Learning Objectives

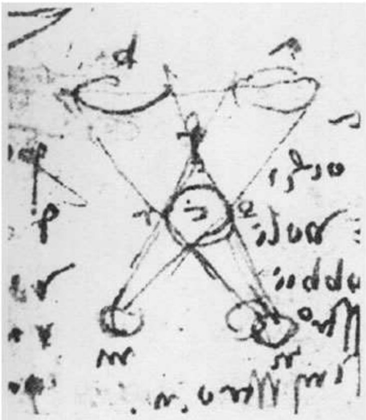
- Learn the geometry of a stereo sensor, and how the two camera are related.

- Learn how to derive the location of a point in 3D given its projection on the two images of a stereo sensor.

Stereopsis

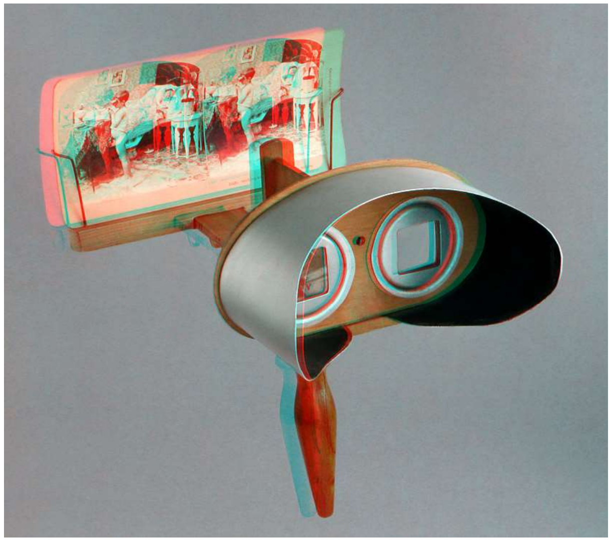
- Charles Wheatstone (1838): "… the mind perceives an object of three dimensions by means of the two dissimilar pictures projected by it on the two retinæ …''

