

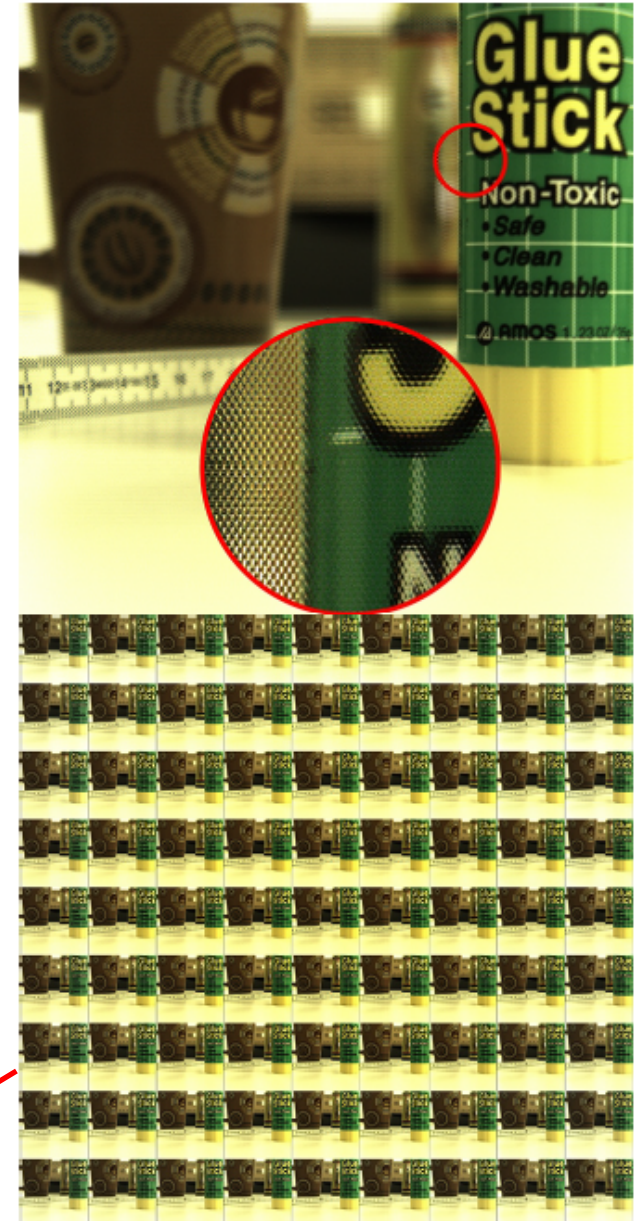
Light Field Stitching for Extended Synthetic Aperture

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arXiv: 1611.05003

Introduction

- Many light field cameras sacrifice spatial resolution to gain angular information
- By combining multiple light fields, it can obtain new capabilities and enhancements
 - spatial resolution
 - aperture size
 - ...
- Epipolar geometry of light field data



Sub-aperture
images

Pre-Processing

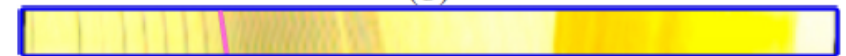
- Lytro raw image decoding
- Vignetting correction
 - Denoising with Gaussian filter
 - Color correction
- Image center correction



(a)



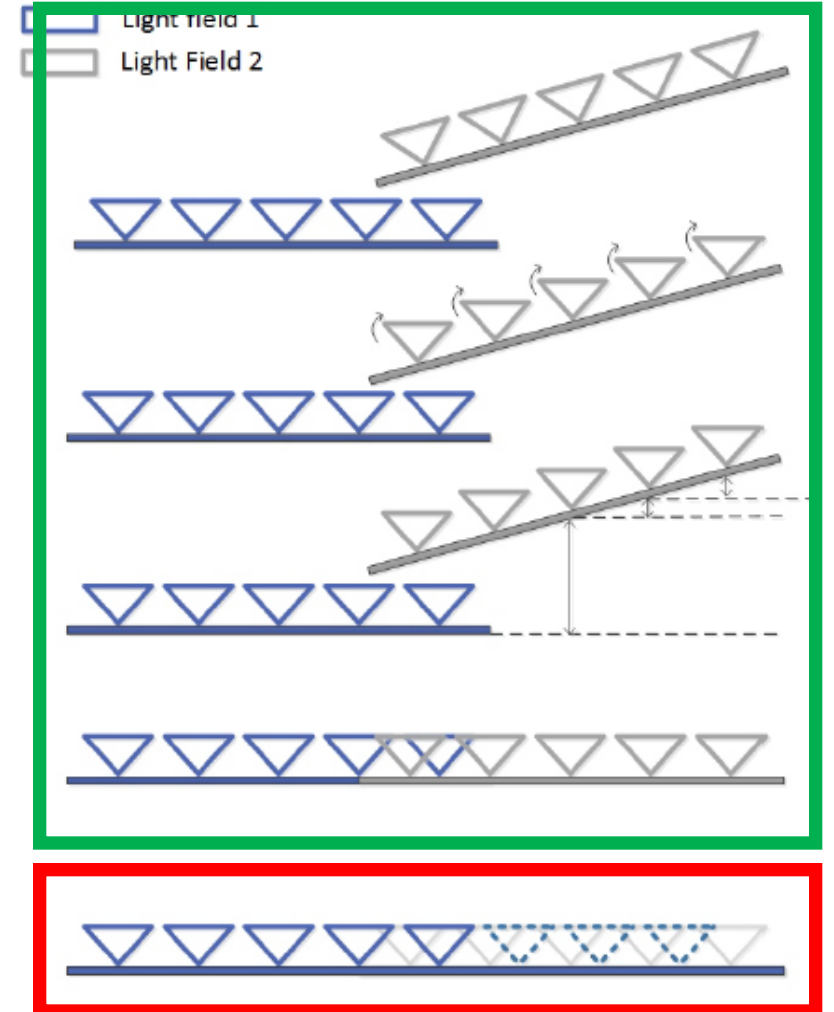
(b)



(c)

