


3D Modeling & Visualization in Construction

Semi-automatic Single View Reconstruction & Visual Registration

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Outline

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3D Reconstruction

- In traditional Photogrammetry and Computer Vision, one of the major topic is how to recover 3D model from images, i.e. 3D Reconstruction.

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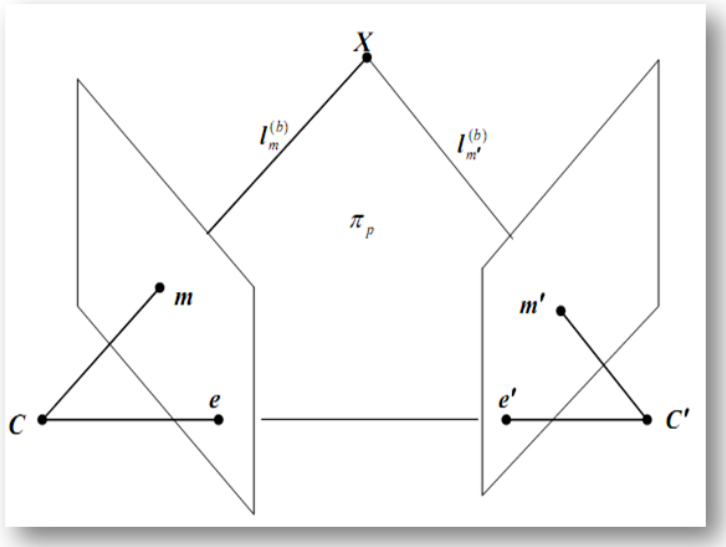
Multiple View Reconstruction



Multiple images needed, correspondence problem

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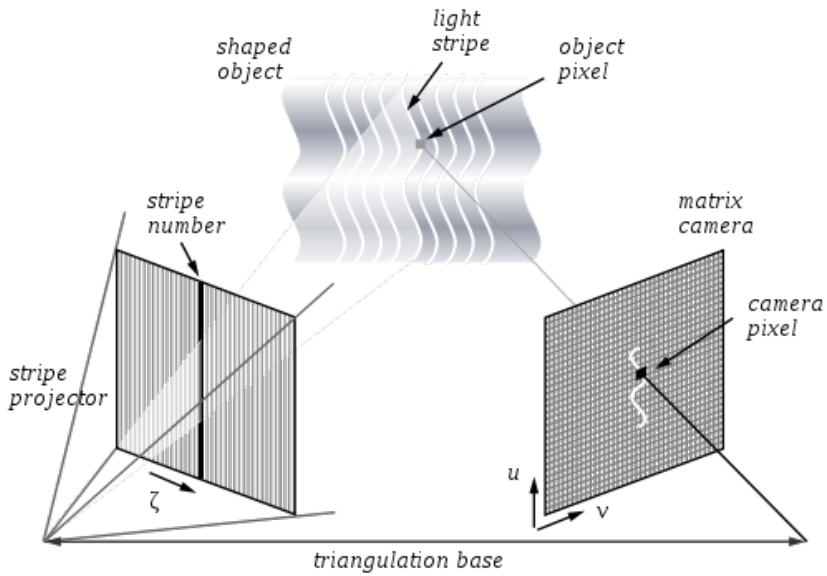
Structural Light



Special devices needed, relative small range

3D Reconstruction

- What if
  - User have only one picture of the scene
  - User have a painting that satisfies central projection

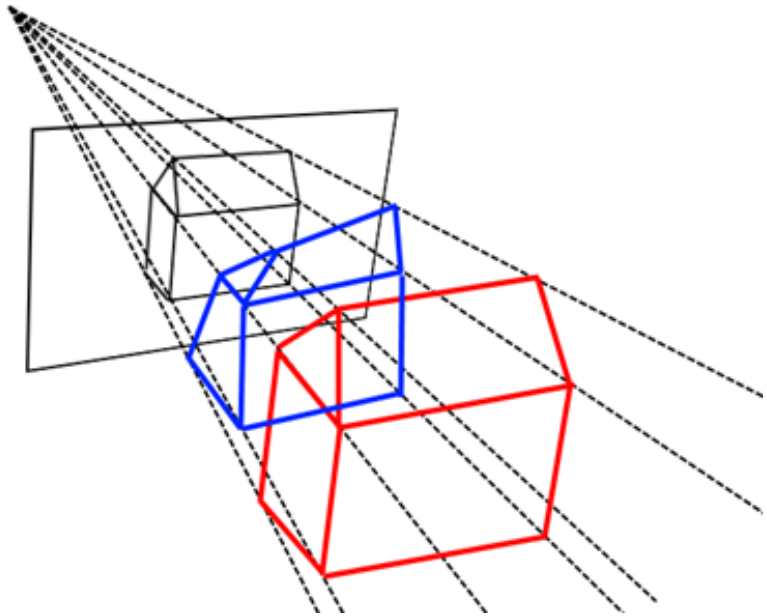
3D Reconstruction

- What if
  - User have only one picture of the scene
  - User have a painting that satisfies central projection
- This requires a reconstruction algorithm that
  - Needs only one image
  - No need for special devices
  - Relatively large applicability

3D Reconstruction

- One possible solution:

Single View Reconstruction (SVR)



