Steps of the stereo process

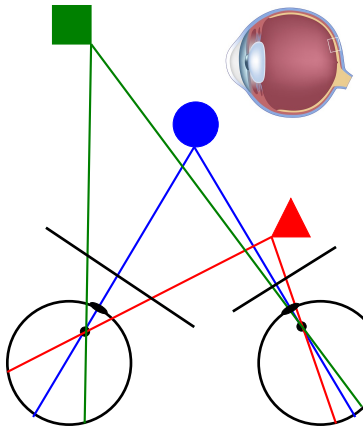
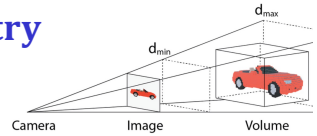

left right

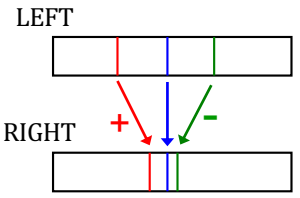
- extract features from the left and right images, whose stereo disparity will be measured
- match the left and right image features and measure their disparity in position

  "stereo correspondence problem"
- use stereo disparity to compute depth

1

Stereo viewing geometry



LEFT RIGHT

positive stereo disparity
→ in front of fixation point
negative stereo disparity
→ in back of fixation point
zero disparity

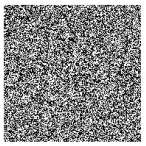
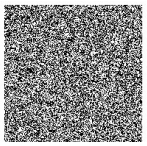
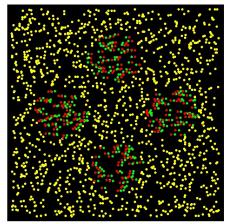
2

Stereo disparity


left right

3

Random-dot stereograms

- Bela Julesz, 1971
- stereo system can function independently
- we can match "simple" features
- highlight the ***ambiguity*** of the matching process

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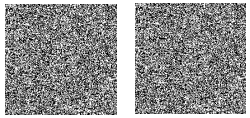
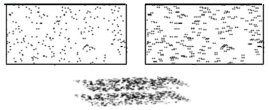
Constraints on stereo correspondence

- uniqueness
- similarity
- continuity
- epipolar constraint





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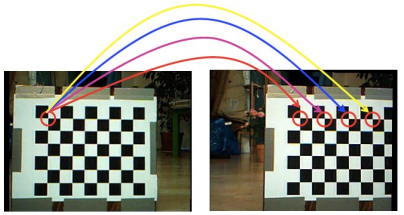
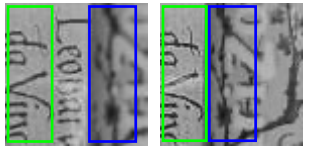
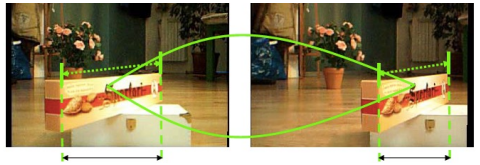
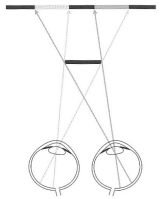
The real world works against us sometimes…









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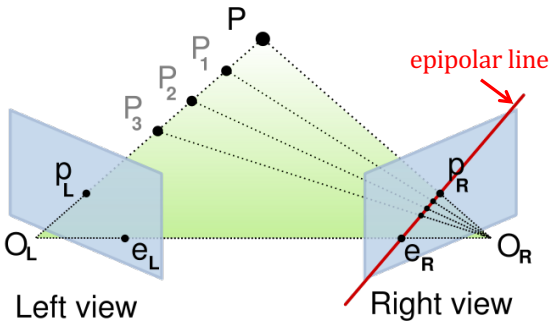
Epipolar constraint



possible matching candidates for p_L in the left image lie along a line in the right image - the *epipolar line*

