Recap

easy_install

- By now you should be able to install packages
- py.test and coverage should be installed
- Today, we will try to install pip and nose

- Understand paths

While loops: Animation Process

Animations in Games or Graphics:

```
while (not finished) {
    MoveEverything();
    DrawEverything();
}
```

Introduction to Computer Vision

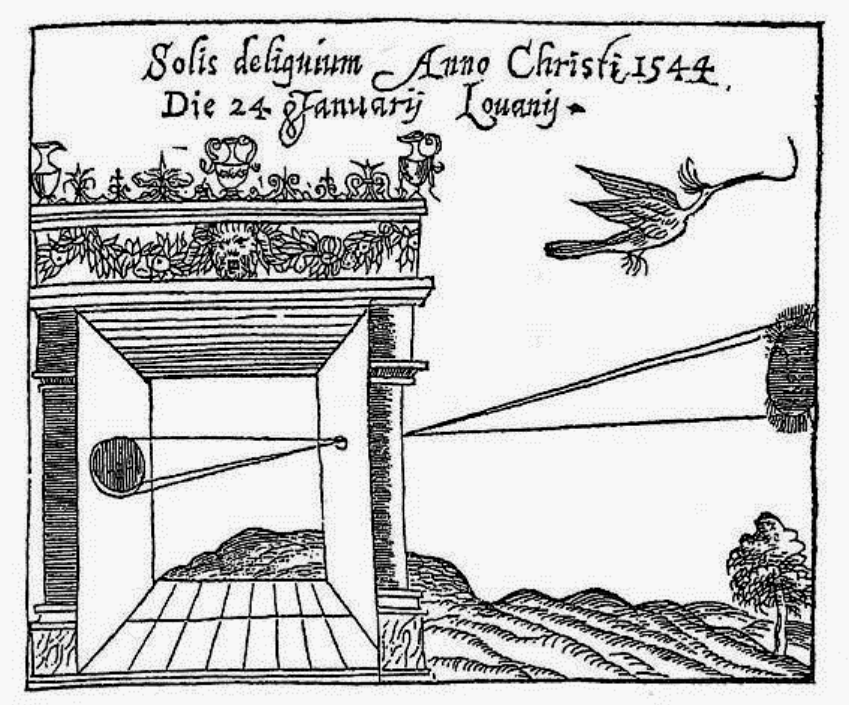
Computational Photography

360 panorama

