image ~~fusion~~ formation: 3D scene → 2D img.

- geometric: loc of a point in scene → loc in img.
- photometric: apperence/brightness of a point in scene → apperence/brightness " in img.

pinhole → perspective projection (cons: don't gather enough light. solution: use lenses.

- focal length
- depth of field
- D focus
- F number

cons:
distortions.
needs adjustment

hemespheric view: can't be done using perspective proj.

Perspective projection with $\boxed{\text{Pinhole}}$

Guarantees light rays travel through 1 point (aka. Pinhole).

1-to-1 projection

f: focal length.

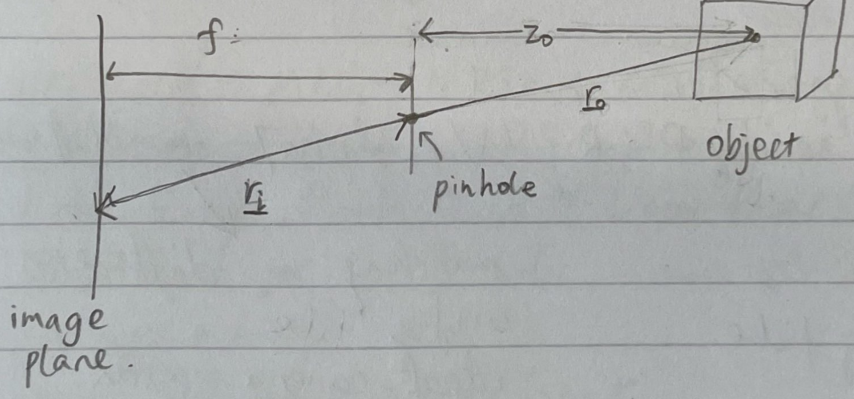
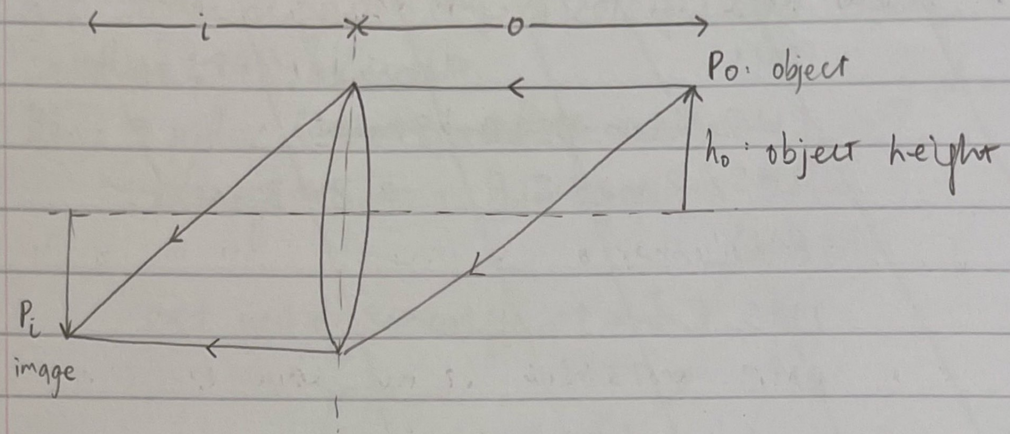


Image formation using lens.



