Computational Photography

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http://www.cs.pdx.edu/~fliu/courses/cs510/

05/24/2022

Last Time

- Stereoscopic 3D I

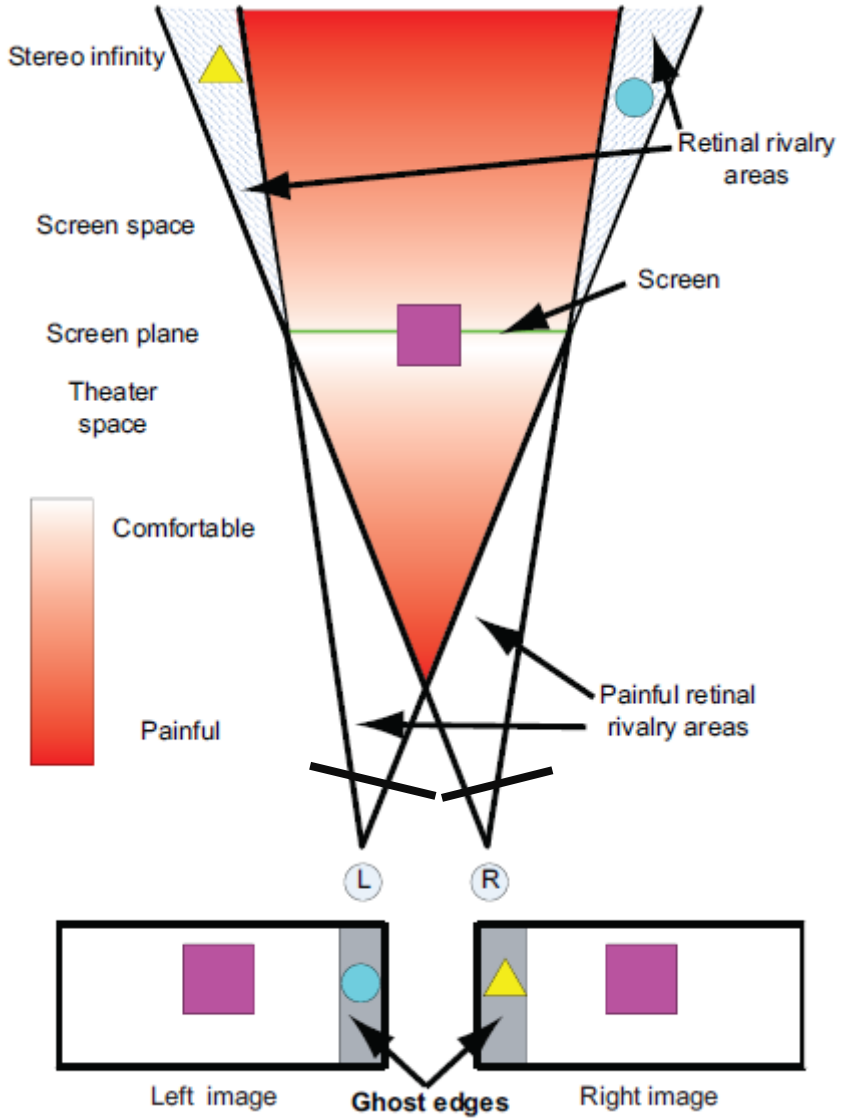
Today

- Stereoscopic 3D II
  - Stereoscopic media post-processing

