Workshop on Computer Vision, Graphics and Image processing

Stereo Reconstruction

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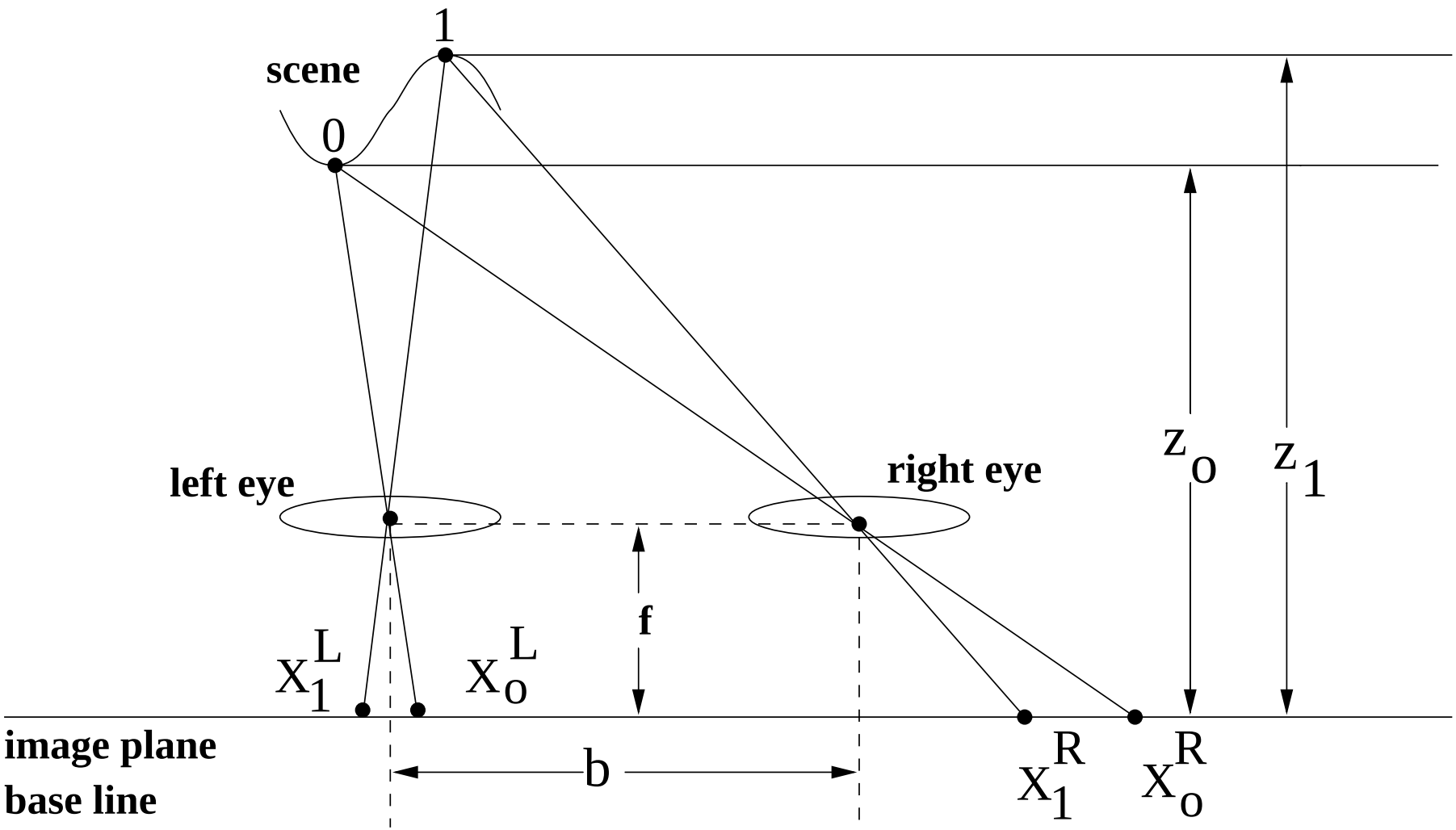
Overview