CAP 5415: Computer Vision

Xiuwen Liu

PINHOLE CAMERA



1558

2012

1568

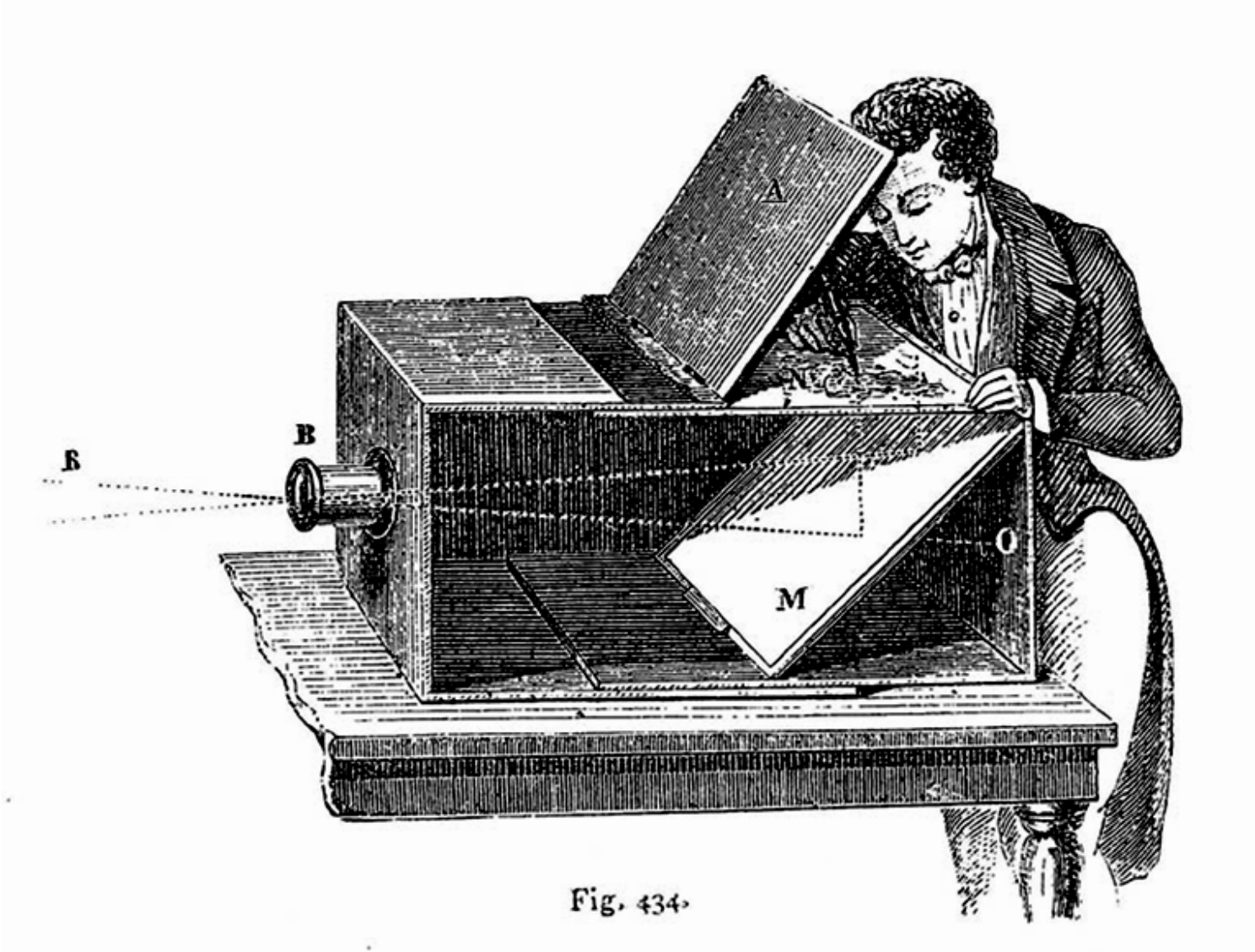
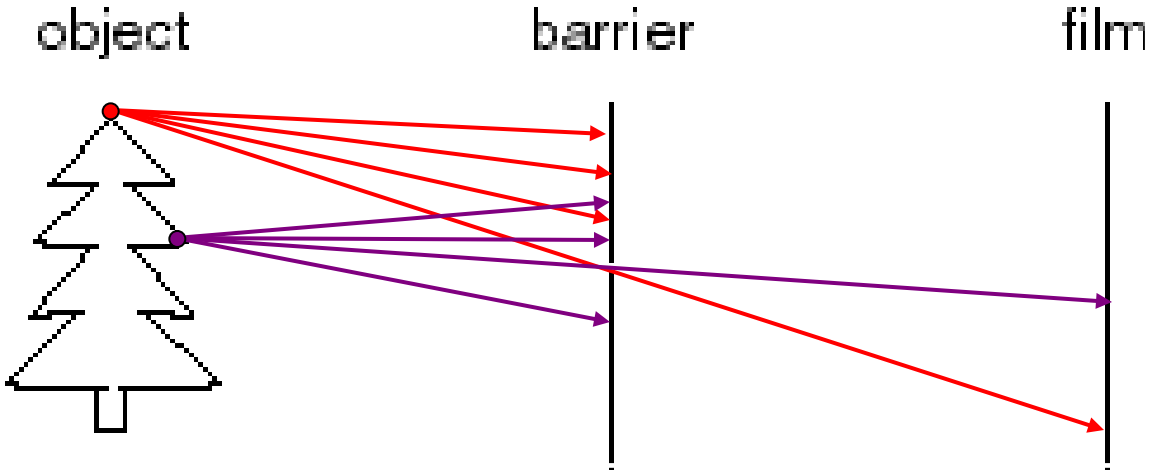


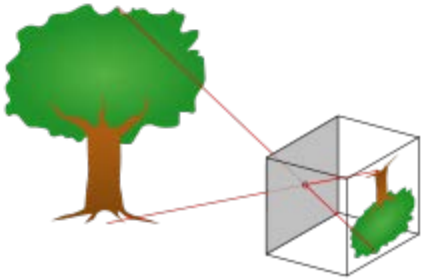
Fig. 434.

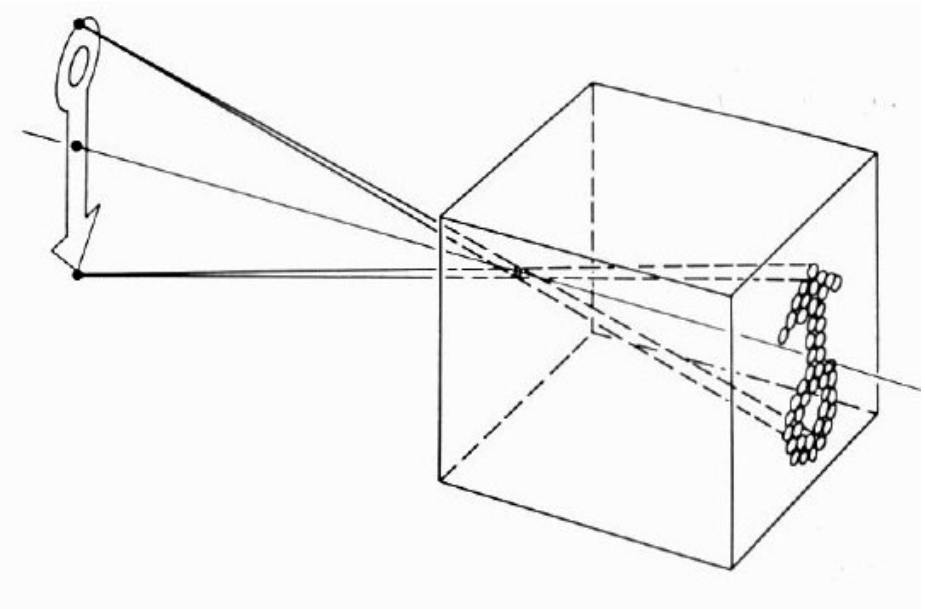
Pinhole camera



- Add a barrier to block off most of the rays
  - This reduces blurring
  - The opening known as the **aperture**
  - How does this transform the image?

