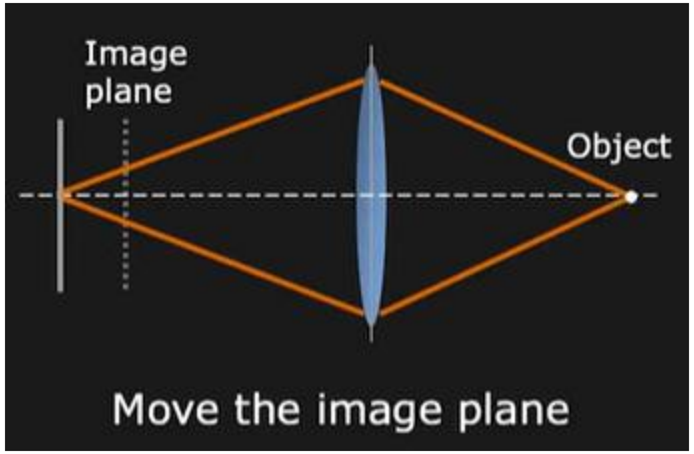


Image
plane
Object
Move the image plane

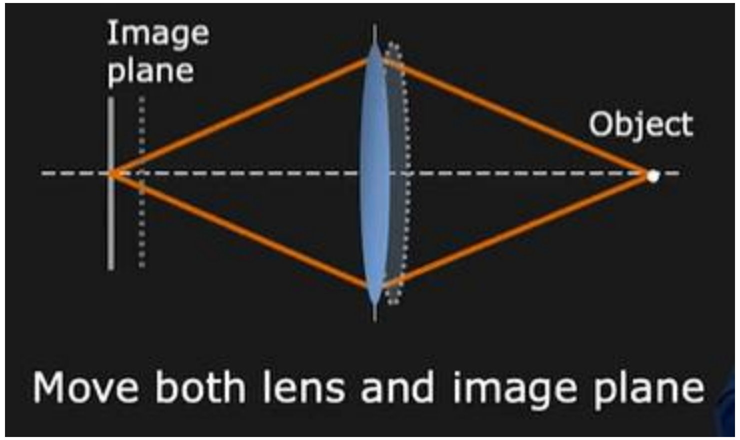


Image
plane
Object
Move both lens and image plane

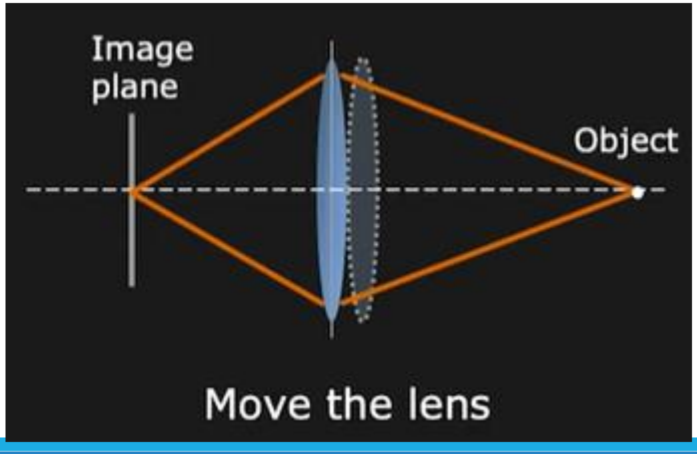


Image
plane
Object
Move the lens

Thank you