- Introduction
- Stereo reconstruction
- Some results
- Conclusions

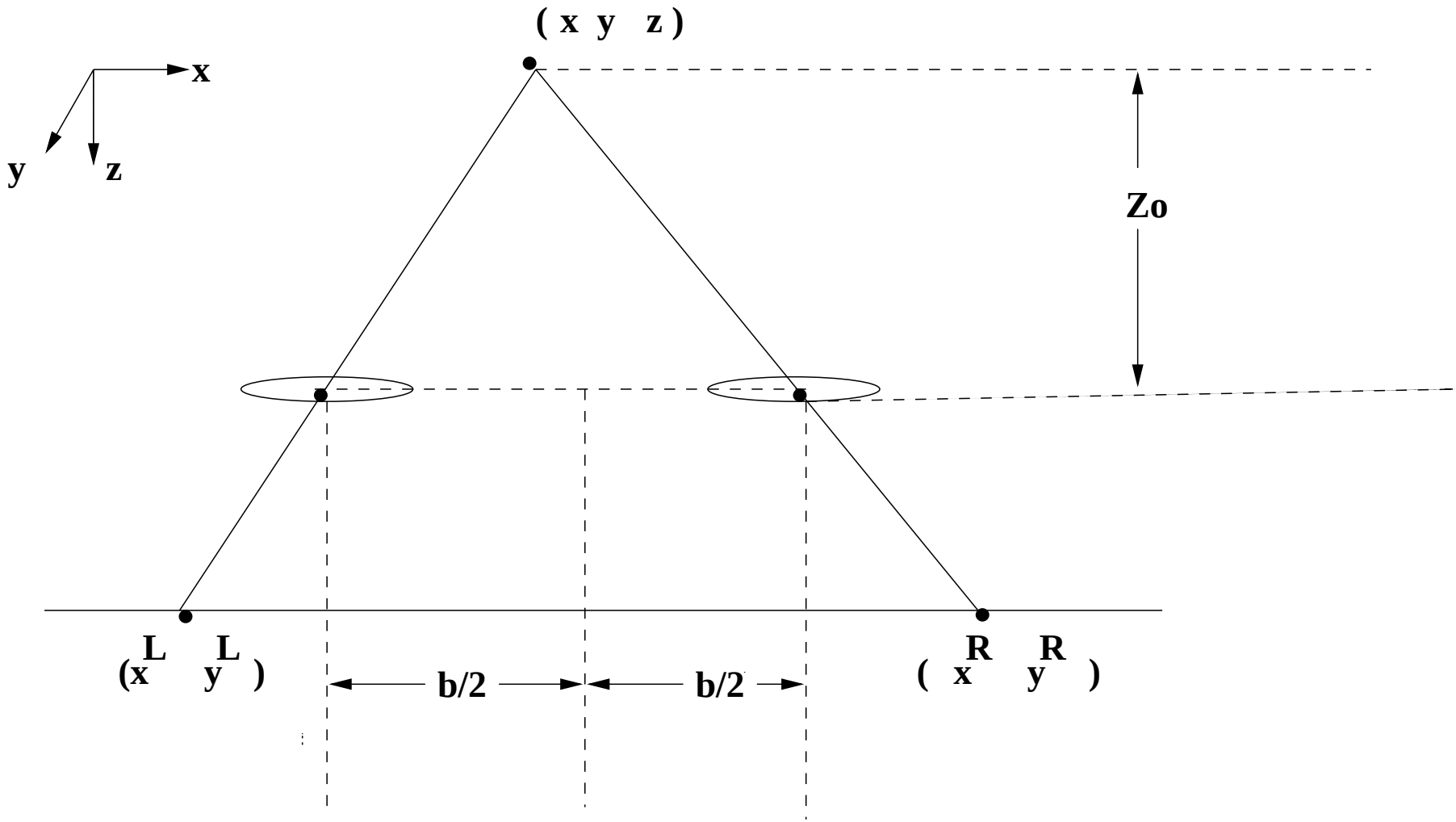
Methods of depth estimation

- Stereo: dense correspondence
- Structure from motion
- Depth from focus: needs more photographs
- Depth from defocus: needs careful settings of the camera
- Depth from multiple views

Stereo


1
scene
0
left eye
right eye
z_o
z_1
f
x_1^L
x_o^L
image plane
base line
b
x_1^R
x_o^R

Stereo contd..



Stereo contd..