Light Field Registration

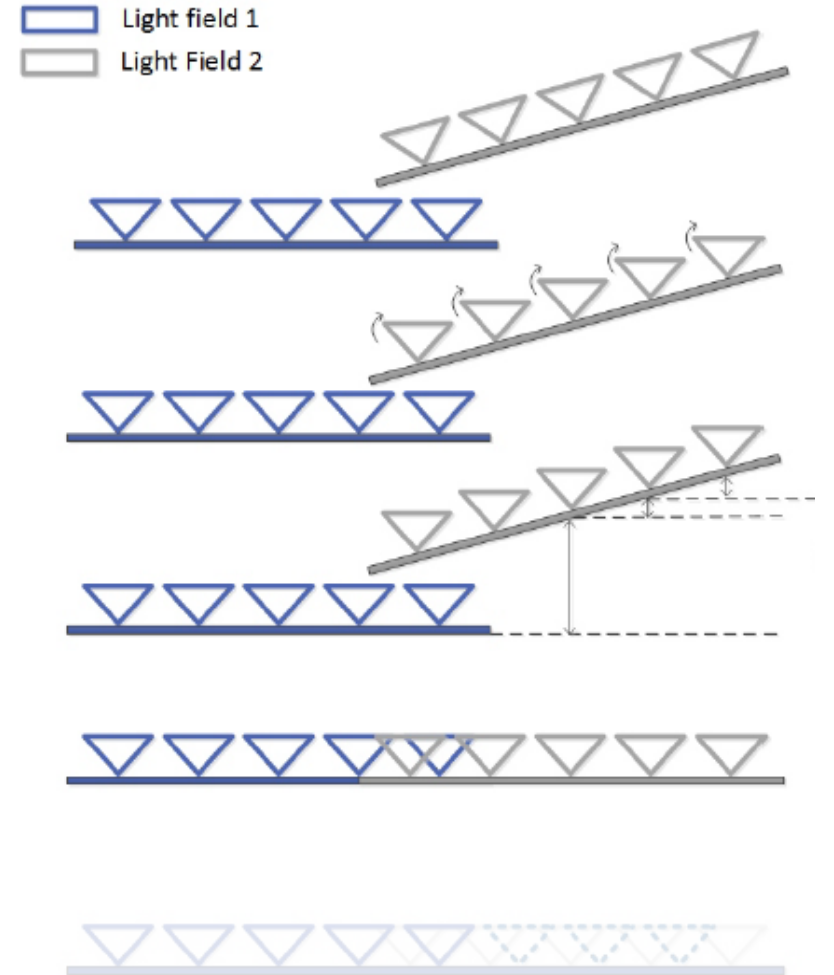
- Rectification
 - Sub-aperture images are compensated for rotation and translation to be on the same plane
- Stitching
 - The rectified sub-aperture images are merged into one light field



Light Field Registration

Rectification

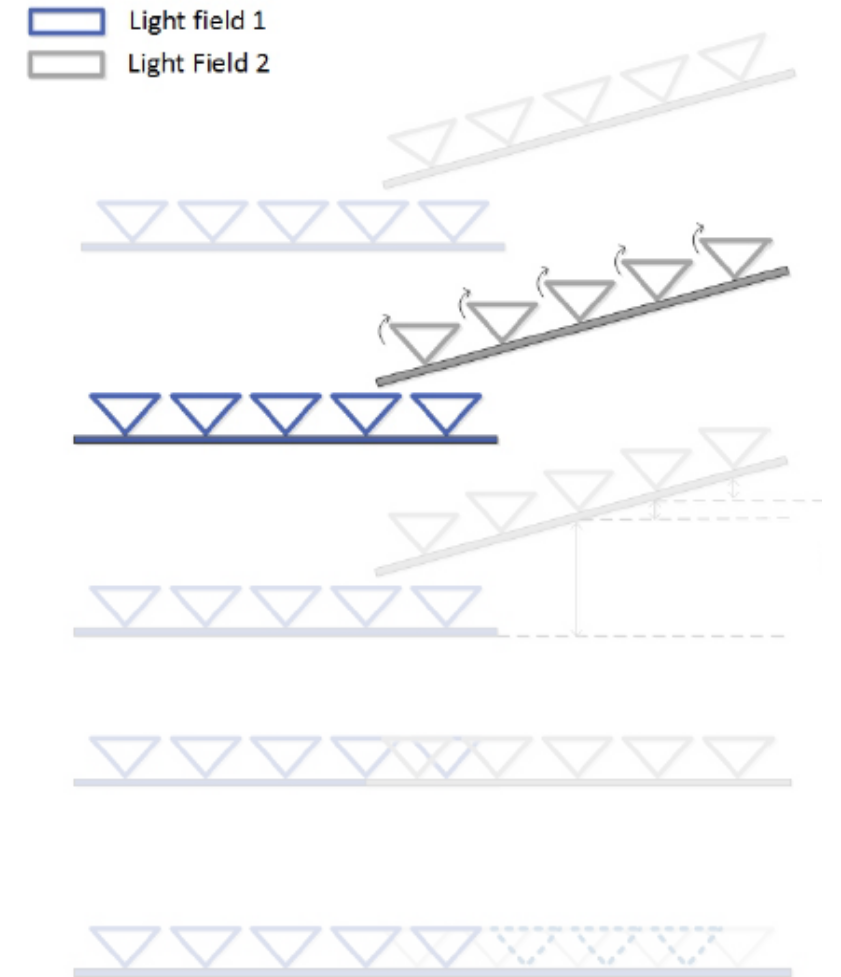
- A light field camera can be modeled as an array of virtual cameras
 - Micro-lens array
 - Sub-aperture images
- Rectify the images to provide regular spacings and identical orientations



