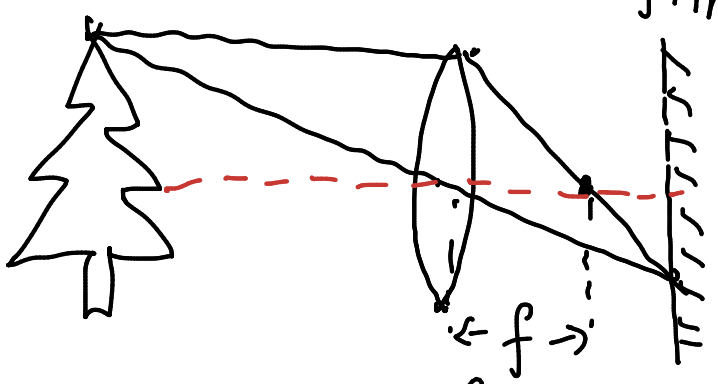
Lect 3 Thin-len Model

Problem for pin-hole camera model

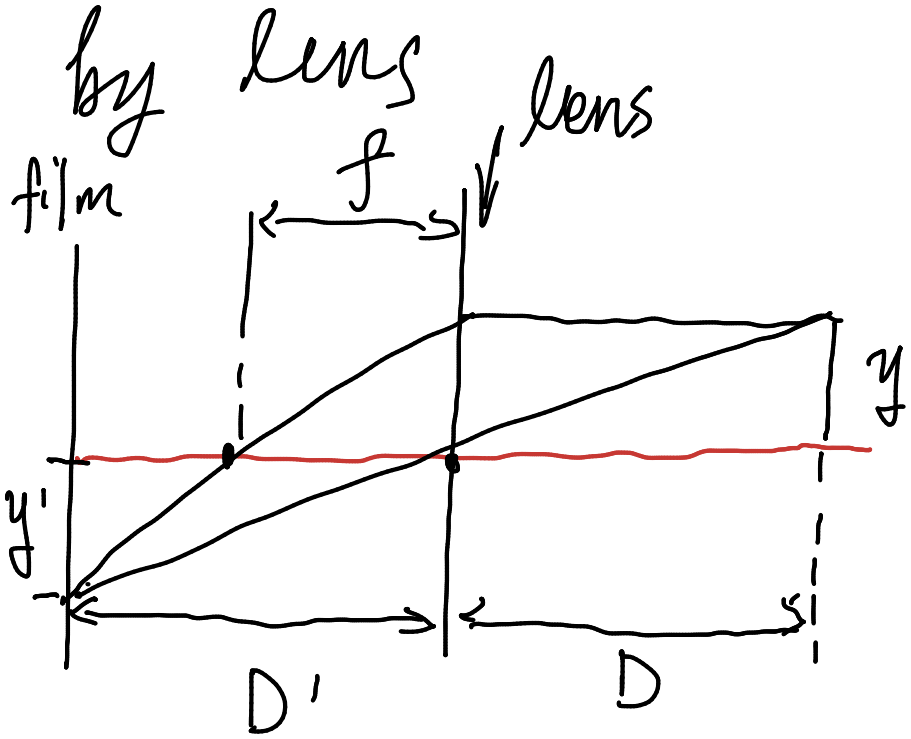
Pinhole → small → dim, hard for sensor
small → diffraction
→ large → blur

Solution



film - Parallel Ray will go through focus point
- Ray passing len center will not change direction

Different from pin-hole camera, "f" is defined by lens



$$\left.\begin{aligned}\frac{y}{y'} &= \frac{D}{D'} \\ \frac{y}{y'} &= \frac{f}{D'-f}\end{aligned}\right\} \quad \frac{1}{D}+\frac{1}{D'}=\frac{1}{f}$$

So in a large image, only a little of image is of great focus.