- Let (X,Y,Z) be the world coord., (x,y,z) be the camera coord., (x^L,y^L) and (x^R,y^R) be the projections on to the left and right cameras. b-baseline, f-focal length, $x^R - x^L$-disparity
- We can write (for the disparity only in the x direction)

$$y^L = \frac{fY}{Z} \qquad \text{and} \qquad y^R = y^L$$

$$x^L = f(\frac{X - b/2}{Z}) \qquad \text{and} \qquad x^R = f(\frac{X + b/2}{Z})$$

$$x^R - x^L = \frac{fb}{Z} \qquad \text{and} \qquad Z = \frac{bf}{x^R - x^L}$$

Disparity is inversely proportional to Z

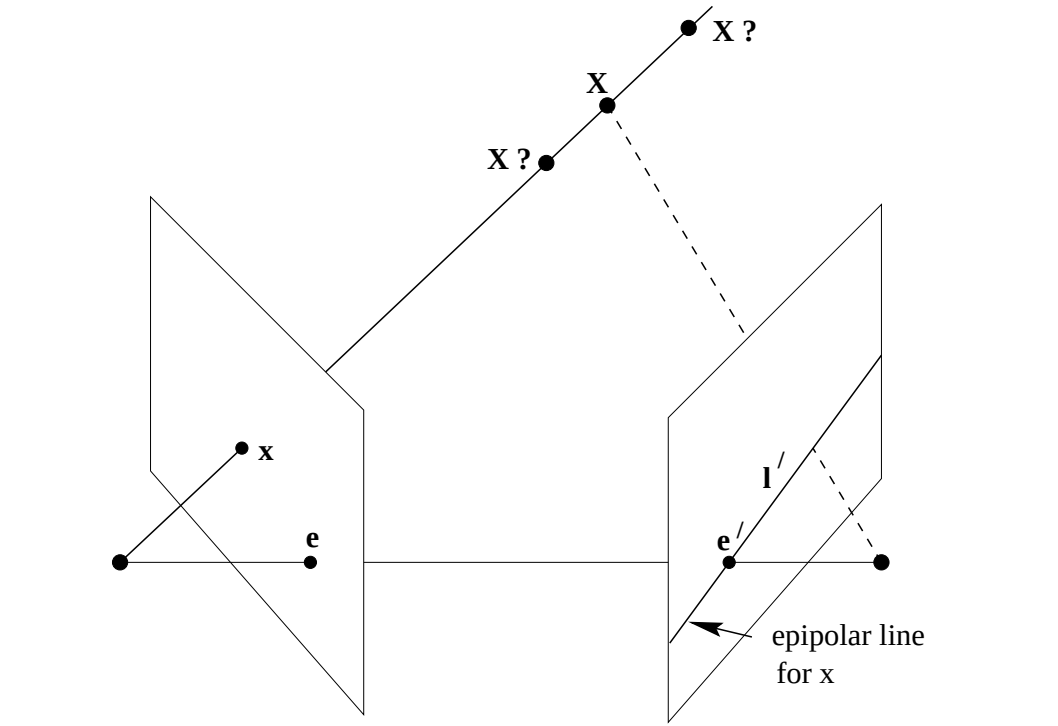
problems with Stereo

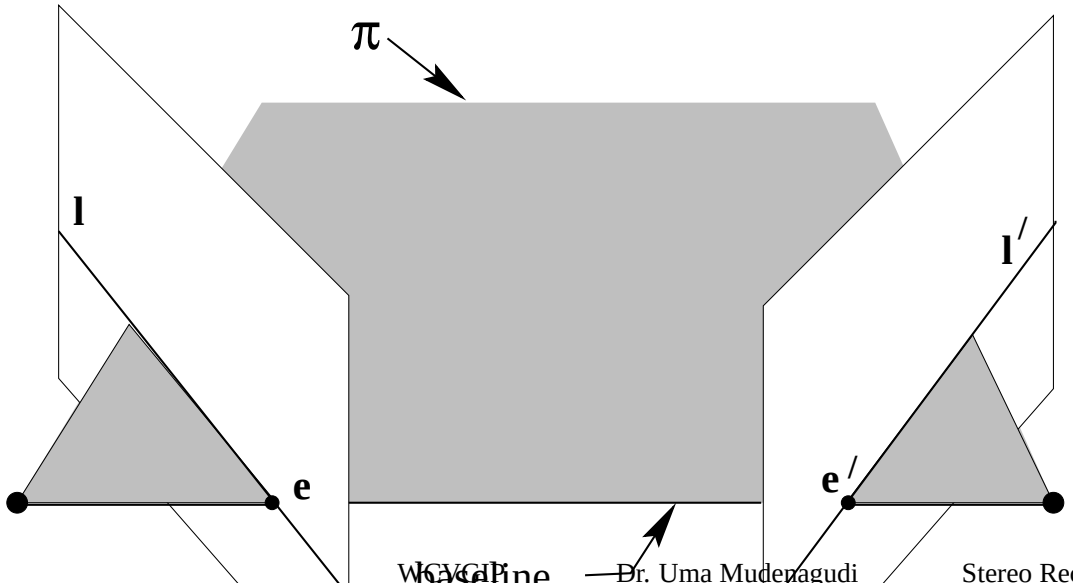
- Occlusions in the wide line stereo
- How do we carry out the matching: correspondence problem
- N^2 points in left and N^2 in the right image: computational complexity exponential
- How do we need to match
- By putting constraints
- Expipolar constraint: epipolar lines parallel to x-axis, since they have the same y-coord.
- Ordering of points, Intensity constraint: intensity at a point in left and right images must be same
- Correlation etc...

