



UNIVERSITY OF
SOUTH CAROLINA

CSCE 590 INTRODUCTION TO IMAGE PROCESSING

Stereo

Camera Calibration

- Camera Model

- $[u \ v \ 1]$ Pixel coords

- $[x_w \ y_w \ z_w \ 1]^T$ World coords

$$z_c \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = A \begin{bmatrix} R & T \end{bmatrix} \begin{bmatrix} x_w \\ y_w \\ z_w \\ 1 \end{bmatrix}$$

- Intrinsic Parameters

- $\alpha_x = f \cdot m_x, \alpha_y = f \cdot m_y$ focal lengths in pixels

- γ skew coefficient

- u_0, v_0 focal point

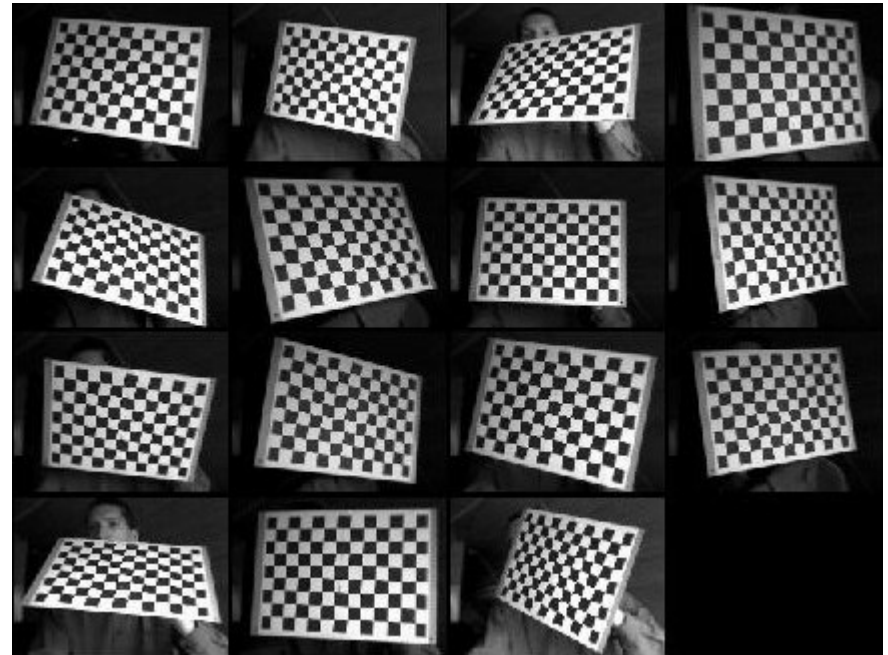
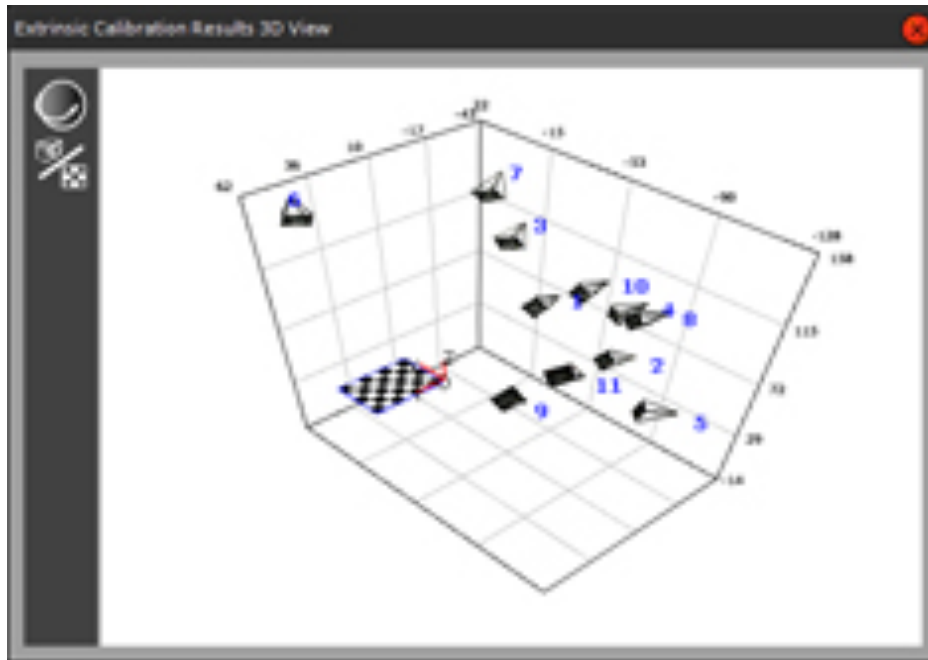
$$A = \begin{bmatrix} \alpha_x & \gamma & u_0 \\ 0 & \alpha_y & v_0 \\ 0 & 0 & 1 \end{bmatrix}$$