Depth of field. (DoF)

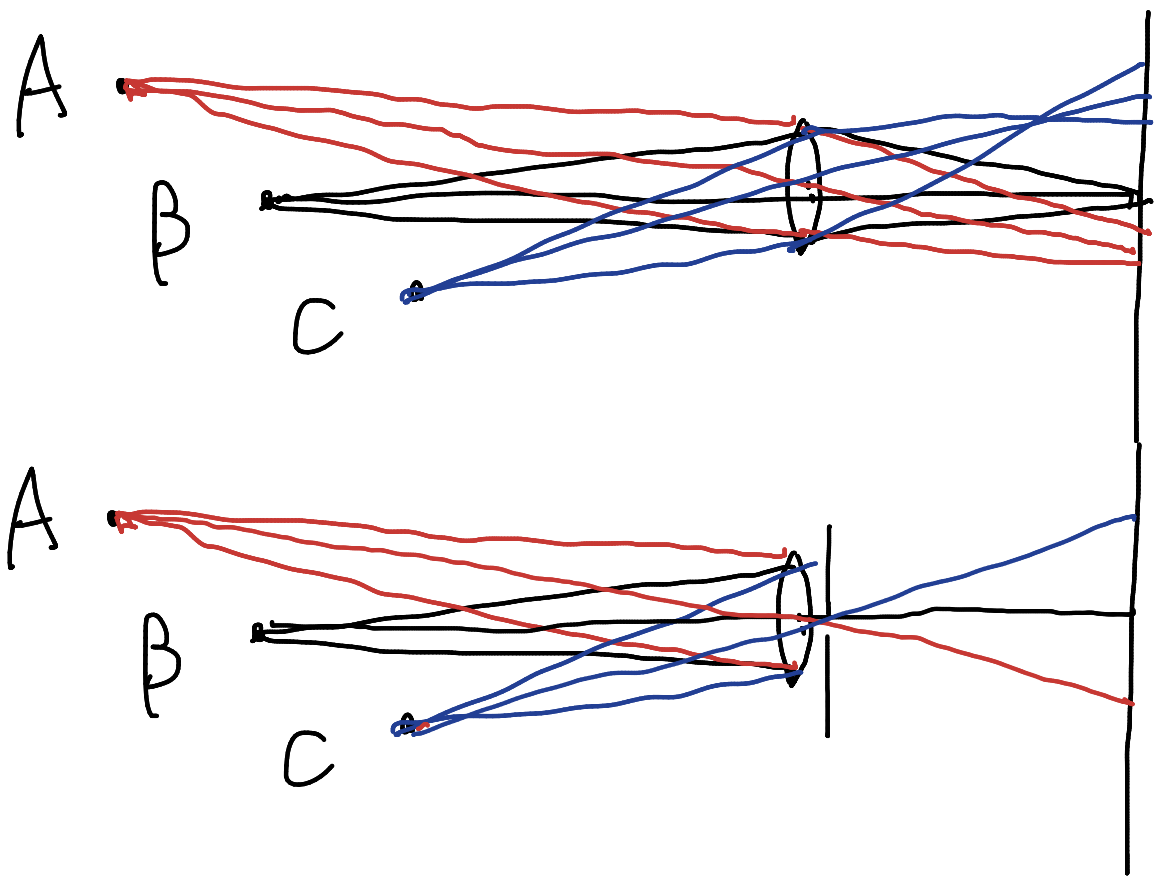
the distance that at least one point is in focus.

DoF → large better resolution

DoF → Small more concentration

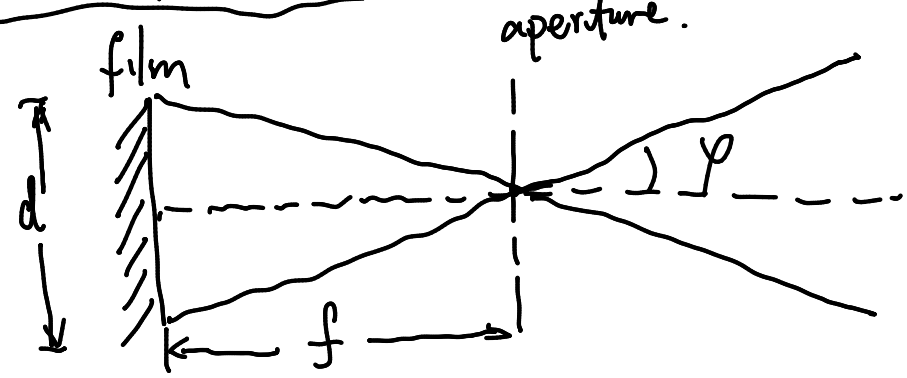
*: Pinhole Camera has inf DoF.