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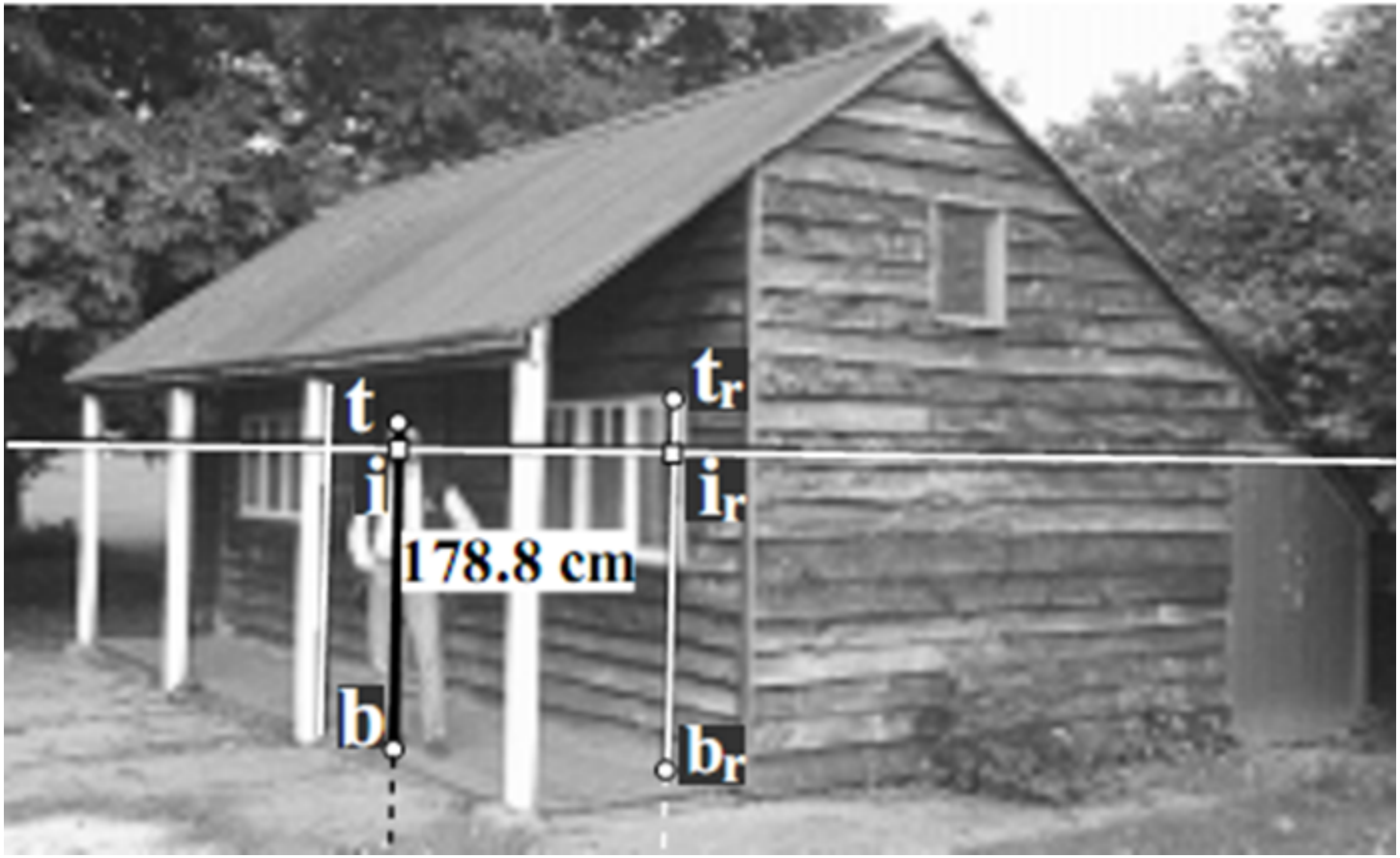
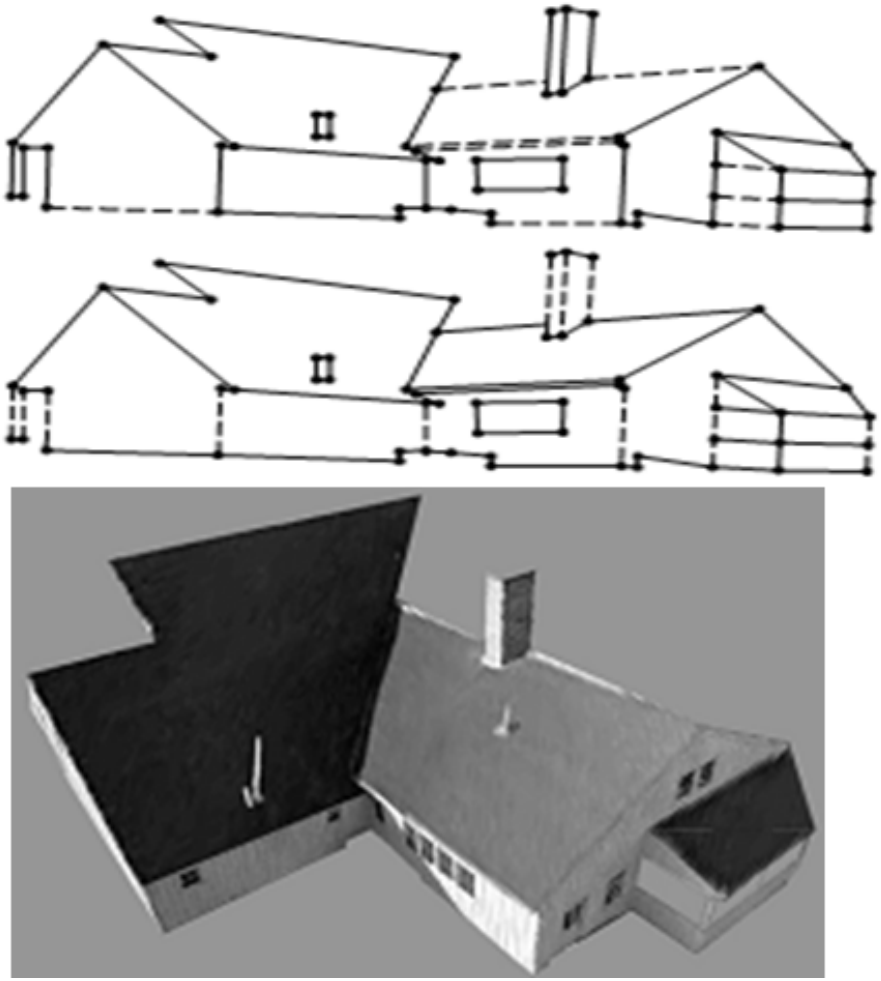
Important Previous Works