- Extrinsic Parameters

- $[R \ T]$ Rotation and Translation



Camera Calibration



Existing packages in MATLAB, OpenCV, etc



Rectified Image Sample

Unrectified



Rectified



From Clearpath Husky Axis M1013 camera



Rectified Image Sample

Unrectified



Rectified



From Parrot ARDrone 2.0 front camera

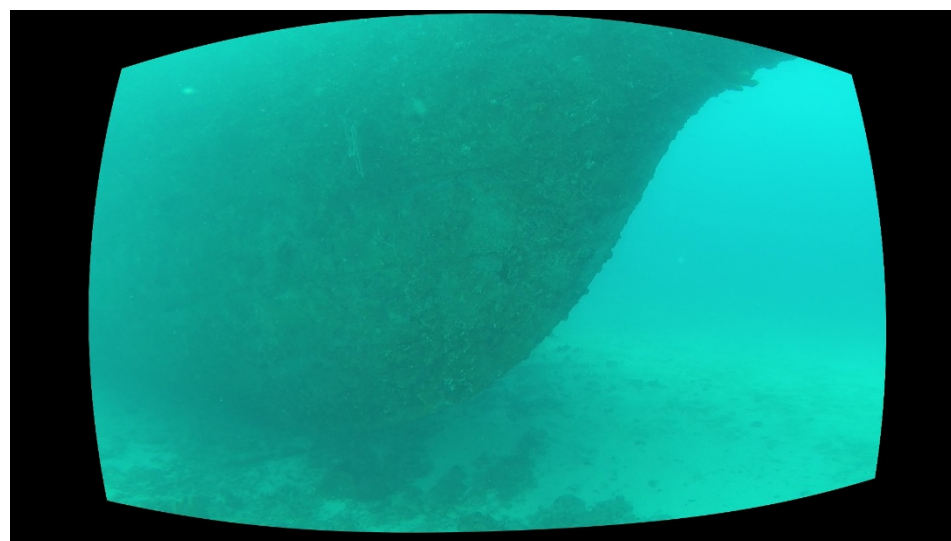


Rectified Image Sample

Unrectified



Rectified



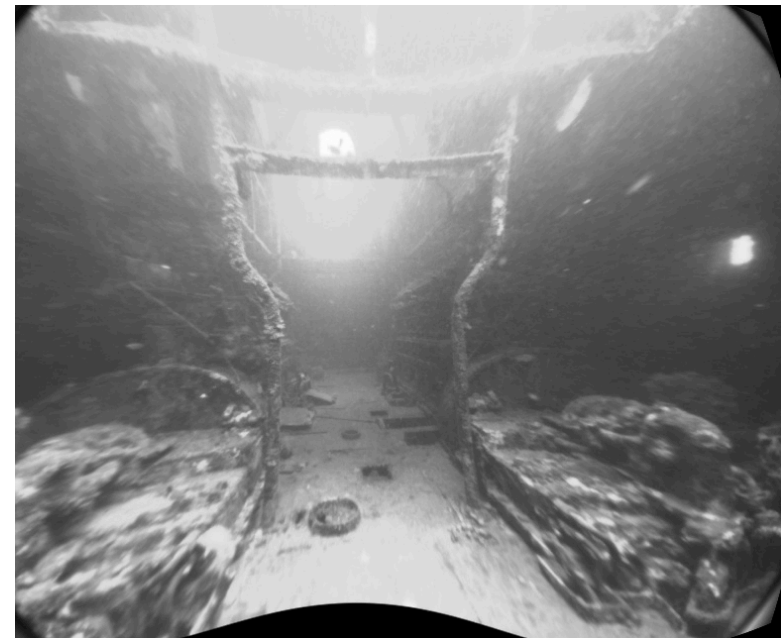
From GoPro HERO3+ at Barbados 2015 Field Trials