- Pre 19th century: Leonardo da Vinci



Peter Hohenstatt : Leonardo da Vinci, 1452-1519, Knemann Verlag, 1998

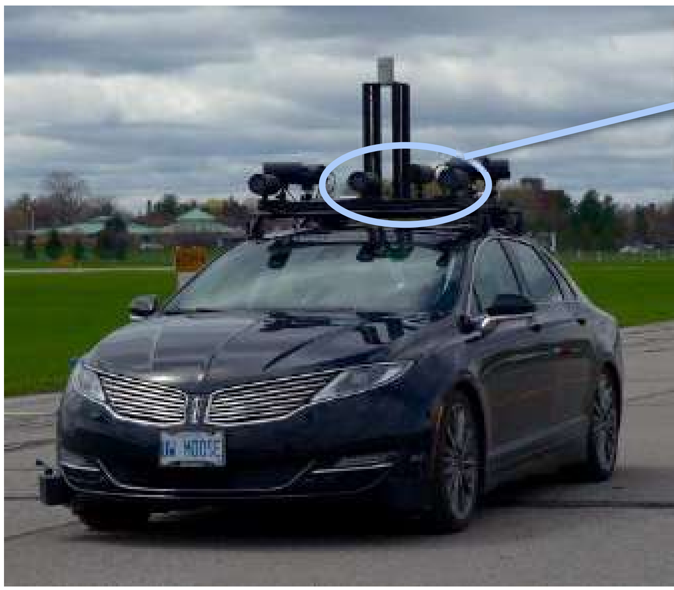
Stereoscopes: A 19th Century Pastime



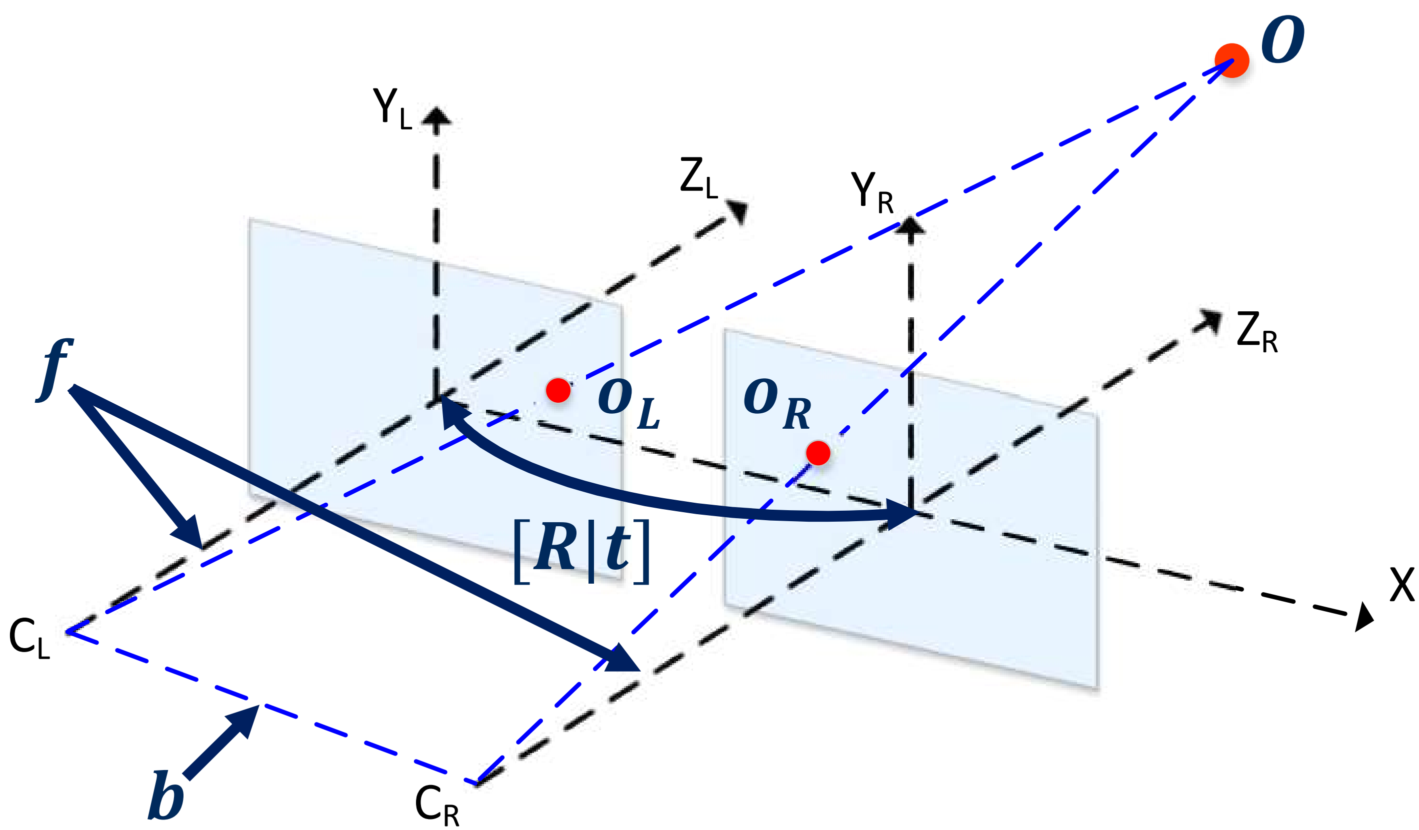
https://commons.wikimedia.org/wiki/File:Holmes_stereoscope_anaglyph_01.jpg

