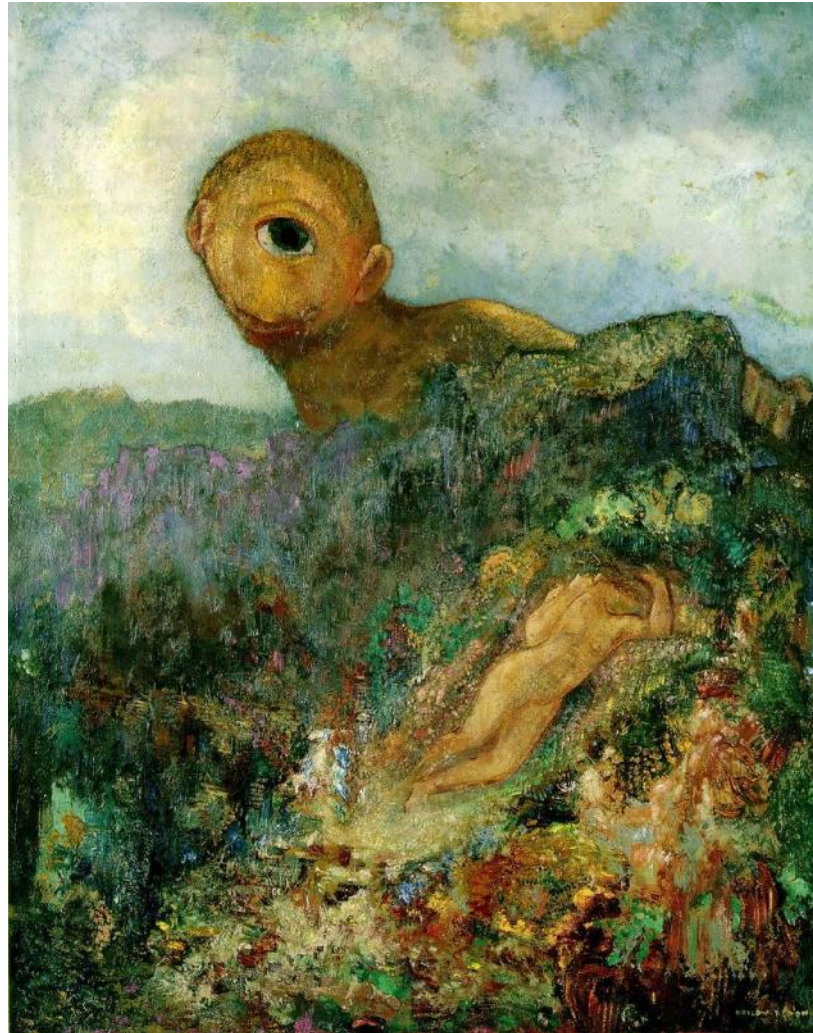


# More Single View Geometry

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*Cyclops* Odilon Redon 1904

CS194: Image Manipulation & Computational Photography

*...with a lot of slides stolen  
from Steve Seitz*

Alexei Efros, UC Berkeley, Fall 2014

