Computer Vision
(Summer Semester 2020)

Lecture 5, Part 4

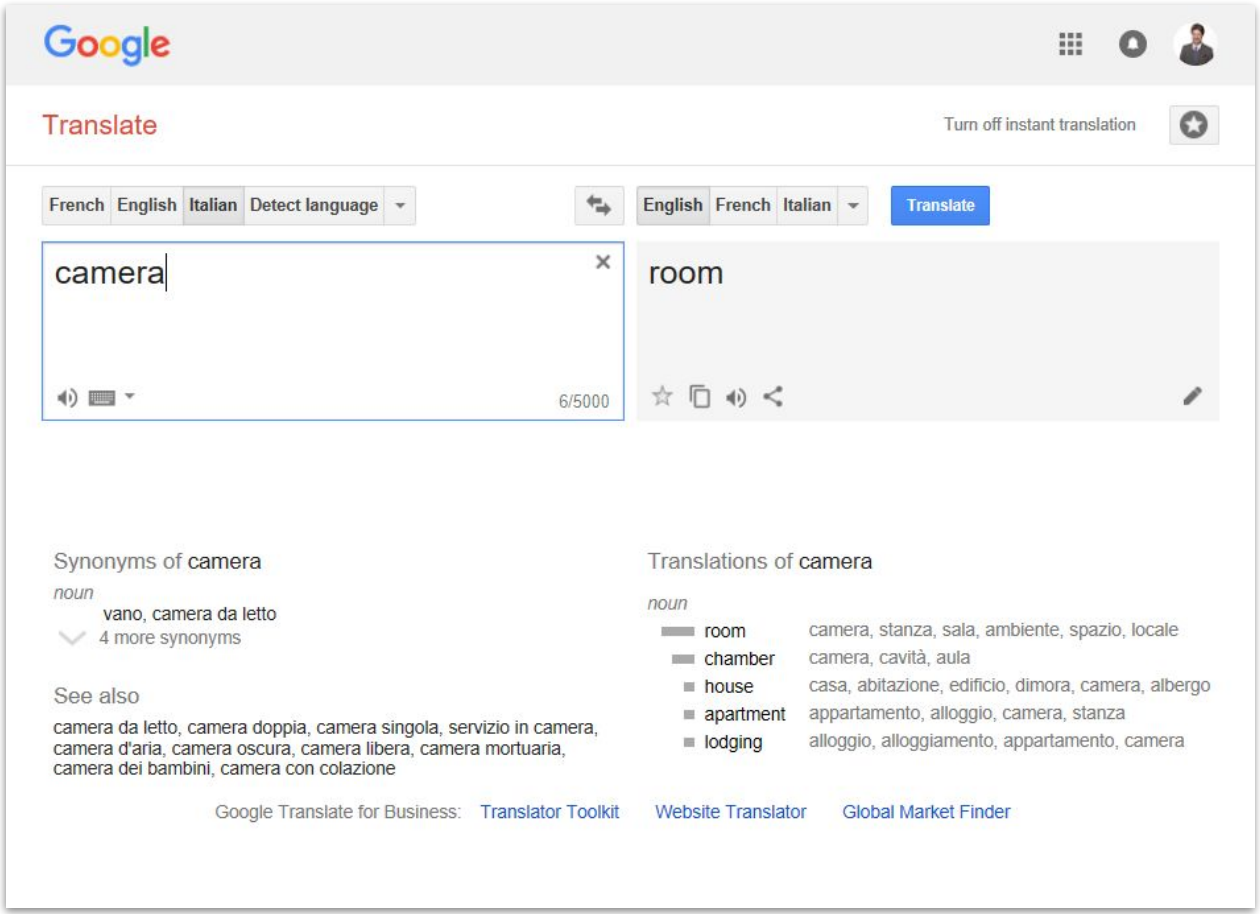
Cameras and Optics (Pinhole Cameras)

Cameras and Optics

- Pinhole Camera Model
- Perspective Projection
- Intrinsic and Extrinsic Camera Parameters

- Note: The core of these slides stems from the class CSCI 1430: “Introduction to Computer Vision” by James Tompkin, Fall 2017, Brown University.

What is a camera?