Pinhole Camera





Pinhole Photography

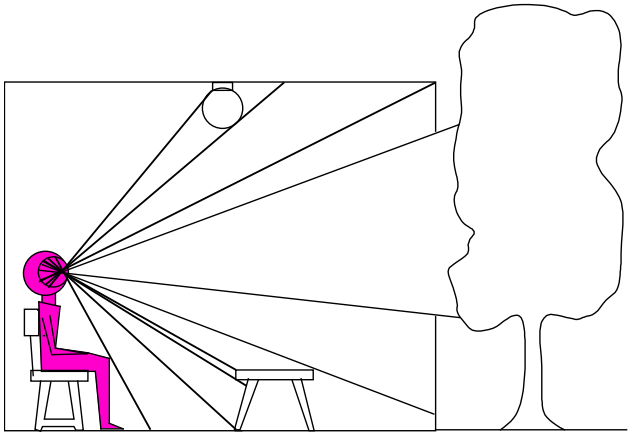
©Charlotte Murray Untitled, 4" x 5" pinhole photograph, 1992

Image Size inversely proportional to Distance

Reading: http://www.pinholeresource.com/

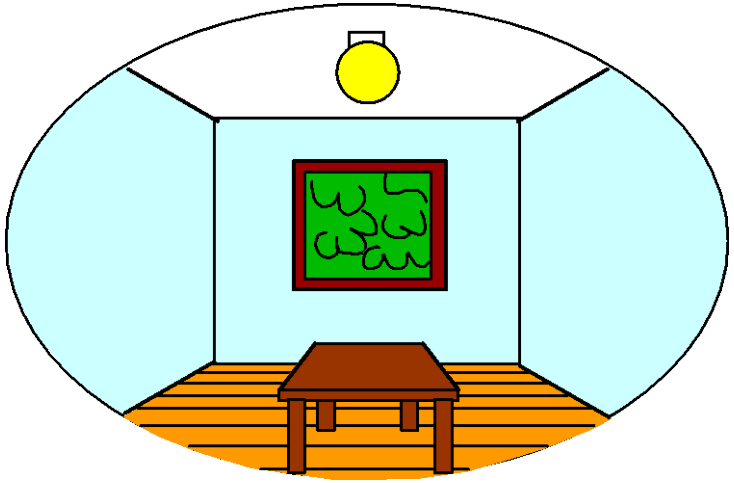
Dimensionality Reduction Machine (3D to 2D)