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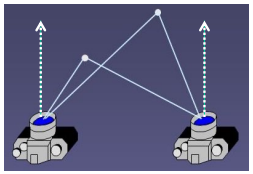
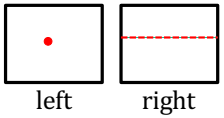
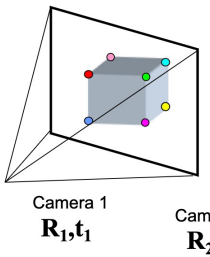
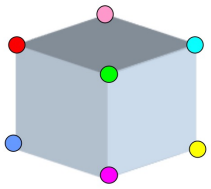
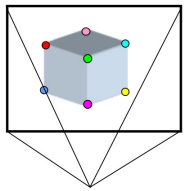
Epipolar constraint











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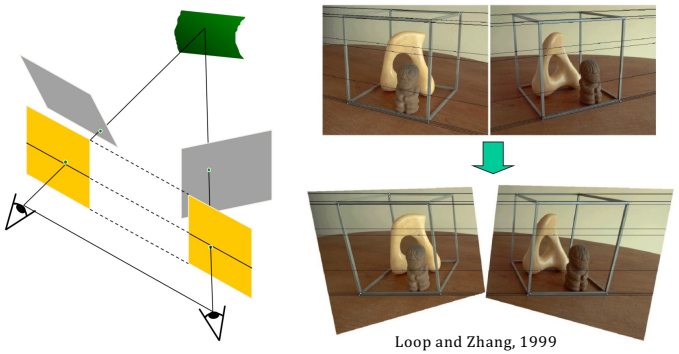
Epipolar constraint



Loop and Zhang, 1999

stereo camera calibration: given known viewing geometry, transform left/right images so that corresponding features lie on the same horizontal lines

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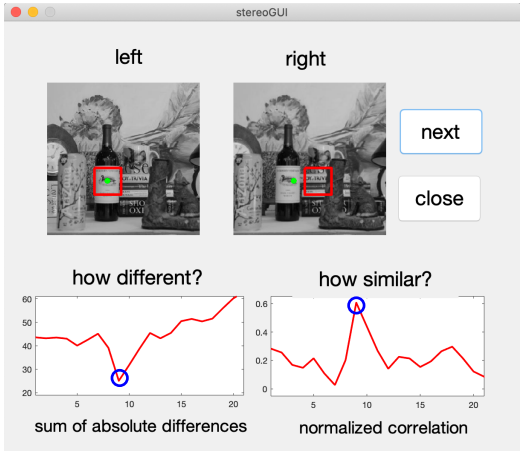
Solving the stereo correspondence problem



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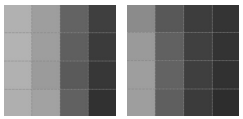
Measuring goodness of match between patches

(1) sum of absolute differences

$$(1/n) \sum_{\text{patch}} | p_{\text{left}} - p_{\text{right}} |$$



p_{left} p_{right}

(2) normalized correlation

$$(1/n) \sum_{\text{patch}} \frac{(p_{\text{left}} - \overline{p_{\text{left}}})\,(p_{\text{right}} - \overline{p_{\text{right}}})}{\sigma_{p_{\text{left}}}\,\sigma_{p_{\text{right}}}}$$

optional: divide by n = number of pixels in patch

$\overline{p}$ = average of values within patch

σ = standard deviation of values within patch

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Region-based stereo matching algorithm

for each row r
  for each column c
    let p_{left} be a square patch centered on (r,c) in the left image
      initialize best match score m_{best} to ∞
      initialize best disparity d_{best}
      for each disparity d from $-d_{\text{range}}$ to $+d_{\text{range}}$
        let p_{right} be a square patch centered on (r,c+d) in the right image
        compute the match score m between p_{left} and p_{right}
          (sum of absolute differences)
        if ($m < m_{\text{best}}$), assign $m_{\text{best}} = m$ and $d_{\text{best}} = d$
    record d_{best} in the disparity map at (r,c)

How are the constraints used??

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