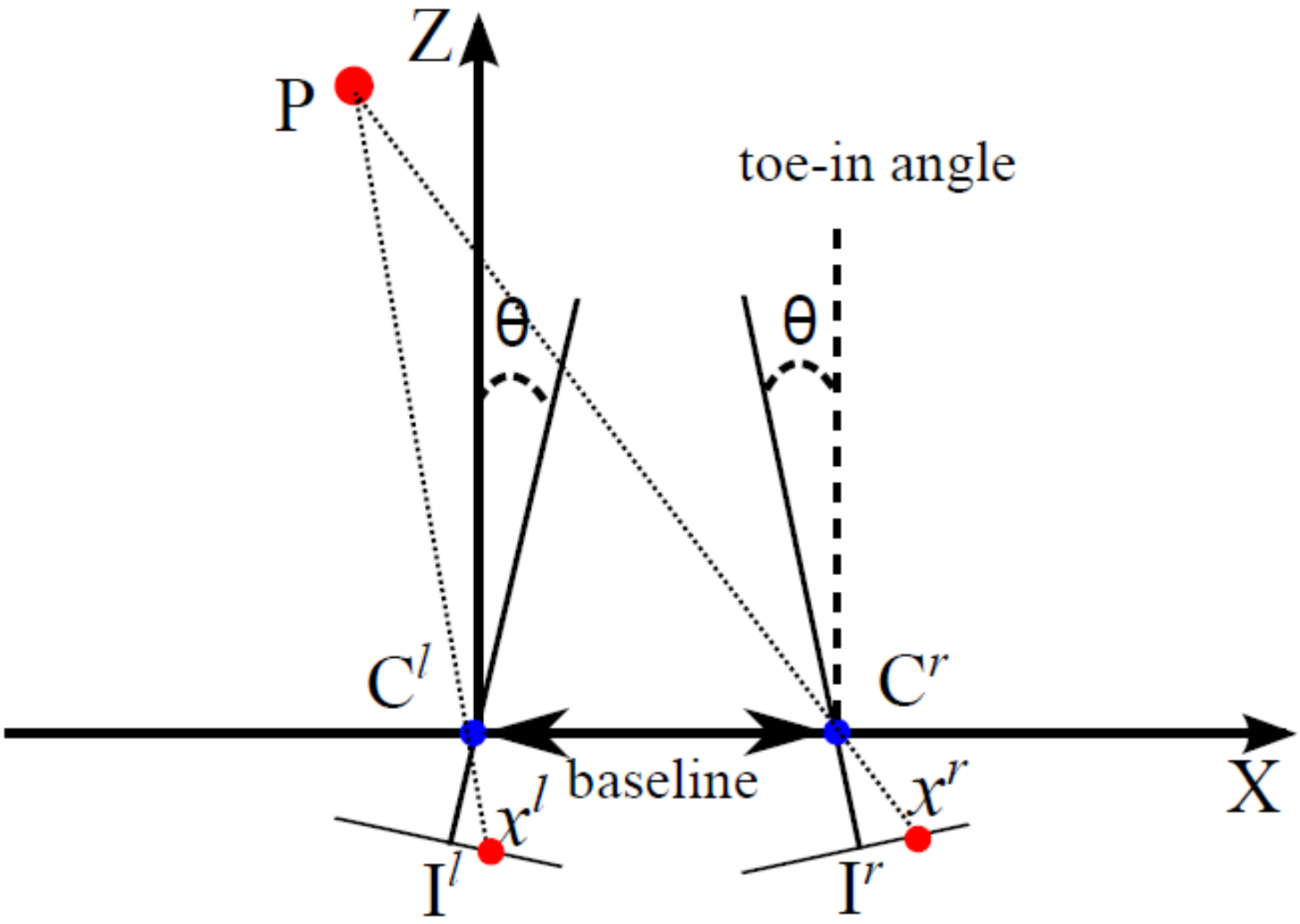
Keystone Correction for Stereoscopic Cinematography

Feng Liu, Yuzhen Niu, and Hailin Jin. Keystone Correction for Stereoscopic Cinematography. IEEE 3-D Cinematography 2012, Providence, RI, June 2012