# Automatic Photo Pop-up



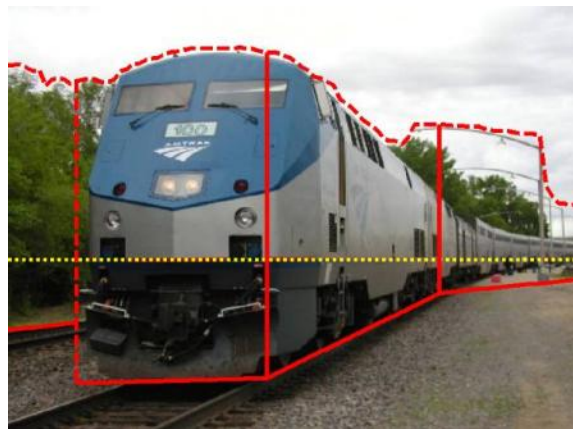
Original Image



Geometric Labels



Fit Segments



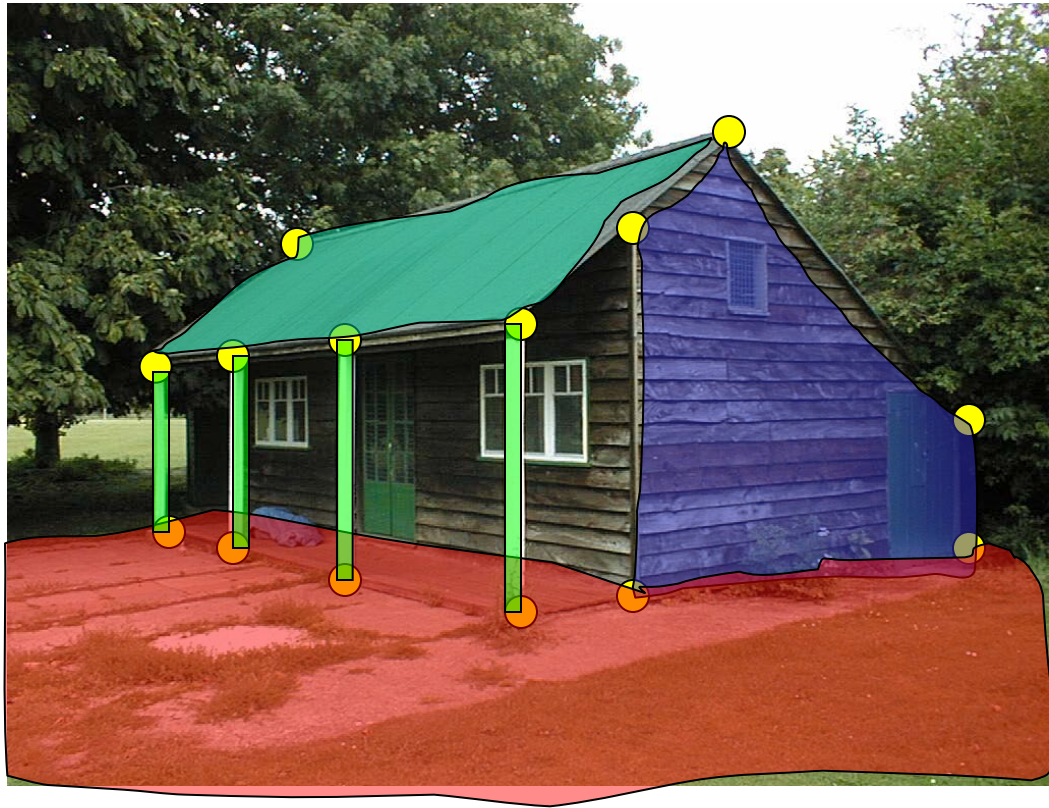
Cut and Fold



Novel View

# How can we model more complex scene?

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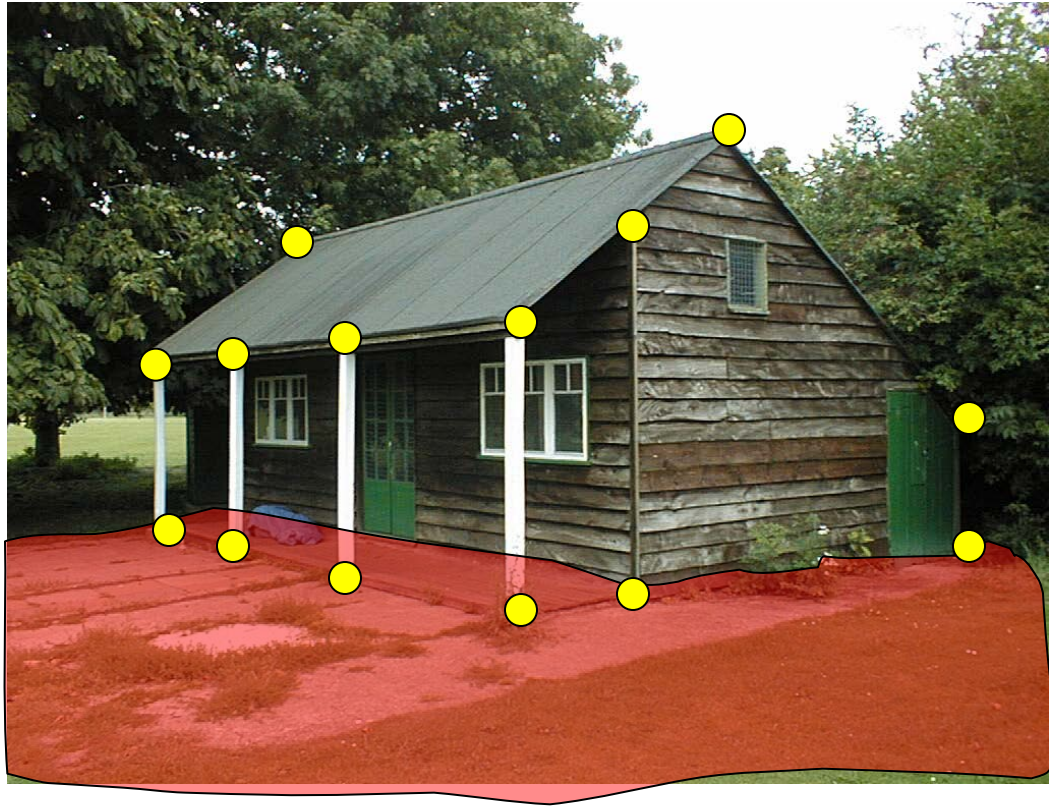