Rectification

Orientation Correction

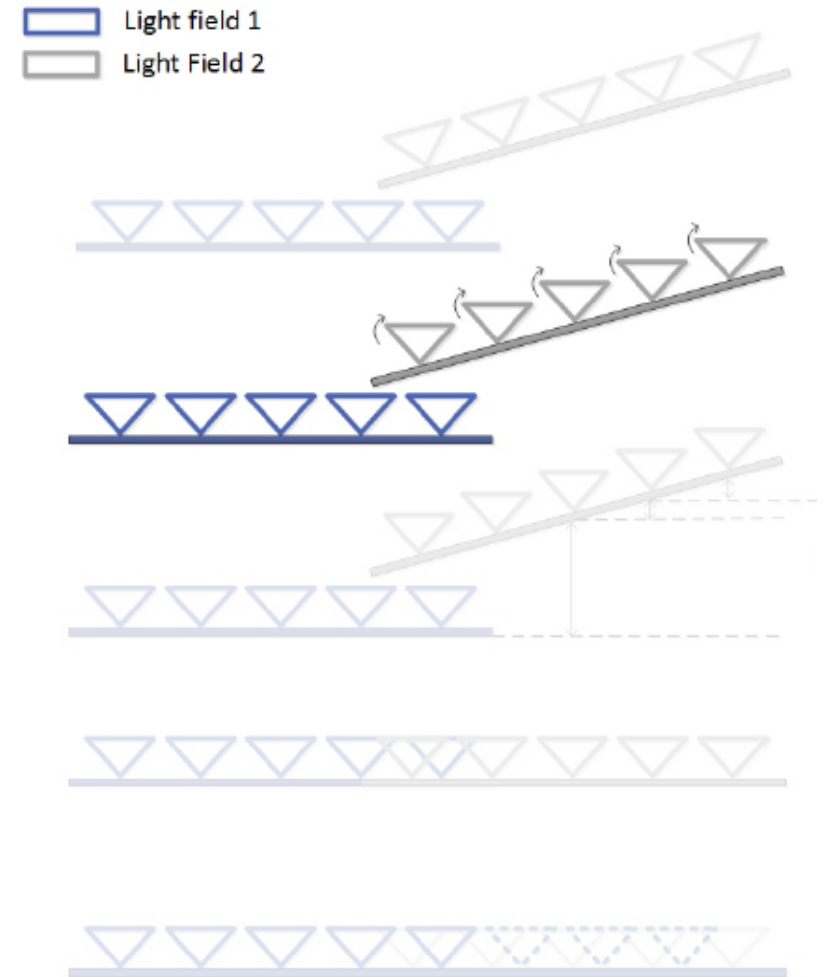
- Goal: find the rotation matrix R and get the transformed coordinates
1. Extract the Harris corner features in the first light field
 2. Obtain the correspondences in the second light field with KLT algorithm
 3. Apply RANSAC to remove outliers



Rectification

Orientation Correction

4. Estimate fundamental matrix F
 - $[u_i, v_i, 1]F[u'_i, v'_i, 1]' = 0$
 - Minimize the re-projection error
5. Get essential matrix E with intrinsic matrix K
 - $E = K^T F K$
6. Decompose E to get U, V with SVD
 - $E = U \Sigma V^T$
 - U, V : orthonormal matrices
 - Σ : a diagonal matrix



Rectification

Orientation Correction

7. Calculate R with W

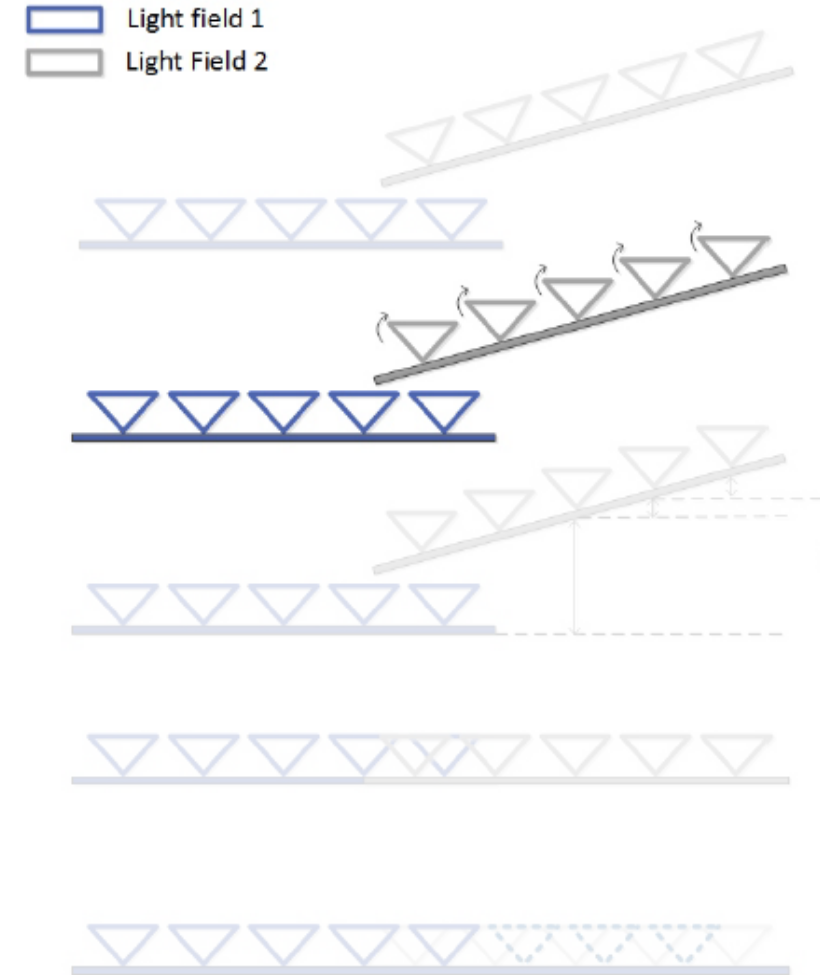
- $R = UWV^T$

- $W = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ or $\begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