https://commons.wikimedia.org/wiki/File:Lincoln_stereoscope.jpg

Stereo Cameras



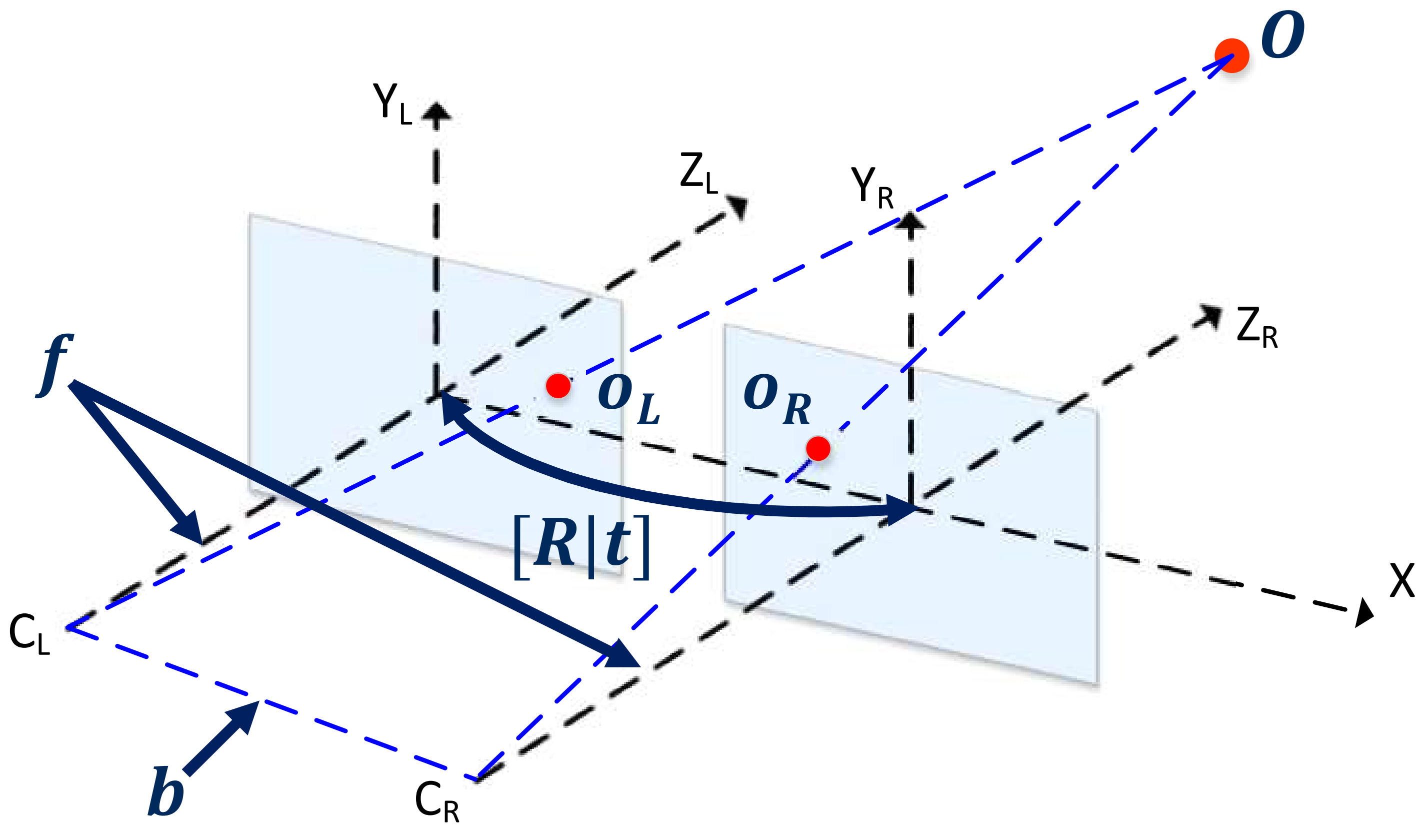
Stereo Camera Model



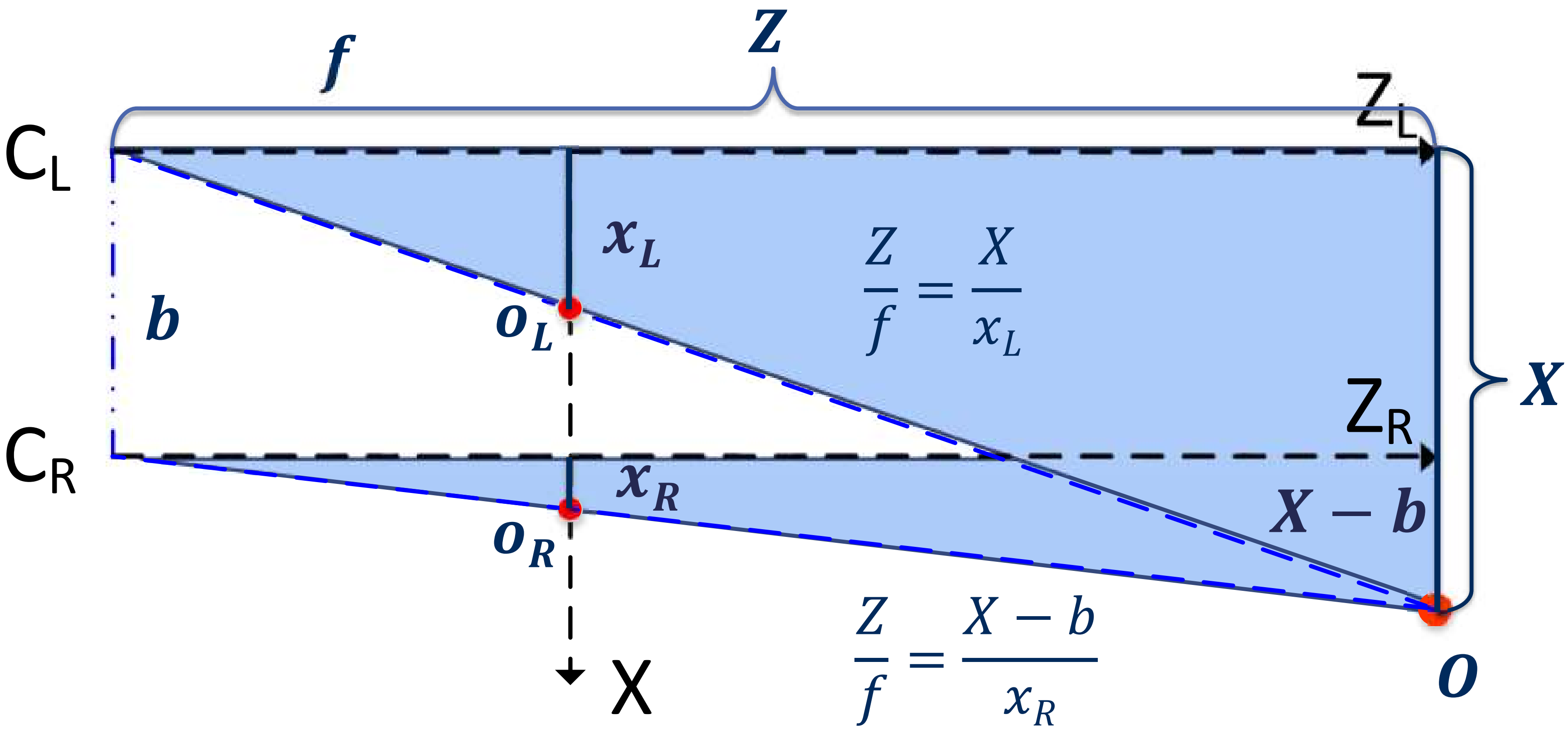
Stereo Sensor: Assumptions

- Sensor is constructed from two identical cameras