Change aperture could change DoF



If aperture is small enough: Thin-lens Model turns to Pin-hole Camera.

Field of View (FoV)



$$\varphi = \tan^{-1}\left(\frac{d}{2f}\right)$$

for Pin-hole Camera

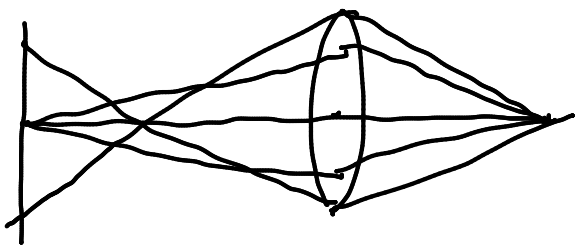
For lens model, we could roughly assume obj is far away from len, then apply this model again

f↑ FoV↓

Lens Flaw (drawback that only lens-model has)

① Chromatic Aberration
Lens react differently for different waveform.

② Spherical Aberration
Ray far from optical center focuses closer

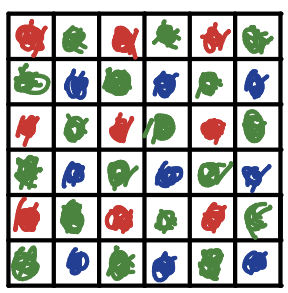


③ Vignetting
Near the edge of the len, image becomes dim and blur

④ Radical Distortion (Avoidable)
lines will appear as curve (球面鏡 vs 非球面鏡)

Bayer Grid

A image will be composed by RGB. But at a certain time, only one image can be captured by the sensor - So, Senser has to decide which element of Light (R/G/B) it is going to capture.



Bayer Grid

Then, applying estimation methods to recover the whole image. (Demosaicing)

Estimation Methods.

1. Nearest Neighbour

   Copy the nearest neighbour's value (up/down/left/right)

2. Linear Interpolation

   Missing value is the mean of its surrounding.

   Can use operator:

$$\frac{1}{4}\begin{bmatrix}0&1&0\\1&0&1\\0&1&0\end{bmatrix} \quad \& \quad \frac{1}{2}\begin{bmatrix}1&0&1\end{bmatrix} \quad \& \quad \frac{1}{2}\begin{bmatrix}1\\0\\1\end{bmatrix}$$

3 Adaptive Gradient

Choose the mean of a direction (vertical or horizontal) that has the smallest difference

e.g.

X	15	X
17		18
X	20	X

vertical difference is $|15-20|=5$

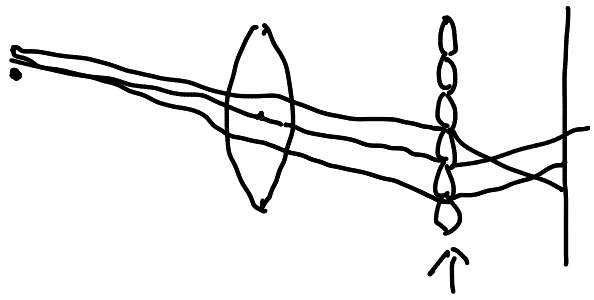
horizontal difference is $|17-18|=1$ ✓ small

the center value is $\frac{17+18}{2}=17.5$

Light Field Camera

Feature:

This camera could enable user to re-focusing after the image is taken.



The pixel value is not pure light intensity. but the super-imp-ose of different light rays.

Mathematically, the function of a len is Fourier Transformation

So, based on the received signal, We could recover the phase, amplitude and direction via IFFT.