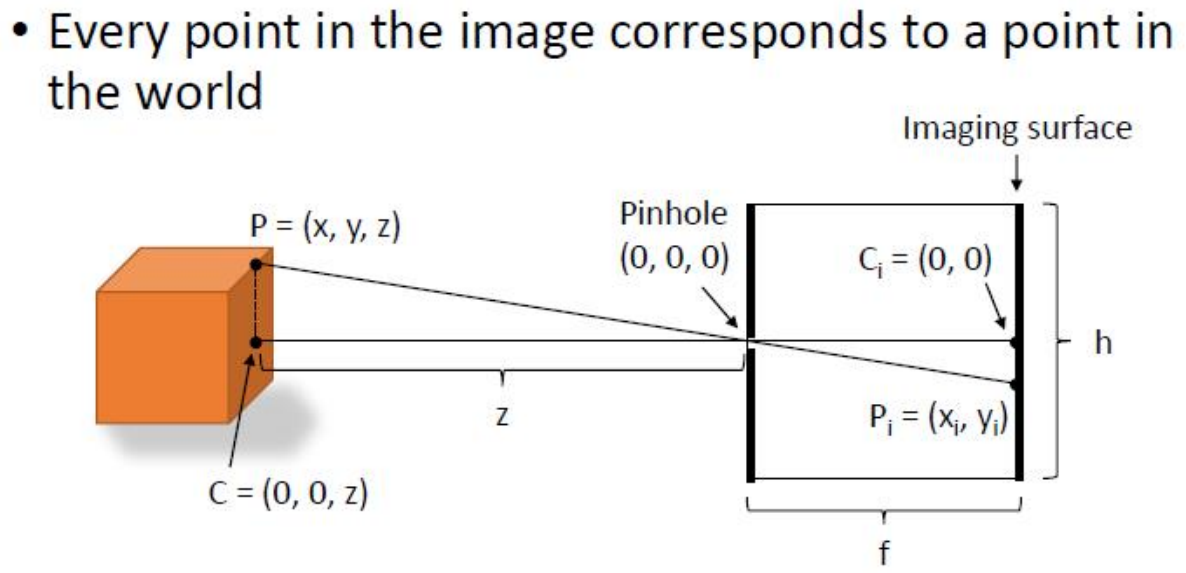
1 - Introduction and imaging basics

Computer vision tasks

- Recognize images
- Localise and identify objects
- Segment image regions
- Model relations between images
- Recover 3D structure
- Perform visual navigation
- Perform visually guided actions (e.g., grasping objects)

Pinhole camera model



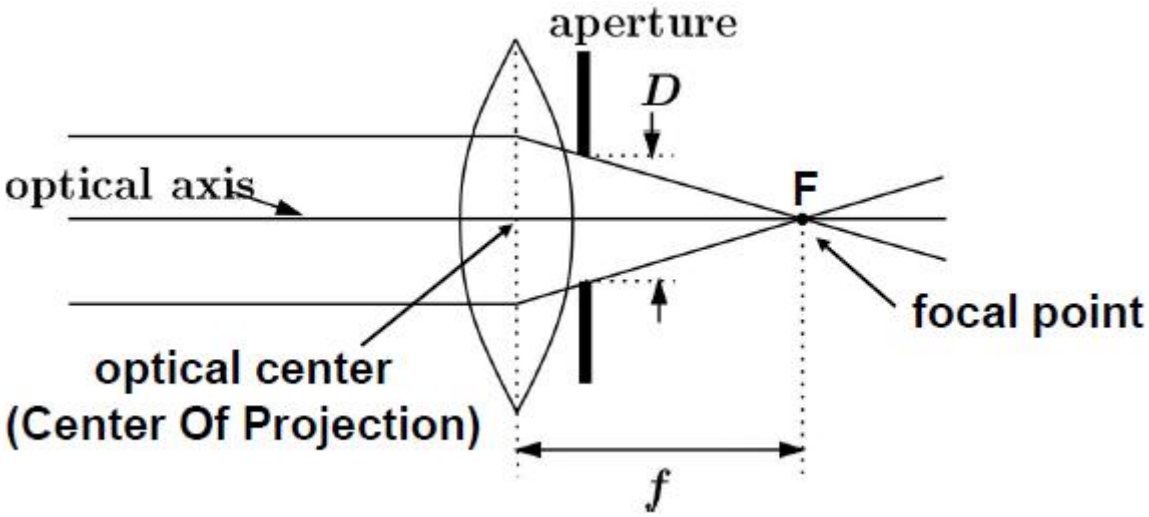
- xi = x * f / z
- yi = y * f / z

Pinhole camera: simple design, not common in practice

- Because of not enough light

Instead of a pinhole, most cameras use lenses

Lenses



- Lenses focus light rays onto a single point (F) at a distance (f) beyond the lens.
- Aperture diameter (D) restricts the range of rays.

