Steps of the stereo process

- 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

Stereo viewing geometry

Stereo disparity

Random-dot stereograms

- Bela Julesz, 1971
- stereo system can function independently
- we can match “simple” features
- highlight the ambiguity of the matching process
Constraints on stereo correspondence

- uniqueness
- similarity
- continuity
- epipolar constraint

The real world works against us sometimes...

Epipolar constraint

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

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

**Solving the stereo correspondence problem**

1. **Sum of absolute differences**
   \[
   \frac{1}{n} \sum_{\text{patch}} | p_{\text{left}} - p_{\text{right}} |
   \]

2. **Normalized correlation**
   \[
   \frac{1}{n} \sum_{\text{patch}} \frac{(p_{\text{left}} - \bar{p}_{\text{left}})(p_{\text{right}} - \bar{p}_{\text{right}})}{\sigma_{\text{left}} \sigma_{\text{right}}}
   \]

   - optional: divide by \( n \) = number of pixels in patch
   - \( \bar{p} \) = average of values within patch
   - \( \sigma \) = standard deviation of values within patch

**Region-based stereo matching algorithm**

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

**How are the constraints used??**