Simple 3D Reconstruction of Single Indoor Image with Perspective Cues

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Problem Statement

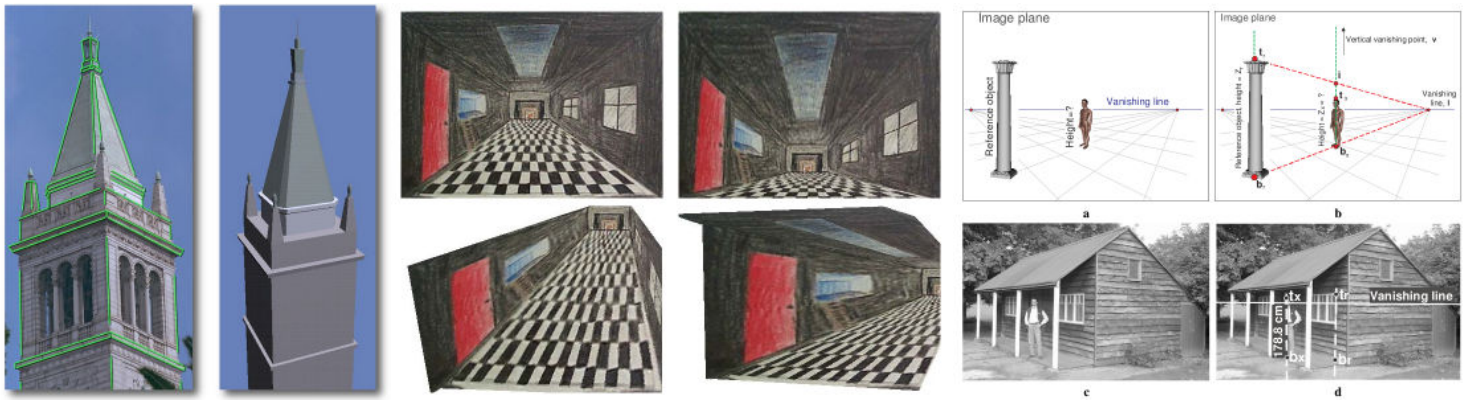
Some Image-Based Modeling Methods:

- Reconstruct from different views (e.g. space carving)
- Reconstruct from single view with different lighting (e.g. photometric methods)
- Reconstruct using visual cues (e.g. stereo vision and motion)

3D Reconstruction from a single image is a difficult problem since we have very limited information.

Previous Work: Methods With Assistance from Users

- Facade by Debevec
- Tour Into the Picture by Youichi et al.
- Single View Metrology by Criminisi



Previous Work: Automatic methods

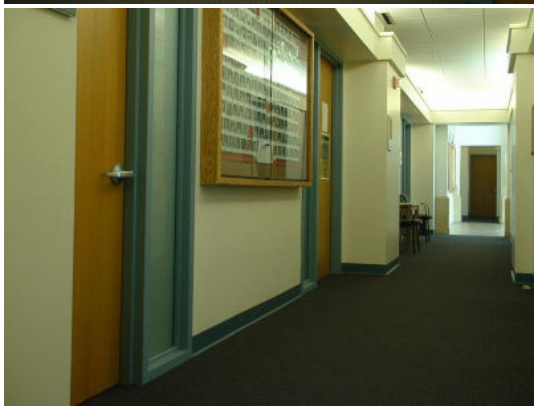
- Automatic TIP by Boulanger
- Photo Pop-up by Hoeim
- Vanishing point detection using Bayesian network
- Markov random field by Delage et al.

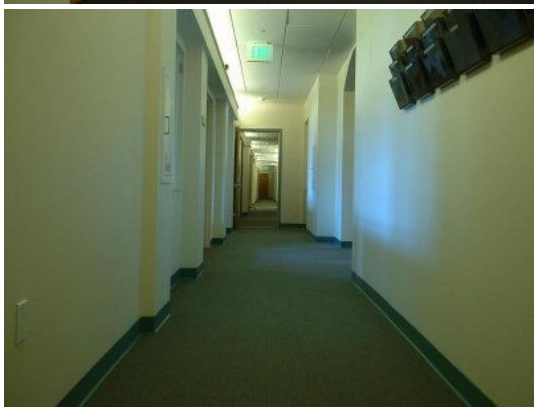
Our Goal

- Focus on specific class of images
- Reconstruct basic geometry
- Emphasis on speed and simplicity

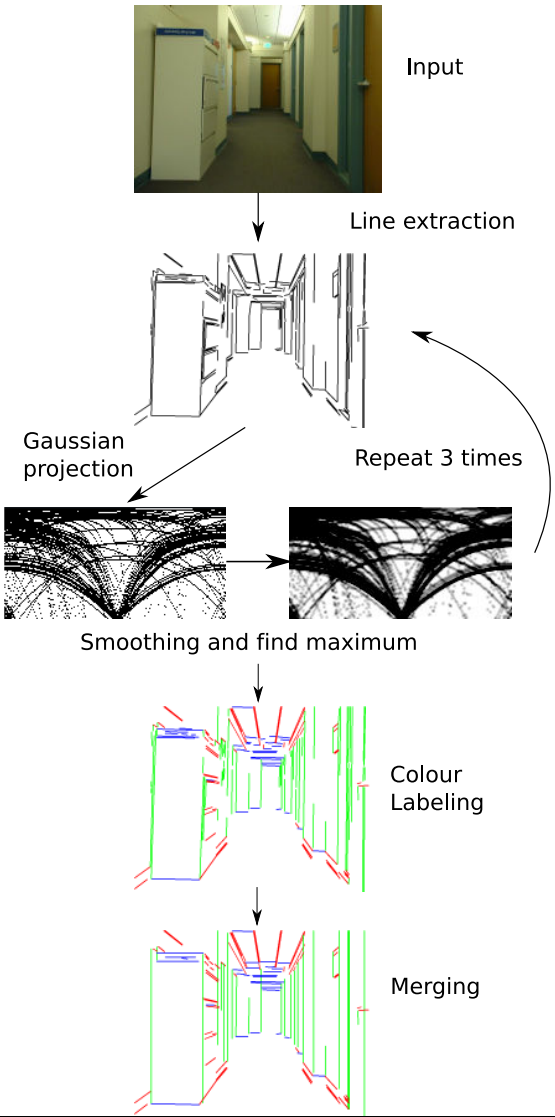
Assumptions

- One-point perspective indoor images consist of orthogonal planes.
- Presence of floor, ceiling, and walls.
- Well-composed images.