- choose the W such that the reconstructed points have positive depths

8. Homographic transformation

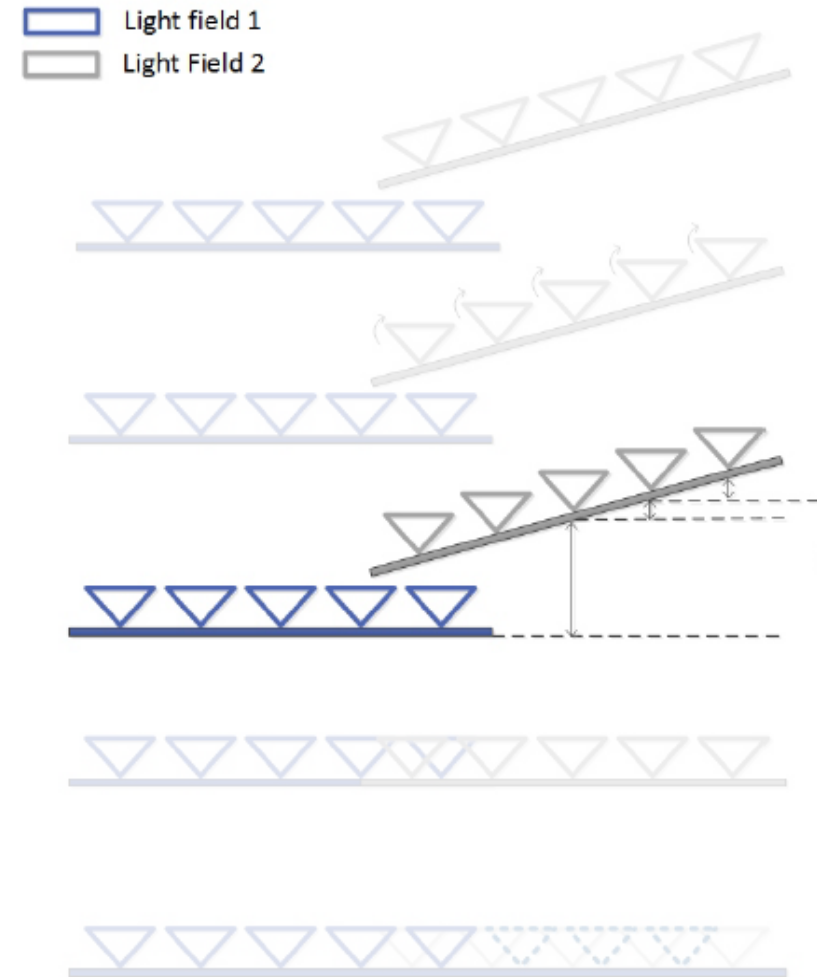
- $[\alpha u'', \alpha v'', \alpha]^T = KRK^{-1}[u', v', 1]^T$



Rectification

Scale Estimation

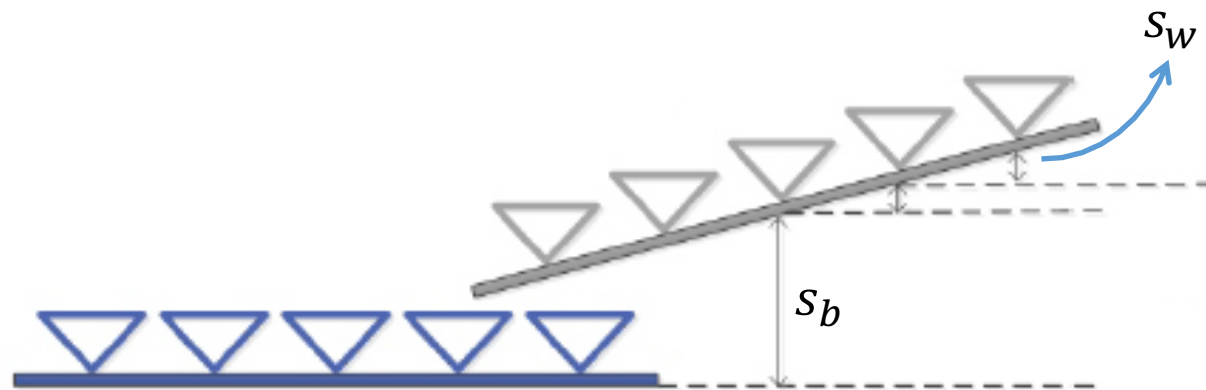
- Two scales to find:
 1. Within-light-field scale s_w
 2. Between-light-field scale s_b



Rectification

Within-light-field scale s_w

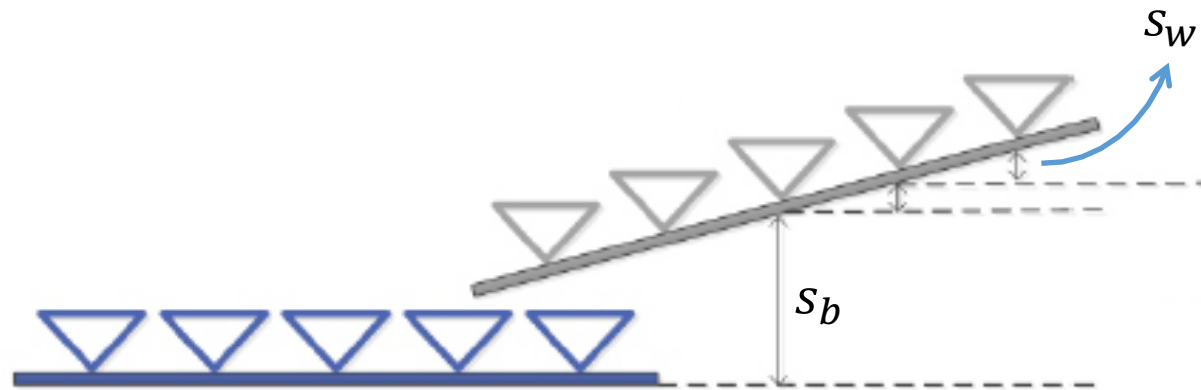
- Estimate the scale between every consecutive pair for they are fixed
- Scale estimation based on feature correspondences
 - Harris corner detection and KLT feature tracking
- Use Silhouette's criterion to get depth clusters
- Get scale with the farthest feature cluster