1. Find world coordinates  $(X, Y, Z)$  for a few points
2. Connect the points with planes to model geometry
  - Texture map the planes



# Finding world coordinates (X,Y,Z)

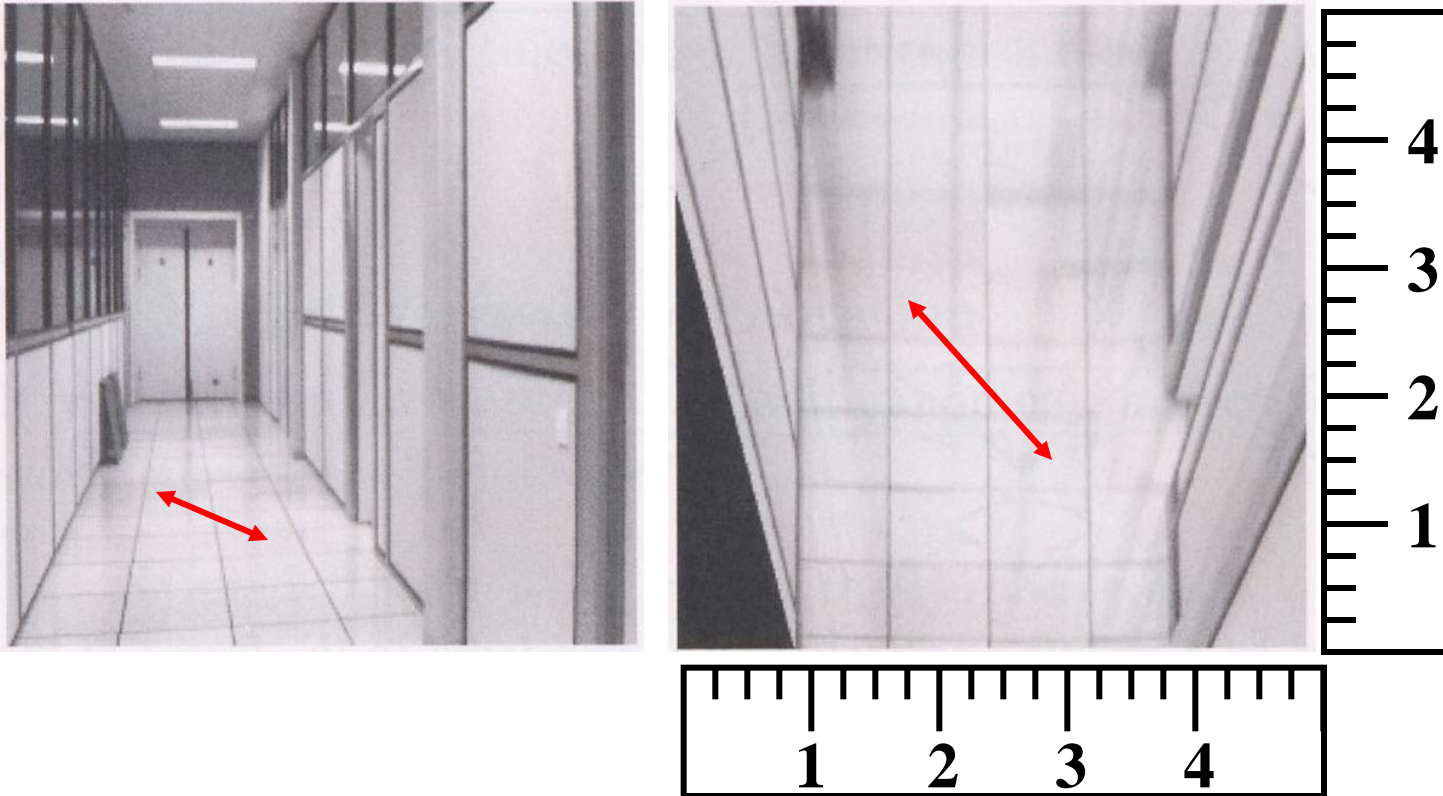
---



1. Define the ground plane ( $Z=0$ )
2. Compute points  $(X, Y, 0)$  on that plane
3. Compute the *heights*  $Z$  of all other points