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

Gaussian lens Law

f: focal length

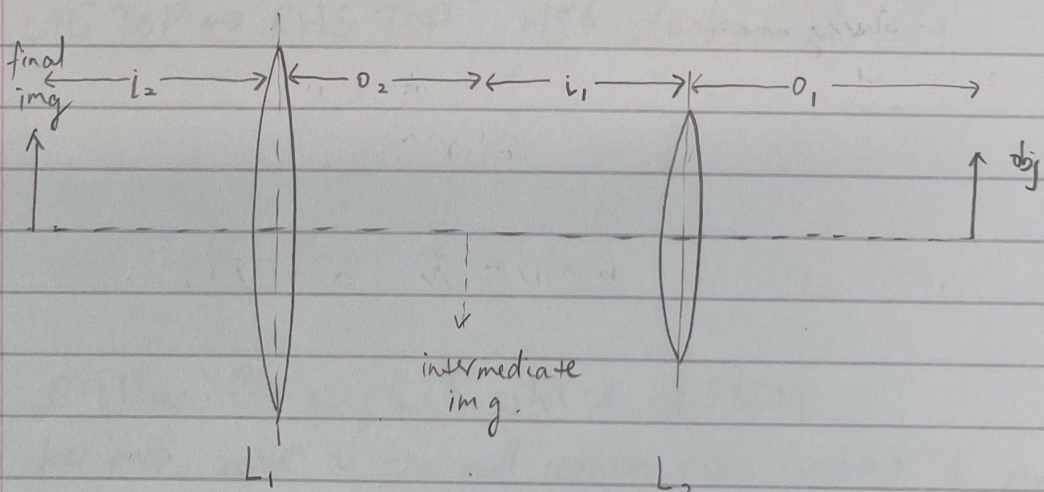
i: image distance

o: object distance

if object is really far, $o = \infty \rightarrow f = i$

magnification: $m = \frac{h_i}{h_o} = \frac{i}{o}$

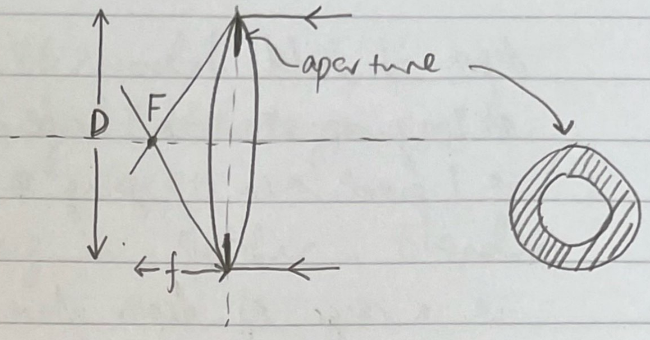
2 lens system



$$m = \frac{i_2}{o_2} \cdot \frac{i_1}{o_1}$$

aparture of lens:

diameter of lens: D.