Rectification

Between-light-field scale s_b

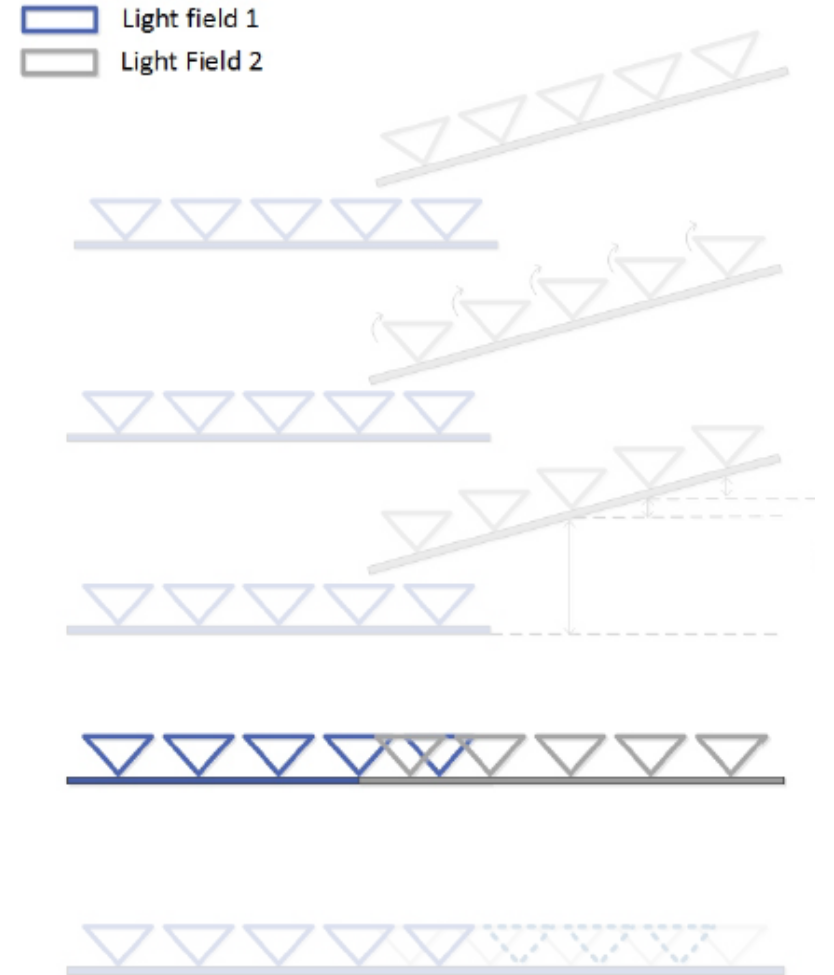
- Apply the same procedure on the middle sub-aperture images of the first and second light fields



Rectification

Scale Correction

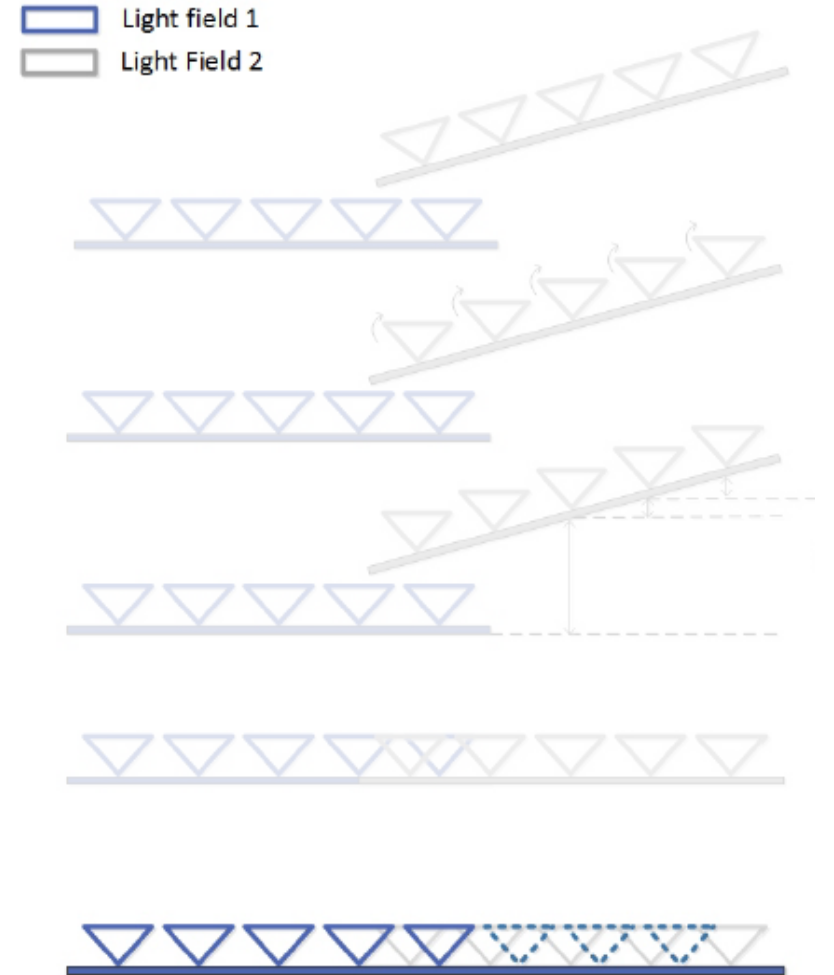
- Multiply s_w and s_b to get scale of each sub-aperture image
- Apply scales to bring all sub-aperture images on the same plane



