STEREOPSIS
PART II

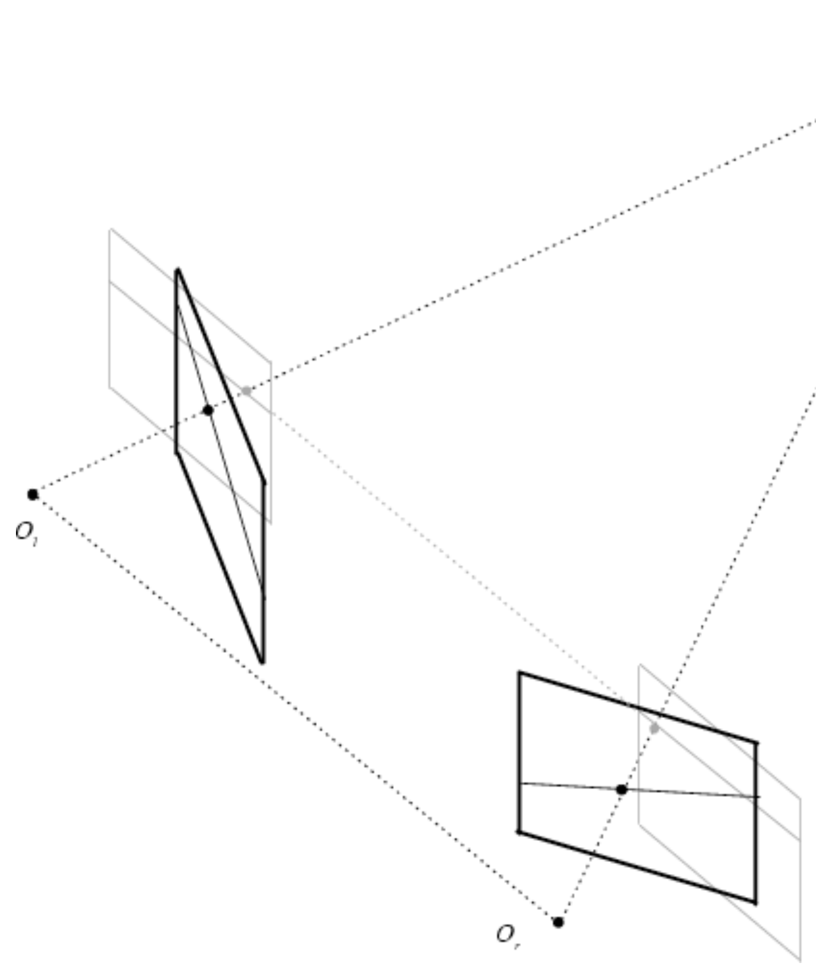
computer vision

SUMMARY

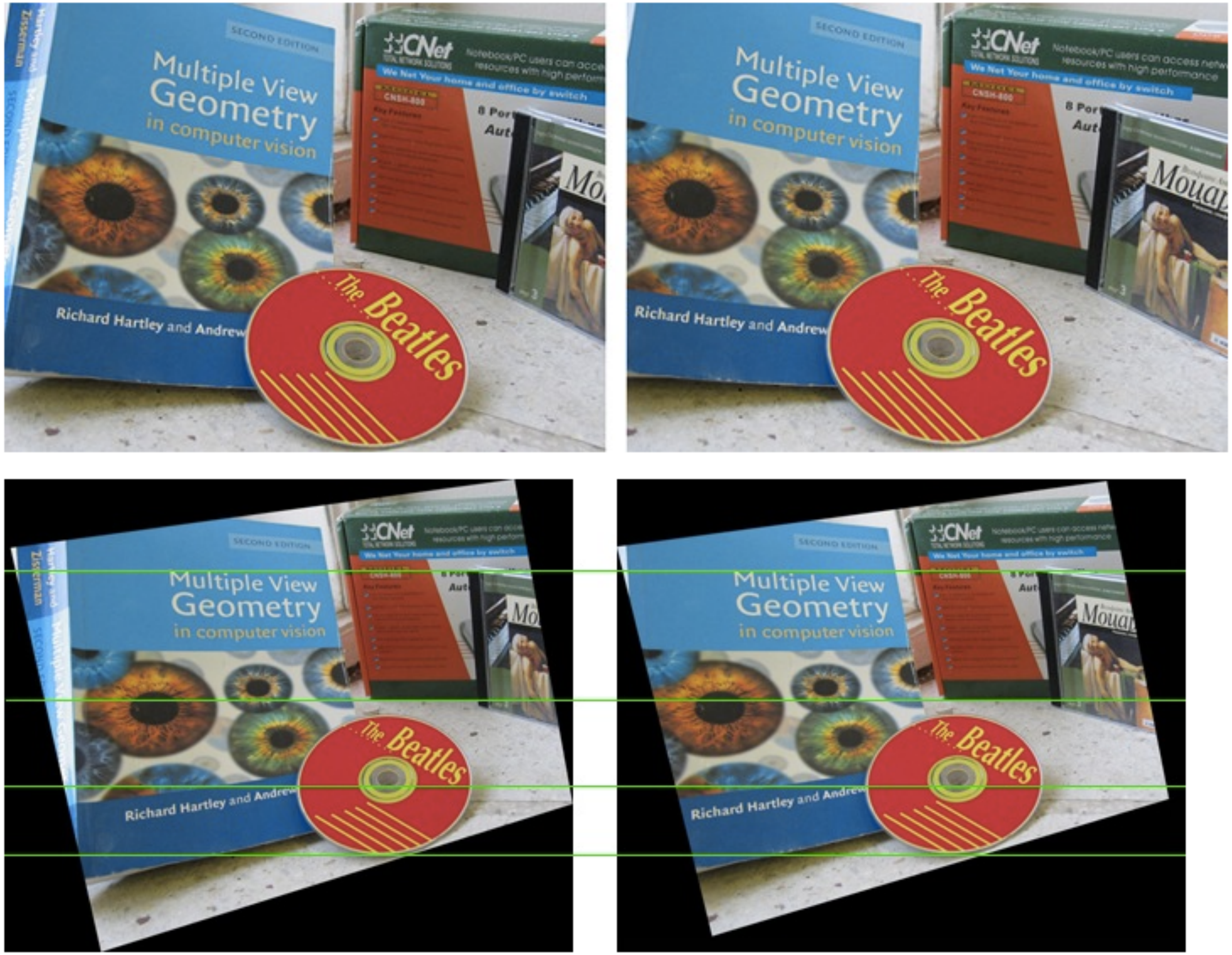
Today we will talk about dense estimate of correspondences on the *rectified* stereo pair