ReRectified Image Sample

Rectified



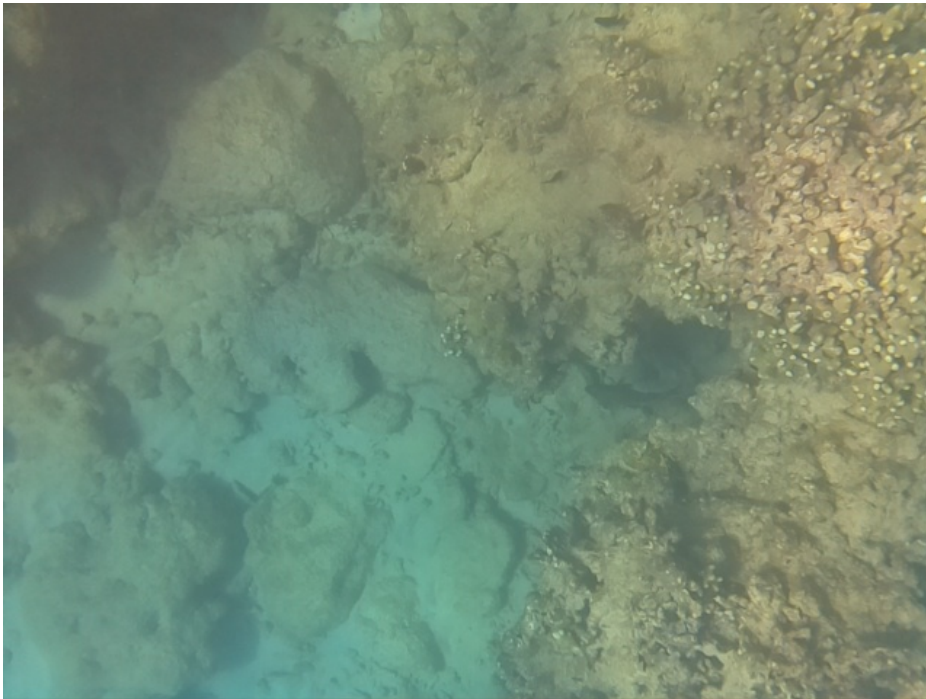
ReRectified



From Aqua front camera at Barbados 2013 Field Trials



Correspondence Problem



From Raspberry PI camera at Barbados 2016 Field Trials