Vanishing Point Detection

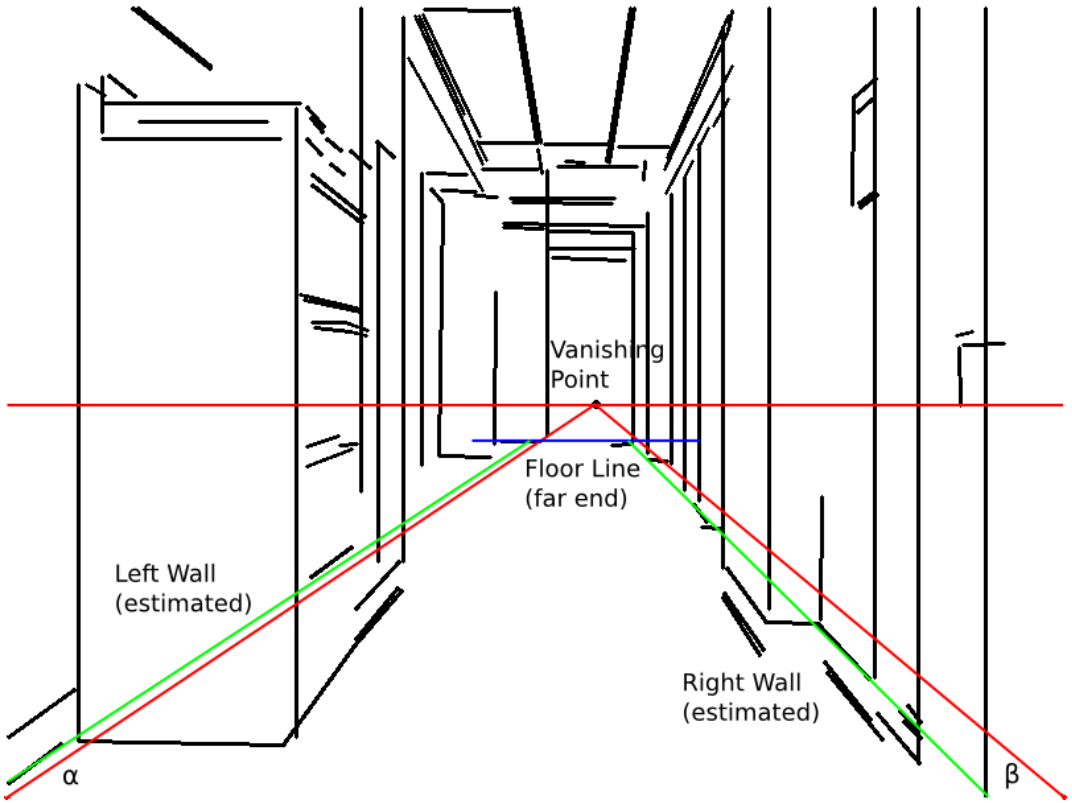


Workflow

1. Canny edge detector
2. Gaussian hemisphere projection
3. Labeling based on vanishing points
4. Merging excessive lines

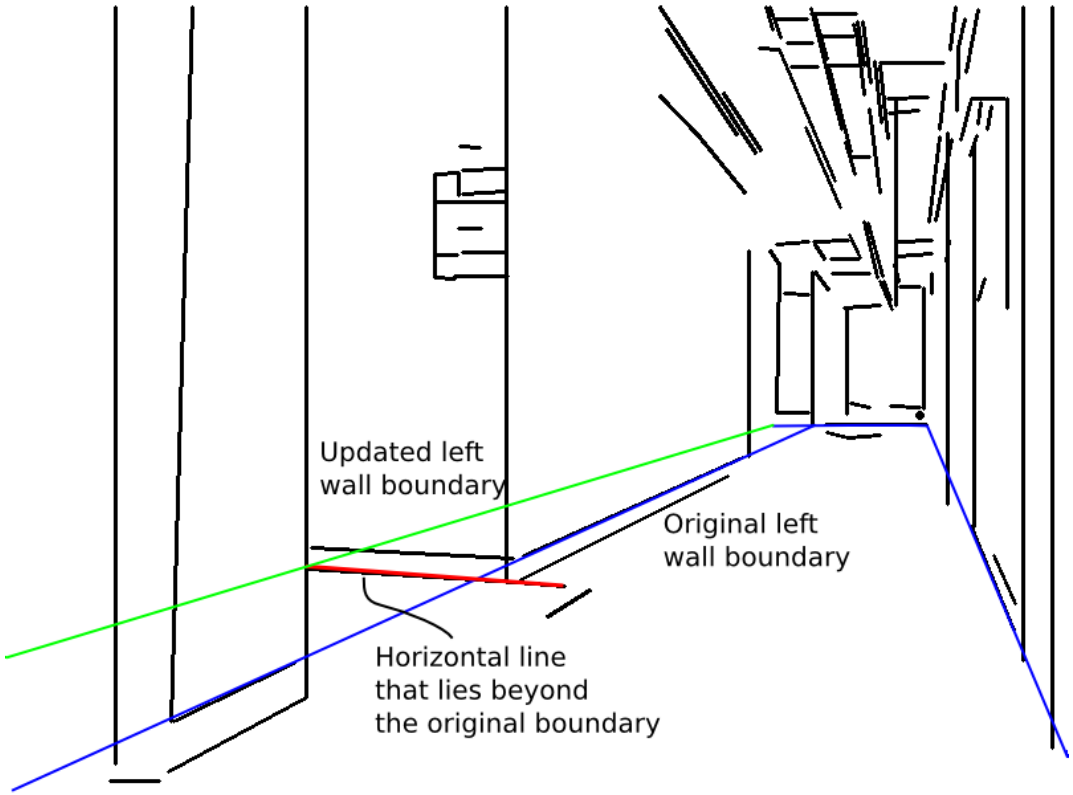
Floor Detection

- Vanishing point marks horizon.
- Horizon and lower corners of the image define a search range for floor boundaries.