2000, A. Criminisi, Single View Metrology



Important Previous Works

1999, Peter Sturm, Piecewise Planar Reconstruction



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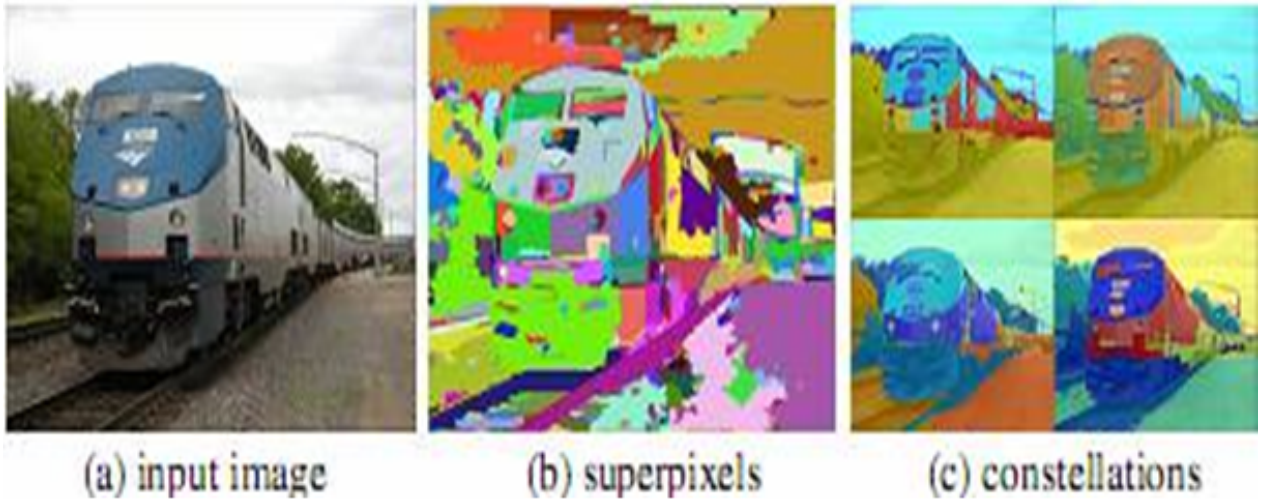
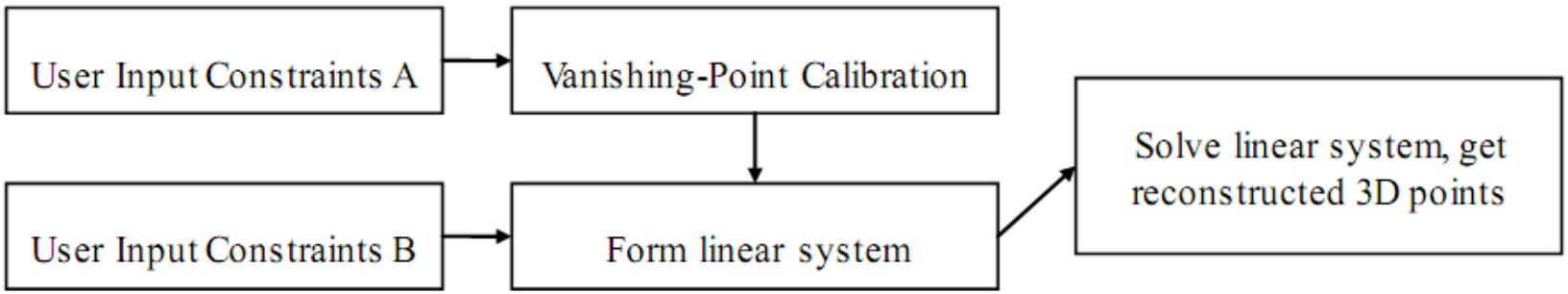
2005, D. Hoiem, Automatic Photo Pop-up



(a) input image (b) superpixels (c) constellations

(d) labeling (e) novel view

General Schema of Traditional SVR Algorithm



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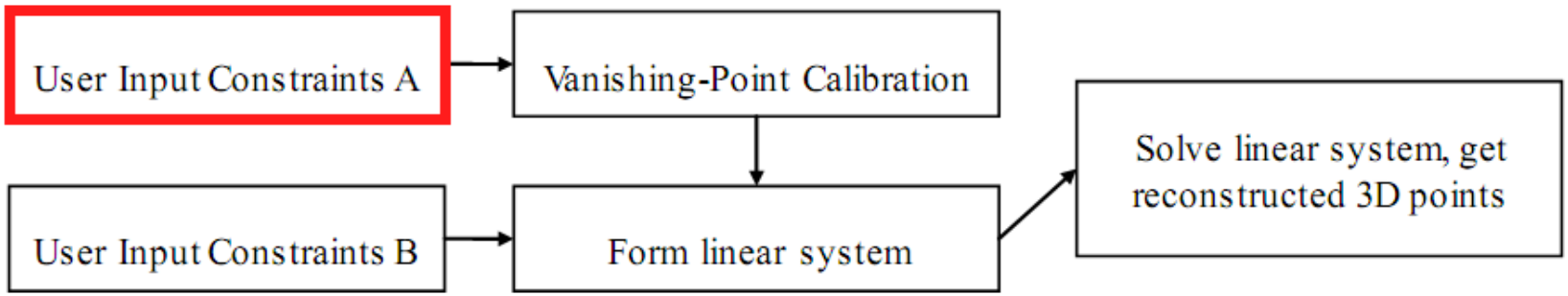

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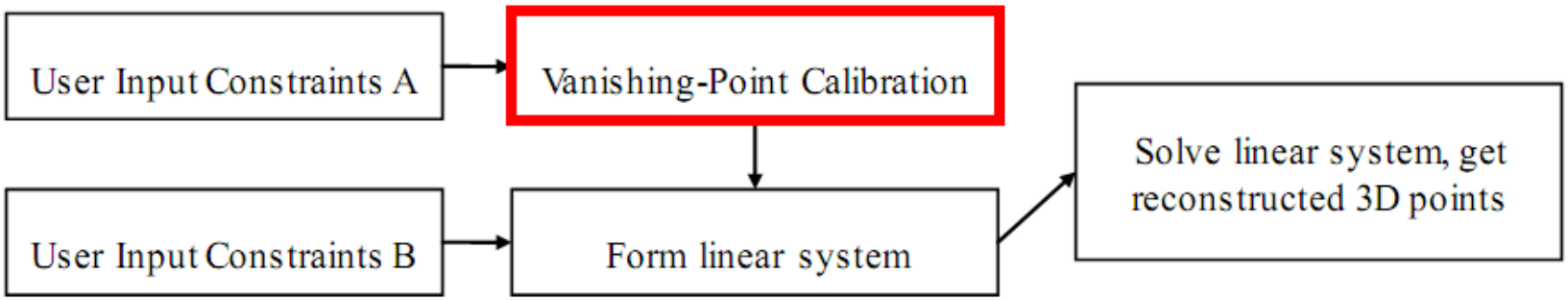

- Vanishing Point Calibration takes advantage of 3 orthogonal vanishing points to get camera's intrinsic parameter (focal length, principle point, etc)

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Vanishing Point (VP)

The intersection point of a group of image lines whose 3D correspondent lines are parallel to each other.

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Orthogonal Vanishing Points

VPs whose 3D correspondent directions are perpendicular to each other.

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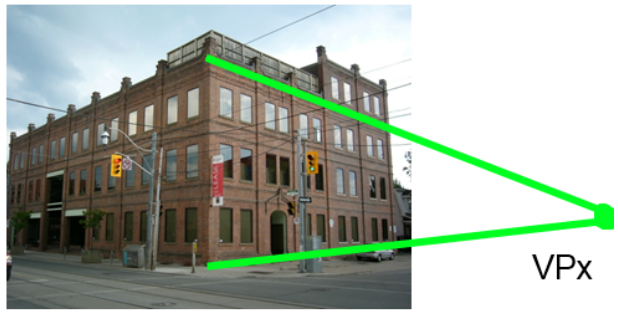

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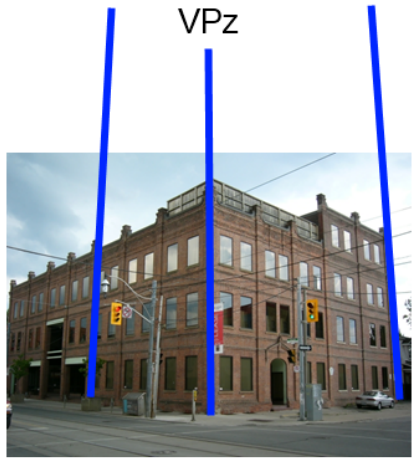

