

Symmetric Piecewise Planar Object Reconstruction from a Single Image

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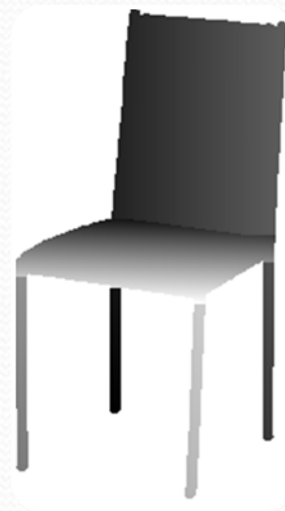
The Chinese Univ. of Hong Kong

Objective

- Recovering 3D geometry from single image



2D image



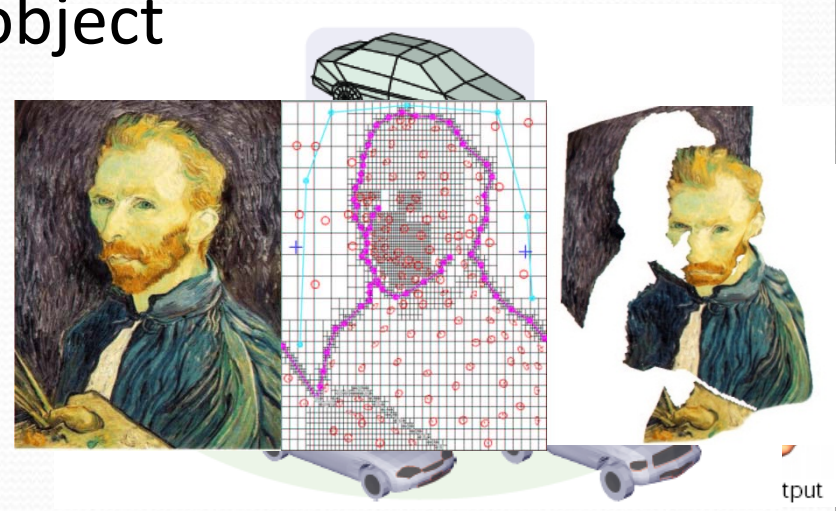
Depth Map Recovery



Reflection-symmetric &
Piecewise Planner

Related works

- Previous approaches
 - Focus on a specific kind of object
 - Face [V. Blanz, SIGGRAPH 99]
 - Car [M. J. Leotta., CVPR 09]
 - Add user interaction
 - [L. Zhang, CVPR 01]



- Our approach

Automatically recover 3D geometry from a single view of **symmetric** object

Our approach:

Recovering 3D Geometry using symmetry

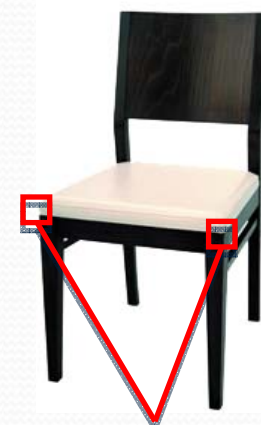
- Symmetry is ubiquitous



- Symmetry provides rich information for reconstruction

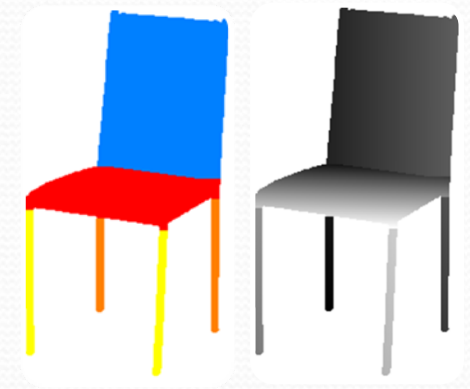


View difference in stereo



View difference in

Reconstruction – Pipeline



2D
image

Line
Detection

Plane Detection

Plane Labeling
& Depth Map
Recovery

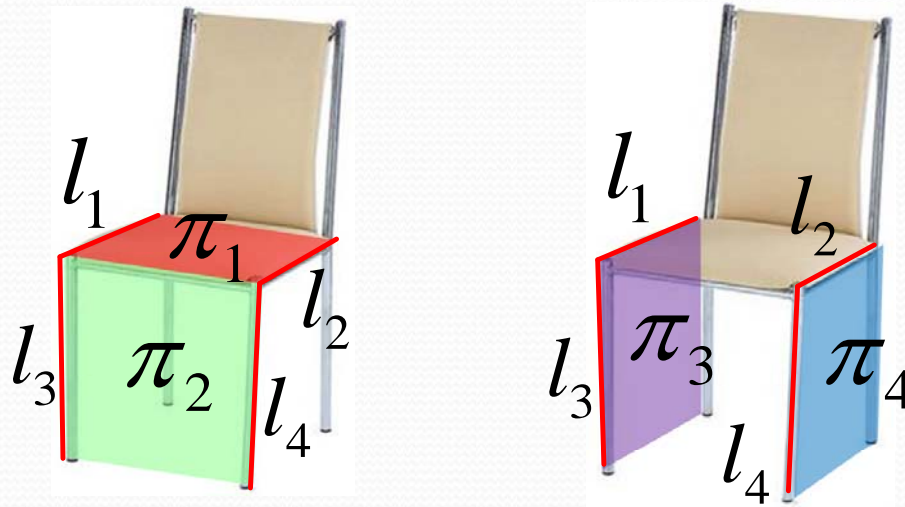


Symmetric &
Piecewise Planner

Reconstruction – Plane Detection

- Plane Detection

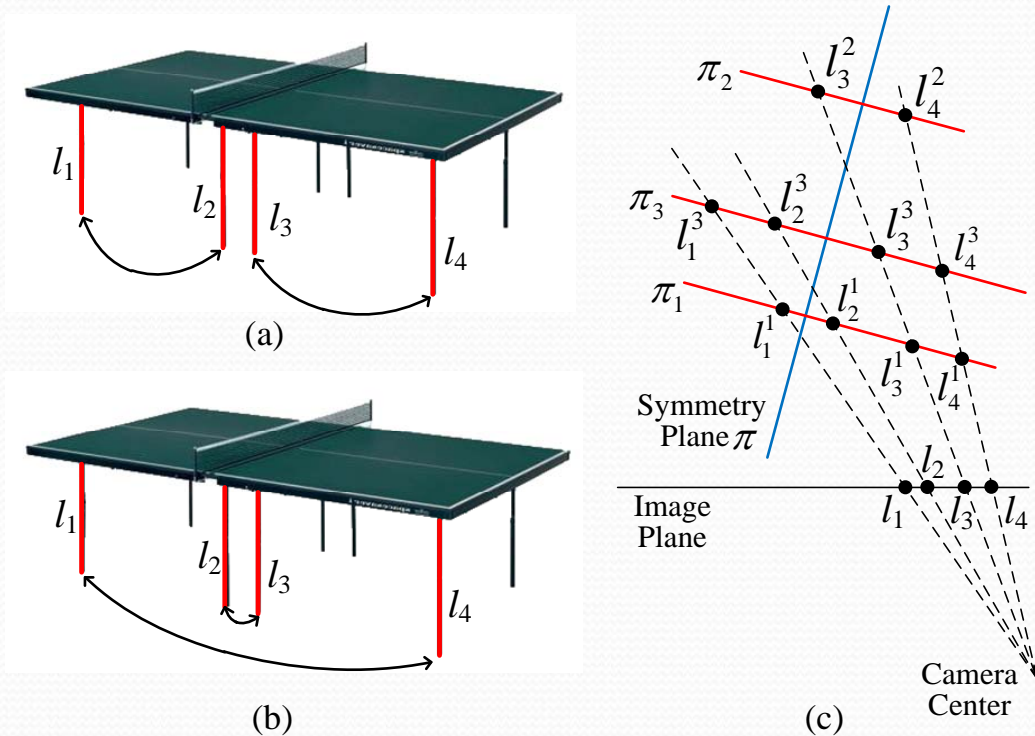
- A symmetric line pair can determine a plane



- Some heuristic rules are proposed to get a set possible symmetric line pair

Reconstruction – Plane Detection

- Plane Detection
 - How to determine whether two lines are symmetric
 - Suppose all the pairs are symmetric



Reconstruction – Plane Detection

- Plane Detection

$$\max_{P' \subset P} \left(|P'| - \alpha |plane(P')| \right),$$

subject to: no common lines in any two pairs $\in P'$,

(l_i, l_j, π_k) : π_k is the plane determined by l_i, l_j

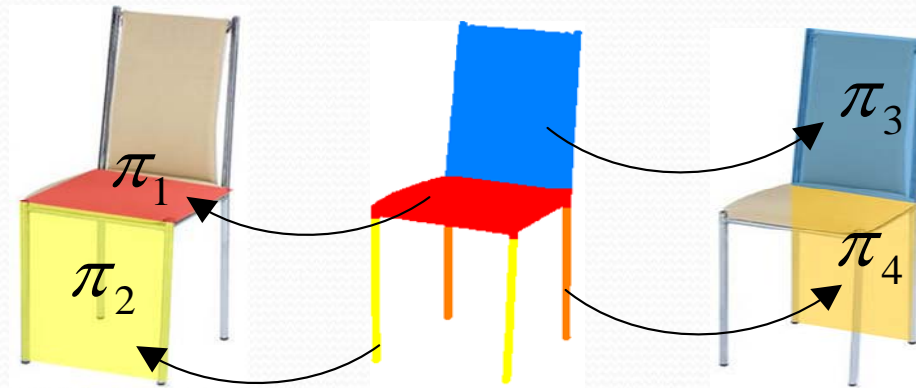
P : The set of all line pairs

P' : The set of correct line pairs

$plane(P')$: The set of planes determined by the pairs in P'