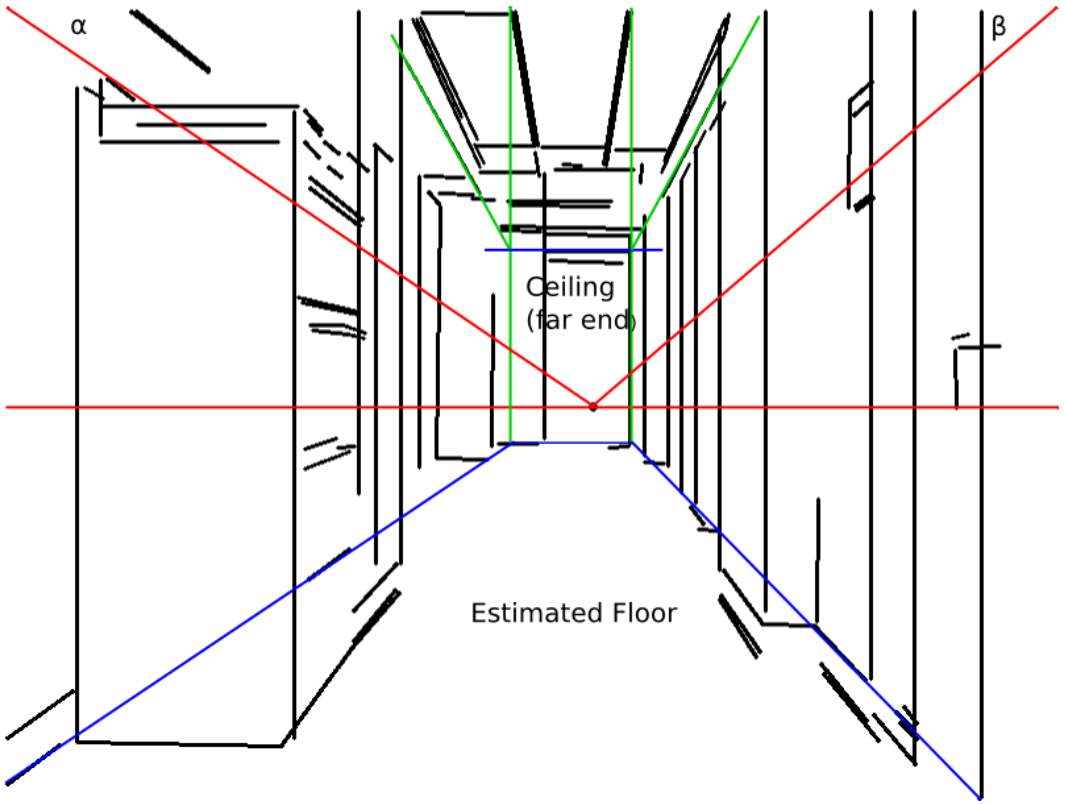
Floor Detection

- Update boundaries after the initial estimation.



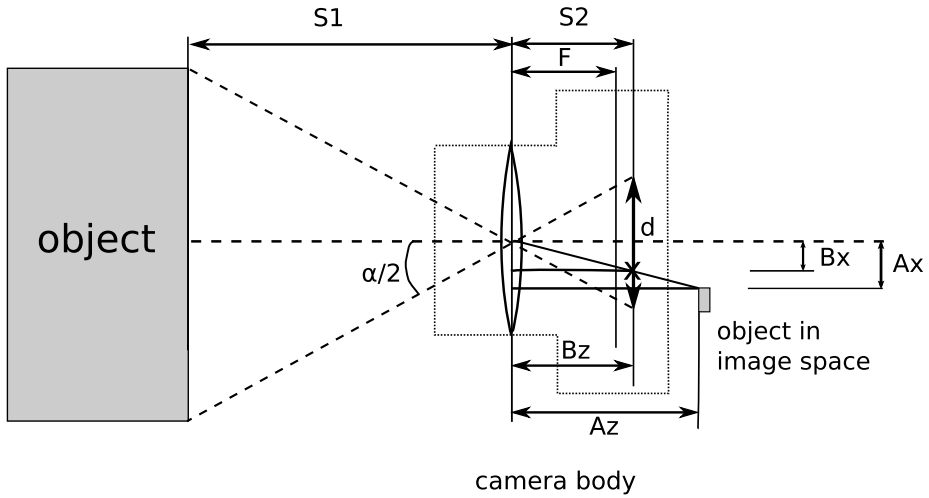
Ceiling Detection

- Horizon and upper corners define a search range for ceiling boundaries.
- User floor boundaries to locate end points of ceiling boundaries.



Focal Length and Room Size

- Approximate the focal length using the optics of photography
- F $\approx$ diagonal size of the photograph



$$\frac{1}{F} = \frac{1}{S_1} + \frac{1}{S_2}$$

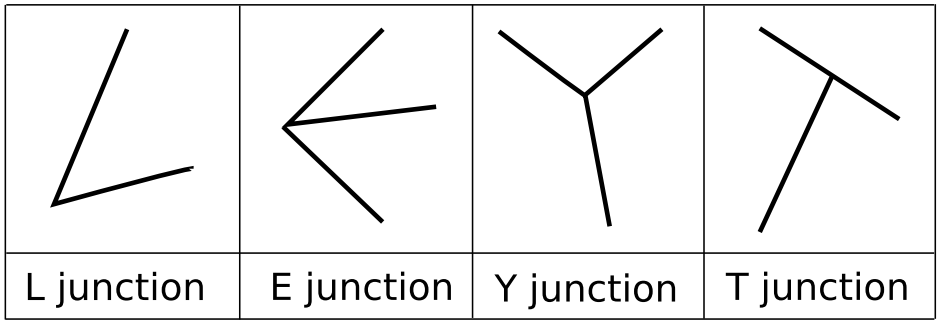
$$S_1 >> S_2$$

$$\frac{B_x}{A_x} = \frac{B_z}{A_z}$$

Multi-pass Junction Point Detection

Junction Points

- A junction point is a good indicator of the orientation of flat surfaces.
- Too many junction points and missing ones in the image.