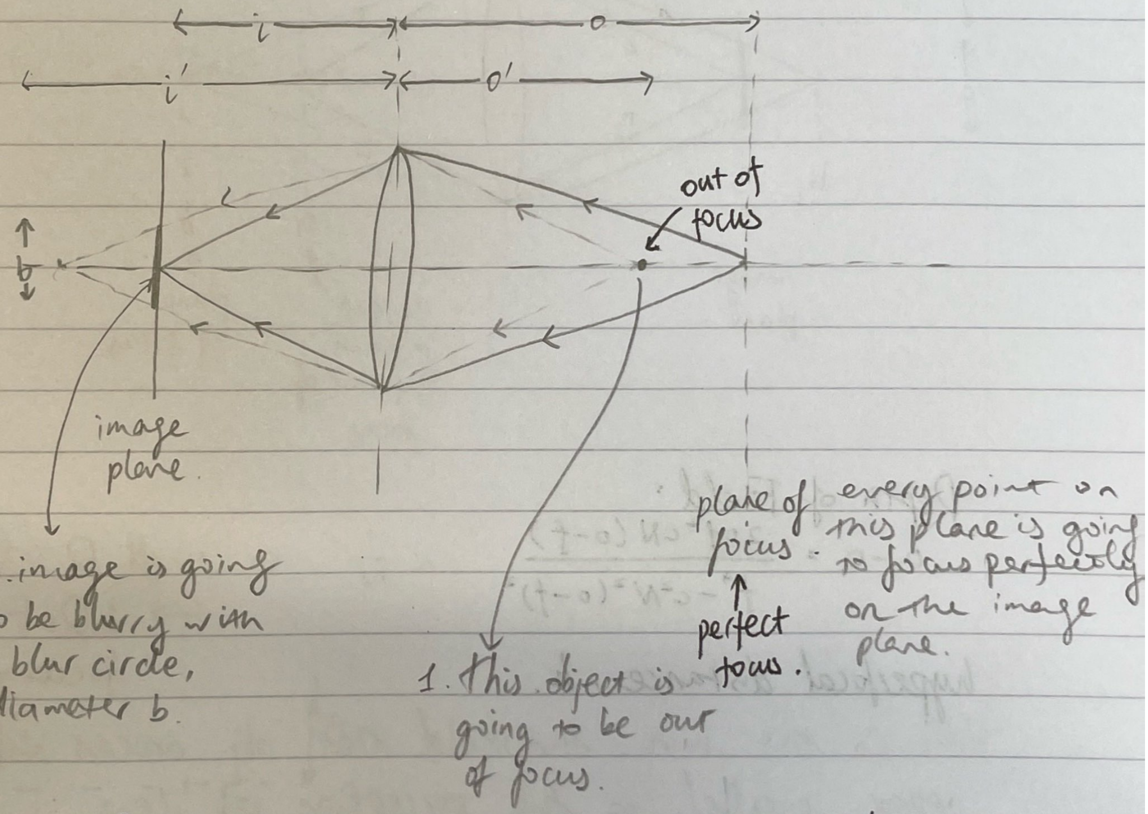


$D = \frac{f}{N}$, N: f-Number of the lens, f: focal length

here D means entrance-pupil diameter. (ie. can be adjusted by aparture) can't change the physical diameter of the lens.

i.e. for a camera len which we can adjust D, D↓, N↑.

<u>lens defocus</u>

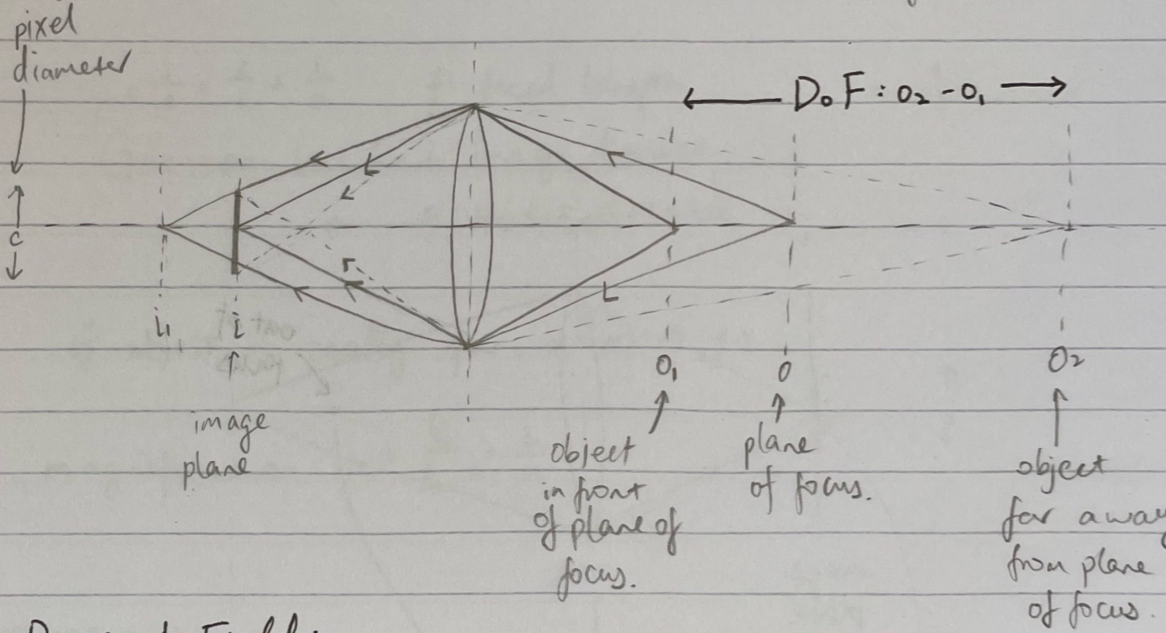


$$b = \frac{D}{i'}|i' - i|, \quad b \propto D \propto \frac{1}{N}, \quad b = \frac{f^2}{N}\left|\frac{o - o'}{o'(o - f)}\right|$$