Google
Translate
Turn off instant translation
French English Italian Detect language
English French Italian
Translate
camera
6/5000
room
Synonyms of camera
noun
vano, camera da letto
4 more synonyms
See also
camera da letto, camera doppia, camera singola, servizio in camera, camera d'aria, camera oscura, camera libera, camera mortuaria, camera dei bambini, camera con colazione
Translations of camera
noun
room camera, stanza, sala, ambiente, spazio, locale
chamber camera, cavità, aula
house casa, abitazione, edificio, dimora, camera, albergo
apartment appartamento, alloggio, camera, stanza
lodging alloggio, alloggiamento, appartamento, camera
Google Translate for Business: Translator Toolkit Website Translator Global Market Finder

Camera obscura: dark room

- Known during classical period in China and Greece (e.g., Mo-Ti, China, 470BC to 390BC)

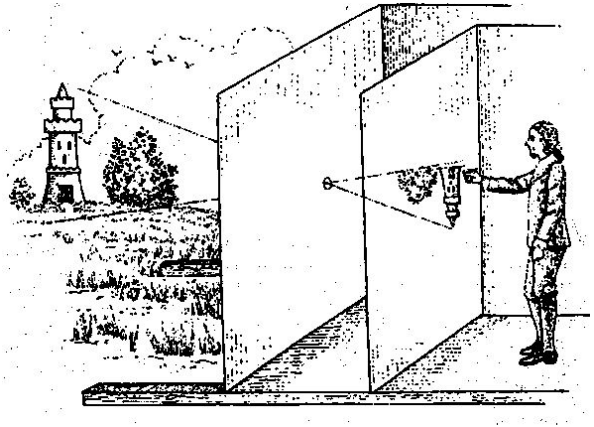
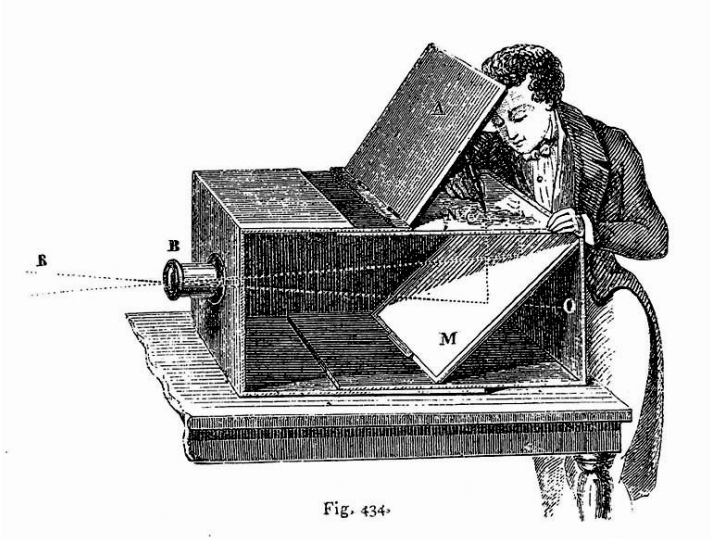


Illustration of Camera Obscura

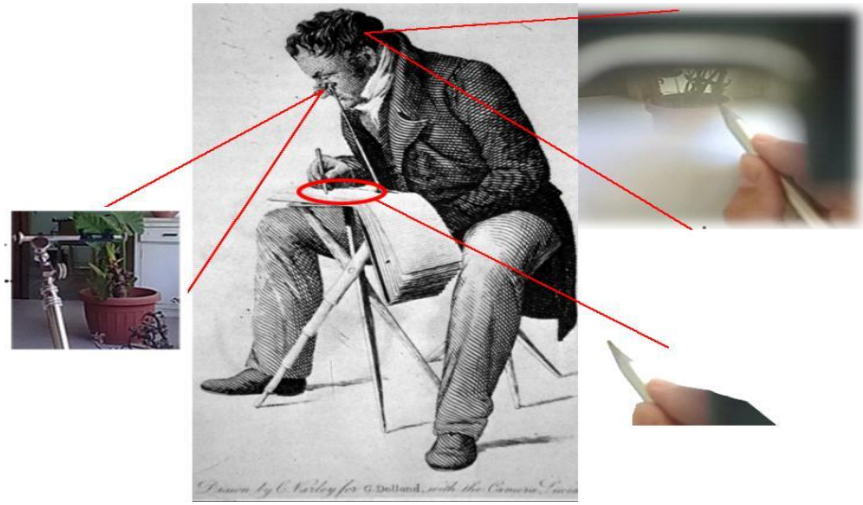
Freestanding camera obscura at UNC Chapel Hill