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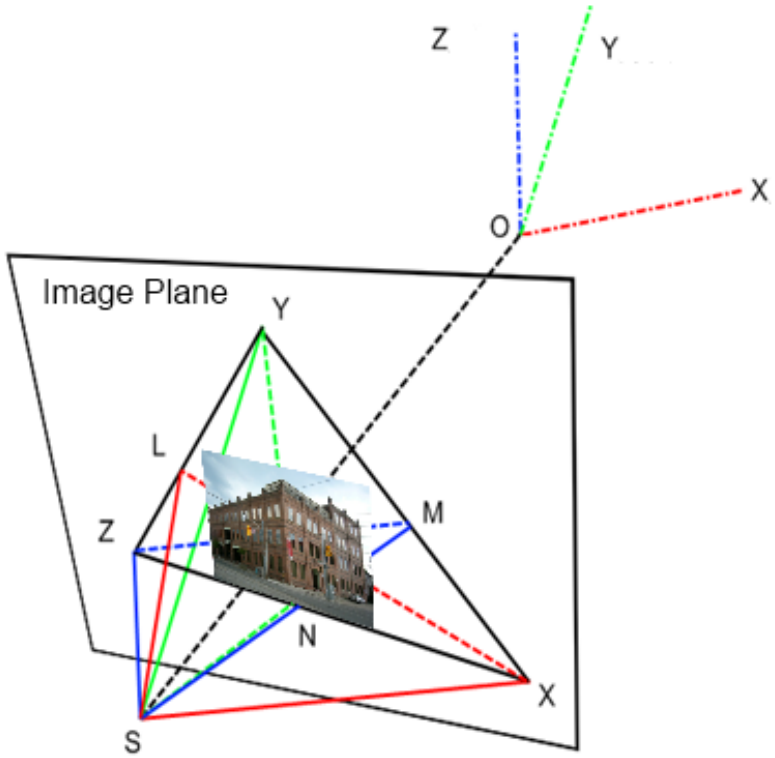

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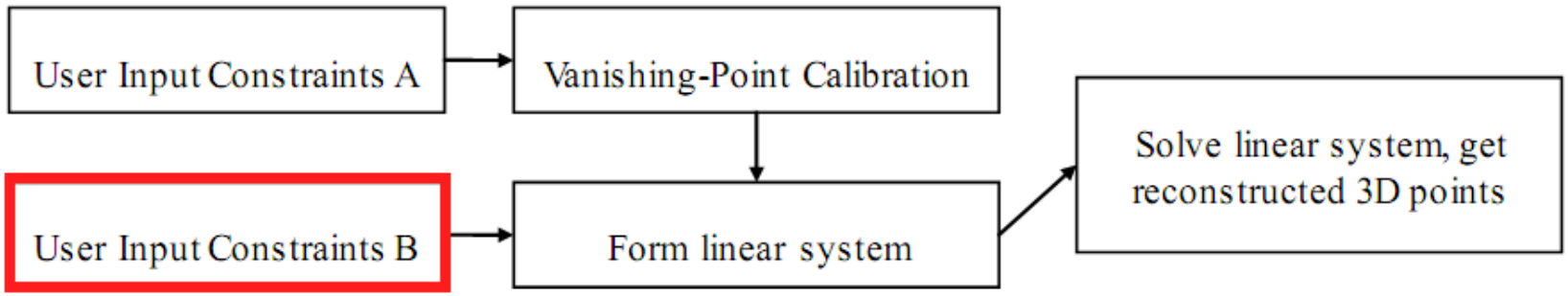
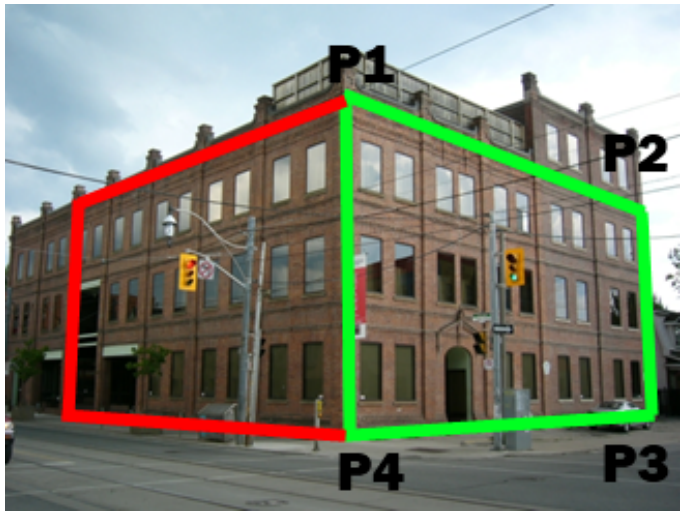


- Constraints B are mainly coplanar constraints



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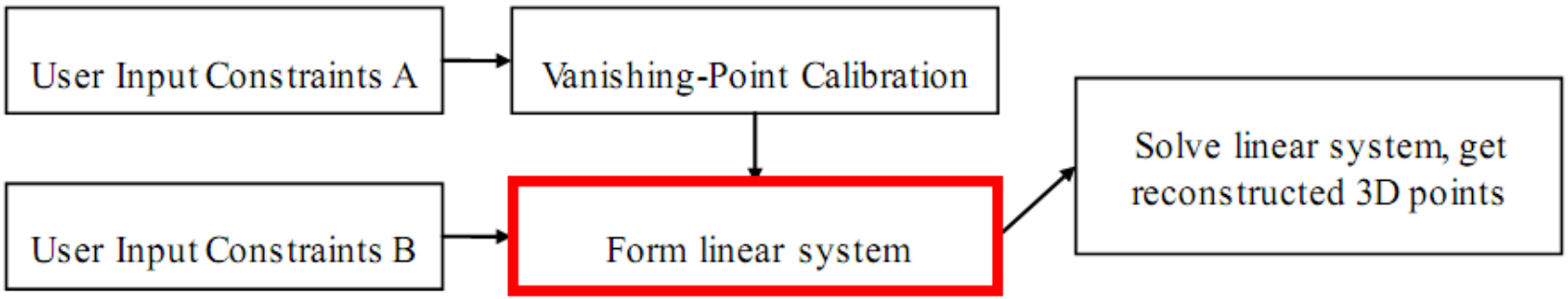

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- After calibrated, the SVR problem can be seem as an optimization problem

$$(\mathbf{X}, \mathbf{K}) = \arg\min_{\mathbf{X},\mathbf{K}} \|\mathbf{x} - f(\mathbf{X}, \mathbf{K})\|^2$$