RECTIFICATION OF A STEREO PAIR

- given a stereo pair, rectification determines a projective transformation (or homography) of each image such that *pairs of conjugate epipolar lines become collinear an parallel to one of the image axes*



A RECTIFIED PAIR



(CALIBRATED) RECTIFICATION

- Let us assume the two initial projection matrices are known (calibrated case)
- build two new (virtual) projection matrices that produce two rectified images of the world
- build two new (virtual) images, rectified

(CALIBRATED) RECTIFICATION

- From the old to the new projections centers have not changed

- In the new projections

  - image planes are parallel to the baseline (left and right focus is constant)

  - epipolar lines are parallel to the X axis (and conjugate points lie on the same scanline)

CORRESPONDENCE PROBLEM

- problem statement: given an element of image A find the corresponding element on image B (and viceversa)

- Assumptions:
  - most scene points are visible from both view-points
  - corresponding point regions are similar

- these assumptions hold for systems in which the distance of the fixation point from the cameras is larger than the baseline

EXAMPLE OF A STEREO SYSTEM

CORRESPONDENCE PROBLEM

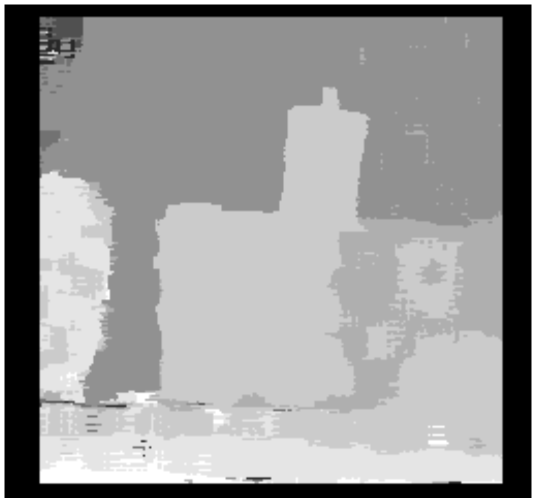
- the correspondence problem involves two decisions:
  1. which image elements to match
  2. which feature description + similarity measure to adopt
- (1) can be solved in two ways:
  - use all pixels in the image (obtaining *dense correspondences*)
  - use subsets of pixels meeting some requirements (obtaining *sparse correspondences*)
- as for (2) we will adopt correlation methods

DENSE CORRESPONDENCES

- we consider the so-called *correlation methods* applied to image patches (neighbourhoods of pixels)

- we assume we have two *rectified images*, where conjugate points lie on corresponding scanlines of the image (“rows”)

- our goal is to obtain a **disparity map** giving the relative displacement for each pixel



- assuming a fixation point at infinity disparity is proportional to the inverse of the distance

- in a standard color coding bright areas correspond to high disparities (closer objects)

