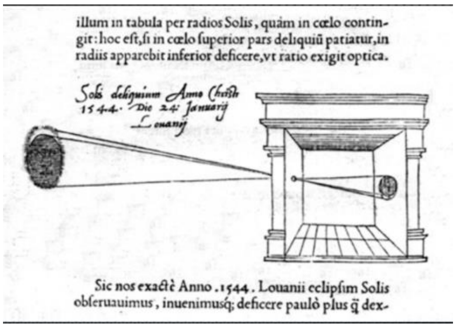
Image Acquisition

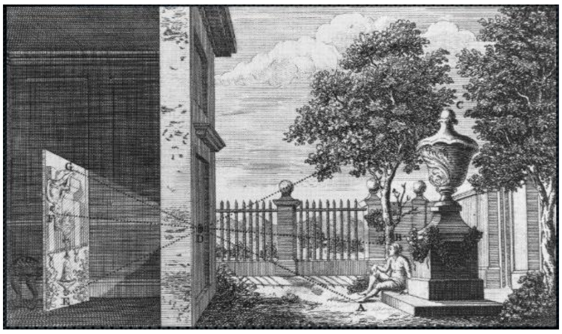
1. Imaging system

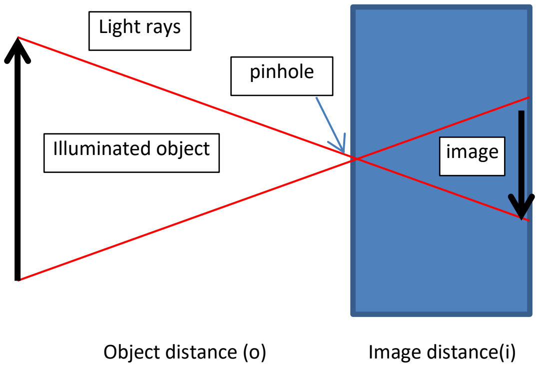
1.1. Pinhole camera,

a camera with a pinhole aperture and no lens, is considered the basic to describe the geometry of a frame camera.



It is used to safely observe the eclipse of the solar Alhazen(10th c.)





1.2. Lens formula:

if an object locates some finite distance from the lens (o), the image distance (i) is greater than the focal length. The relationship formula that is used to express them is called the "lens formula" Equation (1)

$$\frac{1}{o}+\frac{1}{i}=\frac{1}{f} \quad ----equ.(1)$$

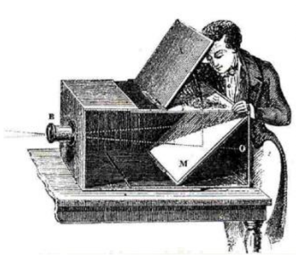
Example 1: Find the image distance for an object distance of 50.0m and a focal length of 50.0cm.

Solution: using equation 1,

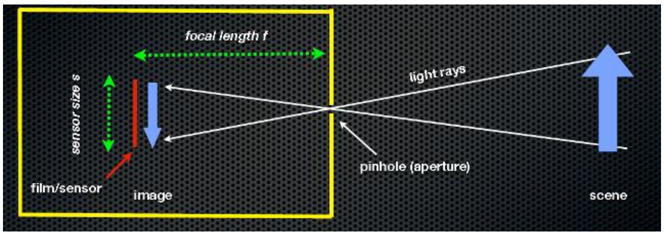
$$\frac{1}{50}+\frac{1}{i}=\frac{1}{0.5} \rightarrow \frac{1}{i}=\frac{1}{0.5}-\frac{1}{50}=2-0.02=1.98 \rightarrow i=\frac{1}{1.98}=0.505m=50.5cm$$

1.3. camera obscure

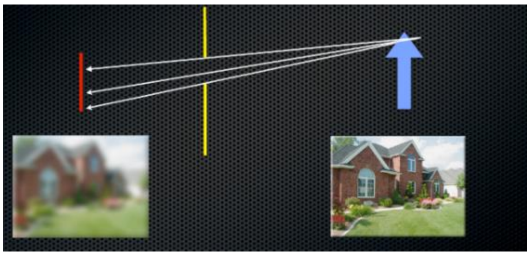
- Later on, the camera obscure developed, which is in Latin "Camera Obscure"= "Darkroom."
- It is defined by the light passing a small hole producing an inverted image on the opposite wall.