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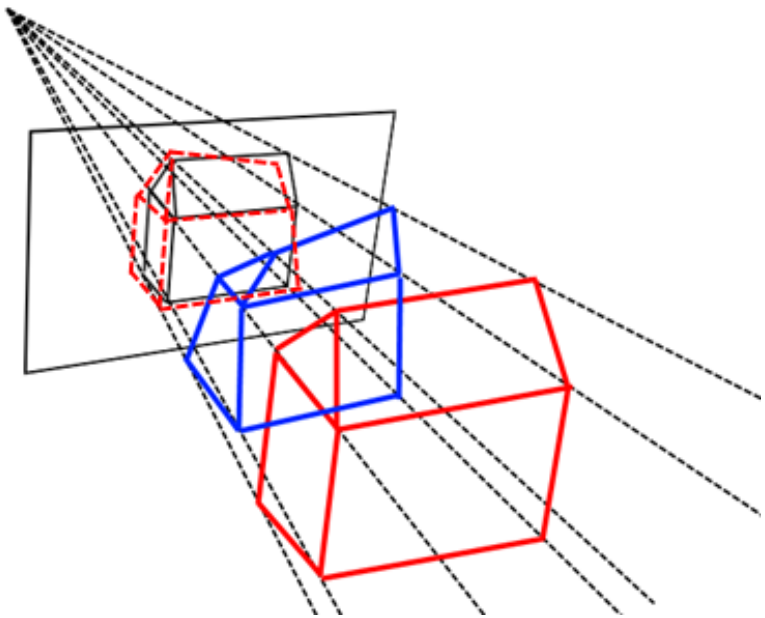

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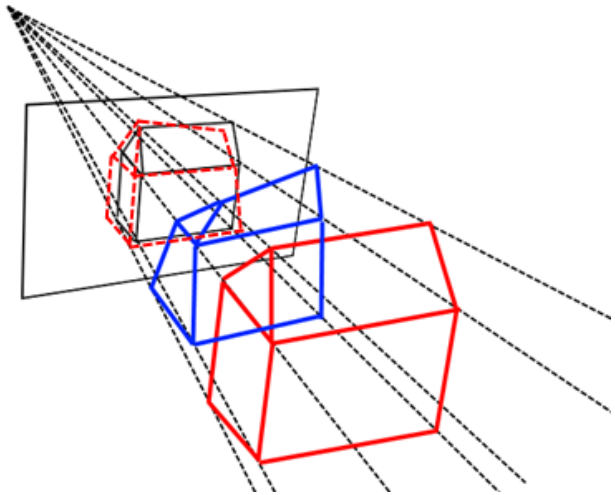
- However, there are infinite number of solutions for the above equation, so constraints are needed

$$g(\mathbf{x}, \mathbf{X}, \mathbf{K}) = 0$$



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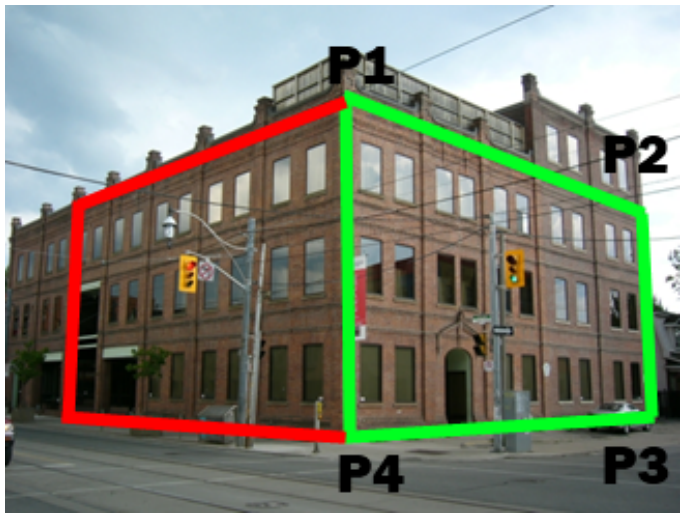
- Typical constraints:

$$\mathbf{P_4} - \mathbf{P_1} = \alpha(\mathbf{P_2} - \mathbf{P_1}) + \beta(\mathbf{P_3} - \mathbf{P_1})$$



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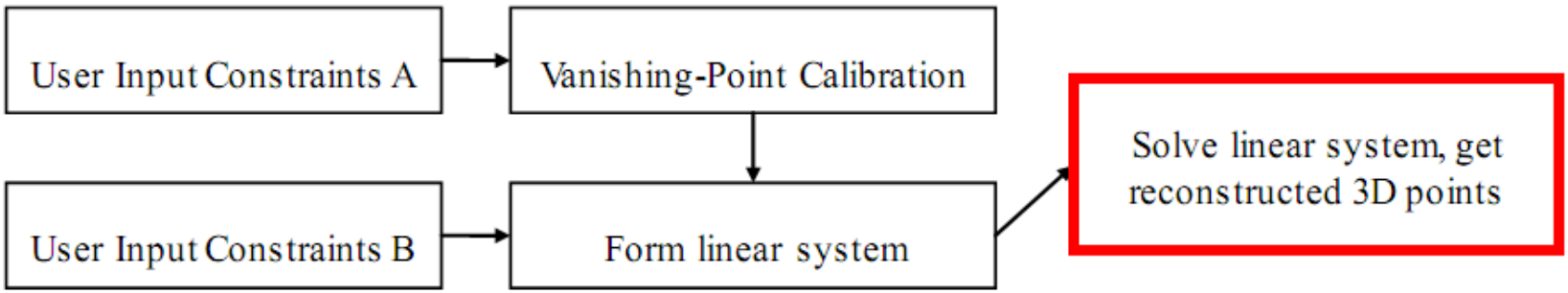

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- We can always find 3 directions perpendicular to each other in a building scene and their corresponding VPs in the image