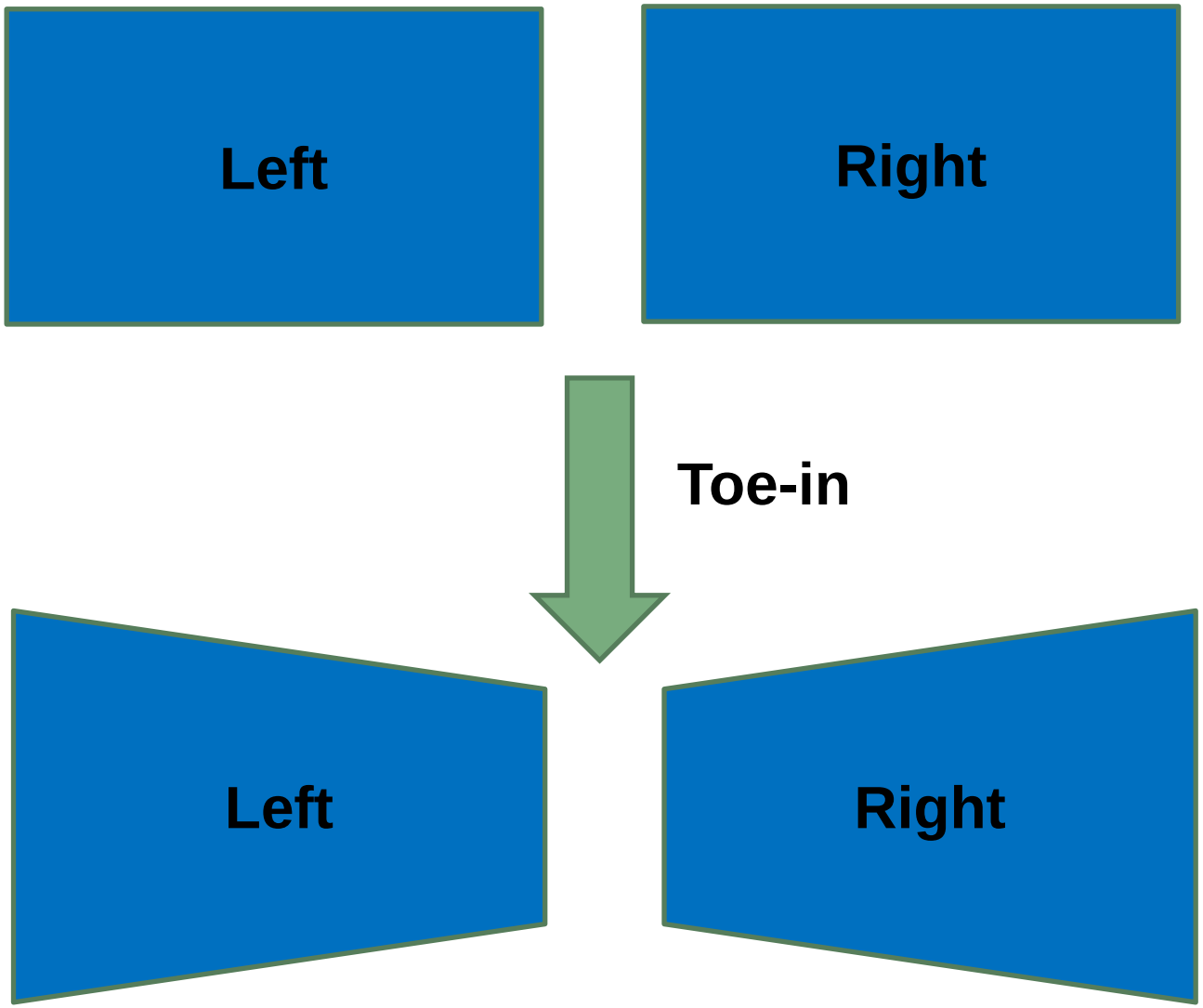
Stereoscopic Comfort Zone



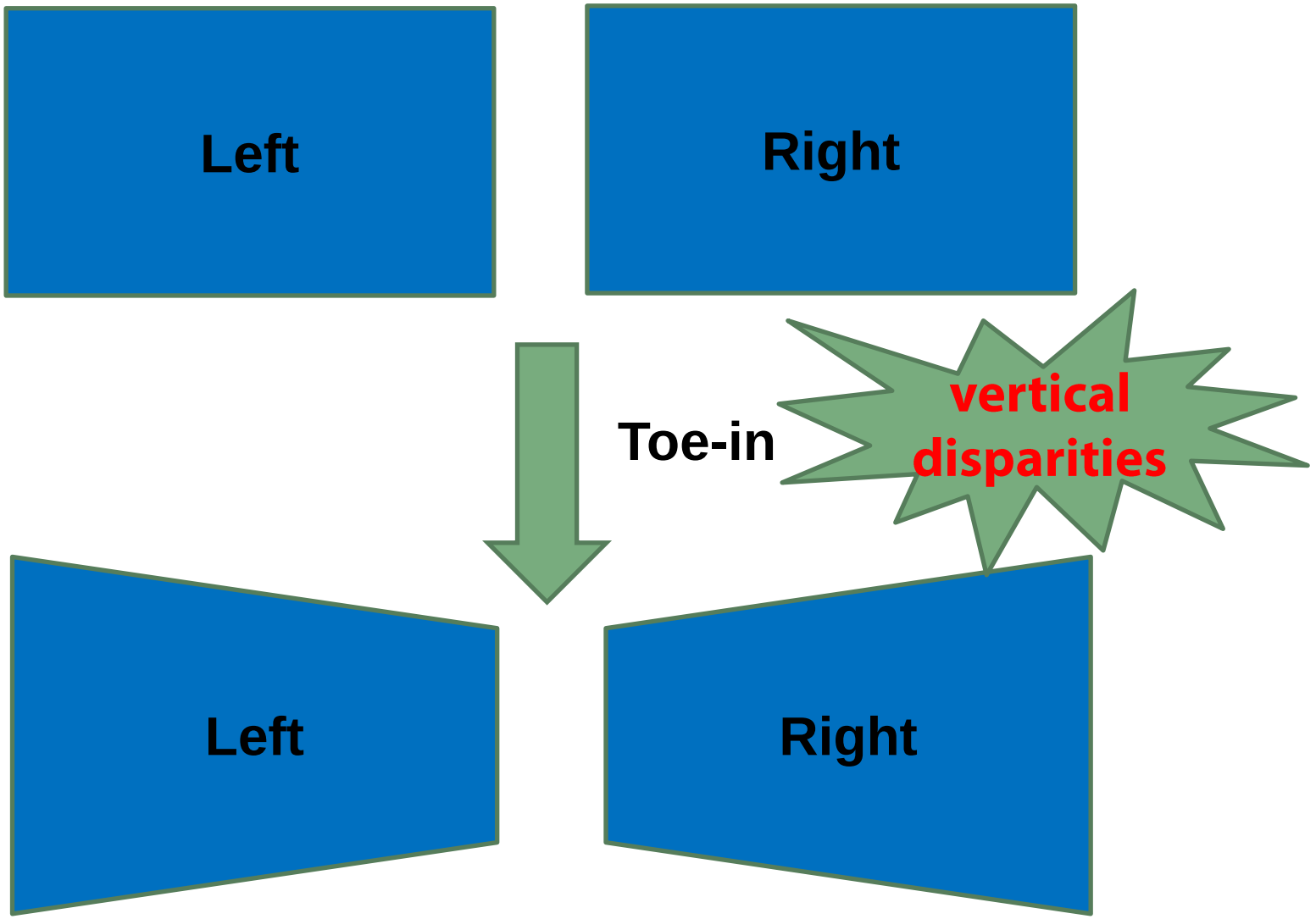
Stereoscopic Camera Model



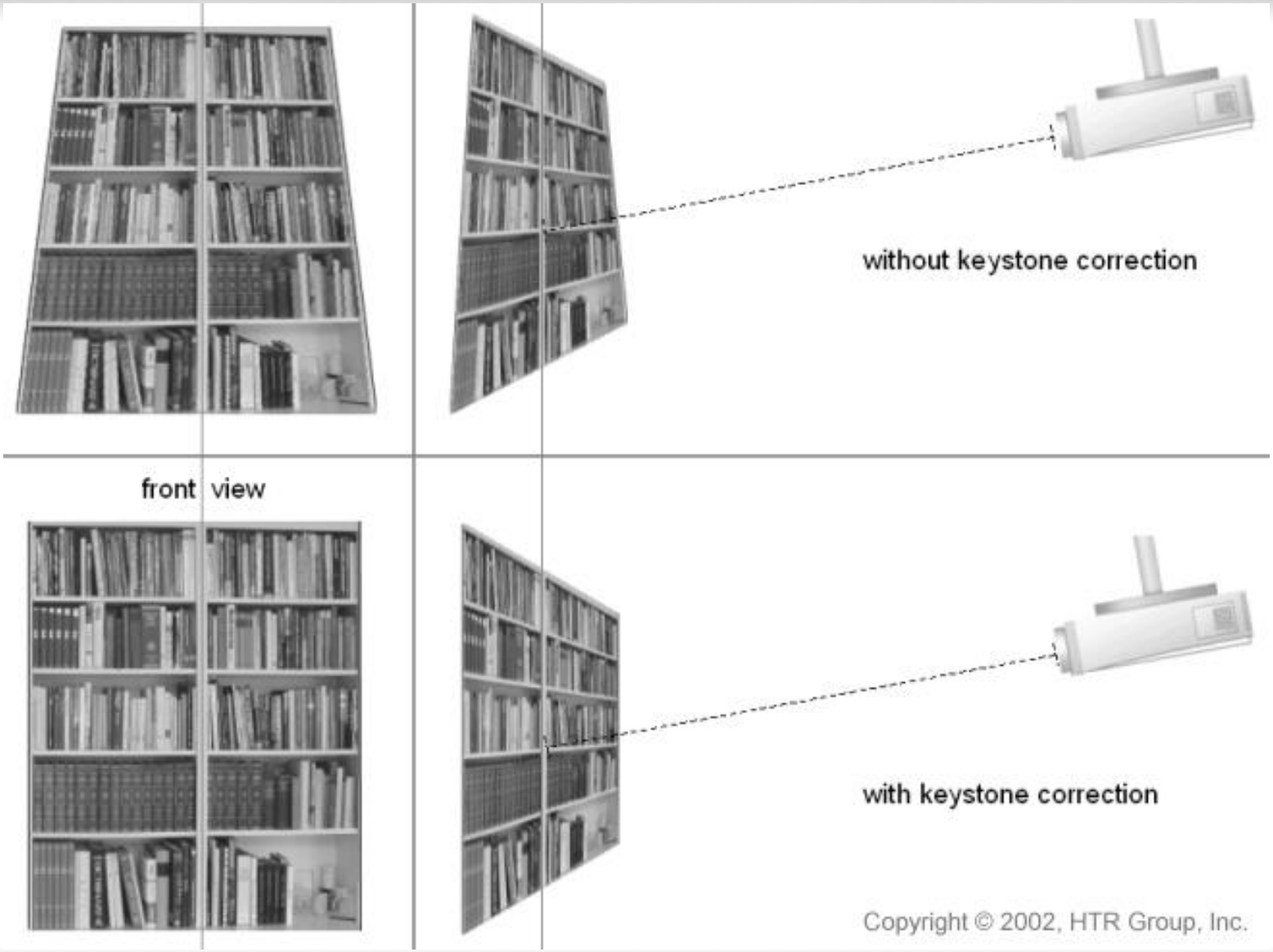
Keystone distortion



Keystone distortion



Keystone in projectors



Images from http://htrgroup.com/

Keystone correction for projectors

- Basics: 3D rotation can be modeled by a homography
- Keystone correction [Raskar and Beardsley 01, Li et al. 04, etc]
  - Estimate 3D rotation or homography
  - Optical keystone correction by modifying the lens system
  - Or digital keystone correction by image warping

Stereo keystone correction

- Projector keystone correction cannot work
  - Revert the toe-in operation
  - Change the desirable (horizontal) disparity distribution
- Stereo keystone correction requires
  - Eliminate vertical disparities
  - Preserve horizontal disparities

Content-preserving warping

- Non-uniformly move image content to target positions
- Avoid noticeable distortion
- Applications:
  - Video stabilization [Liu et al. '09]
  - Disparity editing [Lang et al. '10]