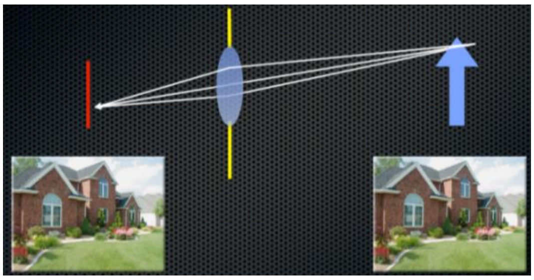

- In the 28 the century artist Canaletto used the camera obscure to draw the view of the building.
- The geometry of the pinhole camera is illustrated below, and it is used to infer the principle of the camer obsecure.
- Each point in the film is illuminated from a single direction



- The printed image on the film is "blurred" because the rays are directed from the source in different directions.



- To solve this problem, Lens has been added to the pinhole to direct the rays to a single point.

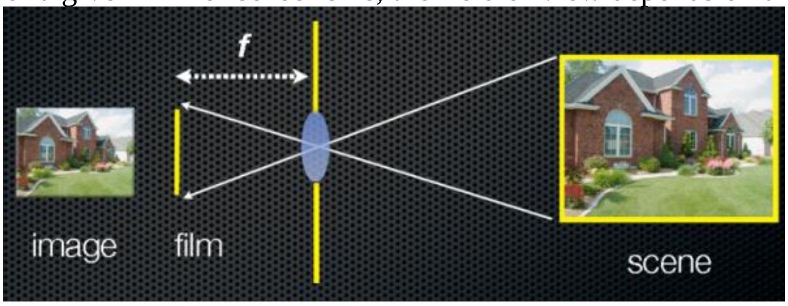


1.4. Camera properties

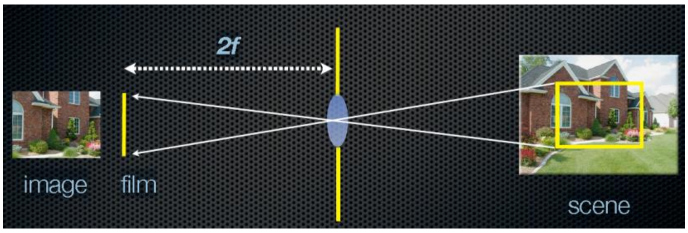
To be with photographs, there are a few specifications of the camera the user should be familiar with them.

a- Field of view

image film scene, For a given film or sensor size, the field of view depends on the focal length **f**

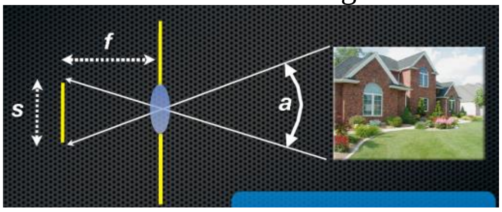


If we double the focal length, we halve the field of view



Short focal length = wide field of view
Long focal length = narrow field of view

- **Field of view,** for known film size **s** and focal length **f** ...



Then Angular field of view, a=$a = 2 * \arctan\frac{s}{2f}$….Equ. (2)

Example 2: if the focal length of the camera is 15mm and the sensor height is 10mm, determine the angular field of the view.

Solution: f=15mm, s=10mm

Then Angular field of view, $a = 2 * \arctan\frac{s}{2f}$=$2 * \arctan\frac{10}{2*152} = 36.86^{o}$.

Examples of different fields of view

Note: By increasing focal length and moving further from the subject, we can drastically change the composition

b-Exposure, Under-exposed Correct exposure Over-exposed Taking a good photo requires getting the right amount of light to the sensor or film

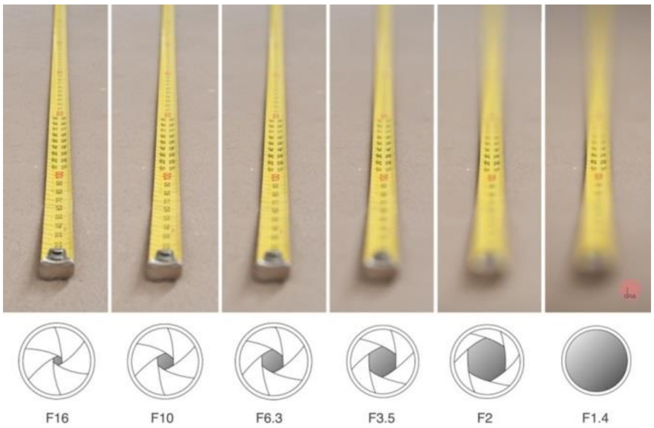
There are two main parameters we can control:
Shutter speed and Aperture area

