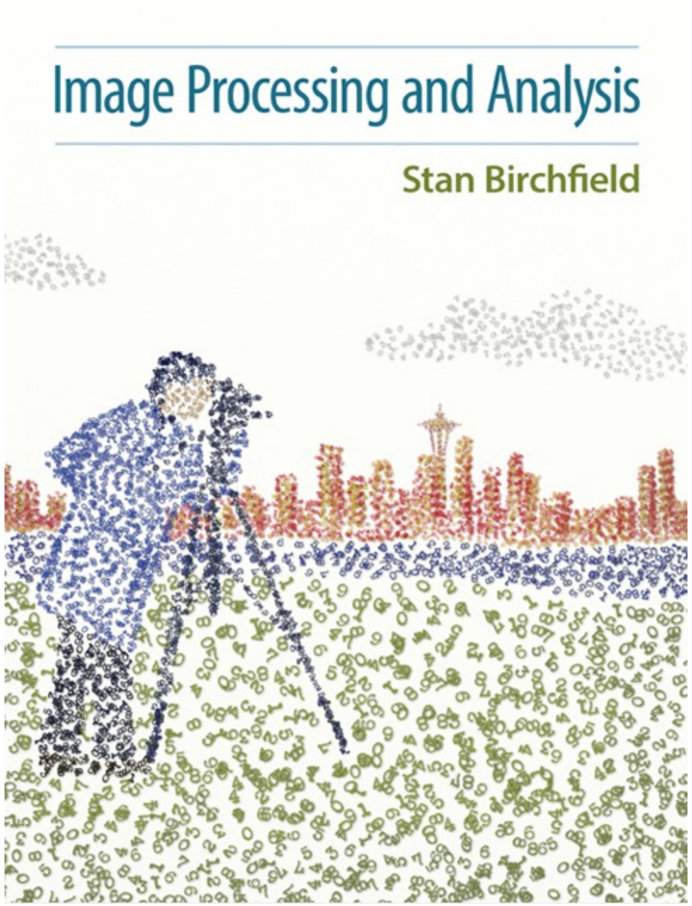
Prof. Kjersti Engan

ELE510 Image processing and computer vision

Finding depth from two views – summary (chap 13.6 Birchfield) 2023

University of Stavanger



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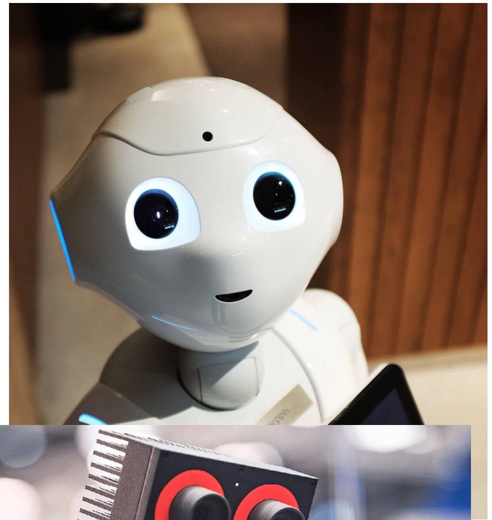
Finding depth – known setup



- Rectified cameras: Use correspondence find disparity map

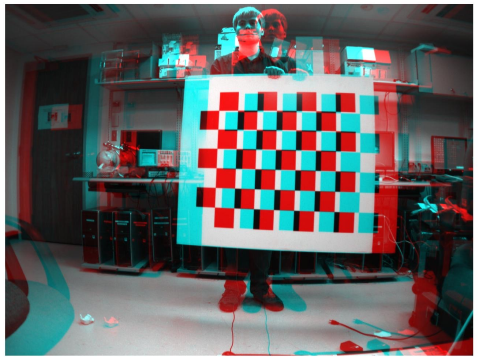
- Remember correspondance constraints, and search the scan lines in the search space for best match. Let dp be disparity in pixels.

- Known geometry: f (focal length m) and T(baseline m), image resolution, r pixels/m in sensor.
- find depth Z from disparity in meter, d (d = dp/r) :

$$Z_l = Z_r = Z, \qquad X_r = X_l - T$$

$$\begin{cases} \dfrac{Z}{f} = \dfrac{X_l}{x_l} \\[2ex] \dfrac{Z}{f} = \dfrac{X_l - T}{x_r} \end{cases} \Rightarrow \begin{cases} X_l = \dfrac{Z}{f} x_l \\[2ex] X_l = \dfrac{Z}{f} x_r + T \end{cases}$$

$$\frac{Z}{f}\left(x_l - x_r\right) = T \quad \Rightarrow \quad Z = \frac{fT}{x_l - x_r} = \frac{fT}{d}$$