3D world



Point of observation

2D image

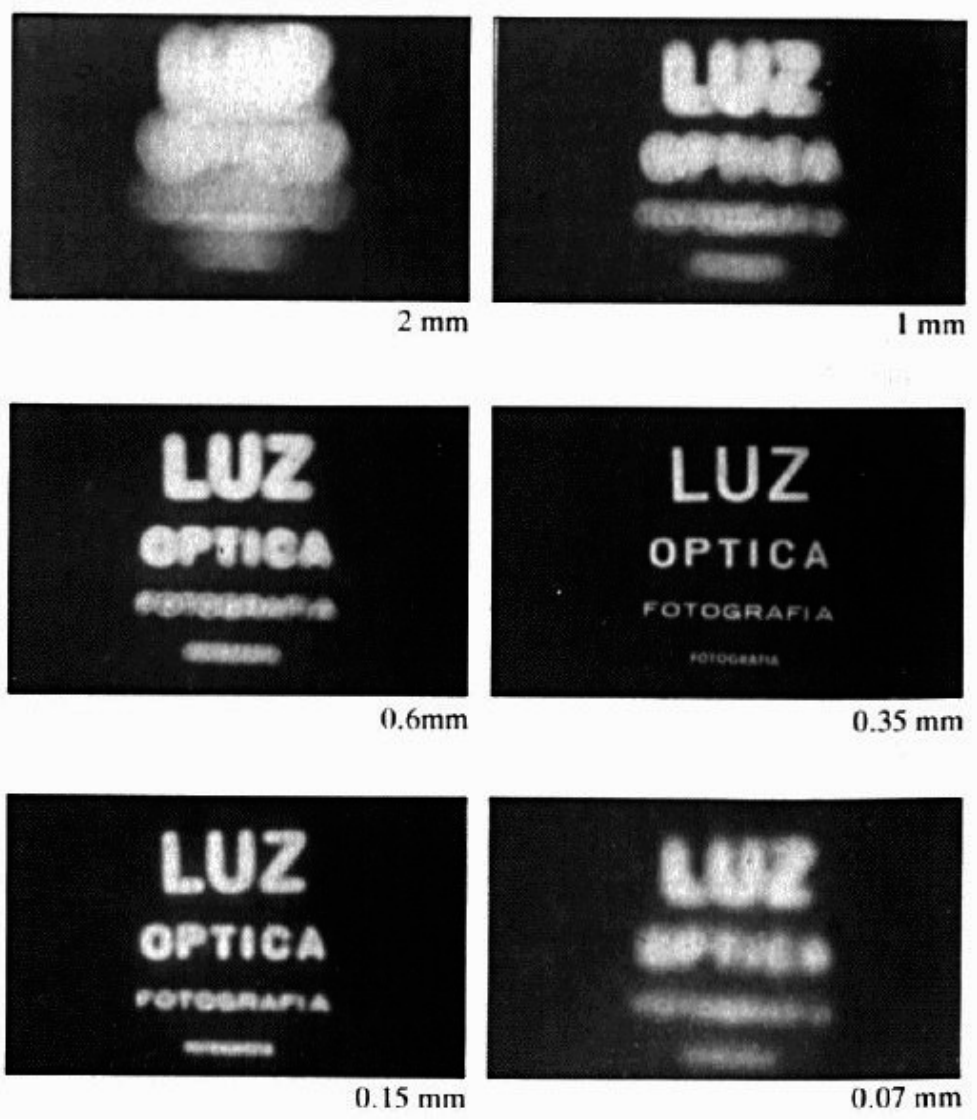


What have we lost?

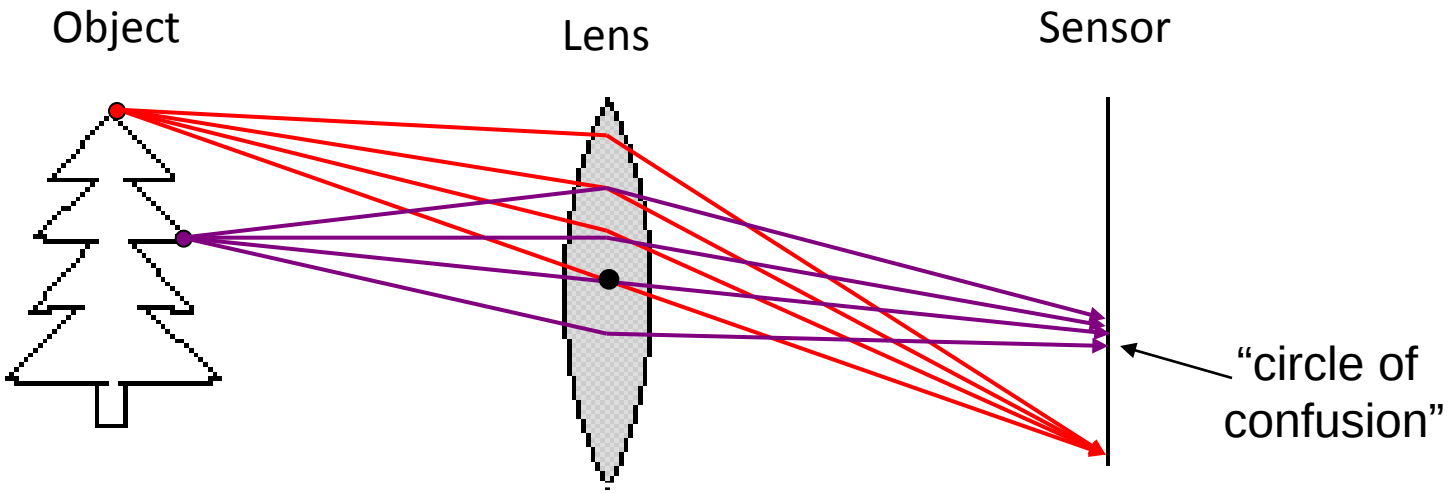
- Angles
- Distances (lengths)