Epipolar geometry (point correspondence)

- $\mathbf{X}$ in space is imaged in two views at x and x'
- Aim of stereo: correspondence between x and x'
- Baseline: line joining the camera centres
- Intersection of image planes with the pencil of planes having baseline as axis
- Points x, x', $\mathbf{X}$ and camera centers are coplanar, lying in π
- The back projected rays from x and x' intersect at $\mathbf{X}$
- Given x how the corresponding point x' is constrained?

Point correspondence geometry cont..

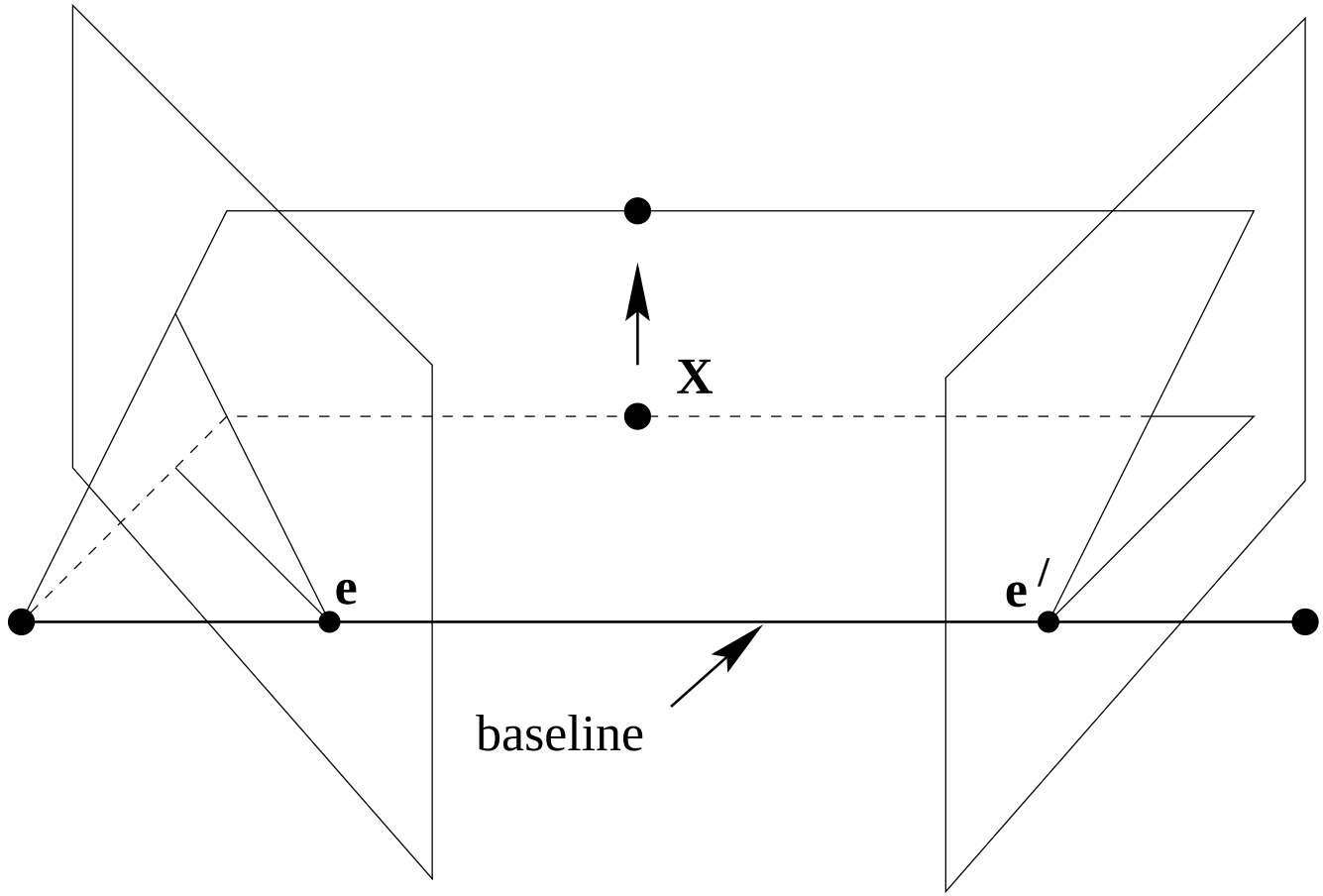




Epipolar geometry contd..