Light Field Registration

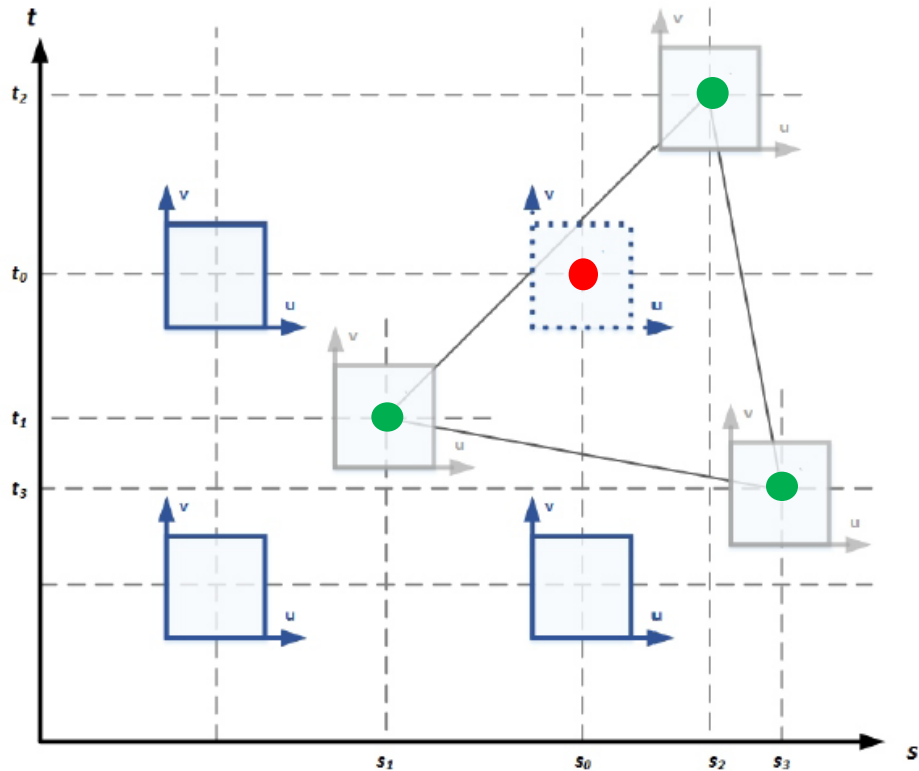
Light Field Stitching

- Merge the light fields into a single one
- Within-light-field translation
 - Average distance between every pair in sub-aperture image
- Between-light-field translation
 - Distance between middle sub-aperture images of the light fields