Shutter speed

Controls how long film is exposed for
Measured in fractions of a second
e.g. 1/30, 1/60, 1/125, 1/250, 1/500
Fast shutter reduces motion blur BUT admits less light

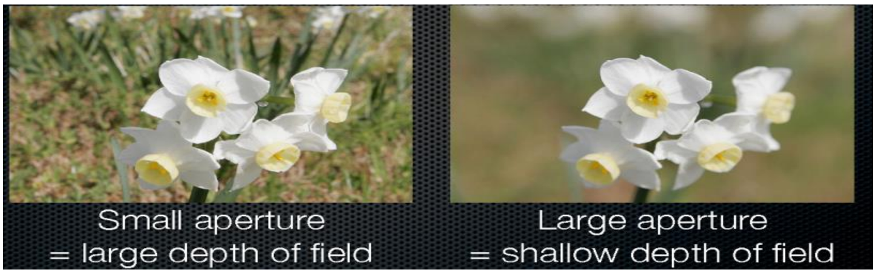
Aperture

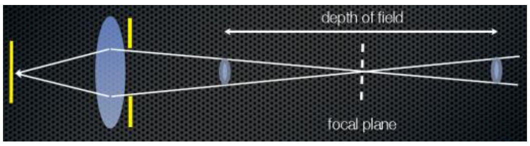
- Diameter of the lens opening
- Expressed as a fraction of focal length (called *f-number*)
  - e.g. f/2 on 50mm lens = 25 mm aperture
- **Big** f-number means a **small** aperture
- Large aperture = more light, but shallow "depth of field"

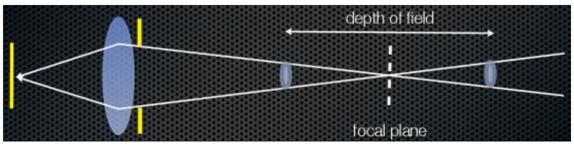


d-Depth of field

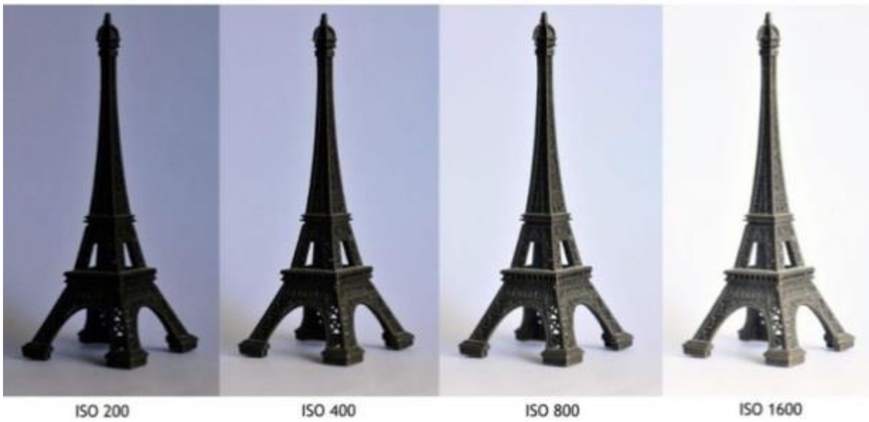
Range of distance that is acceptably "in focus"







e-Sensitivity (ISO scale)



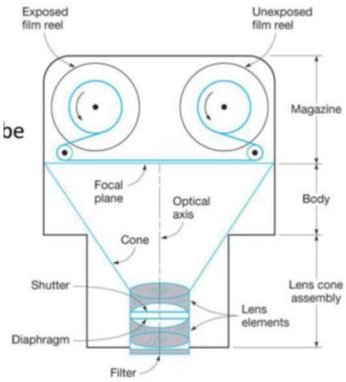
- Additional variable affecting exposure
- ISO scale indicates chemical film sensitivity to light:
- **ISO 100** - low sensitivity, good for bright conditions, static scenes, wide aperture, slow shutter
- **ISO 1600** - high sensitivity, good for low light, dynamic scenes, small aperture, fast shutter.