depth of field.

as long as the blur circle is sufficiently small, i.e. diameter < 1 pixel, then it's going to appear perfectly in-focus on the image

i.e. a range of depth where image is going to appear perfectly in focus. when object are sufficiently far away, the light ray from that obj. to the lens is approx. parallel. Lens focus parallel light rays into 1 point/ focal point i.e image appear sharp.



Depth of Field:

$$o_2 - o_1 = \frac{2of^2cN(o-f)}{f^4 - c^2N^2(o-f)^2} \quad \propto \frac{1}{N}$$

so small D , $\uparrow N$ $\rightarrow \downarrow$ DoF $\rightarrow$ more in focus $\rightarrow$ but image darker

hyperfocal distance, h.

DoF is the min. threshold that obj. appears sharp / rays approx. parallel to the perception of lens.

we calc. h $\propto \frac{1}{N}$.

$$h = \frac{f^2}{Nc} + f$$

focal distance is a property of the lens, fixed. unless zoom lens.

certain distance beyond which, img is always going to be in focus. we set 'distance you can focus on' d = h, to maximise DoF.

h is a property determined by len's inherent property focal length f (which is determined by curvature of the lens) and aparture.

If the distance we set, d, is less than h,

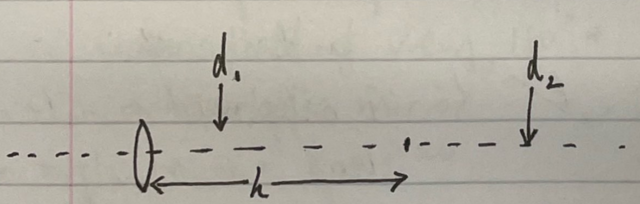
Adil

INTR_Adil > MBAG > MBAG_46 > model
Looking for the key point img & Excel keypoint file.
v4.2 → Blender
research_plugin > plug-in folder in Blender

go through pipeline_gen-val_set

software-dev / Jerome, Chris : software team responsible for dashboard.

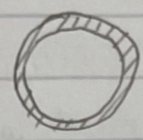
vF Calibr – use / not use



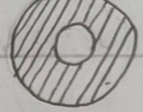
case 1: $d < h$, DoF (which is the range which image appears in focus) doesn't go to inf, DoF is a range including some distance before plane of focus + some distance after plane of focus.

case 2: $d > h$, well, we still have obj to ∞ in focus, but we lose the ~~foret~~ foreground: note h is a distance where anything from $\frac{h}{2}$ to ∞ are in focus. so if you move $d > h$, you lose foreground.

Therefore, to maximise DoF, we set d exactly at h.

trade off: large aperture: 