Photo by Seth Ilys

Camera obscura / lucida used for tracing



Lens Based Camera Obscura, 1568

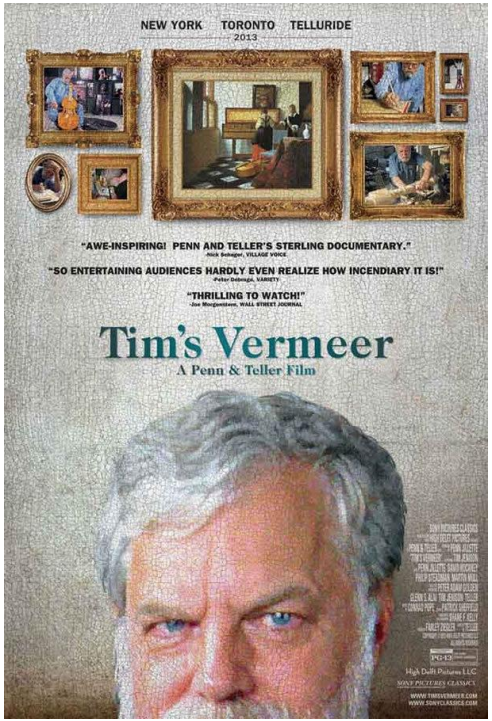


Camera lucida

drawingchamber.wordpress.com

Tim's Vermeer

Johannes Vermeer, The Music Lesson, 1665



Tim Jenison (Lightwave 3D, Video Toaster)

Tim's Vermeer -- Video Still

First Photograph

Oldest surviving photograph
Took 8 hours on pewter plate

Joseph Niepce, 1826

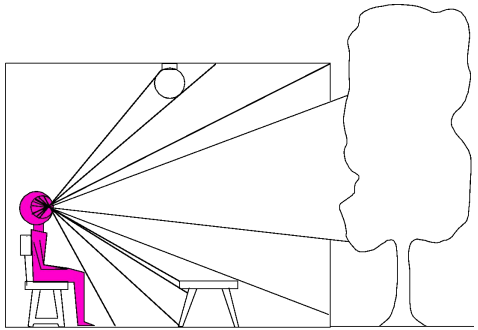
Photograph of the first photograph

Stored at UT Austin

Niepce later teamed up with Daguerre, who eventually created Daguerrotypes

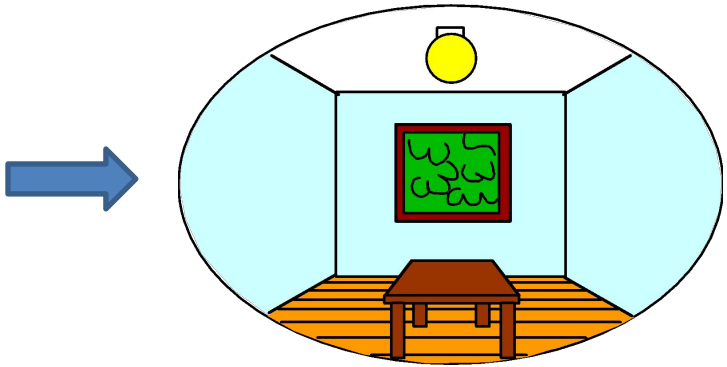
Dimensionality Reduction Machine (3D to 2D)

3D world



Point of observation

2D image



Figures © Stephen E. Palmer, 2002

Lake Sørvágsvatn in Faroe Islands

100 meters above sea level

optical tricks/illusions via 3D → 2D

Lake Sørvágsvatn in Faroe Islands

~~100~~ 30 meters above sea level

optical tricks/illusions via 3D → 2D

amusingplanet.com, thanks to Aaron Gokaslan

optical tricks/illusions via 3D → 2D

optical tricks/illusions via 3D → 2D

Holbein's The Ambassadors - 1533

optical tricks/illusions
via 3D → 2D

Holbein's The Ambassadors – Memento Mori

optical tricks/illusions
via 3D → 2D

Cameras and World Geometry

How tall is this woman?

How high is the camera?

What is the camera rotation wrt. world?