Slide by A. Efros

Shrinking the aperture

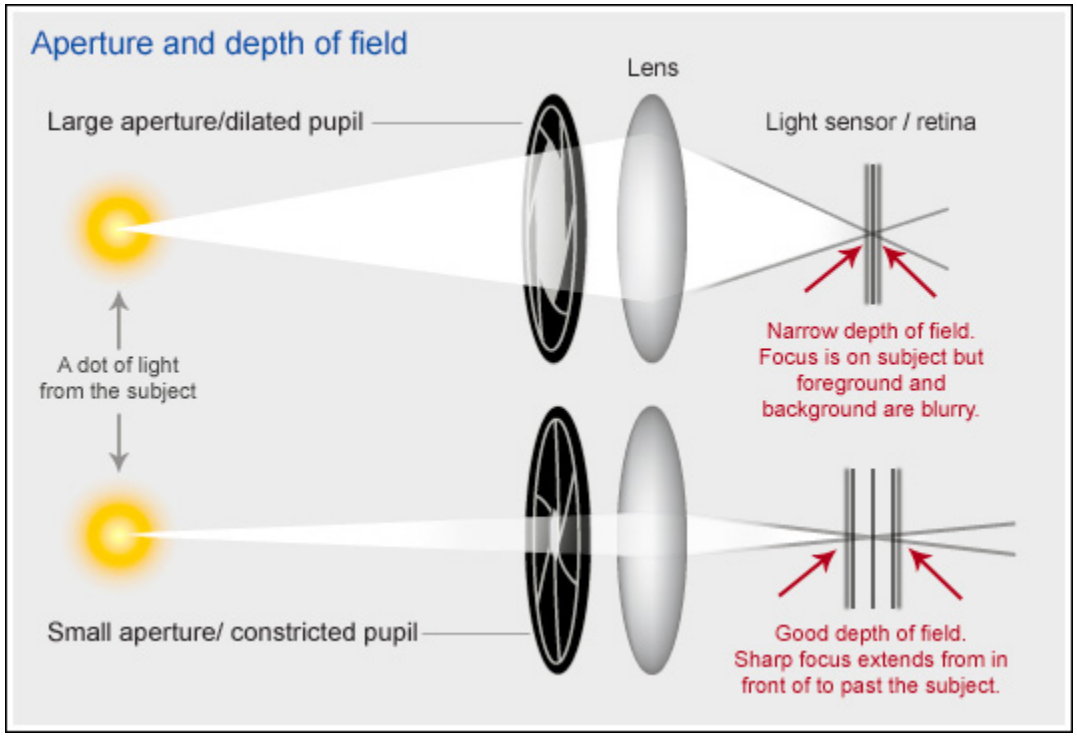


Adding a lens

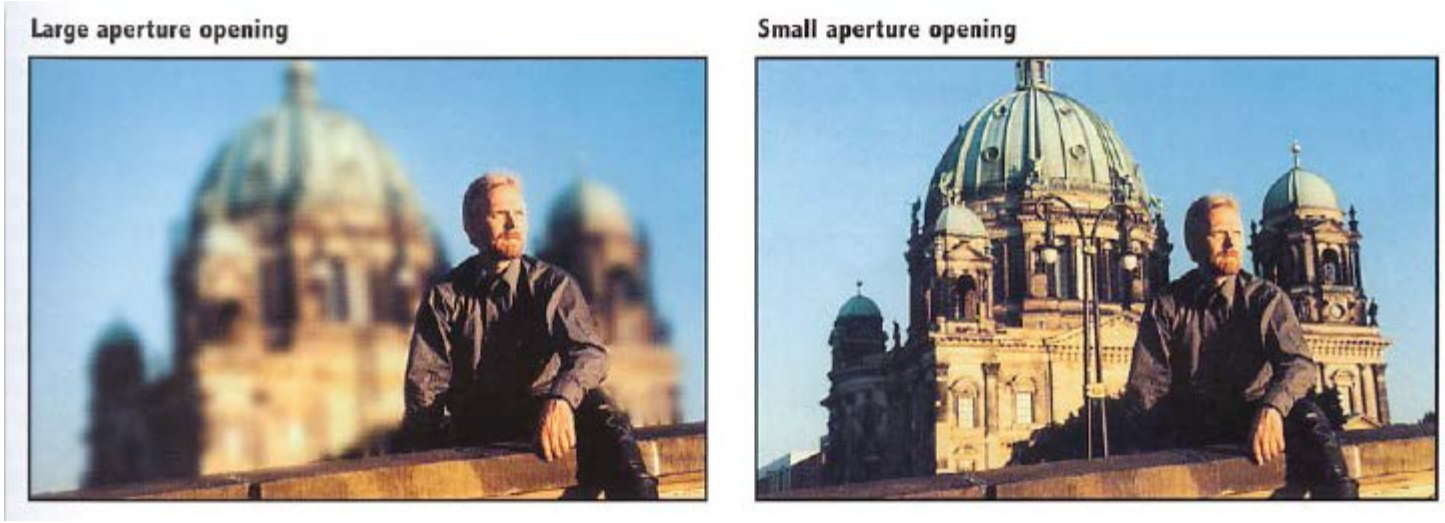


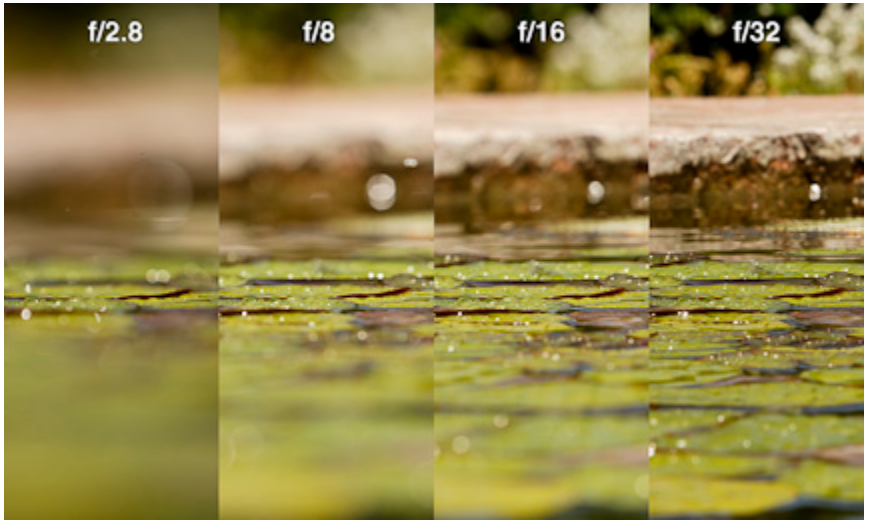
- A lens focuses light onto the film
  - There is a specific distance at which objects are "in focus"
  - Changing the shape of the lens changes this distance