Correspondence

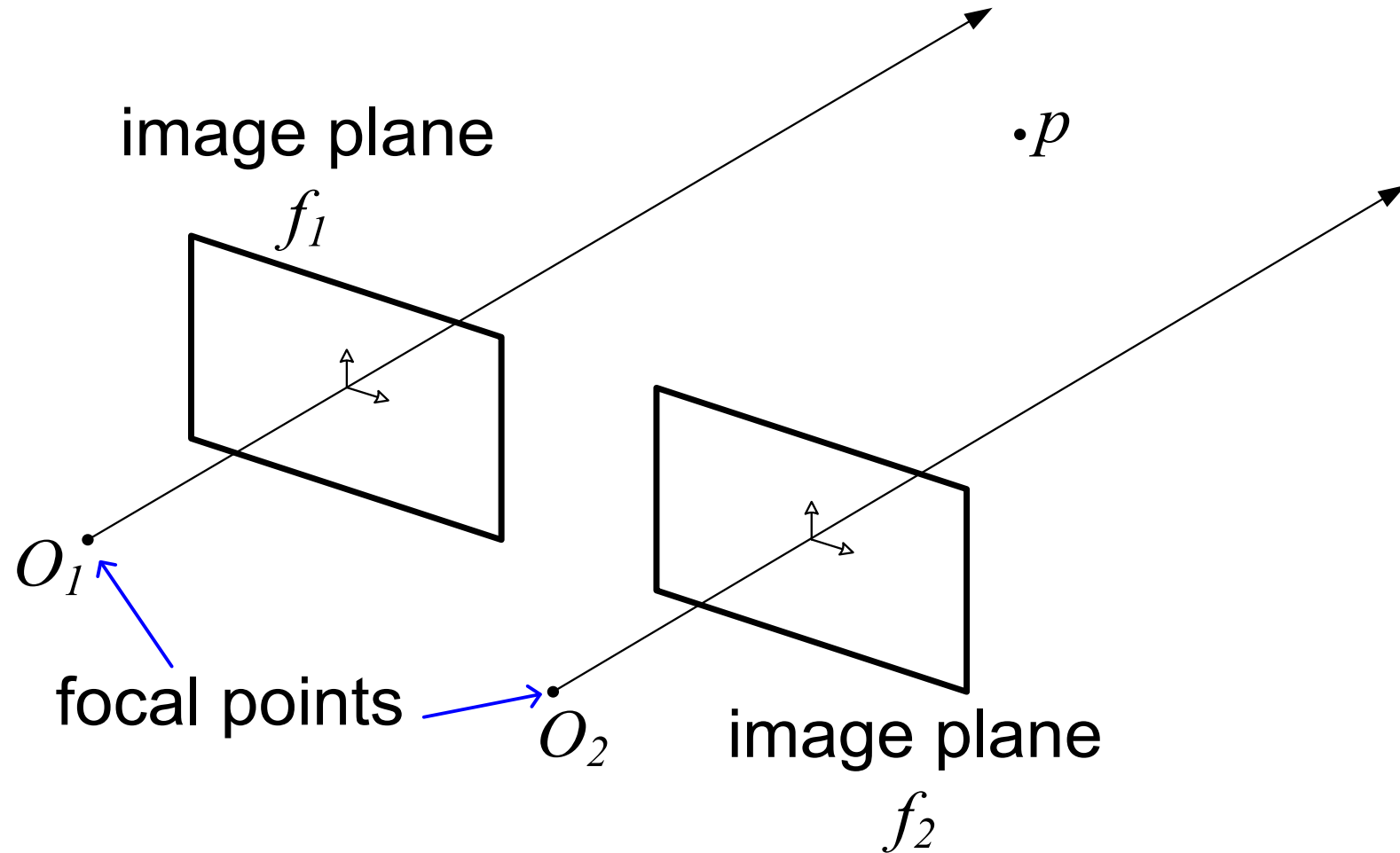
From I_1



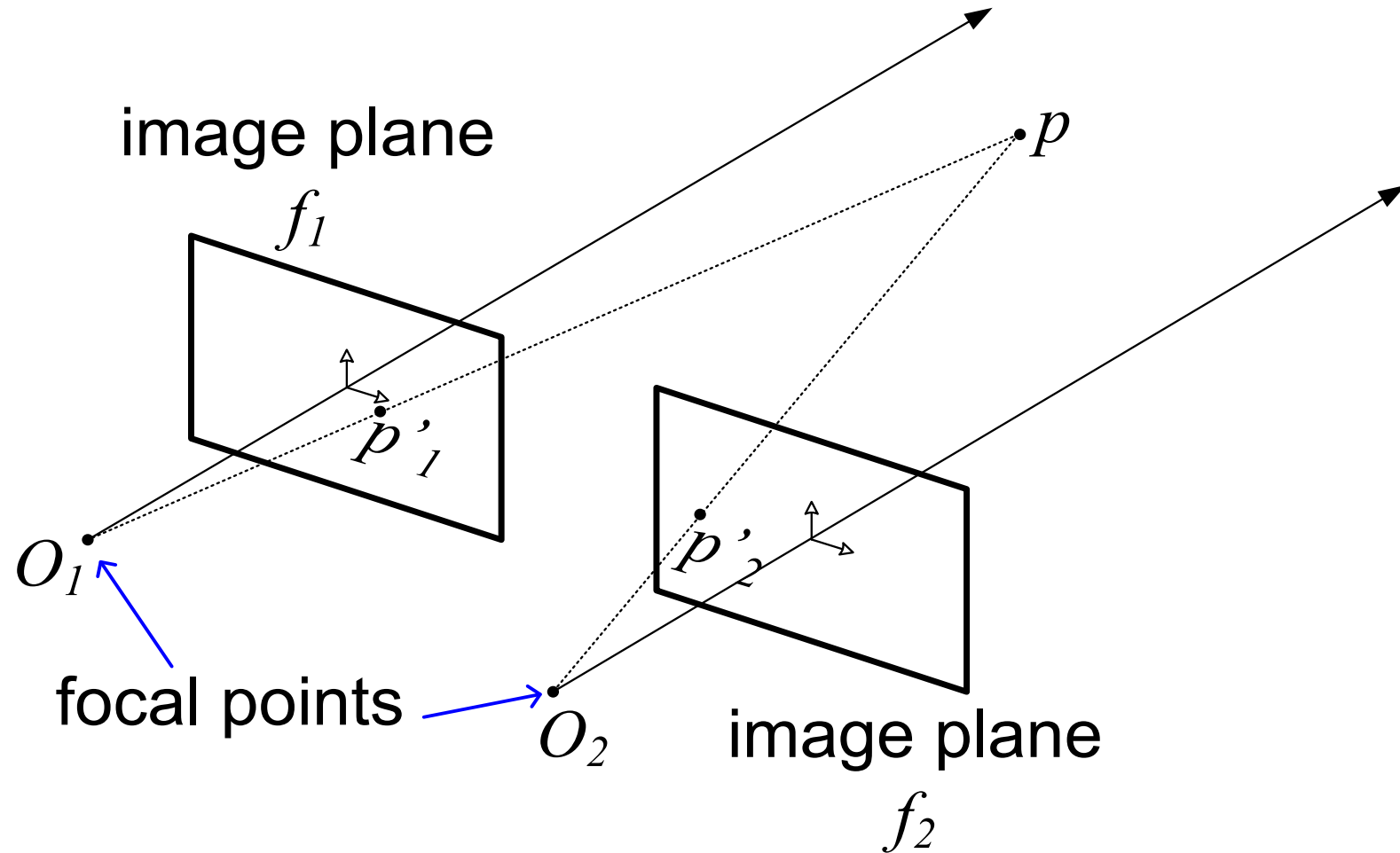
From I_2



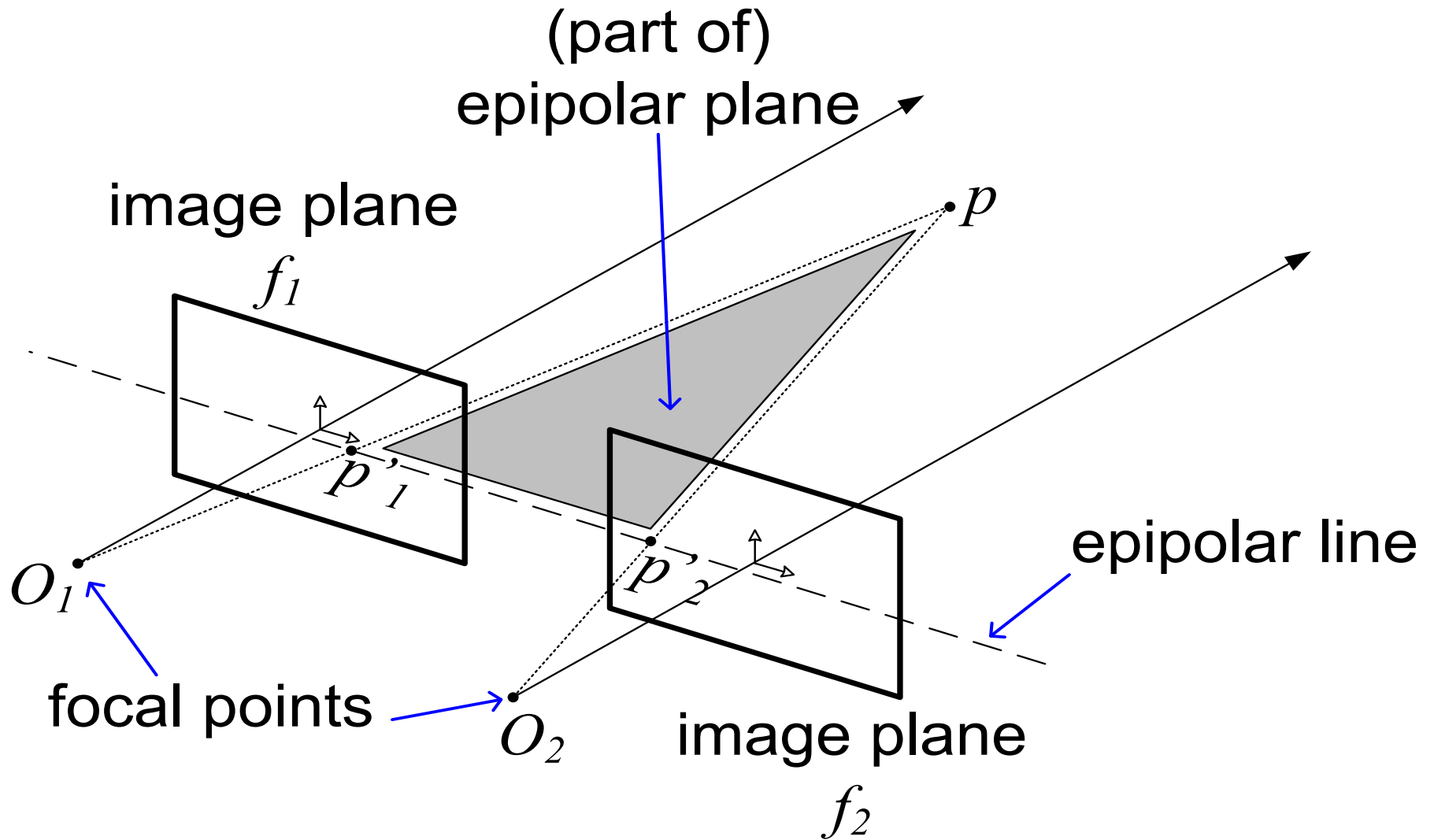
Stereo Vision: Pinhole Camera



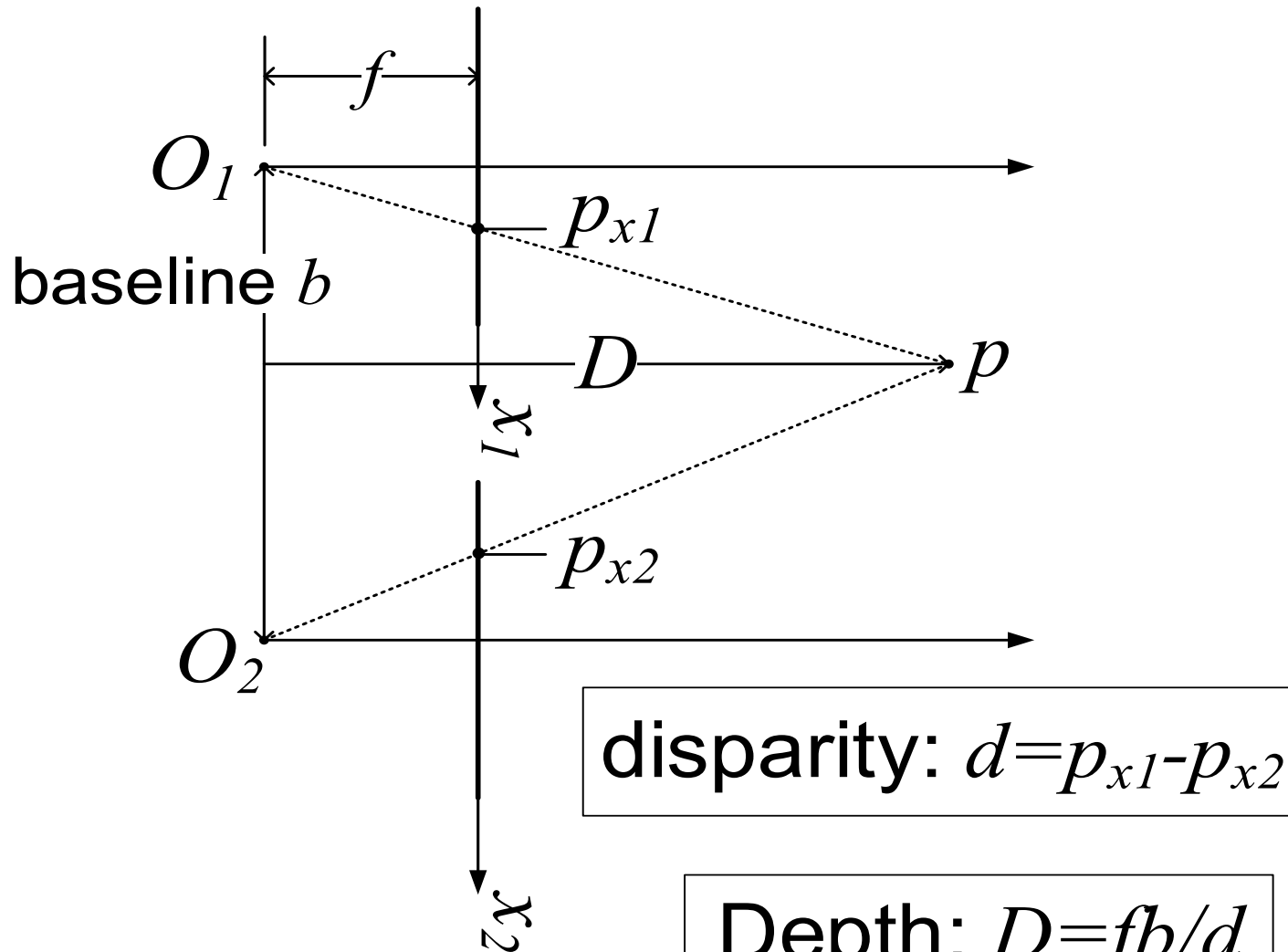