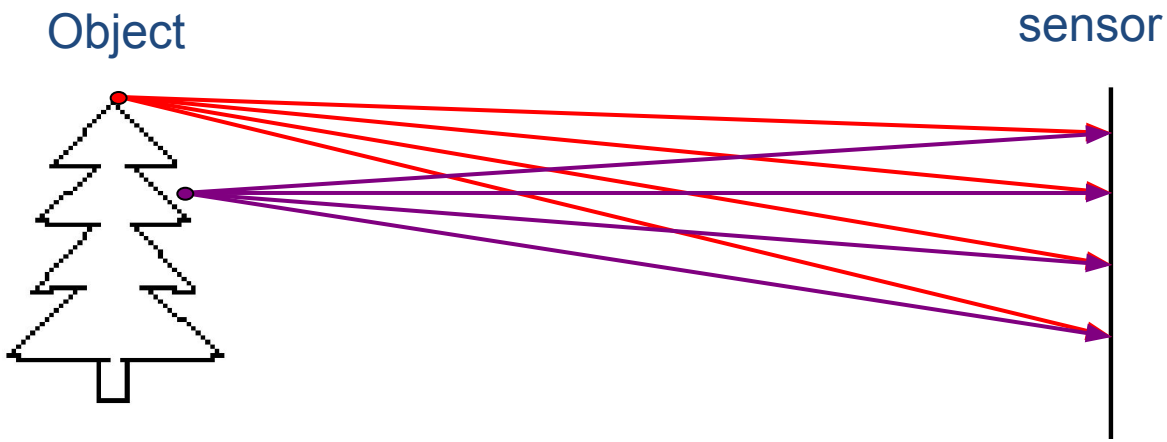
Which ball is closer?

https://www.youtube.com/watch?v=IgBQCoEfiMs

1. Feature Matching
2. Registration
3. Camera Calibration

Let's design a camera

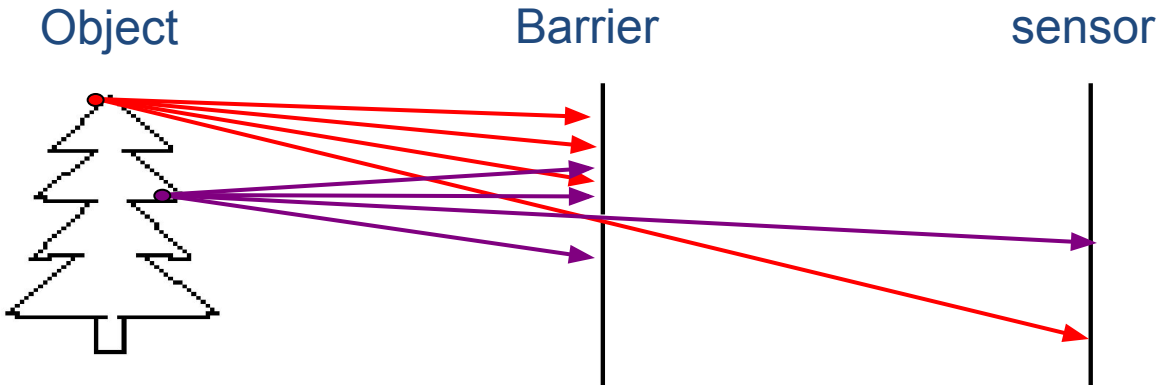
Idea 1: Put a sensor in front of an object
Do we get a reasonable image? → multiple features get mapped to same points on the sensor