Correction by content-preserving warping

- Use a spatially-varying warping method
  - Non-uniformly move image content to remove vertical disparities and preserve horizontal disparities
  - Avoid noticeable image distortion

Stereo keystone correction

- Feature correspondence estimation
- Target feature position estimation
- Image transformation via content-preserving warping

Feature correspondence estimation

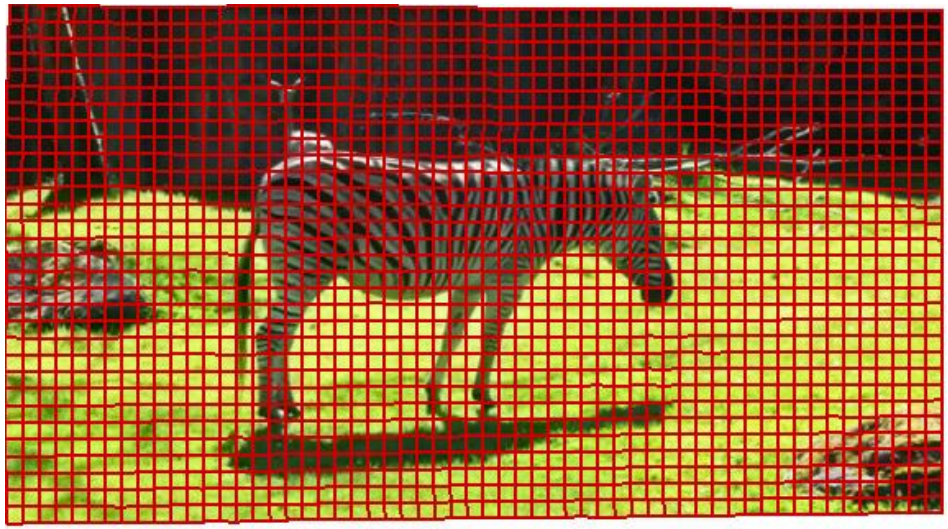
Input: left image with disparity and right image

- Detect SIFT features from the left and right image
- Establish feature correspondence [Lowe ‘04]
- Remove outliers using the epipolar geometry constraint [Hartley and Zisserman ‘00]

Target feature position estimation

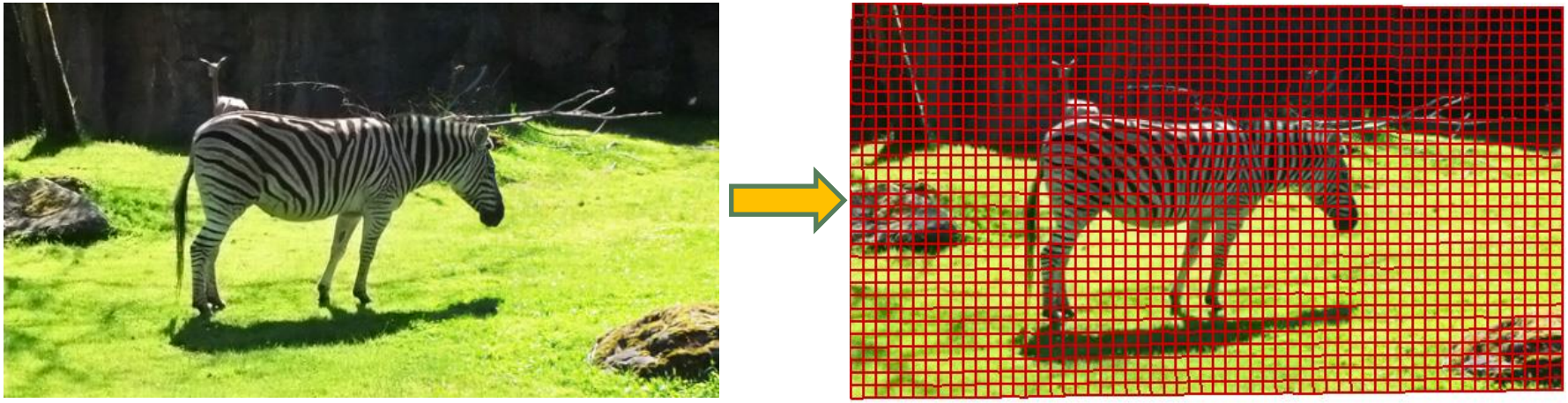
- Keep the input horizontal coordinates to
  - preserve horizontal disparities
- Average the left and right vertical coordinates for each feature pair to
  - remove vertical disparities