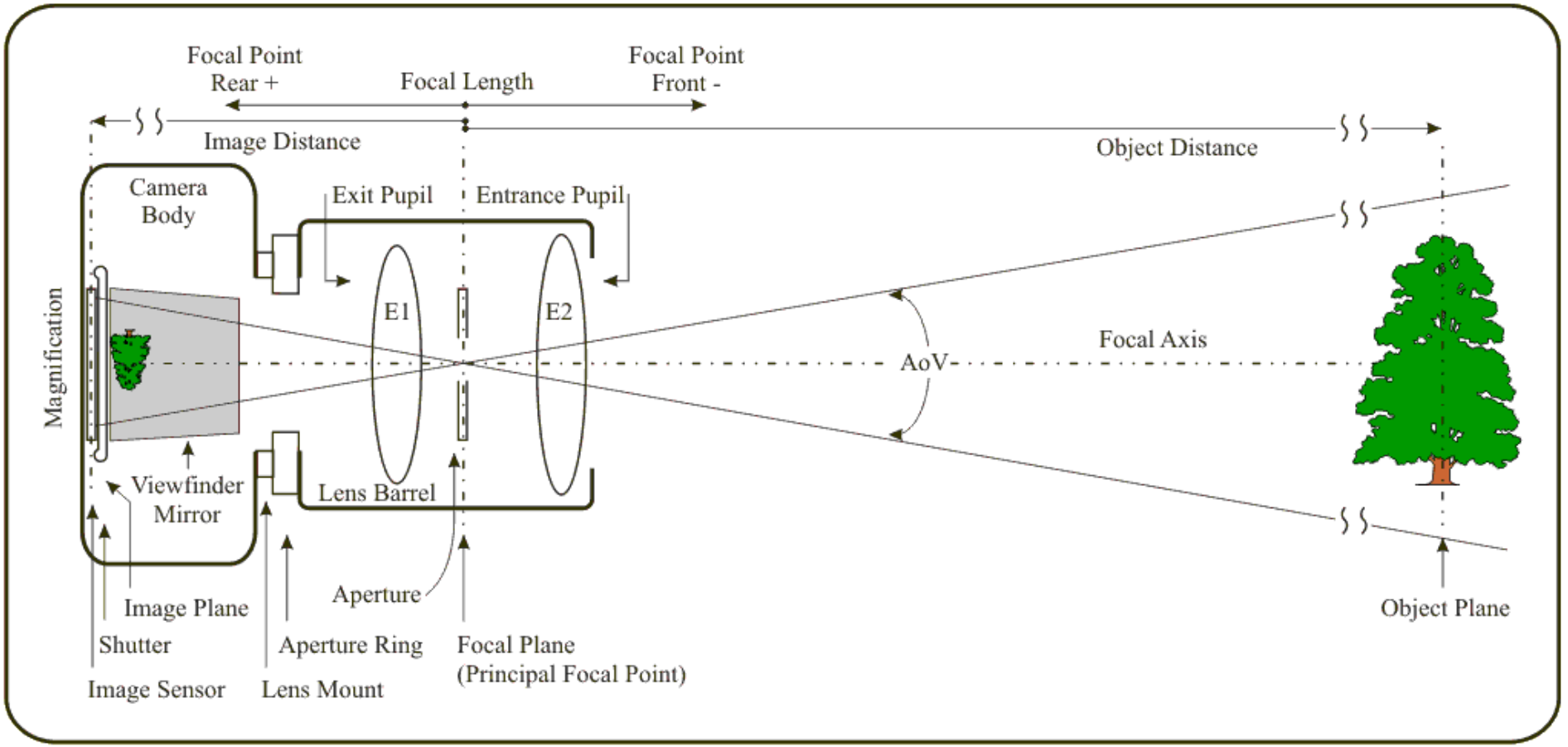
Aperture


Aperture and depth of field
Lens
Large aperture/dilated pupil
Light sensor / retina
A dot of light
from the subject
Narrow depth of field.
Focus is on subject but
foreground and
background are blurry.
Small aperture/ constricted pupil
Good depth of field.
Sharp focus extends from in
front of to past the subject.

Aperture






Focal Point
Rear +
Focal Length
Focal Point
Front -
Image Distance
Object Distance
Camera
Body
Exit Pupil
Entrance Pupil
E1
E2
Magnification
AoV
Focal Axis
Viewfinder
Mirror
Lens Barrel
Aperture
Image Plane
Shutter
Image Sensor
Aperture Ring
Lens Mount
Focal Plane
(Principal Focal Point)
Object Plane