Light Field Stitching

Image Interpolation



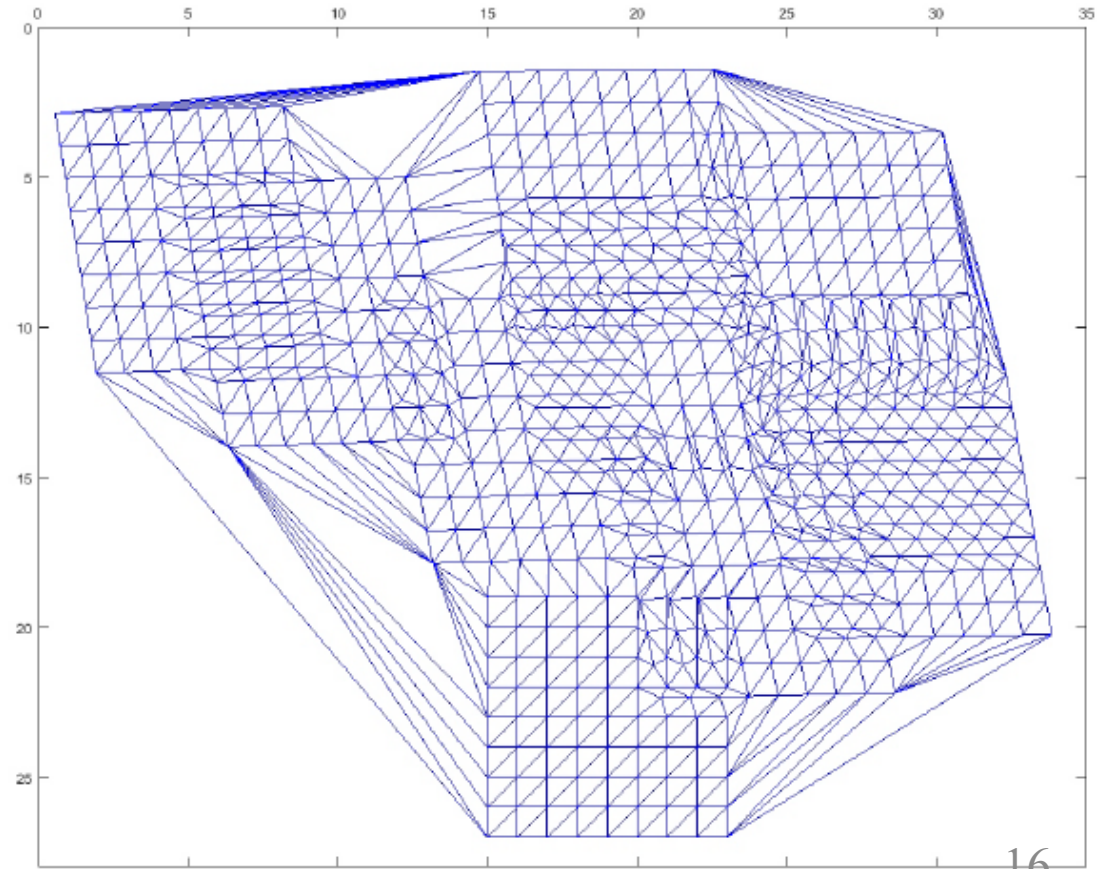
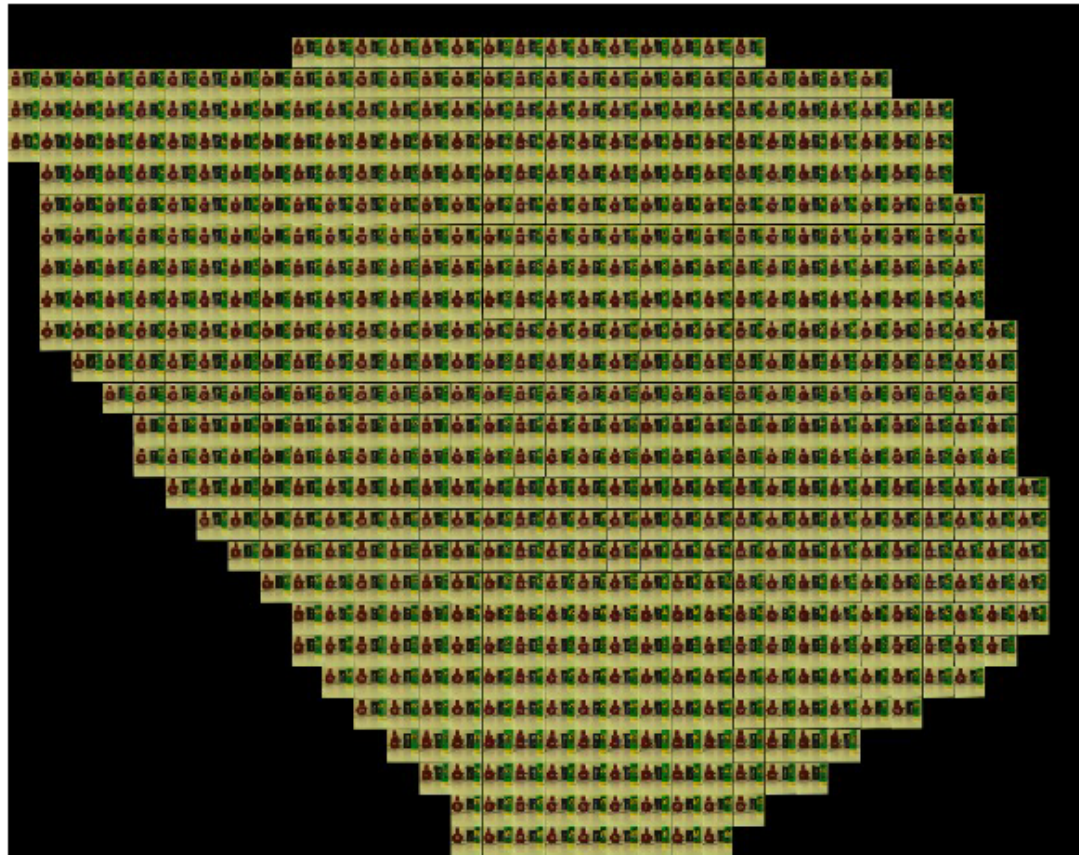
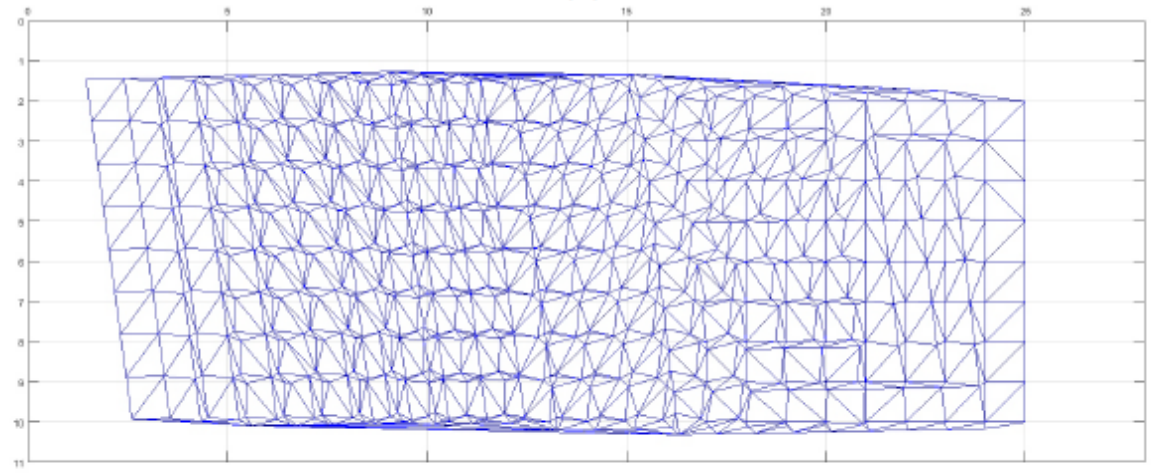
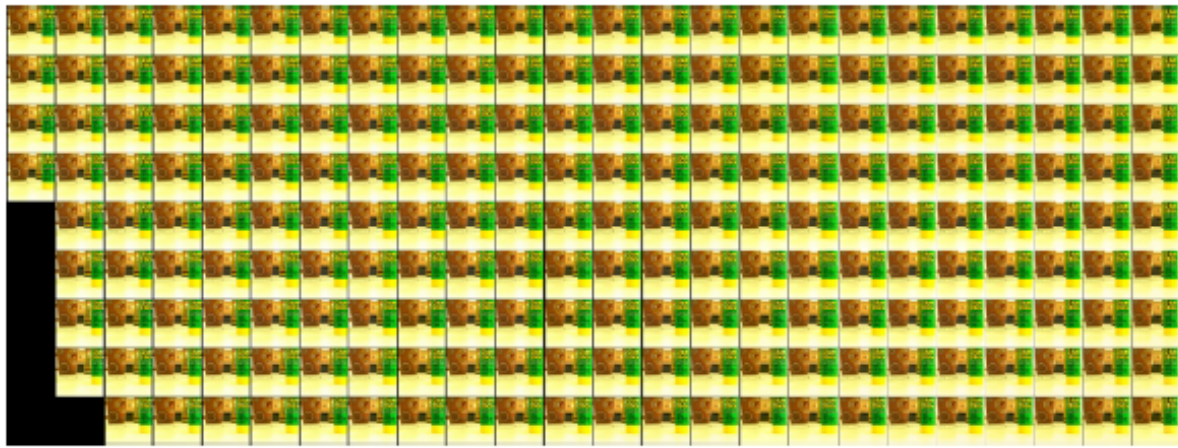
- Goal: obtain a light field on a regular grid
- Use Delaunay triangulation for interpolation
- $I'(u, v, s_0, t_0)$ is interpolated as a weighted sum of recorded $I(u, v, s_i, t_i)$

$$I'(u, v, s_0, t_0) = \frac{\sum_{i=1}^3 \left(\frac{1}{\|(s_i, t_i) - (s_0, t_0)\|} \right) I(u, v, s_i, t_i)}{\sum_{i=1}^3 \left(\frac{1}{\|(s_i, t_i) - (s_0, t_0)\|} \right)}$$