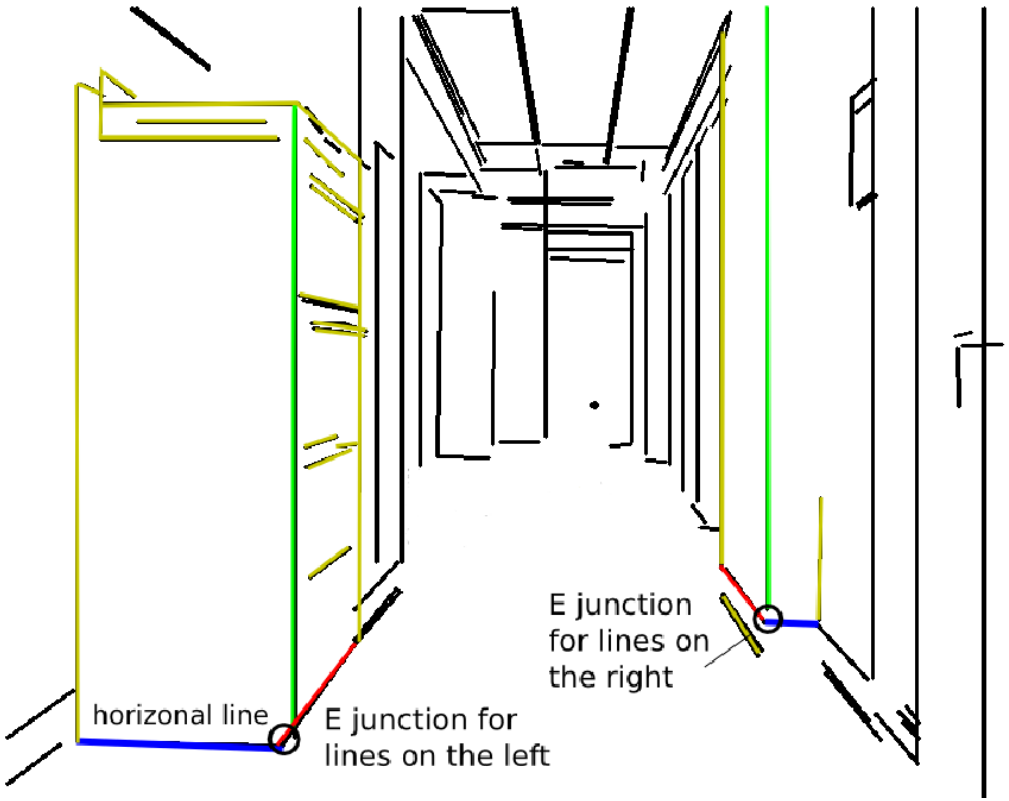


Divide and Conquer

- Process easy cases first
- Remove processed lines
- Infer missing lines

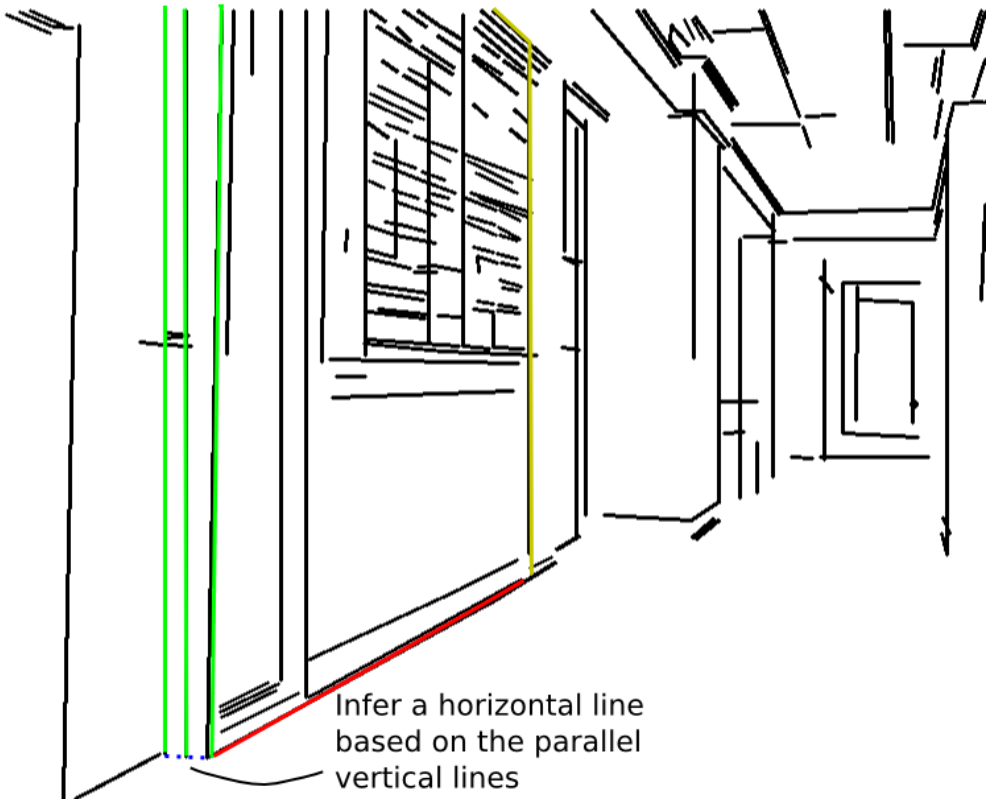
First Pass

- Scan horizontal lines on the floor.
- Focus on E junctions.
- Trace L junctions that can become E junctions.