- An image point x back projects to a ray in 3 space defined by the first camera center C and x
- This ray is imaged as a line l' in the second view
- The 3-space point $\mathbf{X}$ which projects to x must lie on this ray, so the image of $\mathbf{X}$ in the second image must lie on l'
- The ray corresponding to the x' lie in π, hence point x' lies on line of intersection of l' of π with the second image plane
- This line l' is the image in the second view of the ray back projected from x
- The correspondence is now restricted to the line l'

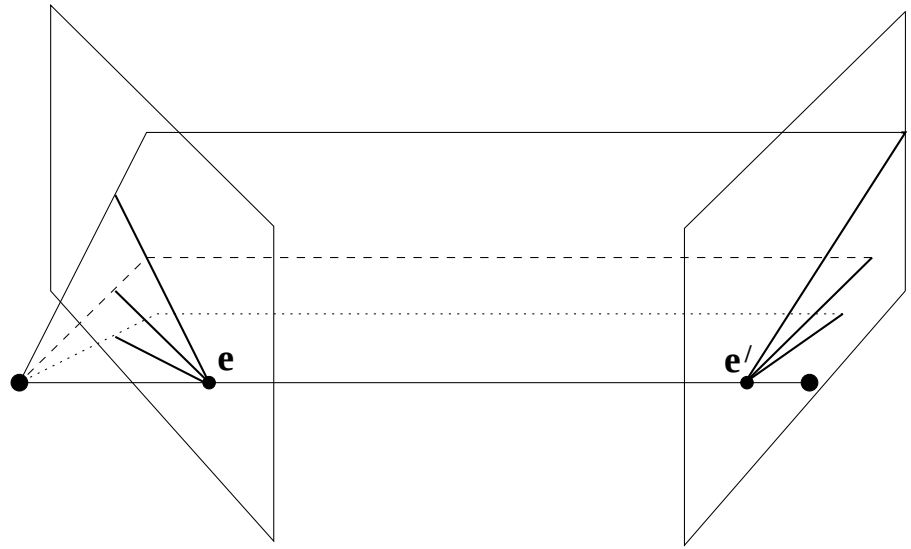
Epipolar geometry cont..