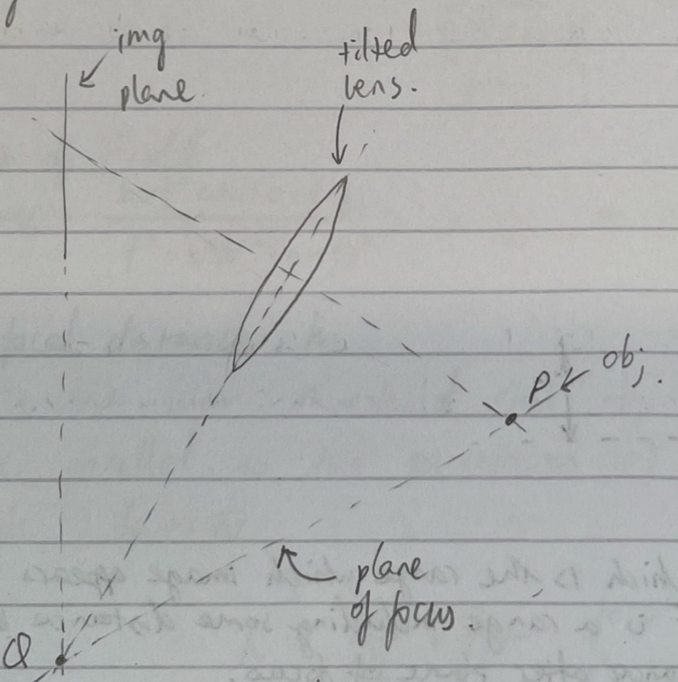
bright image → shorter exposure time
<u>shallow</u> DoF (far obj. blurry)

small aperture: 

darker img → longer exposure time
large DoF (everything in focus)

plane of focus aka the distance to which objects are perfectly in focus, is independent of the aperture

<u>tilting the lens</u>

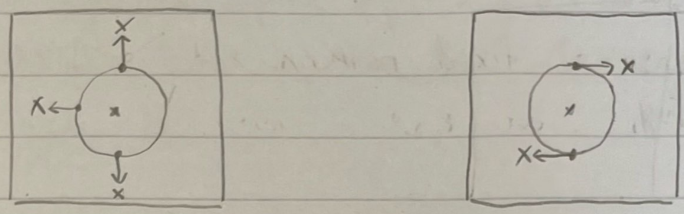


schiempflug condition
(shine-flu-g)

eg. image you're in a flat by the window, and want to take a photo of the street underneath.
I only need to tilt the lens *to the right angle* s.t. plane of focus is parallel to the road, so entire road is captured in perfect focus

problem with lens.

1. vignetting - darker around periphery due to multiple lens (aperture)
2. chromatic aberration: red/ green/ blue img. are focused at a different distances → causes colour shifts in imgs.
3. distortion. 1. radial distortion (points away from the focal point gets pushed out) 2. tangential distortion.



1.
(Barrel) distortion

2.

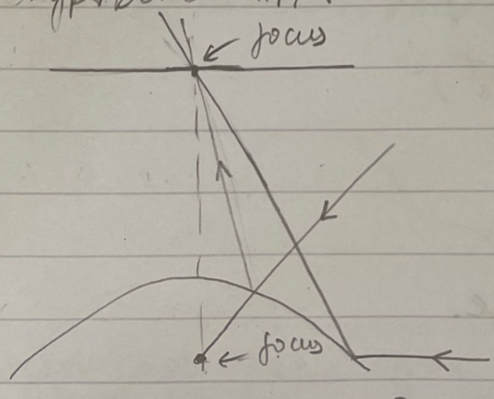
fish eye lens → 170°. v. difficult to go beyond 180°. (lens purely)
panorama lens → 360° (len + mirror)

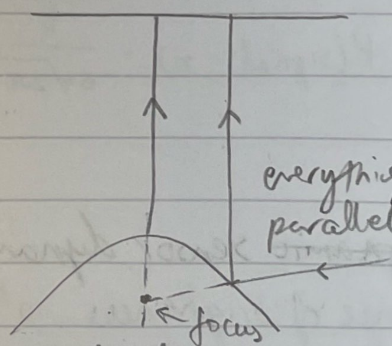
use mirror to manipulate the location of camera/field of view
optical folding.

catadioptrics = use of mirror + use of lenses. eg. catadioptrics systems.

want field of view 180°+ ? use curved mirror.

hyperbolic mirror vs. parabolic mirror → panorama 360° using software.





pros: field of view 180°+ cons: have blind spot in the middle of the image.