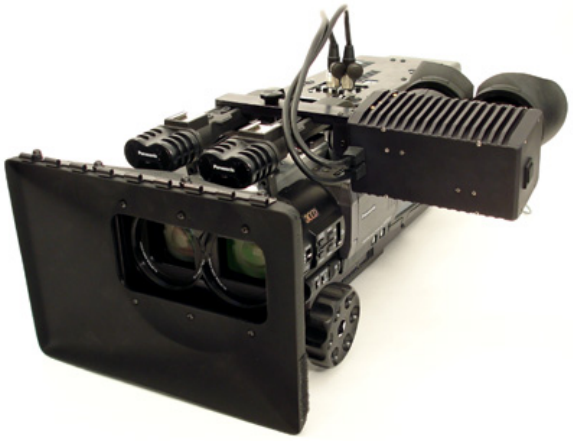
Depth of Field

- Range of object distances over which image is sufficiently well focused.

http://images.dpchallenge.com/images_portfolio/27920/print_preview/116336.jpg

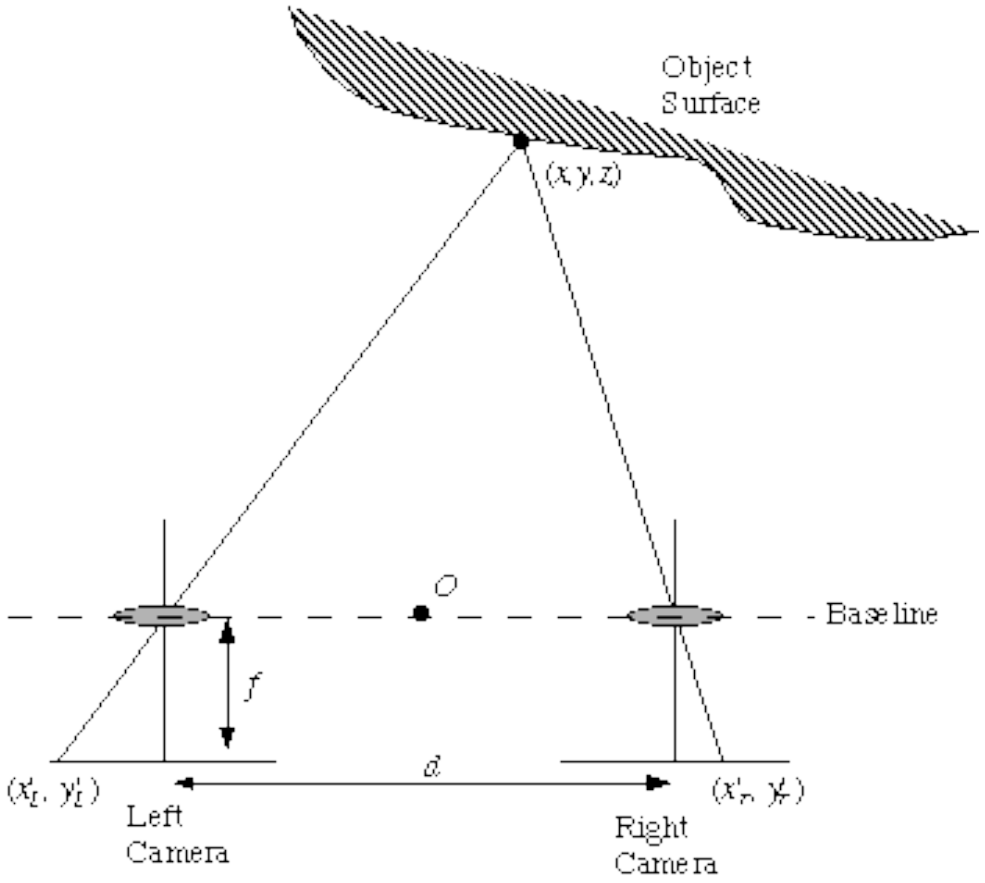
3D Photography

- Replicate 3D objects, Make 3d Movies
- Recognize 3D Structures



- Just an extension of pin hole camera concepts

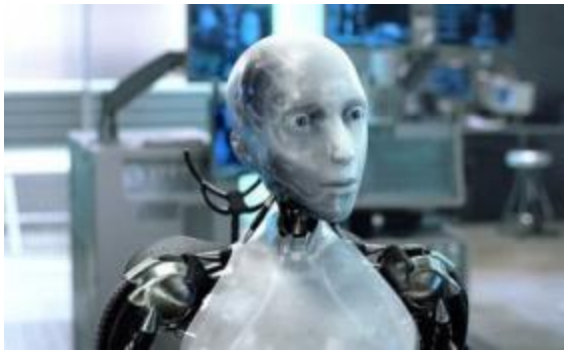
Main Concept



2x pinholes

3D Vision: Self Driving Cars

Computer Vision
Artificial Intelligence
Machine Learning
Pattern Recognition



Other Applications: Face Recognition, Image Search, OCR, Remote Sensing …

Back to Python

“It's the little details that are vital. Little things make big things happen.”