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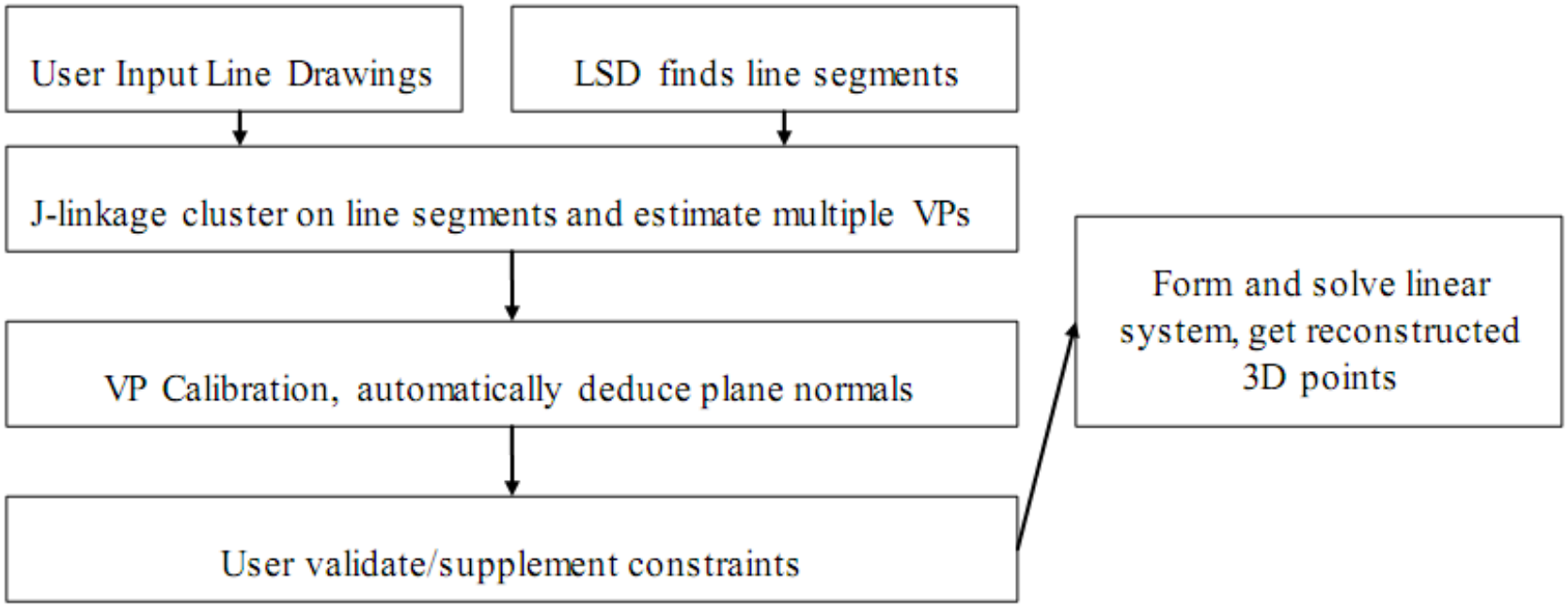

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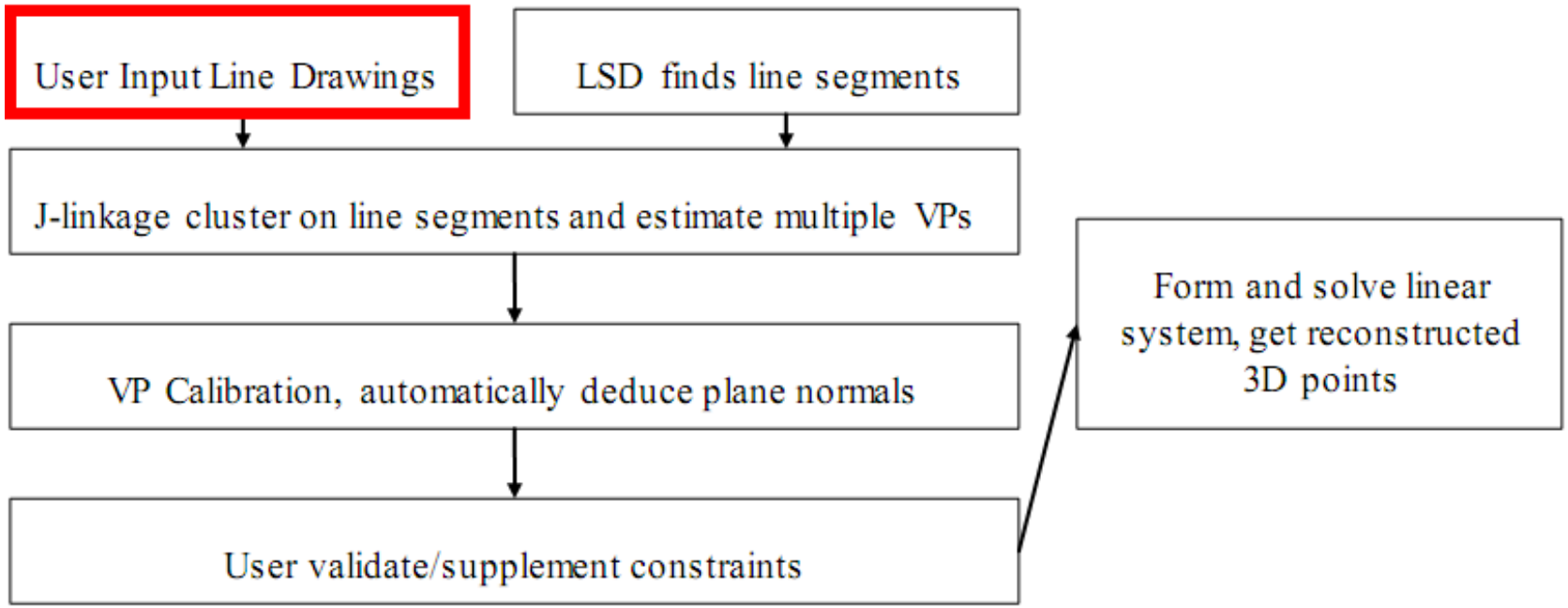

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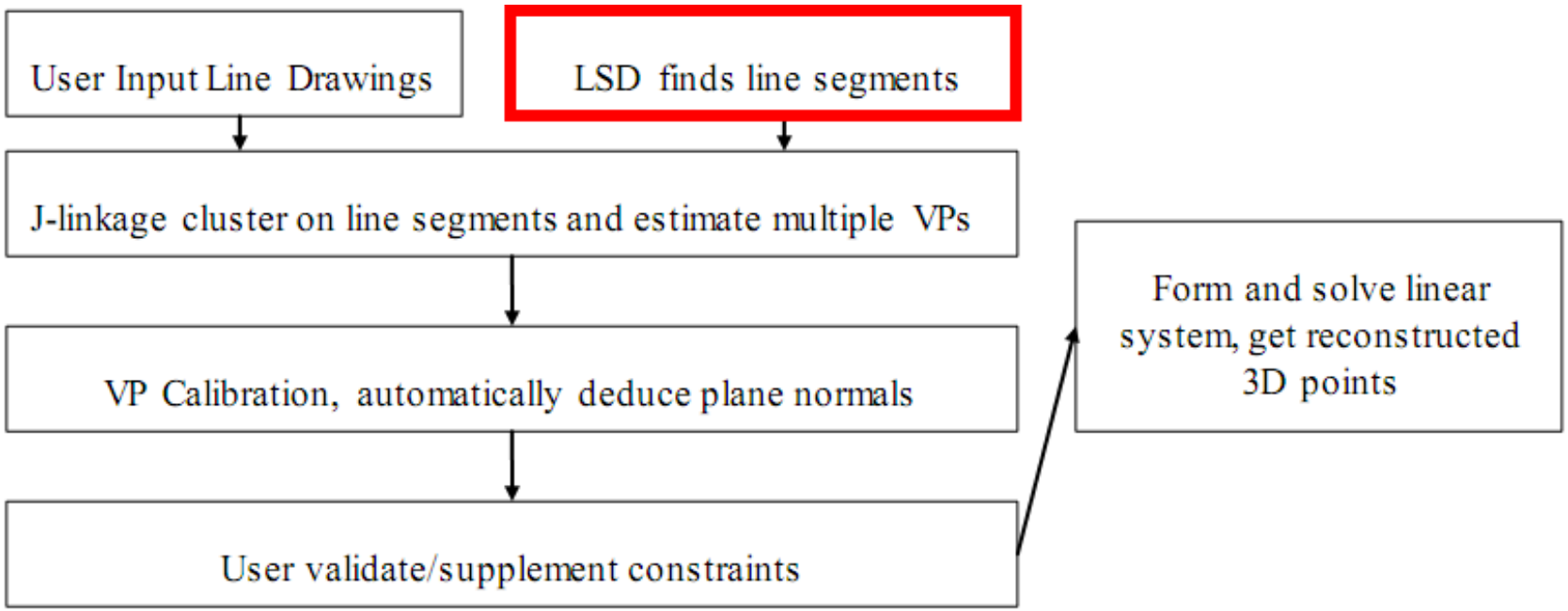