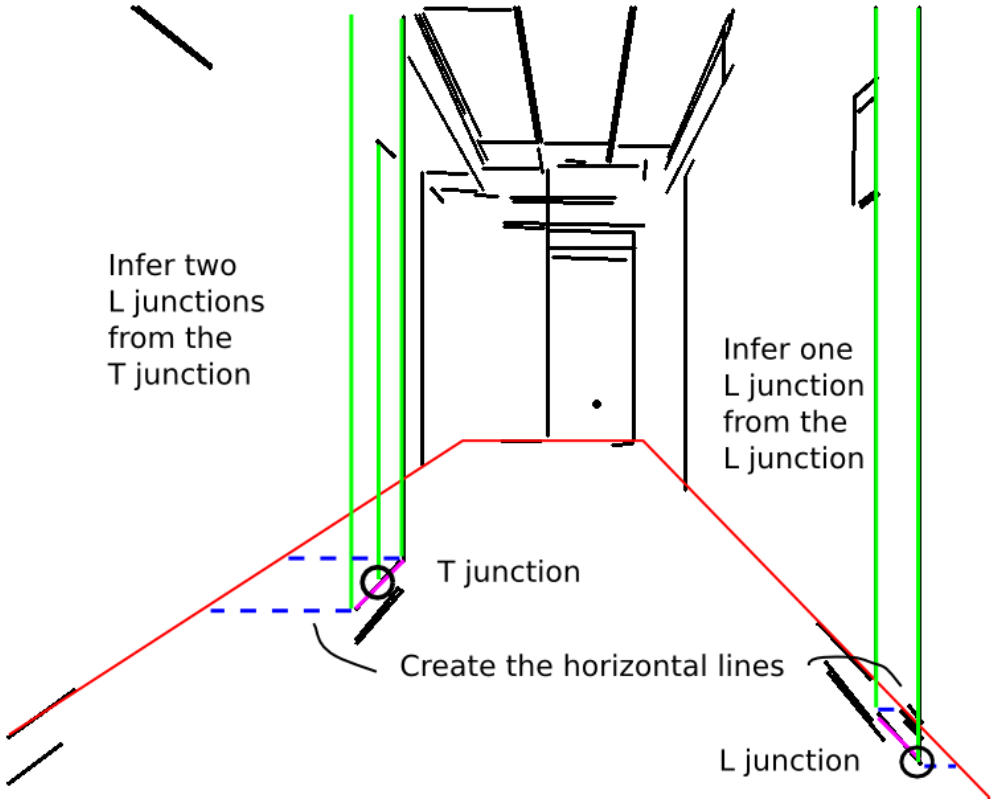
Second Pass

- Sometimes the edge detector would miss horizontal lines.
- We can only infer certain ones.
- Repeat the first pass after adding the inferred lines.



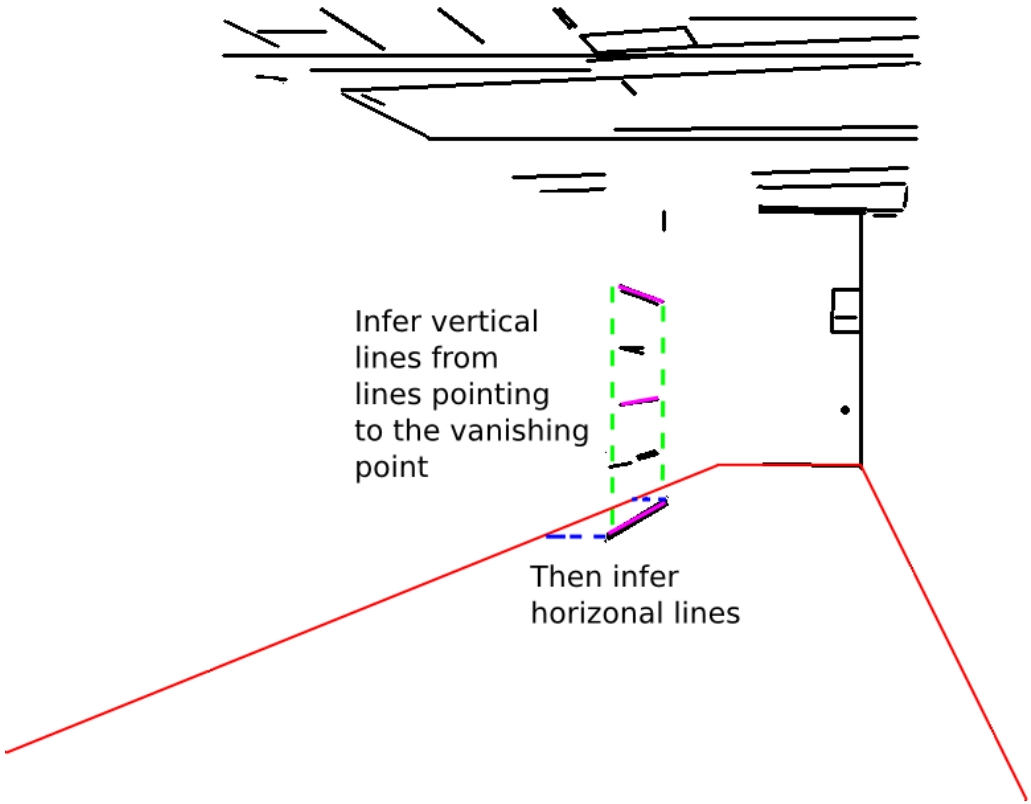
Third Pass

- No horizontal line on the floor in this pass.
- Scan vertical lines on the floor to find L junctions.
- T junctions can also be formed because we removed lines in previous passes.



