Learning Objectives

- Learn how to estimate the disparity through stereo matching.
- Learn how to constrain disparity estimation through epipolar constraints.

Computing 3D Point Coordinates

- Two main problems:
  - We need to know f, b, u_0, v_0
    - Use stereo camera calibration
  - We need to find corresponding x_R for each x_L
    - Use disparity computation algorithms

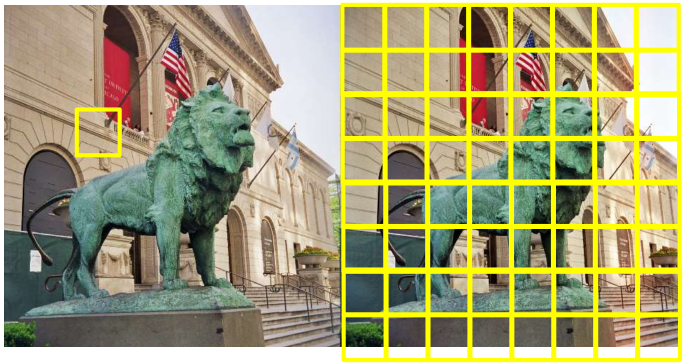
Stereo equations:

$$Z = \frac{fb}{x_L - x_R} = \frac{fb}{d},$$

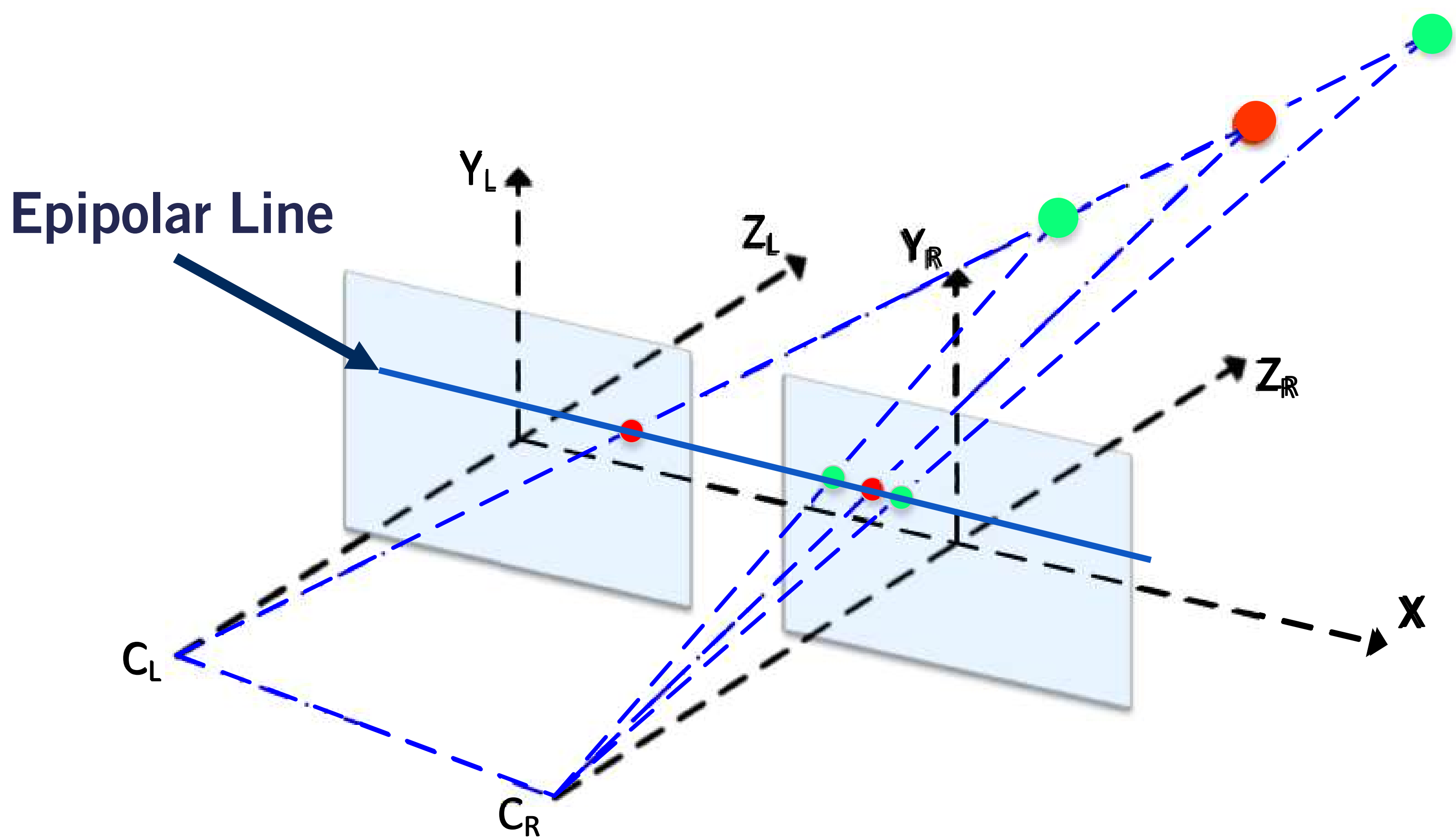
$$X = \frac{Zx_L}{f}, \qquad Y = \frac{Zy_L}{f}$$

Computing 3D Point Coordinates (Review)

- **Disparity**: The difference in image location of the same 3D point under perspective to two different cameras
- **Correspond** pixels in the left image to those in the right image to find matches
- **Brute Force Solution**:
  - Search the whole image for each pixel?