2. **Camera types:** Photogrammetry is the science that depend mainly on the image for obtaining measurements. The type of the camera that used in photogrammetry is as follow:

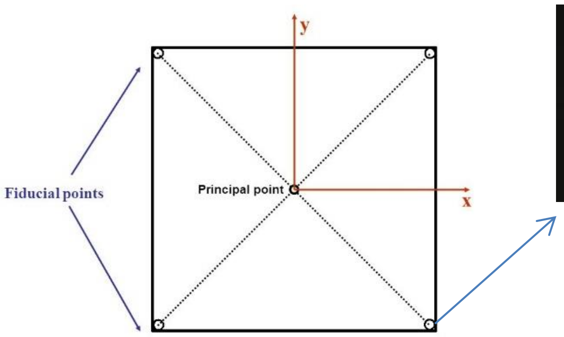
2.1. <u>Aerial frame Camera or Airborne Camera sensor.</u>

2.1.1. Analogue Single lens frame camera.

The most important photogrammetric instrument is Aerial Mapping Camera. The aerial camera is capable to capture large number of photographs in a rapid succession while moving in an aircraft at high speed. It is referred as frame camera since it exposes an entire frame in essentially one instant of time.



The **Single lens frame camera** is able to print images of the fiducial mark on the photographs.

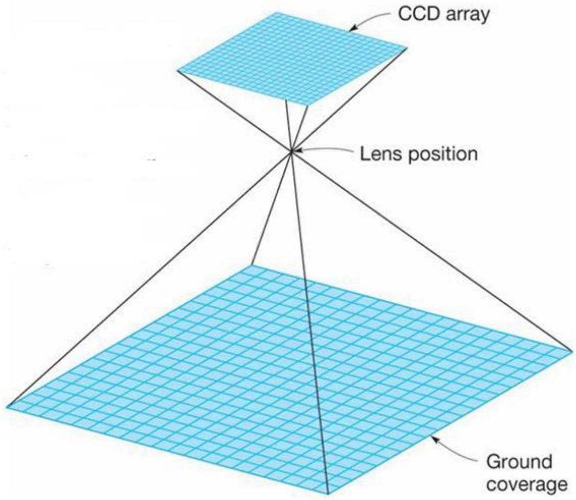


Analogue frame camera fiducial marks

Analogue aerial imagery

Magnified fiducial mark

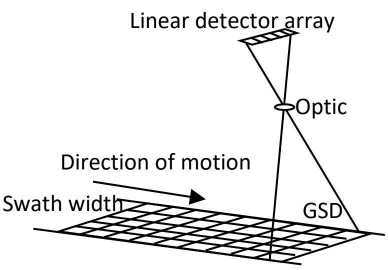
2.1.2. A Digital aerial frame camera is currently used in Aerial photogrammetry. A solid-state detector is used instead of the film and placed on the focal plane. The most common type of detector is a charged-coupled device (CCD). The array is composed of tiny sensors arranged in continuous rows and columns see below figure.



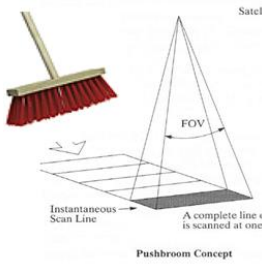
Each detector size is between 5 to 15 microns, and it senses the energy received from its corresponding ground scene, constituting one “picture element” (Pixel) within the overall image. The size of the CCD is measured by the number of pixels or rows and columns for example, 1000 rows and columns produce 1,000,000 pixels=1megapixeel. Therefore, the Aerial camera can capture an image with a size reaching to 136-megpixels as UltrCamX camera.

2.1.3. Airborne pushbroom line scan camera

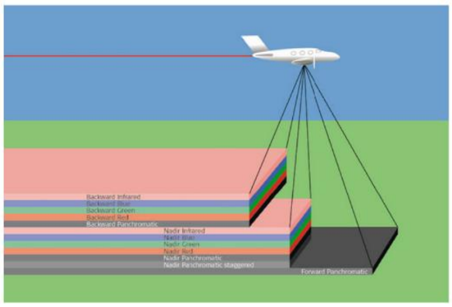
- The ADS40 camera is a three-line-scanner that captures imagery looking forwards, nadir and backwards from the aircraft.
- Every portion of the ground surface is imaged multiple times. With its simultaneous capture of data from different bands, the ADS40 provides unparalleled qualities of image and position data.
- The image capturing principle differs from the frame in that a linear array is used and continuously takes ground photos instead of a frame.