Stereo Vision: Pinhole Camera



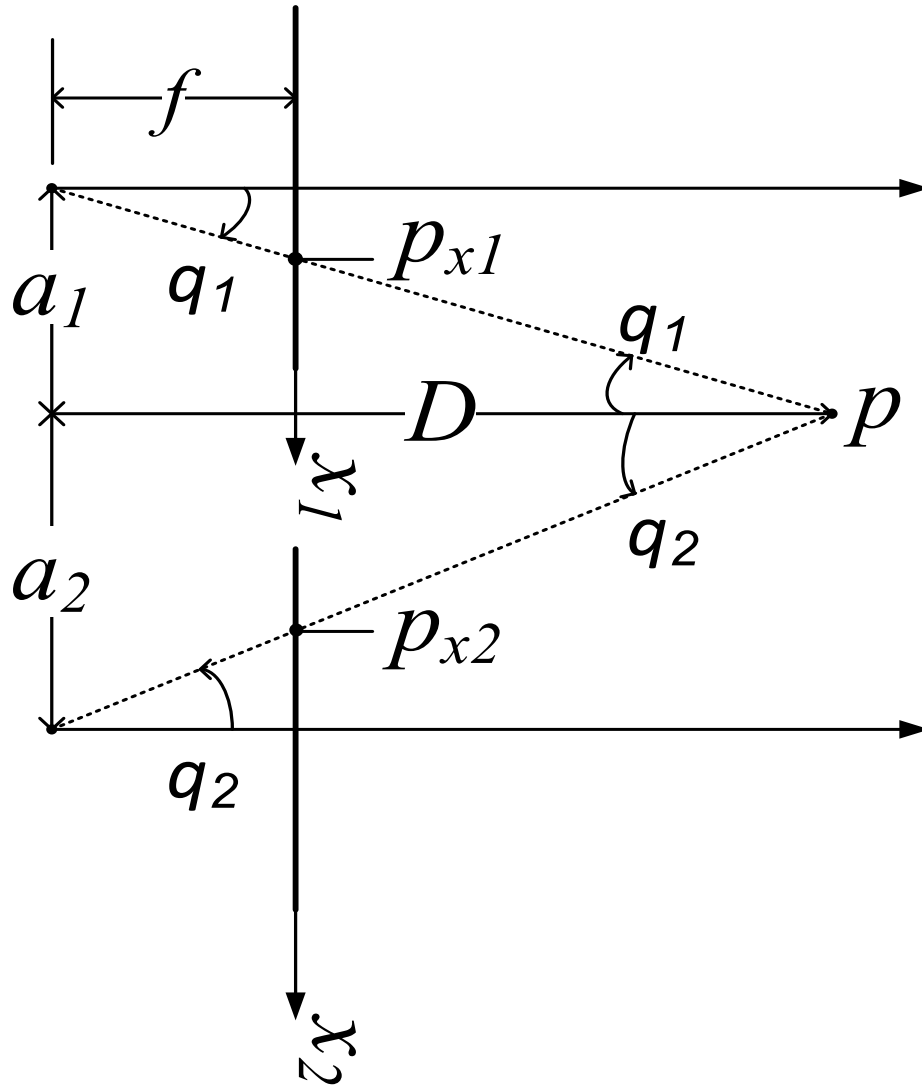
Stereo Vision: Pinhole Camera



Stereo Vision: Pinhole



Stereo Vision: Pinhole



$$\frac{p_{x1}}{f} = \frac{a_1}{D}$$

$$\frac{p_{x2}}{f} = \frac{a_2}{D}$$

$$a_1 + a_2 = b$$