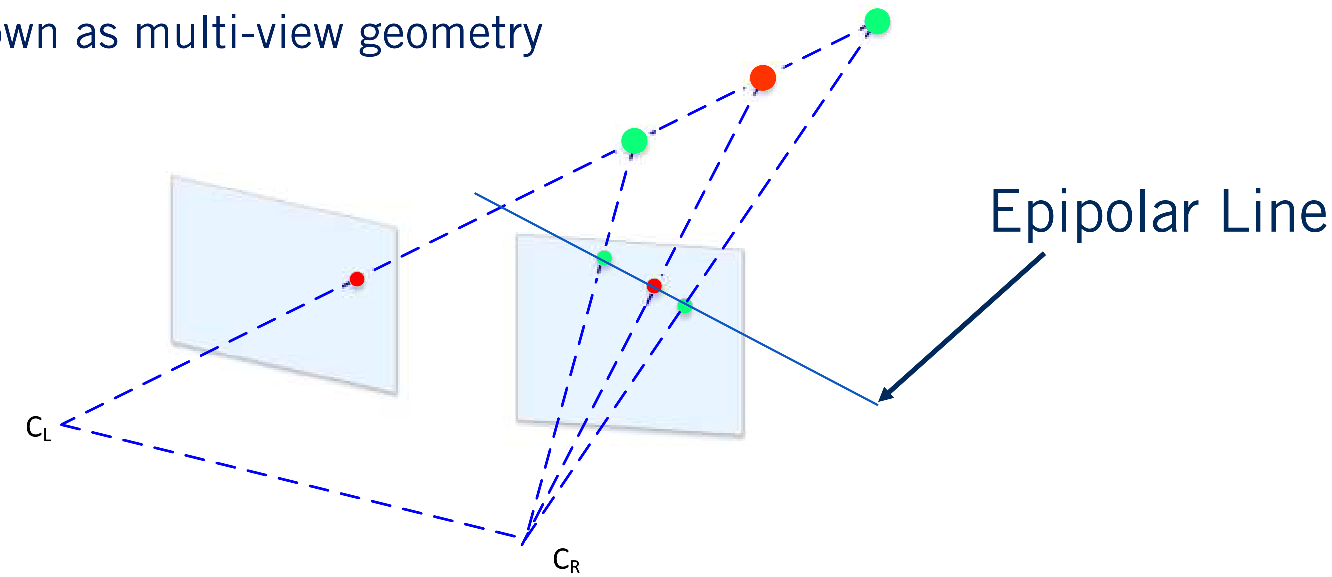


Epipolar Constraint for Correspondence



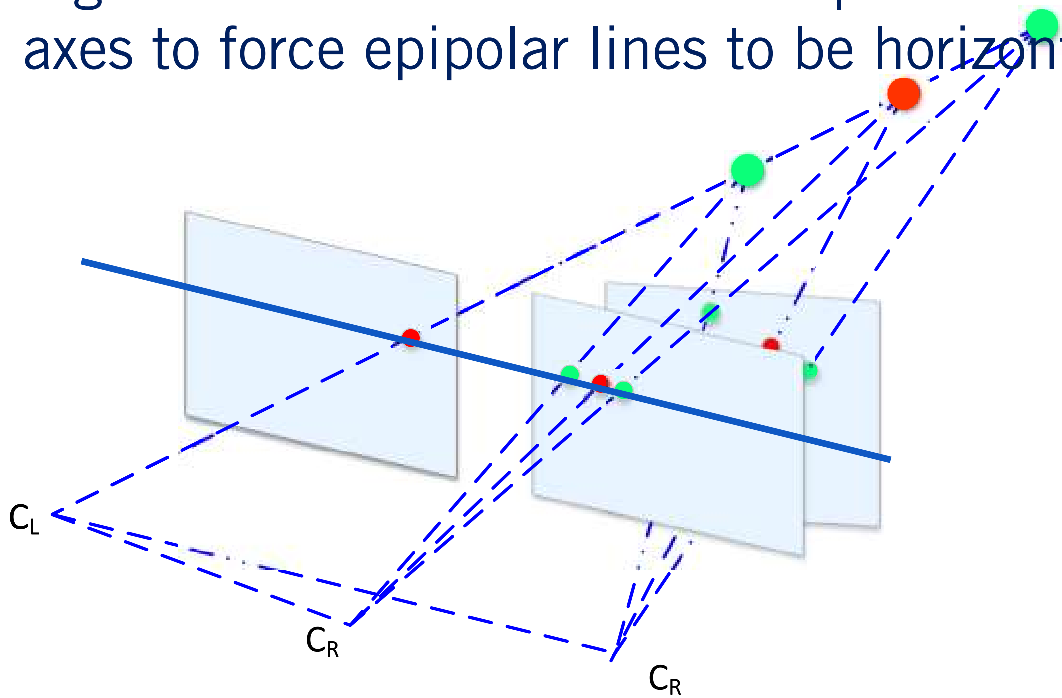
Non-Parallel Optical Axes

- Horizontal epipolar lines only occur when the optical axes of the two cameras are parallel.
- If this condition is not met, epipolar lines will be skewed
  - Known as multi-view geometry



Disparity Computation

- We can use **stereo rectification** to warp images originating from two cameras with non-parallel optical axes to force epipolar lines to be horizontal.