Content-preserving warping



Keystone correction result: left with disparity and right with mesh

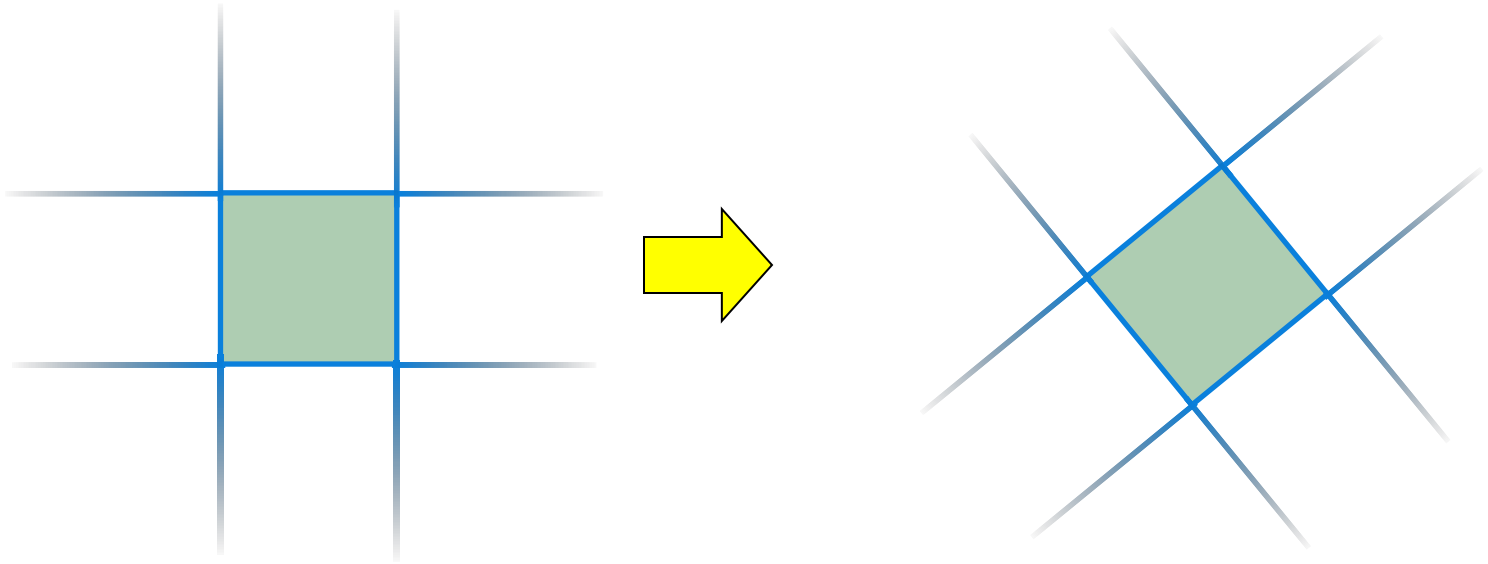
Warping algorithm



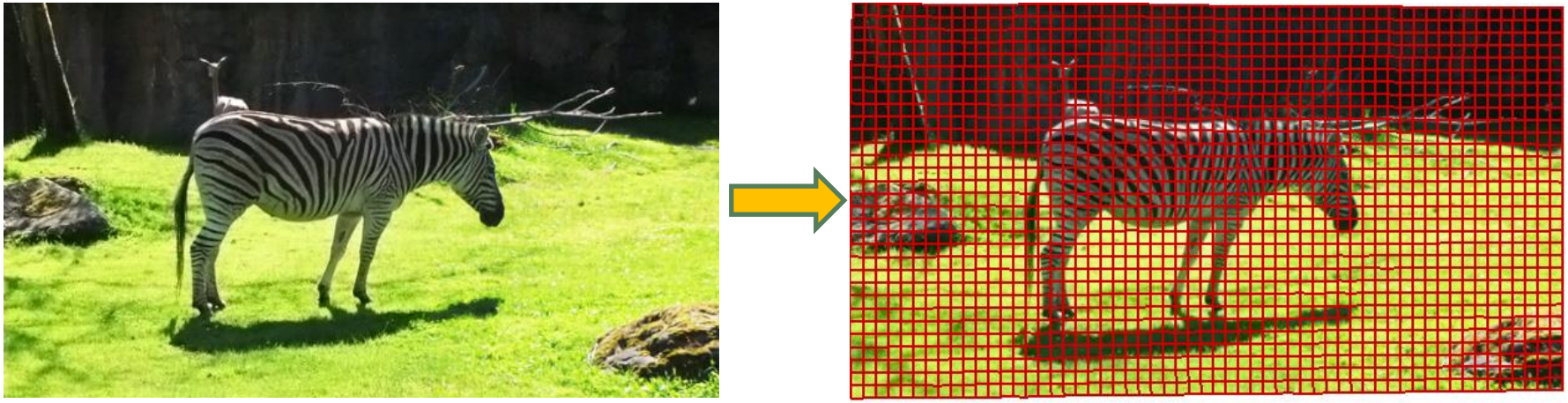
- Build a grid mesh from input image
- Warp input image by least-squares minimization
  - Data term: move features to target positions
  - Smoothness term: avoid visual distortion

Smoothness term: minimize visual distortion

Local similarity transformation constraint



Warping algorithm



- Build a grid mesh from input image
- Warp input image by least-squares minimization
  - Data term: move features to target positions
  - Smoothness term: avoid visual distortion
  - Solved by a linear solver

Camera-centric disparity editing

- Estimate the relative camera pose between the left and right camera and a sparse set of 3D points
  - 6-point algorithm [Stewenius et al. '05]
- Adjust the baseline and toe-in angle
  - Compute output feature positions
- Content-preserving warping

Disparity adjustment

Input

Disparity adjustment

Input

Disparity adjustment

Input

Vertical disparity from 3D rotation

Disparity adjustment

Input

Our result

Disparity adjustment

Examples

Input anaglyph and disparity

Examples: Move the train near the screen