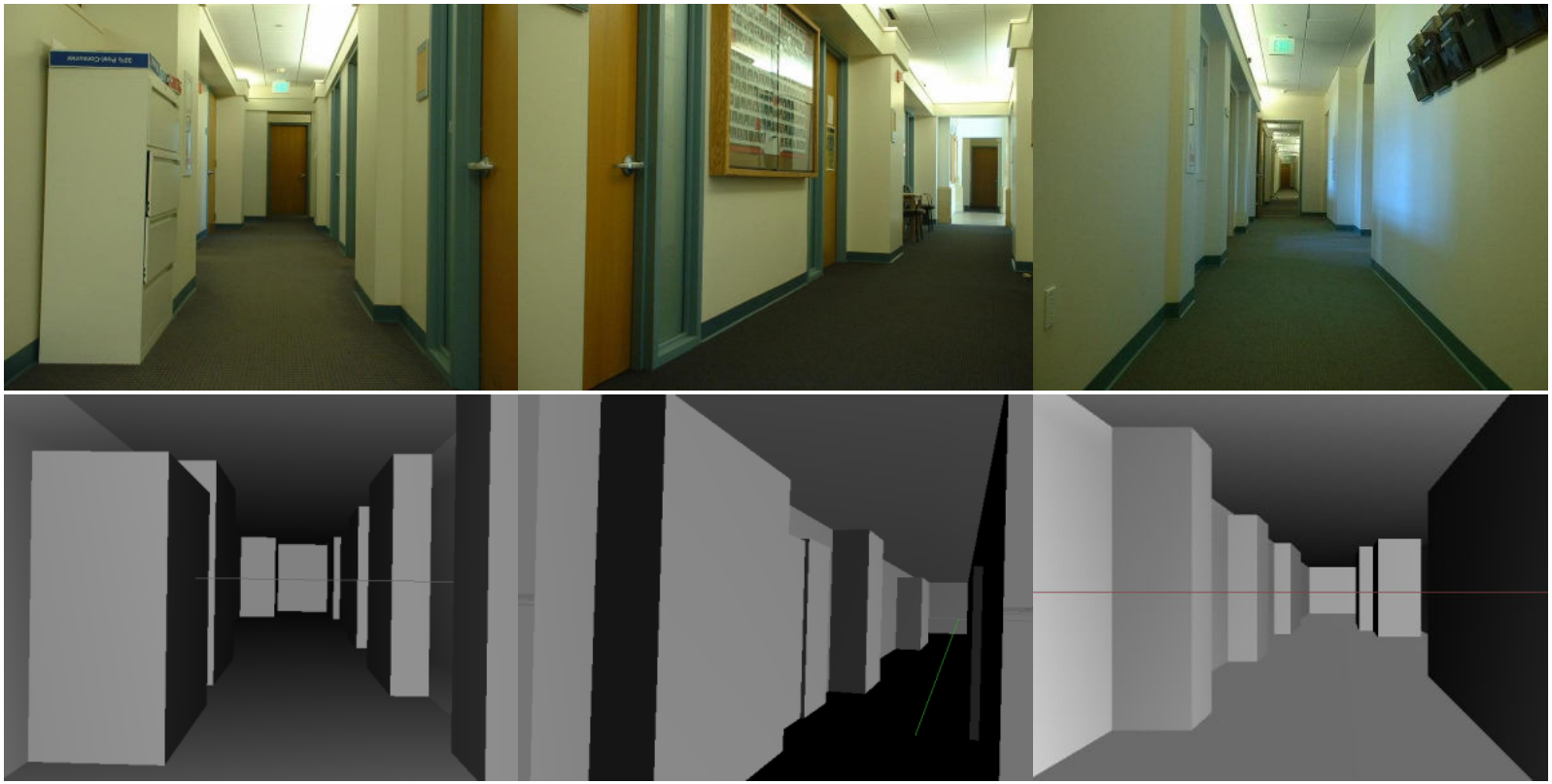
Fourth Pass

- On the floor only lines pointing to the vanishing point are left.
- We may miss some vertical lines because of edge detector and line removal.
- We can infer some vertical lines.