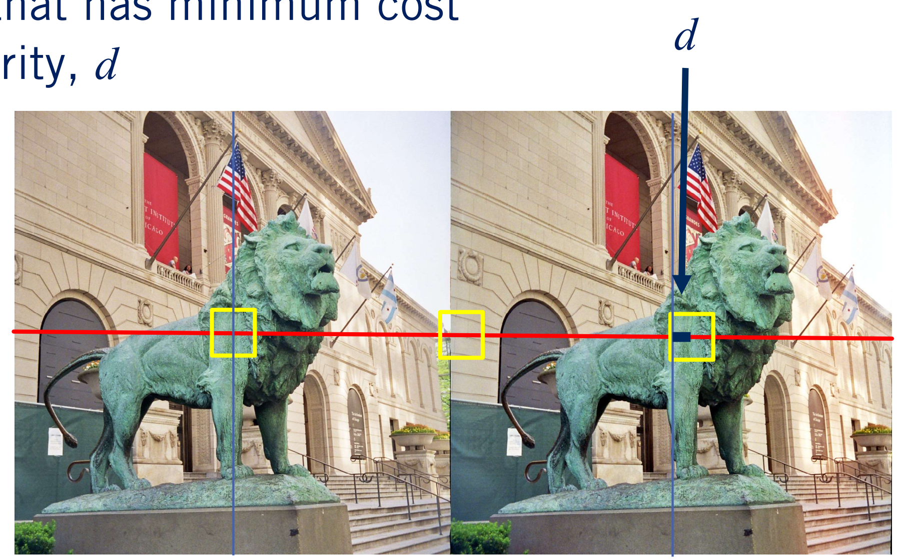


A basic Stereo Algorithm

Given: Rectified Images and Stereo Calibration.

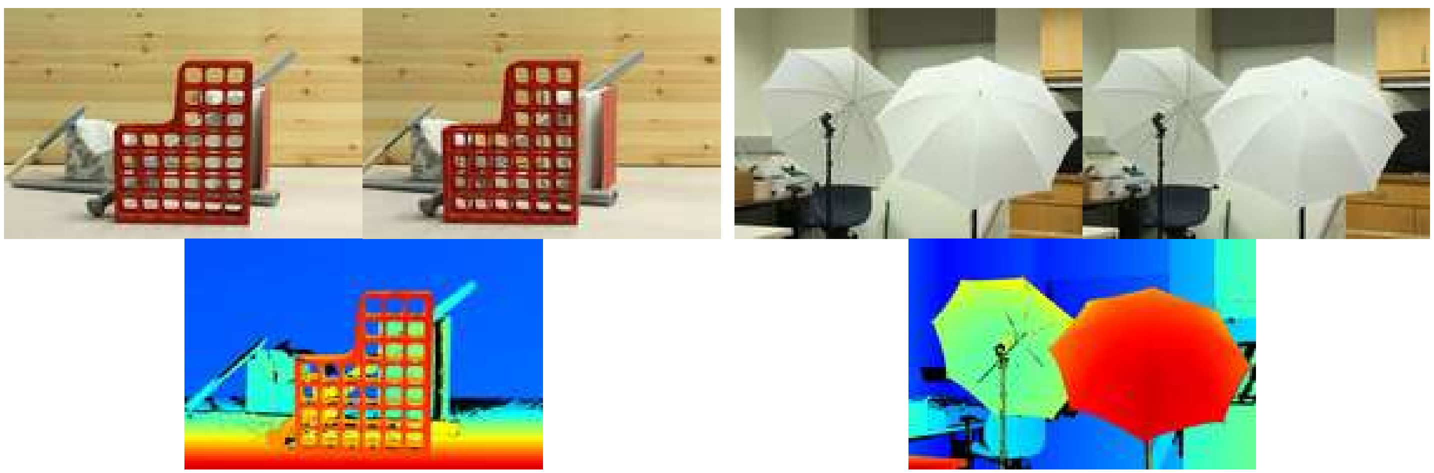
For each epipolar line,

1. Take each pixel on this line in the left image
2. Compare these left image pixels to every pixel in the right image on the same epipolar line
3. Pick the pixel that has minimum cost
4. Compute disparity, d



Stereo Matching

- Stereo matching is a very well-studied problem in computer vision
- Survey at: http://vision.middlebury.edu/stereo/eval3/



Summary

- Disparity estimation can be performed through stereo matching algorithms

- Efficient solutions exist as the problem is constrained with epipolar constraints

- **Next: Image Filtering**