- The two cameras have parallel optical axes
- Project to Bird's eye view for easier geometry

Stereo Camera Model



Stereo Camera Model



Computing 3D Point Coordinates

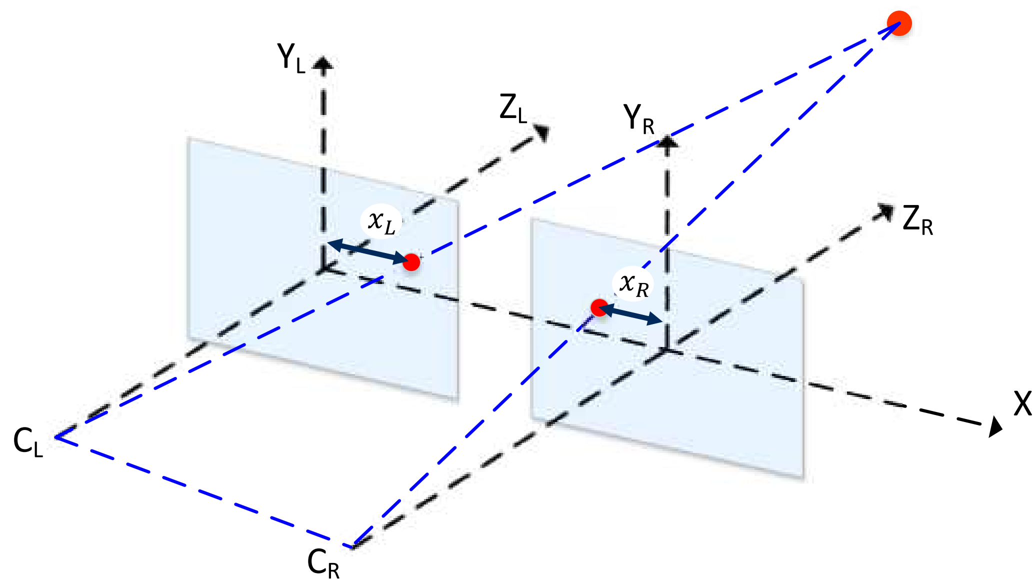
- Disparity:

$$d = x_L - x_R$$

where $x_L = u_L - u_0$

$$x_R = u_R - u_0$$

$$y_L = v_L - v_0$$



Computing 3D Point Coordinates

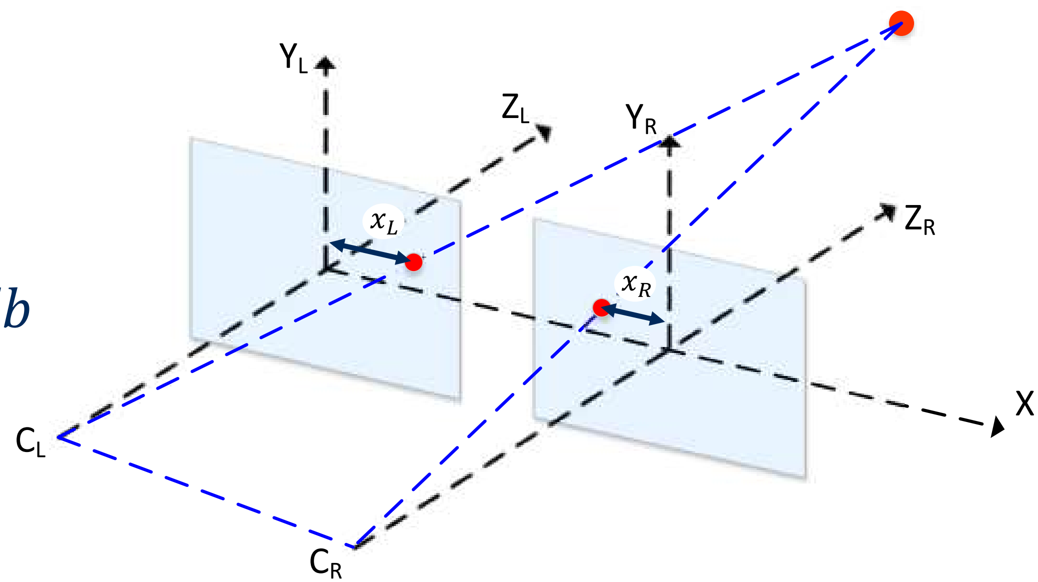
Main stereo relations:

$$\frac{Z}{f} = \frac{X}{x_L} \rightarrow ZxL = fX$$

$$\frac{Z}{f} = \frac{X-b}{x_r} \rightarrow ZxR = fX - fb$$

$$Zx_R = Zx_L - fb$$

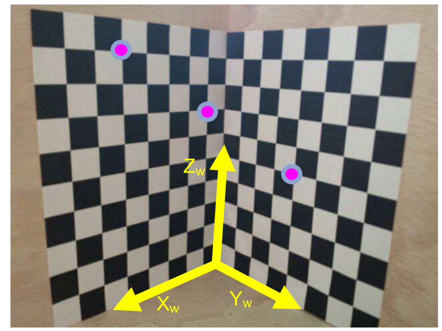
$$Z = \frac{fb}{d}$$

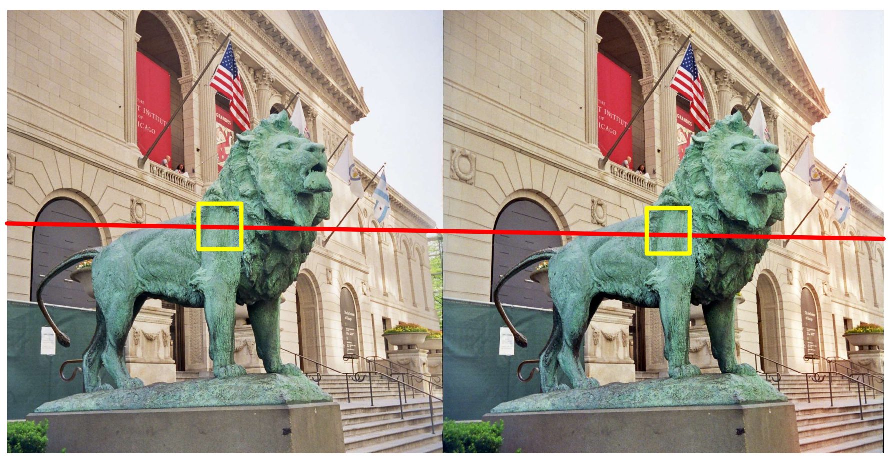


From above: $X = \frac{Zx_L}{f}, \quad Y = \frac{Zy_L}{f}$

Computing 3D Point Coordinates

- Two main problems:
  - We need to know $f, b, u0, v0$
    - Use stereo camera calibration
  - We need to find corresponding x_R for each x_L
    - Use disparity computation algorithms





Summary

- Stereopsis as a phenomenon was well known as early as the 19th century.
- Given the geometric transformation between the two cameras of a stereo sensor, and the disparity, you can estimate the 3D location of pixel.
- Next: Disparity Computation