Reconstruction – Plane Labeling

- Plane Labeling
 - Assign each pixel to the plane it belongs to



- This problem is modeled as a Markov Random Field

$$E = \sum_p E_d(\pi^p) + \sum_{(p,q) \in N_4} E_{ls}(\pi^p, \pi^q) + \sum_{(p,q) \in N_s} E_s(\pi^p, \pi^q)$$

Reconstruction – Plane Labeling

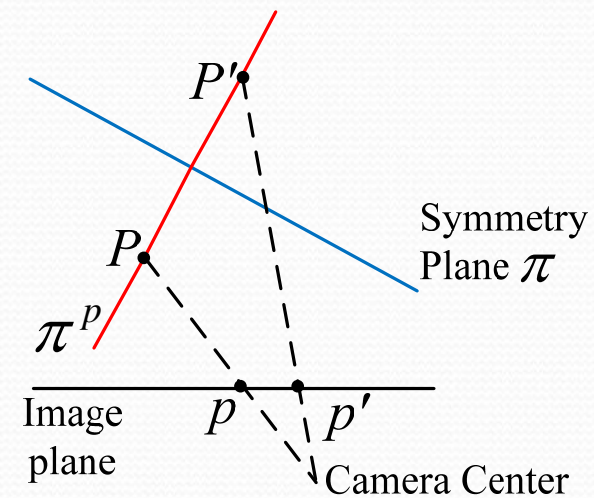
- Plane

Energy function:

$$E = \sum_p E_d(\pi^p) + \sum_{(p,q) \in N_4} E_{ls}(\pi^p, \pi^q) + \sum_{(p,q) \in N_s} E_s(\pi^p, \pi^q),$$

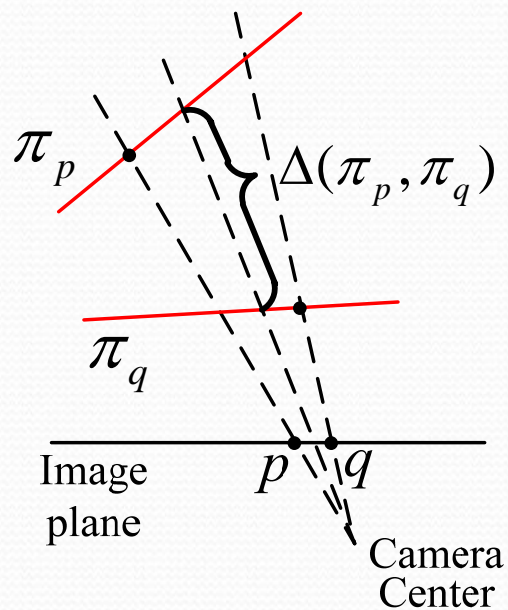
- Data Term

$$E_d(\pi^p) = \begin{cases} R(\|I_p - I_{p'}\|/50), & \text{if } p' \in I_F, \\ 2, & \text{otherwise,} \end{cases}$$