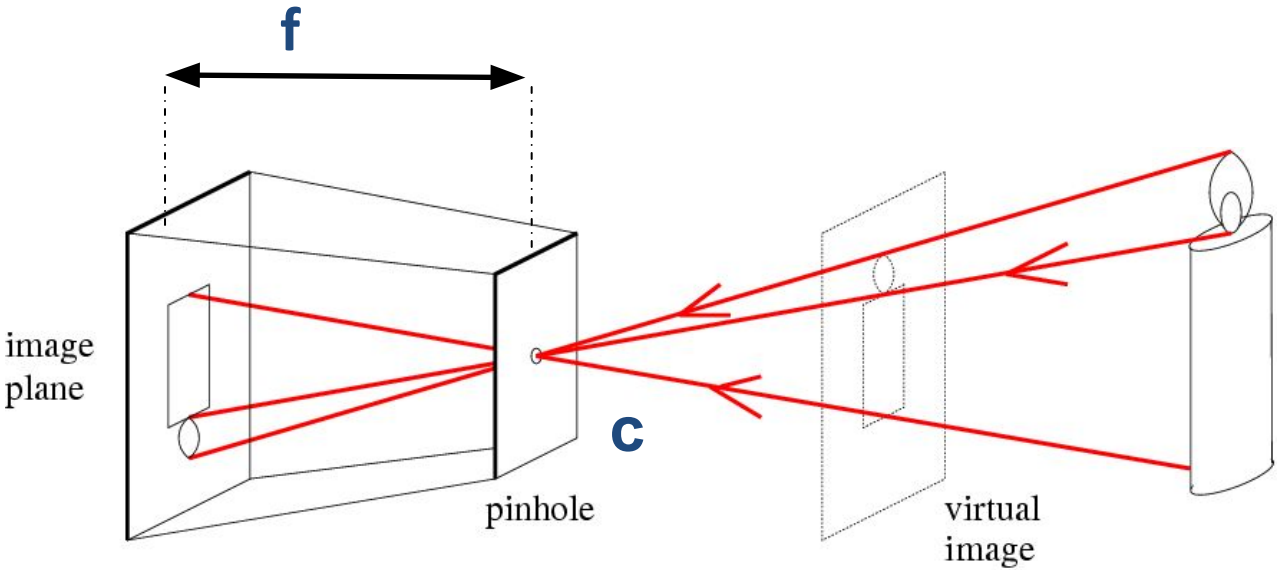
Let's design a camera

Idea 2: Add a barrier to block most rays

- Pinhole in barrier
- Only sense light from one direction.
  - Reduces blurring.
- In most cameras, this **aperture** can vary in size.

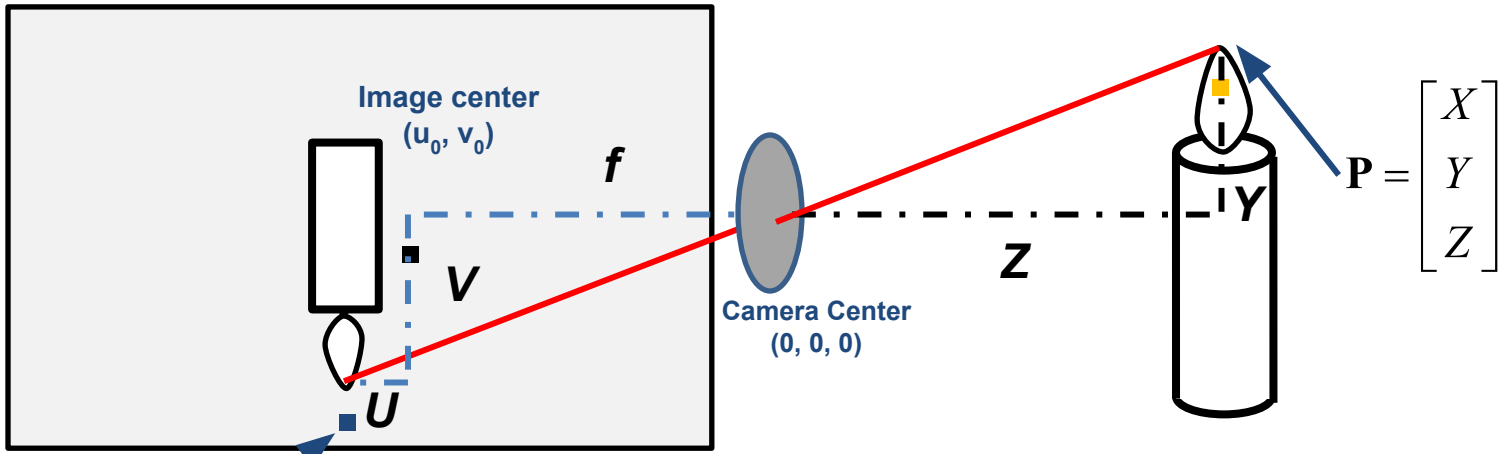


Pinhole camera model



f = Focal length
C = Optical center of the camera

Projection: world coordinates → image coordinates



$$U = -X * \frac{f}{Z} \qquad V = -Y * \frac{f}{Z}$$

p = distance from image center

What is the effect if f and Z are equal?