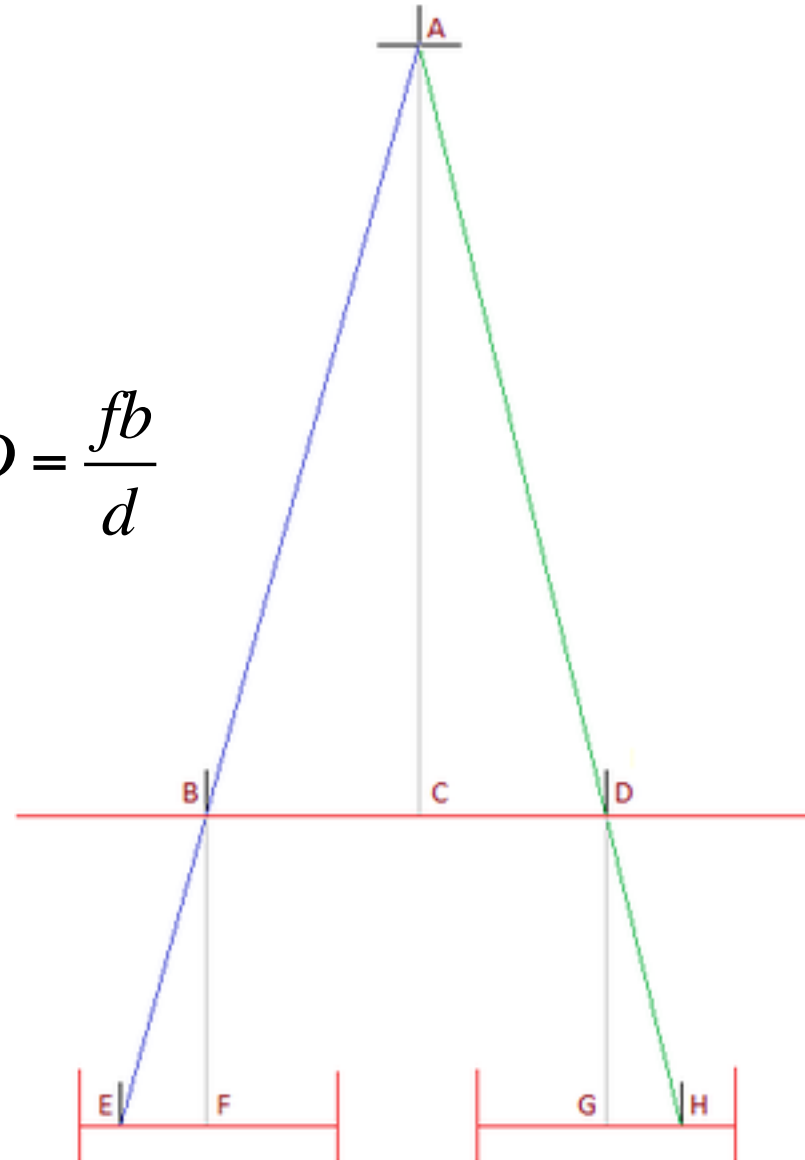


Stereo continuation

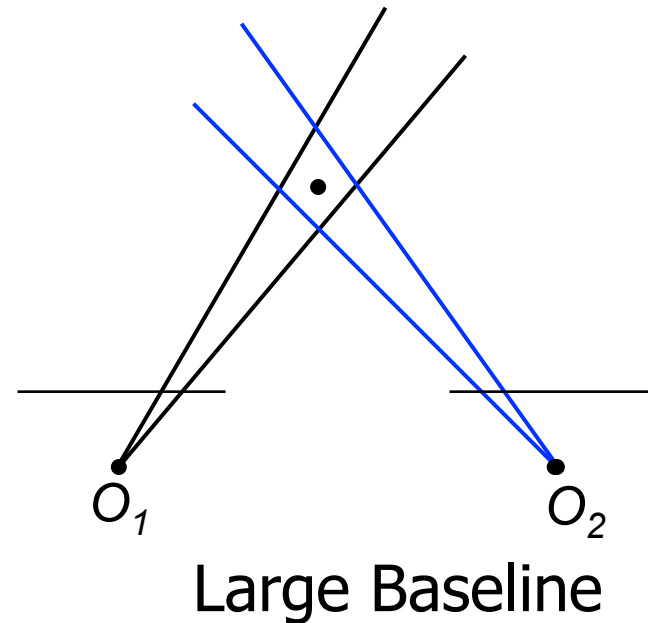
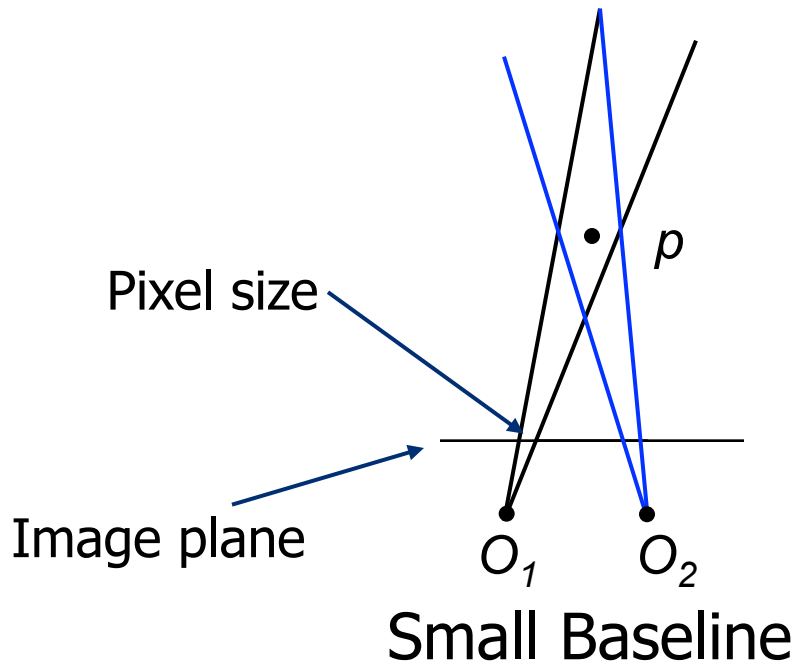
The disparity is $EF+GH$

SO:

$$\frac{|EF| + |GH|}{f} = \frac{\alpha_1 + \alpha_2}{D} \Leftrightarrow \frac{d}{f} = \frac{b}{D} \Leftrightarrow D = \frac{fb}{d}$$



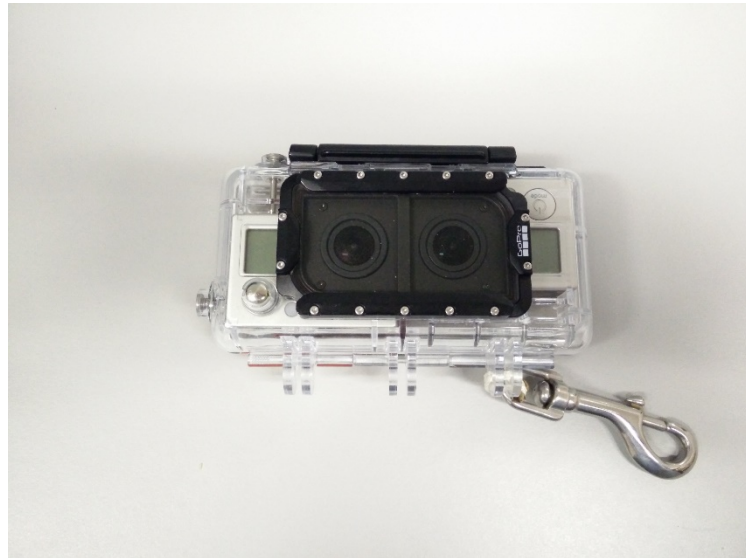
Baseline



- What's the optimal baseline?
 - Too small: large depth error
 - Too large: difficult search problem