3D reconstruction from image pairs – unknown setup

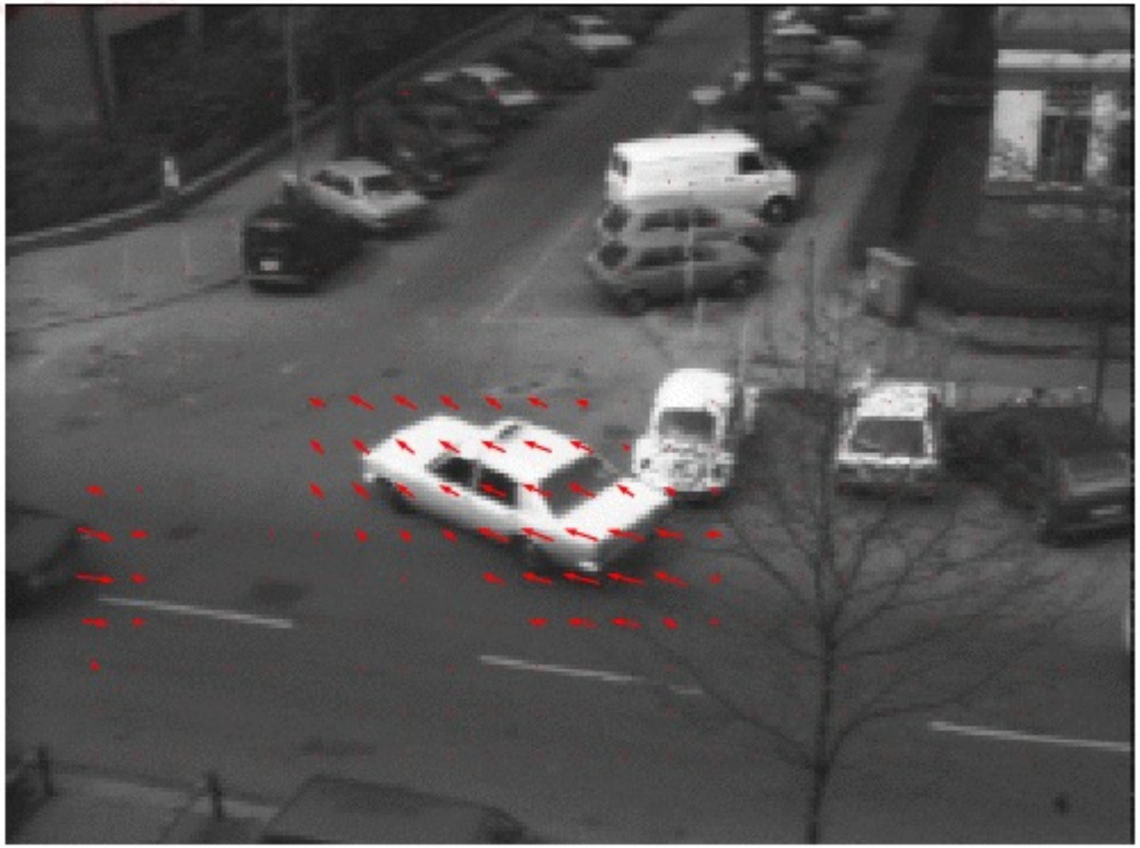
- Find interest points (Harris-Stephens / SIFT)
- Match interest points
- Compute fundamental matrix F
- Calibrate cameras (Zhangs), find K, K´
- Estimate E from F, K and K´, find R, t
- Compute camera matrices P and P’ from K, K´, R and t

Calibrating stereo setup

- Use **F** to limit correspondence to 1D search. Find matching points in new image pairs (after calibration). For each matching image points x and x’, compute world point in scene using (x,y), (x´,y´) P and P´

Optical Flow

Related to estimating disparity between stereo images is displacement between corresponding pixels in a pair of consecutive image frames in video



Optical Flow

- Motion field – projection onto 2D image of 3D velocity vectors of all points in the scene
- Optical flow – apparent motion of britghtnes patterns in the image plane (same as motion field if projected pixel value is the same / brightness constancy assumption)
  - Lucas-Kanade – all pixels in small regions share the same motion
  - Horn-Schunck – dense optical flow is found through regularization with the assumption that neighbouring pixels have similar displacements.
  - FlowNet etc - Newer methods with neural networks

Lucas Kanade

qi are the pixels inside a window (around p).
Ix, Iy and It are partial derivatives

$$\begin{bmatrix} V_x \\ V_y \end{bmatrix} = \begin{bmatrix} \sum_i I_x(q_i)^2 & \sum_i I_x(q_i)I_y(q_i) \\ \sum_i I_y(q_i)I_x(q_i) & \sum_i I_y(q_i)^2 \end{bmatrix}^{-1} \begin{bmatrix} -\sum_i I_x(q_i)I_t(q_i) \\ -\sum_i I_y(q_i)I_t(q_i) \end{bmatrix}$$