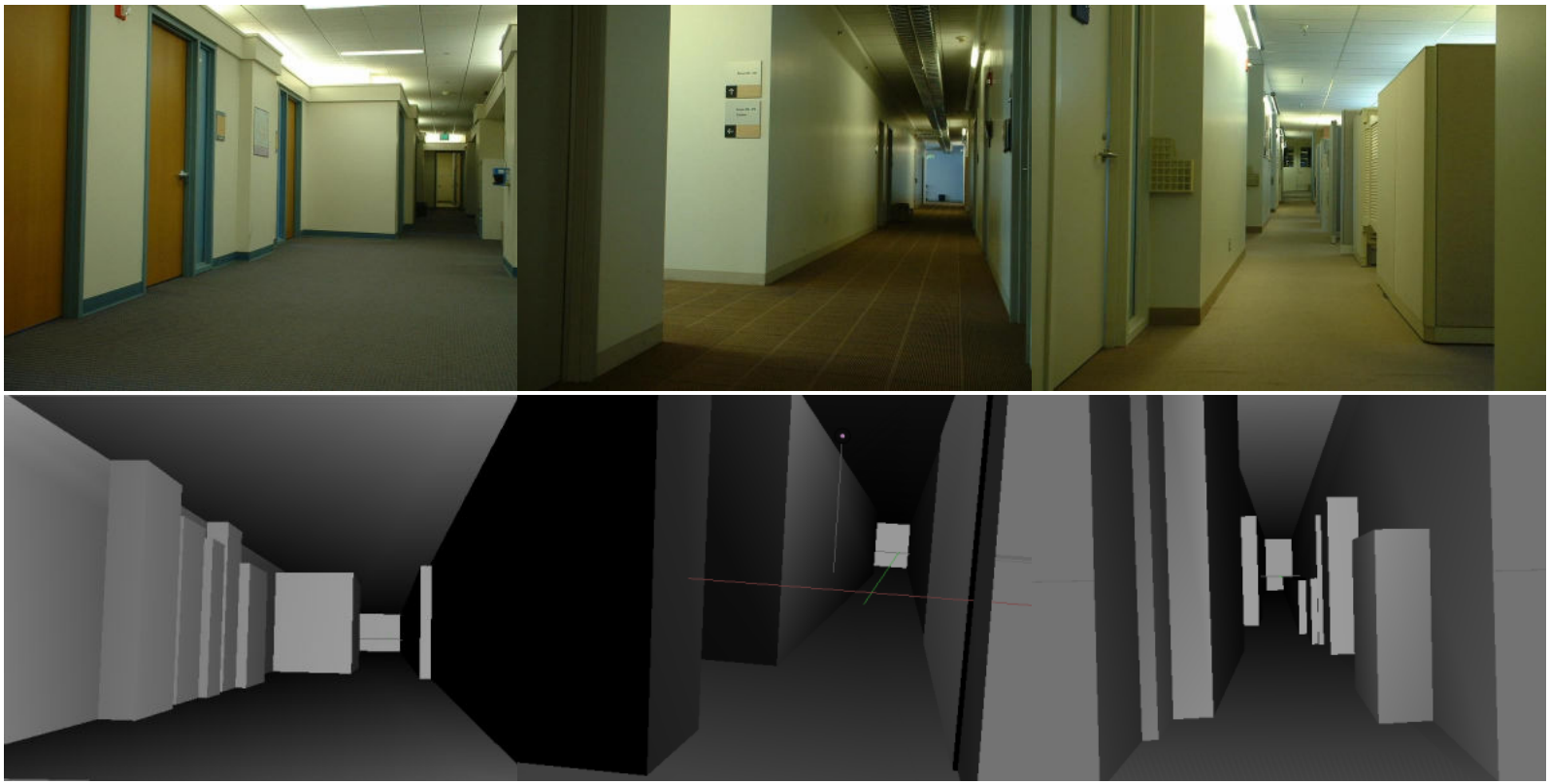
Results and Conclusions

- Smooth and complete structure given the presence of floor, ceiling, and walls.
- Simple to implement and fast to run (2-3 milliseconds per line segment).



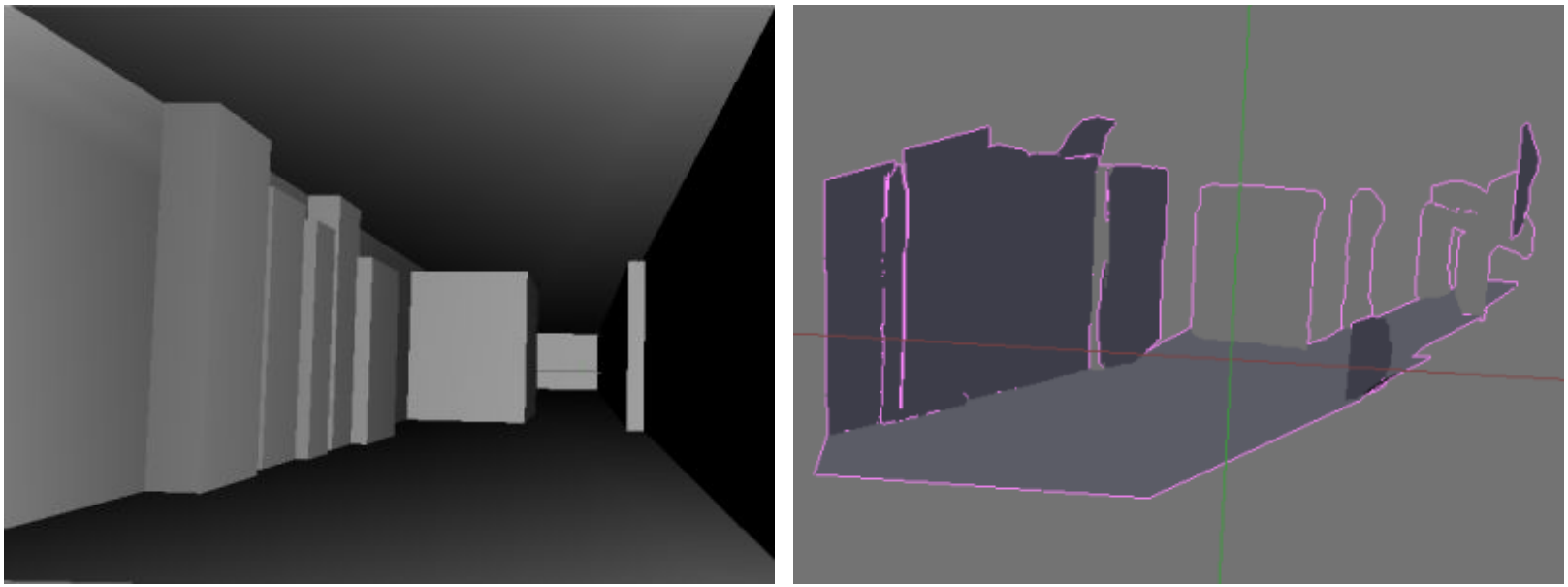
Results and Conclusions

- The result however is not accurate due to the amount of estimation involved.



Comparisons

- The reconstructed models are continuous because we make strong assumptions about the input.