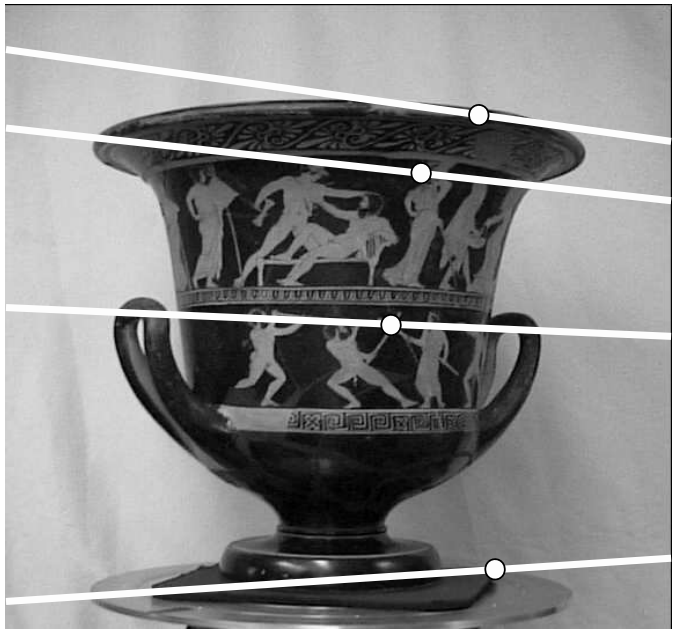


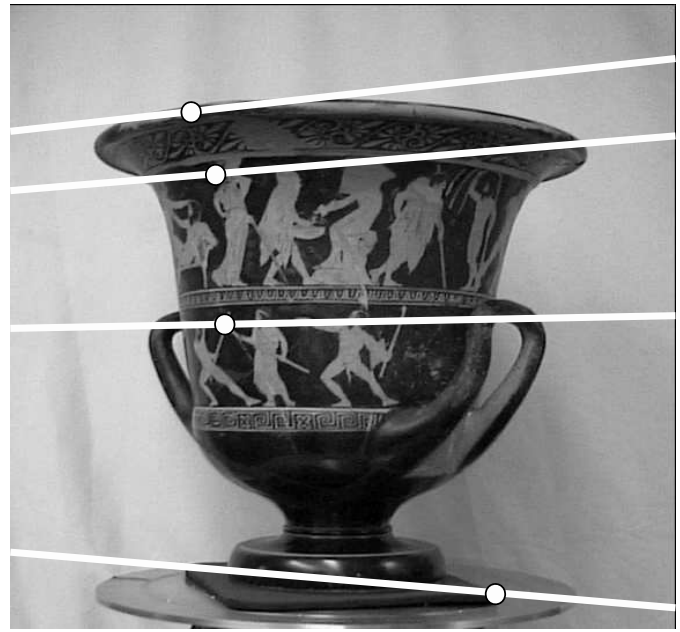
Epipolar geometry contd..

- As the position of the 3D point varies, the epipolar planes rotate about the baseline
- This family of planes is known as an epipolar pencil
- All the epipolar lines intersect at the epipole
- Epipole: point of intersection of the line joining the camera centres with the image plane
- Epipolar plane: plane containing the baseline
- An Epipolar line: intersection of an epipolar plane with the image plane