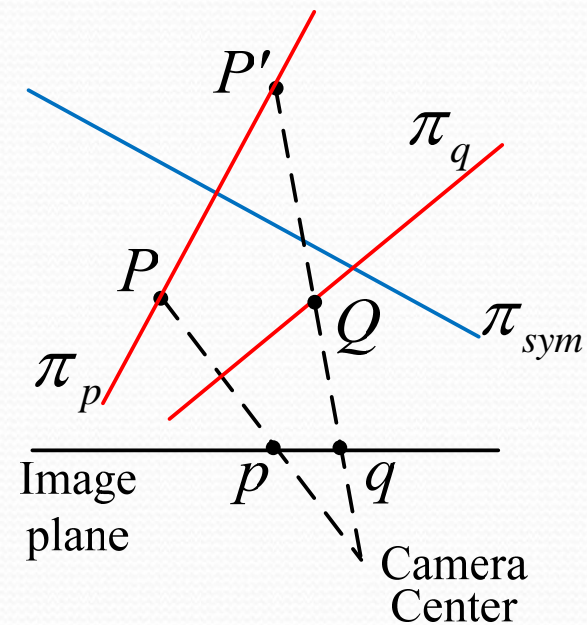


Reconstruction – Plane Labeling

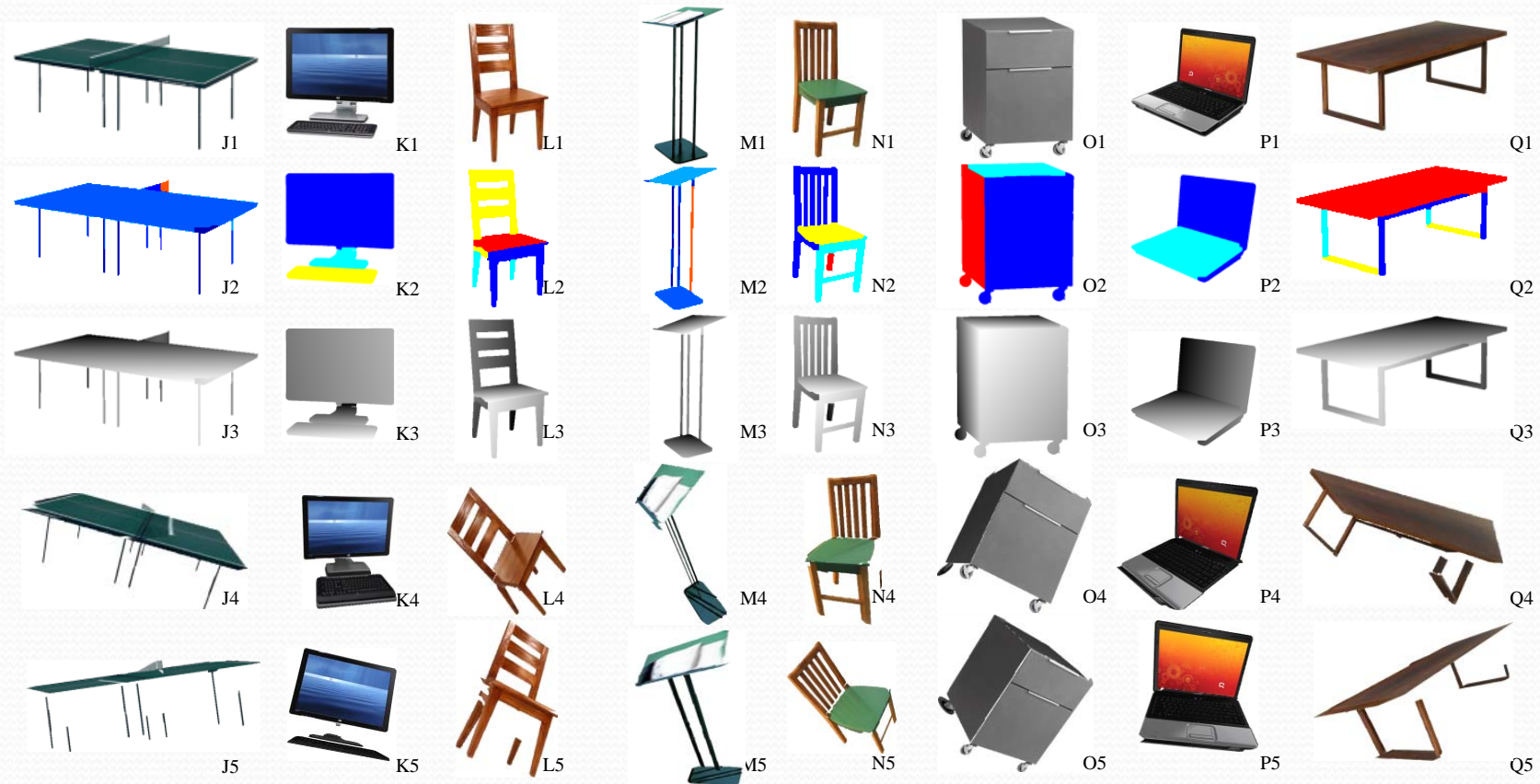
- Plane labeling
 - Smooth Term



- Symmetry Term



Experiment Result



Conclusion

- Conclusion

- **Symmetry is a powerful tool for recovering 3D geometry**

- We focus on reflection symmetry

- Another works in this year CVPR on translation symmetry

- C. Wu, J. Frahm, M. Pollefeys “Repetition-based Dense Single-View Reconstruction”, CVPR, 2011.

- Possible Extensions

- Semi-automatic 3D reconstruction using symmetry

- Combining 3D reconstruction with 3D retrieval

- Improve the learning based 3D reconstruction using symmetry



Q&A

Thank you!