Baseline

GoPro 3D HERO System



$b=3.2\text{ cm}$

source: <http://www.cvlibs.net/datasets/kitti>



$b=54\text{ cm}$

Matching Left and Right



3D reconstruction



Stereo: Disparity Map



Using real-time stereo vision for mobile robot navigation

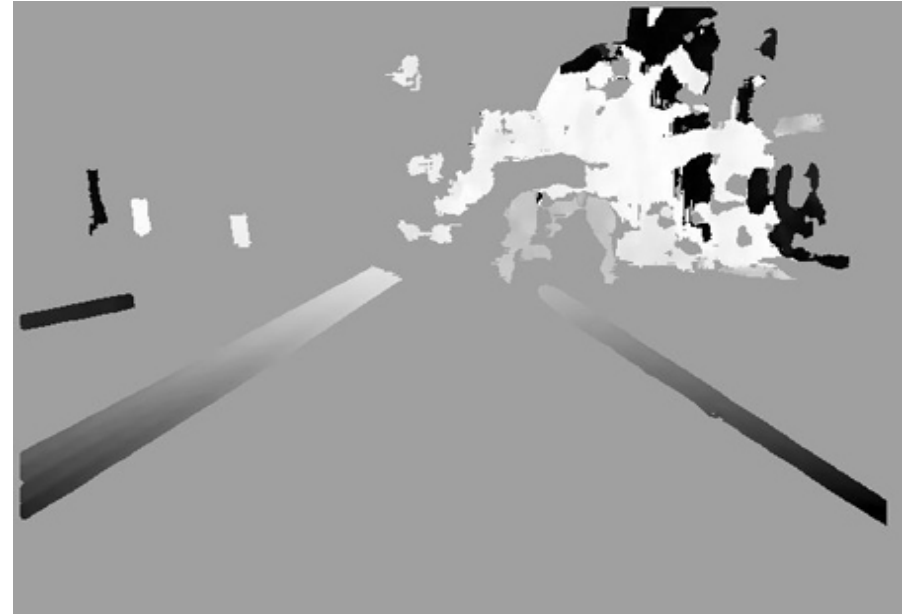
Don Murray

Jim Little

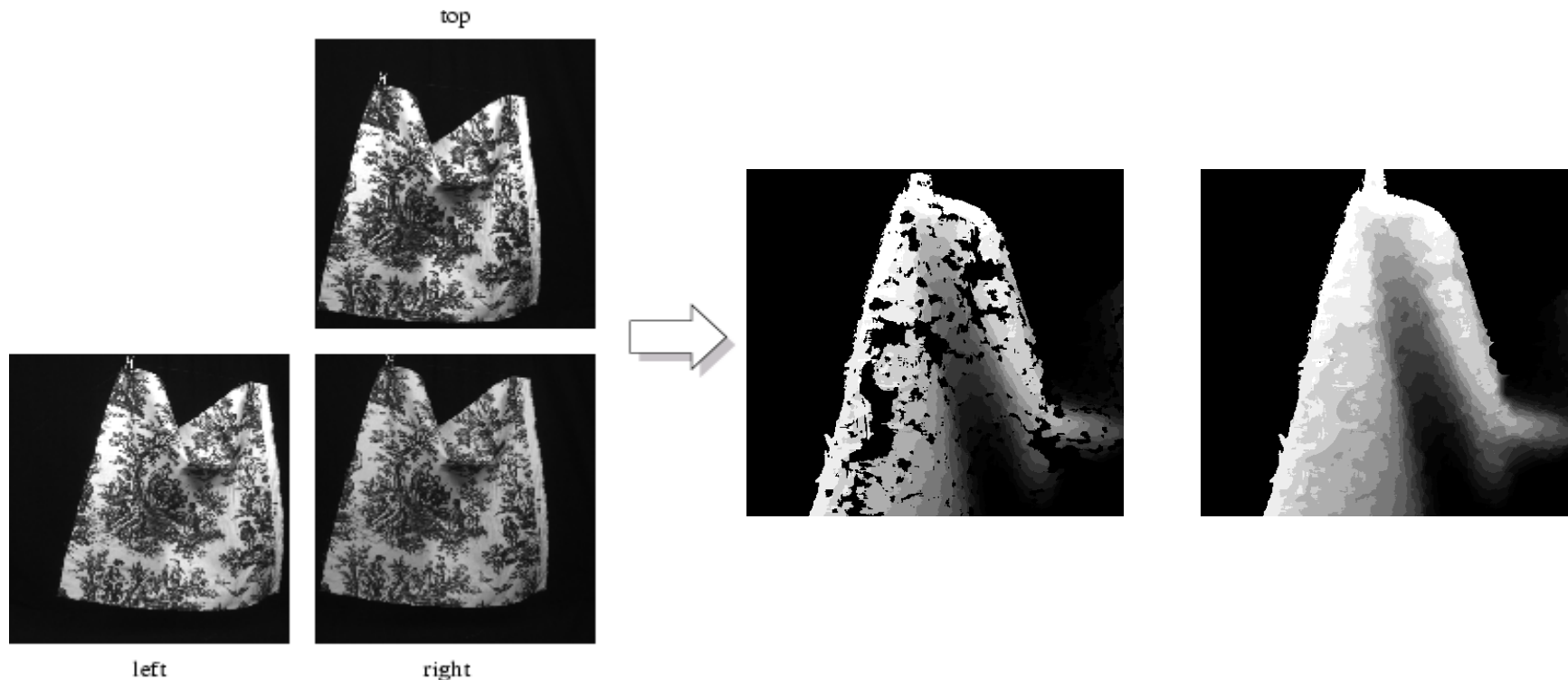
Computer Science Dept.
University of British Columbia
Vancouver, BC, Canada V6T 1Z4



Depth Map in a City



Another Example (Hole Filling)



Cloth Parameters and Motion Capture by David Pritchard
B.A.Sc., University of Waterloo, 2001



Stereo Vision

- Large number of algorithms out there:

<http://vision.middlebury.edu/stereo/>

rank 43 different algorithms.



Questions?