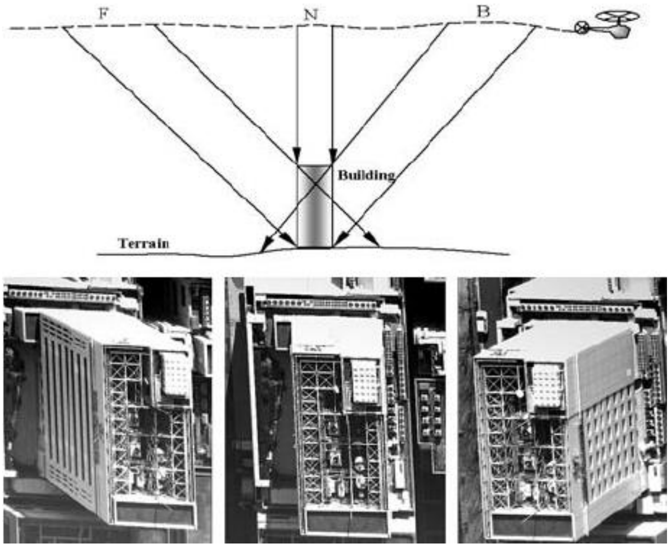
Pushbroom Geometry



Pushbroom concept



Data Collection with pushbroom camera



Forward, nadir and backward view

2.2. <u>Compact camera or Close range photogrammetry camera,</u>

there are different cameras that are used in close-range photogrammetry:

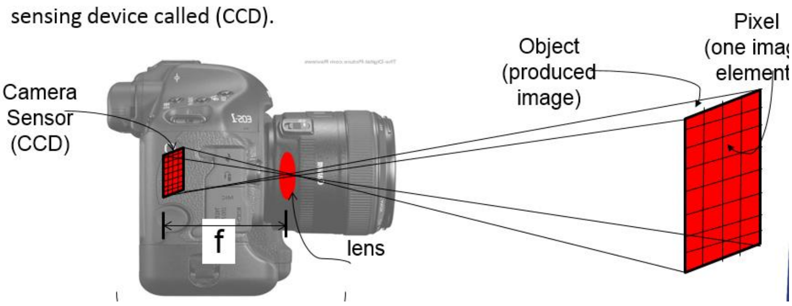
2.2.1. Metric camera includes those cameras manufactured expressly for photogrammetric applications. They have fiducial marks built into their focal planes or have calibrated CCD arrays, which enable the accurate recovery of their principal points. Metric cameras are stably constructed and completely calibrated before use. Their calibration values for focal length, principal-point coordinates, and lens distortions can be applied with confidence over long periods.

2.2.2. Compact digital cameras, this type of camera is specified to have a high number of megapixels (hence high resolution and consequently more information), but the lens is low quality. Therefore the image specified lacks sharpness and clarity.

Canon PowerShot SX610 HS 20MP

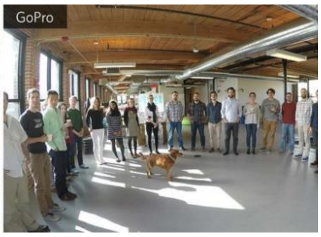
2.2.3. Digital SLR (Single-lens Reflex) cameras, this type of cameras tend to give better results than compact digital cameras. It is specified as follows:

- Equipped with higher quality lenses than compact cameras and therefore give better results.
- Provide more controls for image capture
- Offer the best high ISO performance – this allows working indoors without needing a tripod or flash or stopping down the aperture for increased depth of field.



2.2.4. Wide angle or fish aye angle camera: In photography and cinematography, a wide-angle lens refers to a lens whose focal length is substantially smaller than the focal length of a normal lens for a given film plane

Normal camera



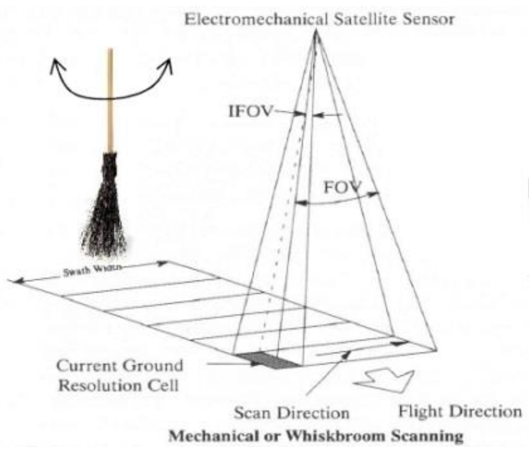
Wide angle

Fish eye

2.3. <u>Satellite Sensors</u>

Two types of satellite sensors are available, and it depends on the capturing system:

2.3.1. Pushbroom Satellite Sensor, the principle of capturing satellite images, is similar to airborne pushbroom images. In this system, a linear detector is implemented to project on the ground to project on an "instantaneous field of view (IFOV)" , at each instant, a row of a pixel are formed. The two-dimensional image is produced as the satellite sweep along.



2.3.2. A Whiskbroom or Spotlight Sensor, this type of imaging using a single pixel which moving across track and then along track.