Focal length / angle of view

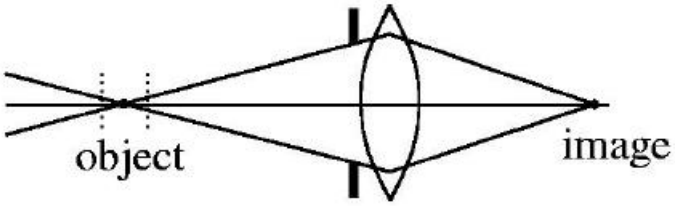
28 mm lens, 65.5° × 46.4°

50 mm lens, 39.6° × 27.0°

70 mm lens, 28.9° × 19.5°

210 mm lens, 9.8° × 6.5°

Depth of field

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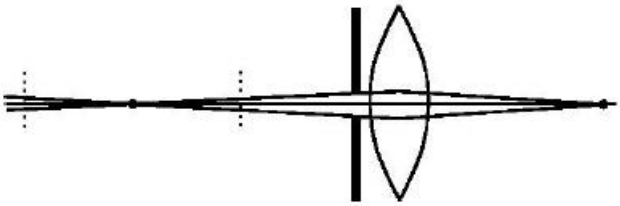


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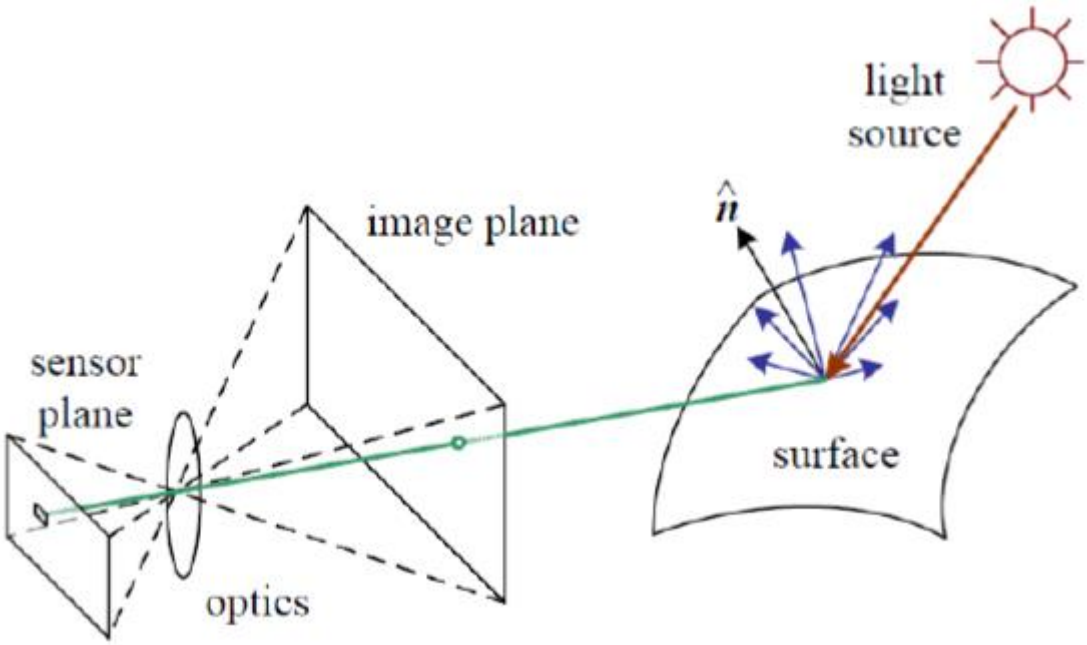
- In cameras, aperture size controls depth of field (smaller aperture = greater range of depth in focus)

Image formation model



- **World parameters**
  - Light source
  - Surface properties
- **Camera parameters**
  - Focal length / angle of view
  - Aperture size / depth of field
  - Lens distortion

Digital images

A tensor (3D dimensional array of values)

- Width x height x channel
- 3 channels = RGB colour image (red, green, blue)
- 1 channel = grayscale image

Note: the exact format can vary across libraries / languages!

- E.g., “channel first” = channel x height x width
- Height x width x channel
- BRG = blue, red, green

Pixel = smallest unit of an image

- Grayscale image: pixel is a grayscale value
- Colour image: pixel is a 1x3 vector
- (0, 0) from left top

Most common data type is uint8 (unsigned 8-bit integers)

- Range 0 - 255
- “24 bit colour” = 3 uint8 channels

But you may encounter other data types:

- double (range 0.0 - 1.0)
- uint16, uint32: medical images
- float32: high dynamic range (HDR) images

File formats

- Lossy compression: Some image formats discard information to save space
    - JPEG (.jpg, .jpeg)
- Lossless compression
    - PNG (.png), BMP (.bmp), GIF (.gif), TIF (.tif, .tiff).

Image manipulation

Image scaling L1.2 P36

- Crop = extract a subset of the image array (doesn’t require resampling)
- Resize = change the dimensions of the image array (requires resampling)

Resampling methods

- Nearest-neighbour: closest value to sample point
    - Simple, preserves hard edges
    - Smooth curves may be blocky/distorted
- Bilinear: weighted average of 4 pixels around sample point
    - Smoother curves, but blurs hard edges
    - Slower to compute
- Other options: bicubic, Lanczos
- Different resampling methods give different results

Summary

- An image is a pattern of light from the world, projected onto a 2D surface
- A digital image is a sample of this pattern, represented as a tensor
- Images of the same scene can vary widely at the pixel level, due to:
    - Camera parameters (focus, field of view)
    - Digital processing steps (compression, resampling)