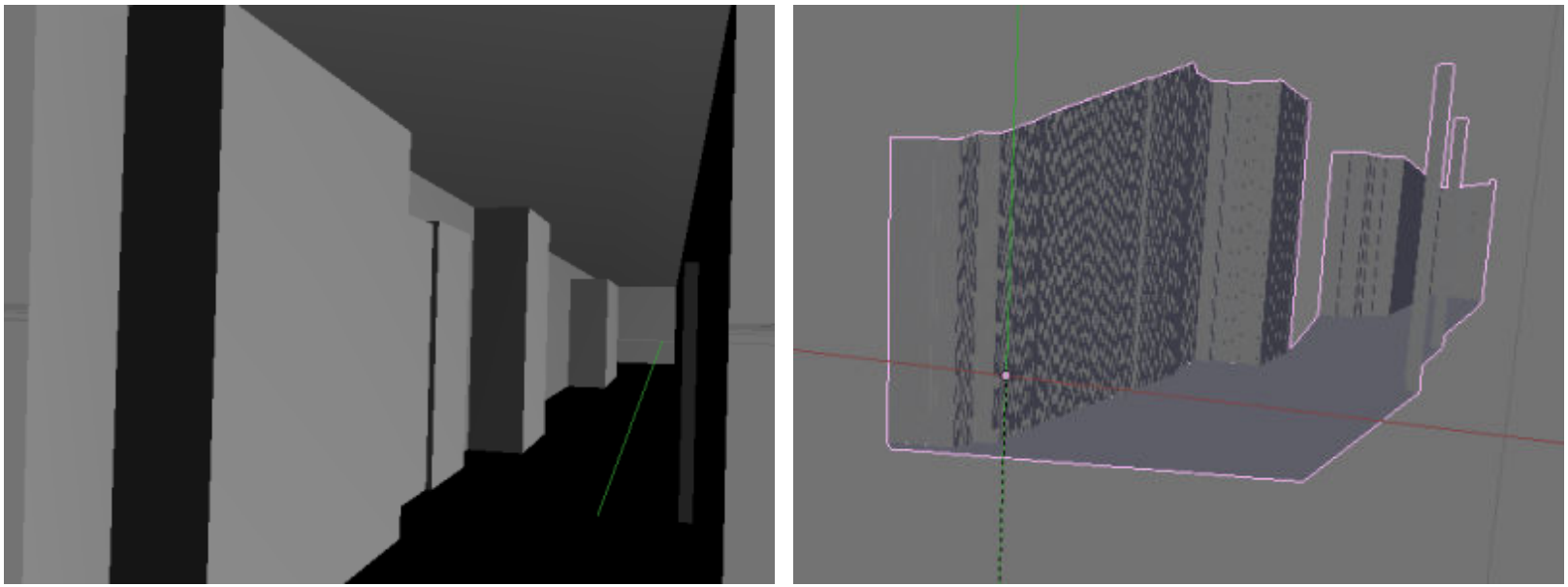


(a) (b)

Figure: Compared with Markov Random Field Method

Comparisons

- Our models don't require complex mesh representation, and have no missing ceiling or wall.



(a) (b)

Figure: Compared with Dynamic Bayesian Network Method

Thank you!
Questions?

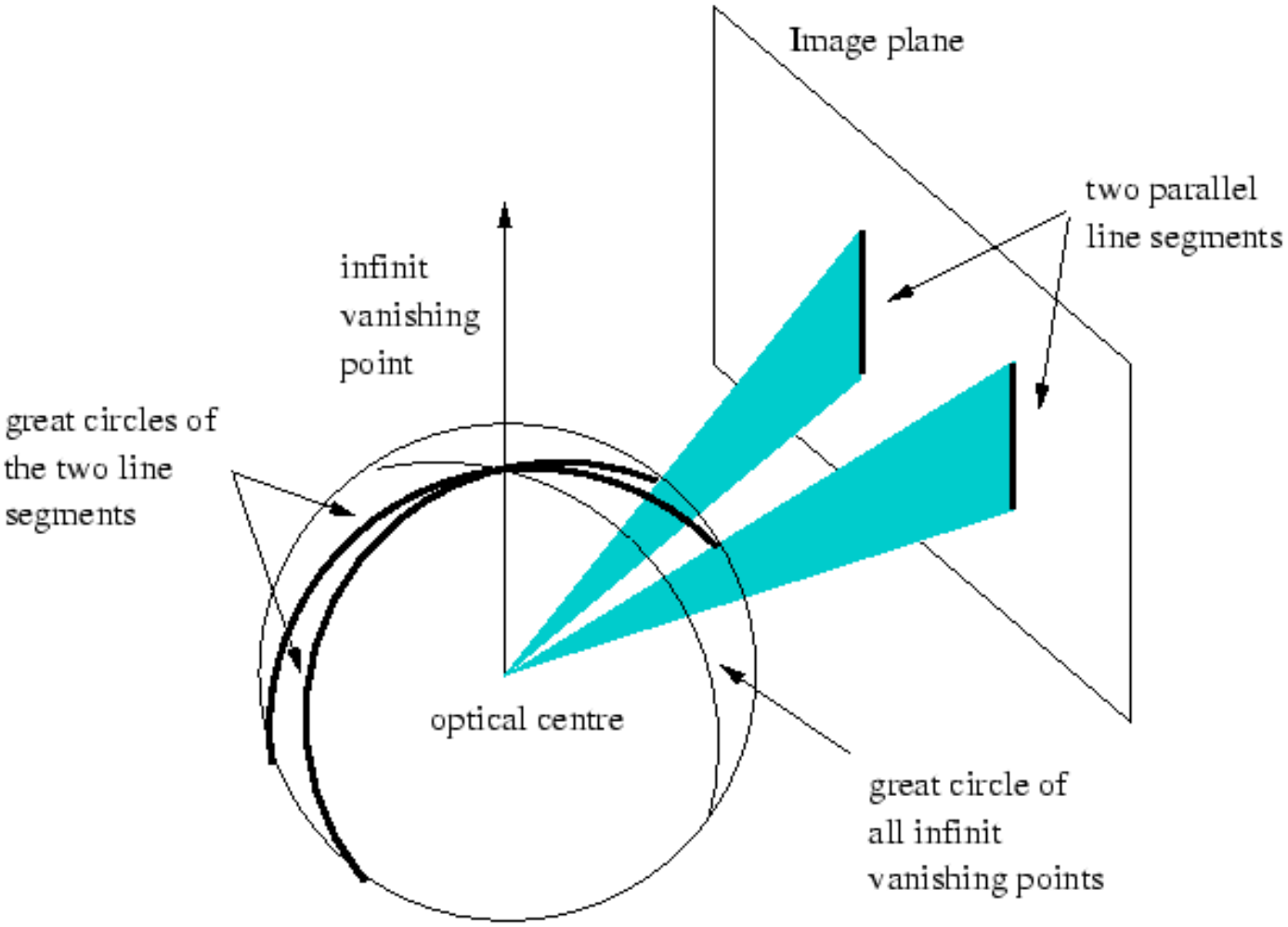


Image plane
two parallel
line segments
infinit
vanishing
point
great circles of
the two line
segments
optical centre
great circle of
all infinit
vanishing points