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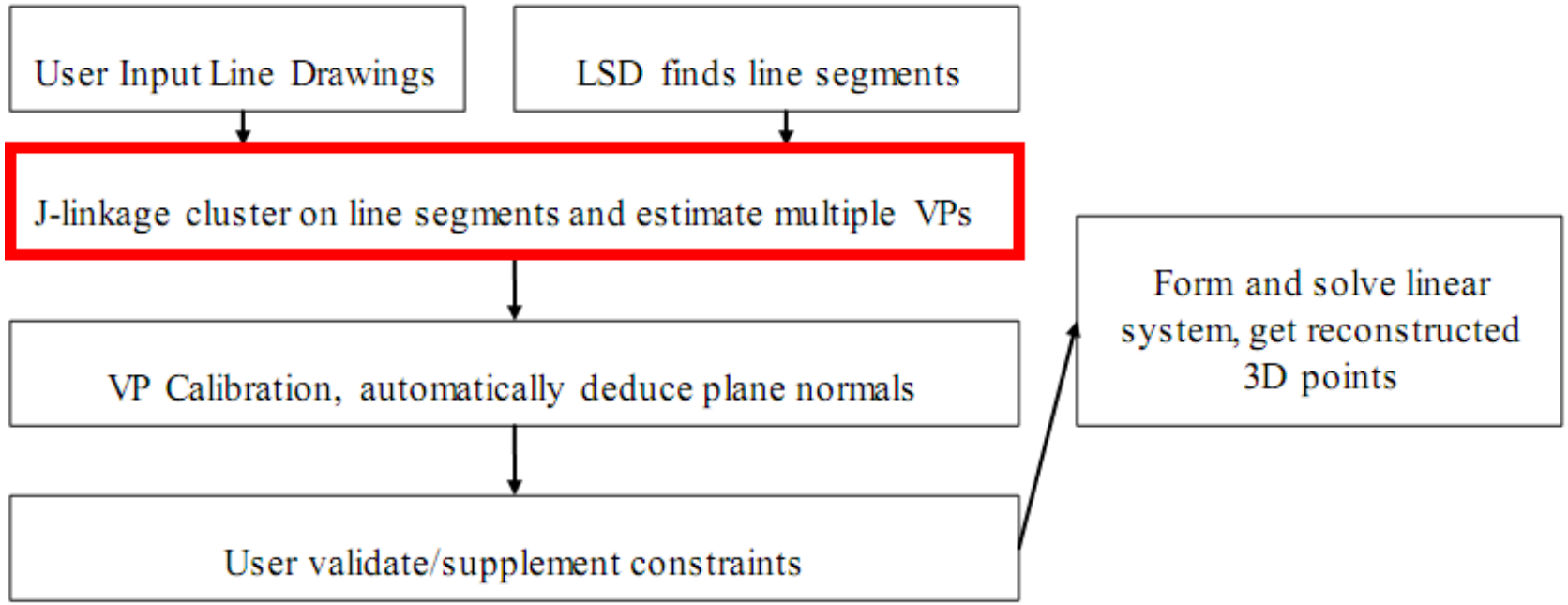

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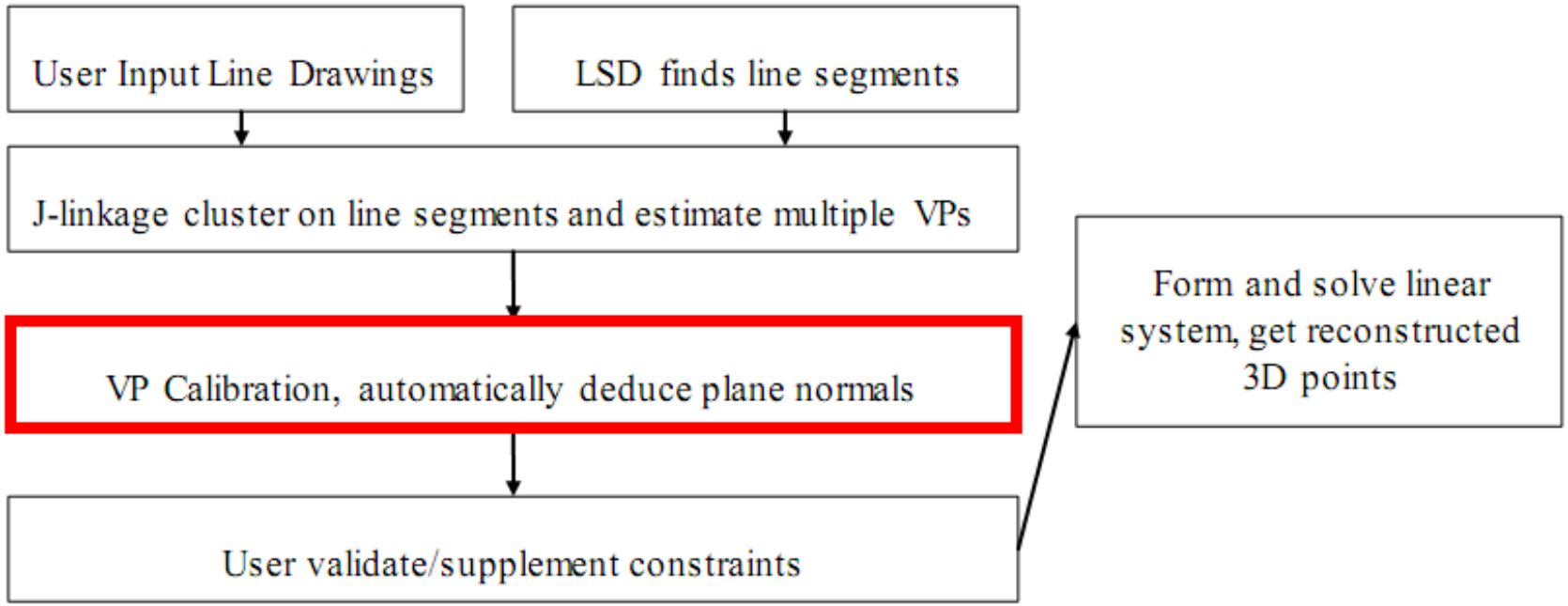