DENSE CORRESPONDENCES: ALGORITHM SKETCH

- input:
  - a stereo pair of rectified images I_l and I_r
  - size of a correlation window W
  - a search range [d_{min}, d_{max}]
- for each pixel p_l of (i,j) coordinates in I_l
  - for each disparity d in the search range
    - estimate the similarity $c(d) = \phi(N1(i,j), N2(i,j+d))$
    - the disparity of the pixel is $\overline{d} = \text{argmax}_{d \in [d_{min}, d_{max}]}\{c(d)\}$

SIMILARITY MEASURE: EXAMPLES

- SUM OF SQUARED DIFFERENCES

$$\phi_{SSD}(N1, N2) = -\sum_{k,l=-\frac{W}{2}}^{\frac{W}{2}} (N1(k,l) - N2(k,l))^2$$

- NORMALIZED CROSS CORRELATION

$$\phi_{NCC}(N1, N2) = \sum_{k,l=-\frac{W}{2}}^{\frac{W}{2}} \frac{(N1(k,l) - \mu_1)(N2(k,l) - \mu_2)}{W^2 \sigma_1 \sigma_2}$$

REMARKS

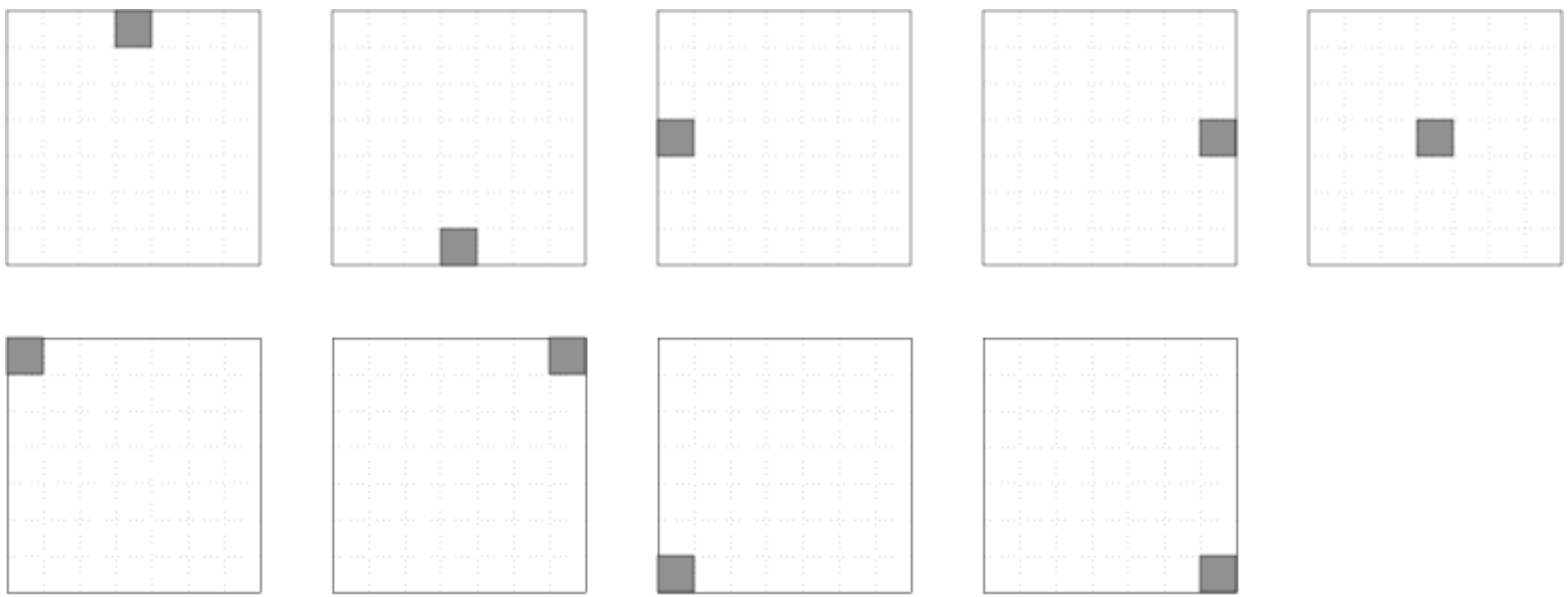
- thanks to the epipolar constraint the search is limited to one line
- thanks to the fact the images are rectified the line is exactly the same row
- with a further prior on minimum and maximum disparity the search interval can be shortened (and is only positive)

LEFT-RIGHT CONSISTENCY

- correspondences are made more difficult by occlusions (points with no counterpart on the other image)
- let us compute
  - D_{lr}: disparity map from I_l to I_r
  - D_{rl}: disparity map from I_r to I_l
- then $D(i,j)=d$ iff $D_{lr}(i,j)= -D_{rl}(i,j+d)= d$

MULTI-WINDOW STEREO MATCHING

- perform the search for the best correspondence considering different possible neighbourhoods



EXAMPLES