--Wooden

Bubble Sort

Pseudocode:

```
for i from 1 to N
    for j from 0 to N – i
       if a[j] > a[j + 1]
           swap( a[j], a[j + 1] )
```

Bubble Sort

Pass 0: 14 12 82 -3

12 14 82 -3

12 14 82 -3

12 14 -3 82

Pass 1: 12 14 -3 82

12 14 -3 82

12 -3 14 82

Pass 2: 12 -3 14 82

-3 12 14 82

Bubble Sort

In python:

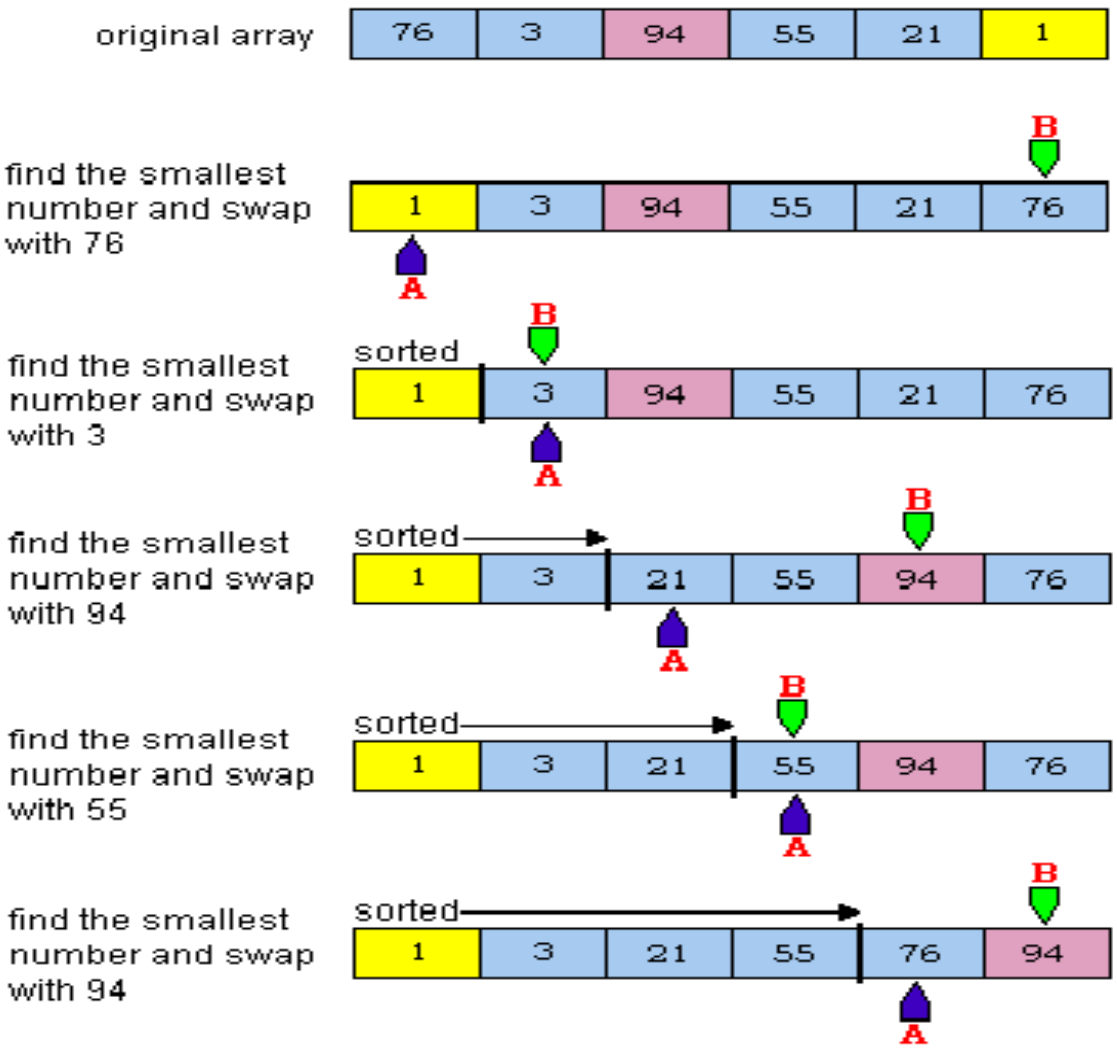
```
>>> arrNumbers=[5,4,3,2,1]
... n=len(arrNumbers)
... for i in range (1, n):
...     for j in range (0, n - i):
...         if( arrNumbers[j] > arrNumbers[j + 1]):
...             temp = arrNumbers[j]
...             arrNumbers[j] = arrNumbers[j + 1]
...             arrNumbers[j + 1] = temp
... print arrNumbers
[1, 2, 3, 4, 5]
```

Selection Sort

```
Pseudocode:

For i = 0 to N-1 do:
        Smallsub = i
        For j = i + 1 to N-1 do:
                If A(j) < A(Smallsub)
                Smallsub = j
                End-If
        End-For
        Temp = A(i)
        A(i) = A(Smallsub)
        A(Smallsub) = Temp
End-For
```

Selection Sort



Selection Sort

```
In python:
>>> arrNumbers=[5,4,3,2,1]
... n=len(arrNumbers)
... for i in range(0,n):
...         min =arrNumbers[i]
...         min_indx=i
...         for j in range(i+1,n) :
...                 if min > arrNumbers[j] :
...                     min =arrNumbers[j]
...                     min_indx=j
...       temp=arrNumbers[min_indx]
...       arrNumbers[min_indx]=arrNumbers[i]
...       arrNumbers[i]=temp
... print arrNumbers
[1, 2, 3, 4, 5]
```