Toe-in result

Examples: Move the train near the screen

Output anaglyph and disparity

Examples: Move the walker near the screen

Examples

Input

Output 1 and 2

Video example


Input sequence


Output sequence

Input

Result

Student Paper Presentations

- Student paper presentations
  - 05/24: Hall, Timothy
    - First-person Hyper-lapse videos
      J. Kopf, M. F. Cohen, R. Szeliski
      SIGGRAPH 2014
  - 05/24 : Kim, David
    - 360° Video Stabilization
      J. Kopf
      SIGGRAPH Asia 2016
  - 05/24 : Panthala, Krishna Sai
    - Steadiface: Real-Time Face-Centric Stabilization on Mobile Phones
      F. Shi, S. Tsai, Y. Wang, C. Liang
      ICIP 2019

Next Time

- 05/26: Haake, Erik
  - Restoring an image taken through a window covered with dirt or rain D. Eigen, D. Krishnan, and R. Fergus.
    IEEE ICCV 2013
- 05/26: Yang, Jimmy
  - Single Image Haze Removal using Dark Channel Prior
    K. He, J. Sun, and X. Tang
    IEEE CVPR 2009
- 05/26: Gromysh, Maria
  - Photo tourism: exploring photo collections in 3D
    N. Snavely, S. M. Seitz, and R. Szeliski
    ACM SIGGRAPH 2006
- 05/26: Sethi, Aashna
  - Time-travel rephotography
    X Luo, X Zhang, P Yoo, R Martin-Brualla, J Lawrence, SM Seitz ACM Transactions on Graphics 2021