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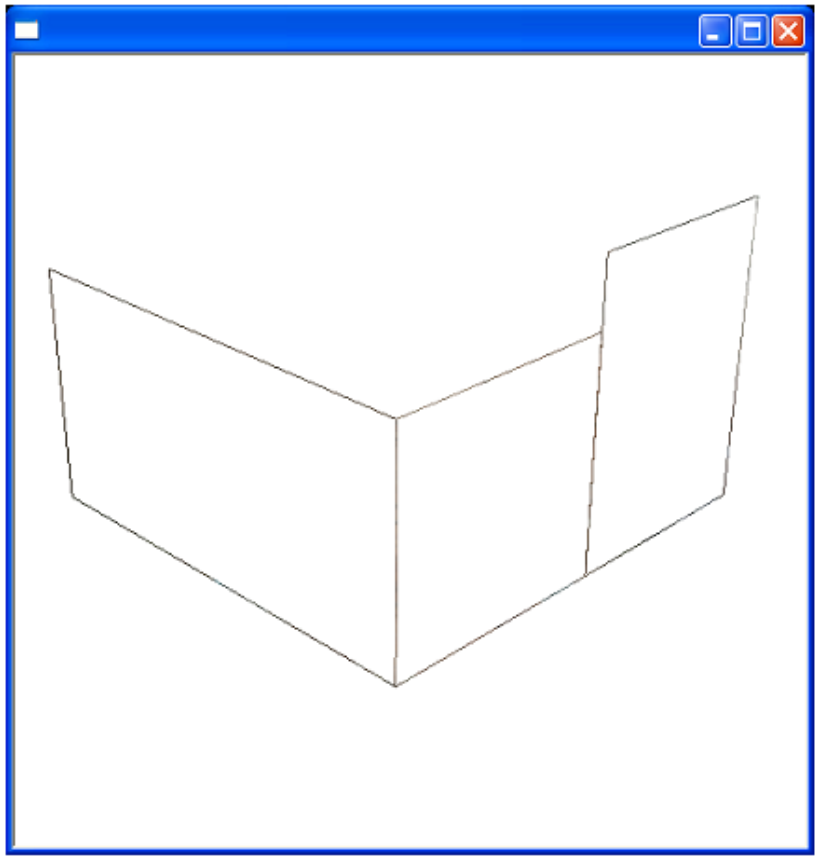

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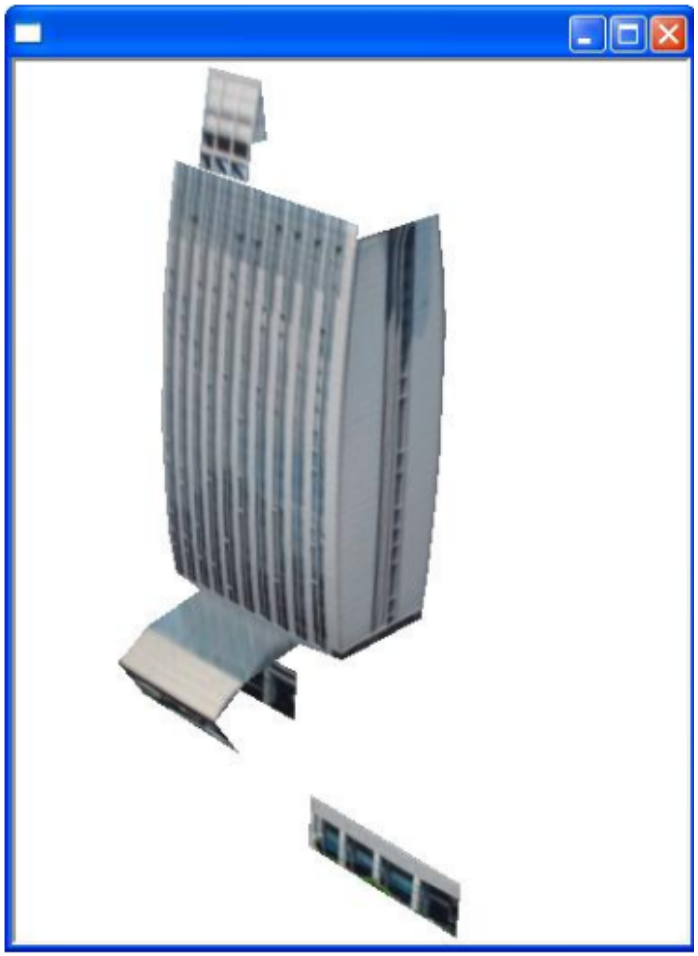

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Robotics

Visual Odometry

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Visual SLAM

Simultaneous Localization And Mapping

Cinematography

Match Moving

It is a synonym for AR in film-making, traditionally a post-processing techniques. Recently real-time product appears.

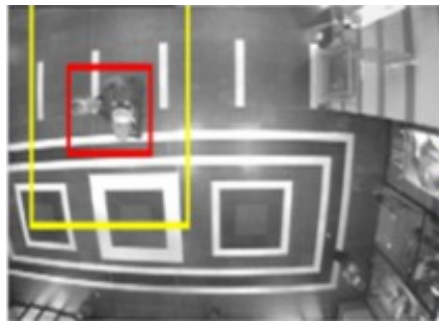
Surveillance

Video Tracking

The process of locating a moving object (or multiple objects) over time using a camera.

Two Major Components

- Target Representation and Localization
- Filtering and Data Association



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All Comes to Tracking ...

- The major issues lie within visual registration methods is tracking problem.
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    Split mapping and tracking in SLAM, in order to use bundle adjustment to increase accuracy
  - PhonySIFT
    - Modify SIFT and FERNS descriptor, make it faster and real-time
    - Even works in mobile platforms!

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Don't Put All Your Eggs in One Basket ...

- Why do we need data fusion?
  - Addendum data to improve precision & accuracy (noise, jitter)
  - Camera may lose track of features
  - Camera know nothing about the world (Relative to Absolute)

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  - IMU for movement
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- Algorithm to learn: Kalman Filter

Selected References

- Caprile, B. and Torre, V. (1990). "Using vanishing points for camera calibration." International Journal of Computer Vision, 4, 127-139.
- Sturm, P. and Maybank, S. J. (1999). "A method for interactive 3d reconstruction of piecewise planar objects from single images." British Machine Vision Conference, Nottingham, England, 1999.
- Daniel Wagner, Tobias Langlotz, Dieter Schmalstieg (2008), "Robust and Unobtrusive Marker Tracking on Mobile Phones", ISMAR
- Klein, G. and Murray, D. (2008), "Parallel tracking and mapping for small AR workspaces", ISMAR

Acknowledgement

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END

Thank You!
Any Questions?