Experiments

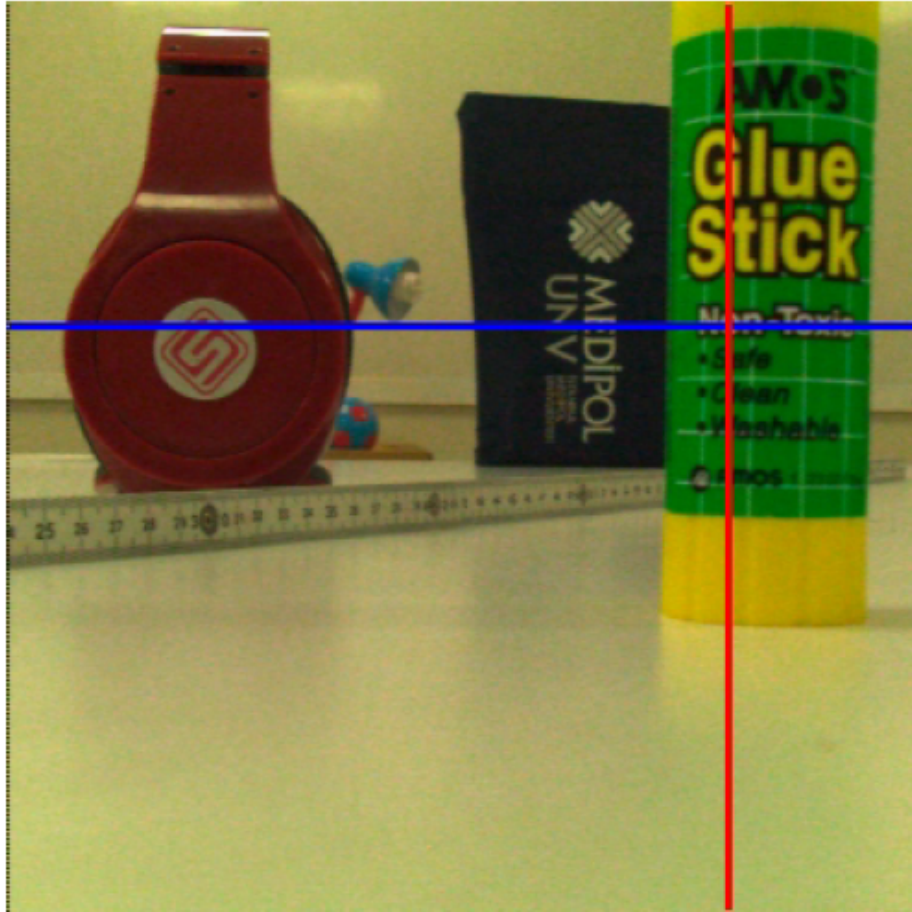
Setup

- Two datasets:
 1. 9 light fields, mainly in the horizontal direction
 2. 10 light fields, Includes horizontal and vertical movements
- pre-processing time per light field: 16 seconds
- rectification time per light field: 10 seconds

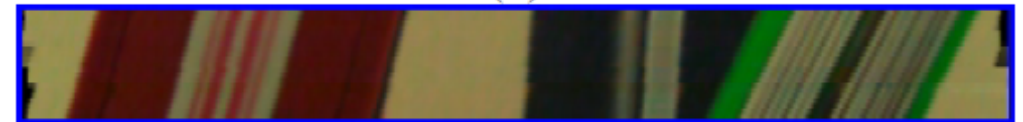


Experiments

EPI



(b)



(c)



(d)



(e)

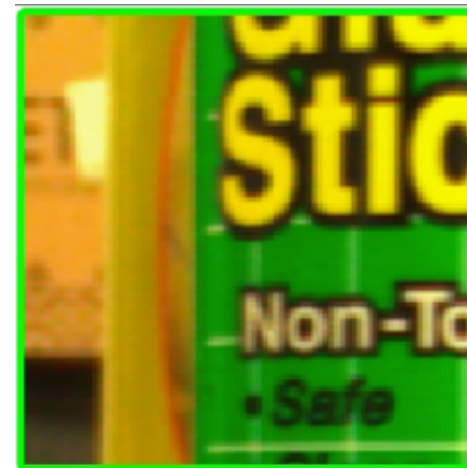
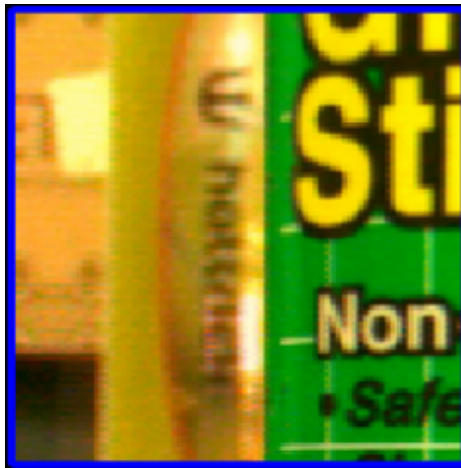
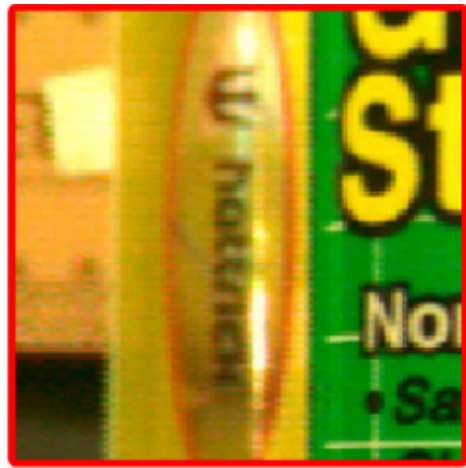
Experiments

Synthetic Aperture



Experiments

Translation Parallax



Conclusion

- Present a light field registration method

Thanks For Listening

Any question?