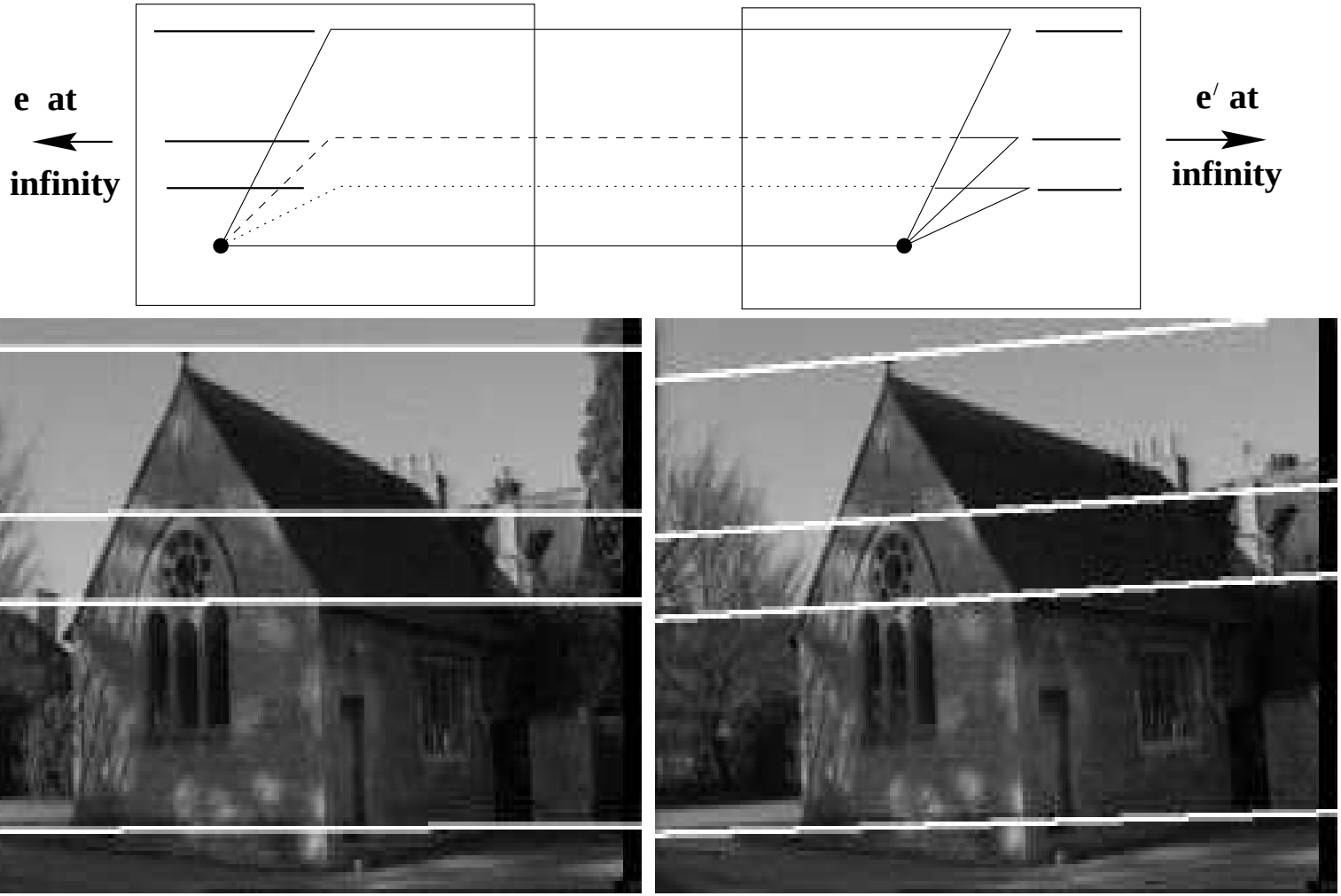
Converging cameras







Motion parallel to the image plane



Stereo contd..

- Epipolar constraint is assumed
- Intensity constraint is assumed
- The problem of depth estimation is nothing but the estimation of disparity
- Disparity is estimated by minimizing the intensity at the corresponding pixel
- In intensity based disparity estimation, the disparity d_{ij} is computed by by minimizing

$$min \quad \sum (x^R_{i,j} - x^L_{i,j+d_{ij}})^2$$

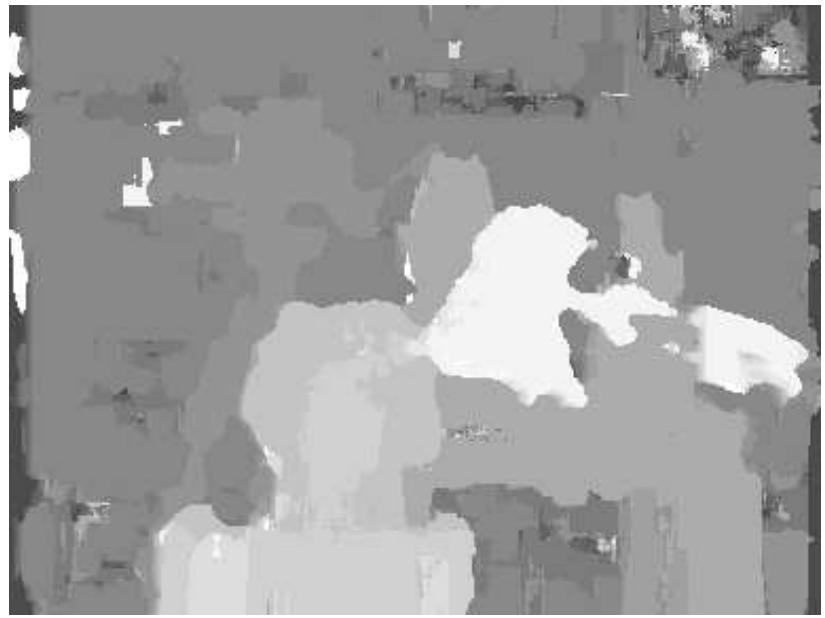
where (x^R_{ij}) and (x^L_{ij}) are the intensity at the pixel location (i,j) in the right image and the left image respectively

Results

Right and left input images

Results contd..

Depth using correlation method



Results contd..

Depth using BVZ method

Results

Depth using KZ2 method