# Measurements on planes

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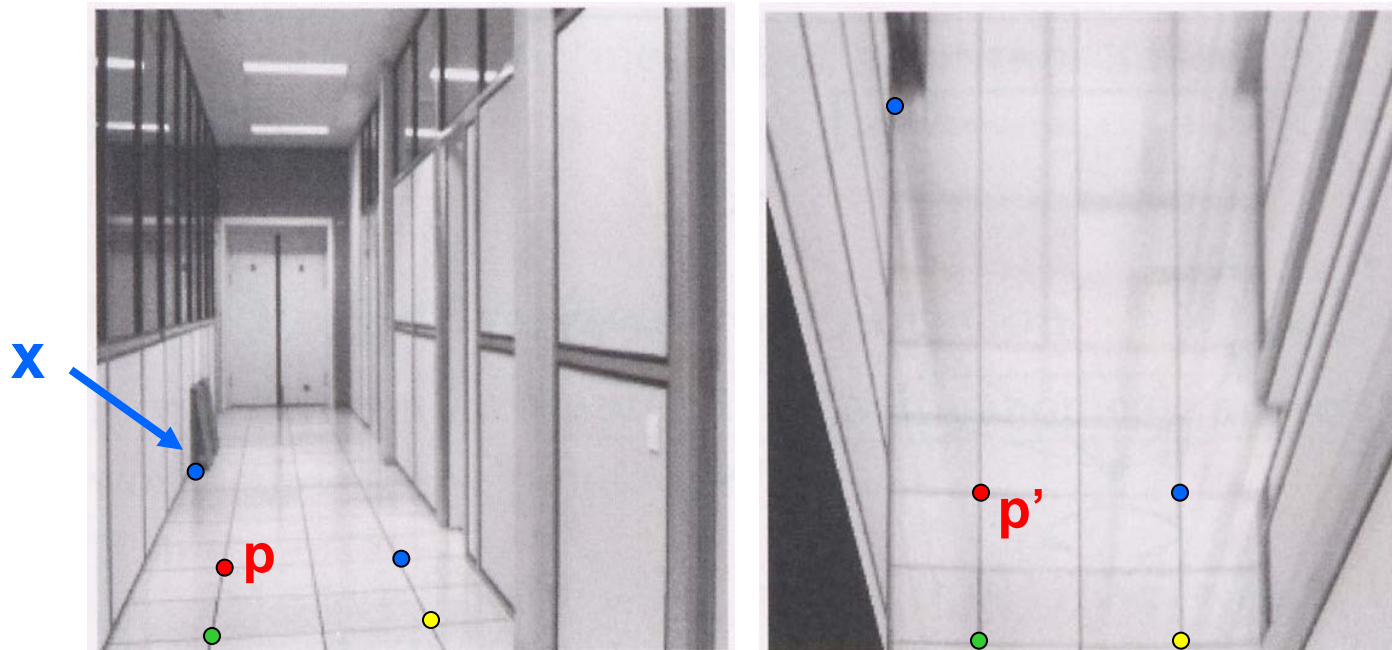


Approach: unwarp, then measure

What kind of warp is this?

# Unwarp ground plane

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Our old friend – the homography

Need 4 reference points with world coordinates

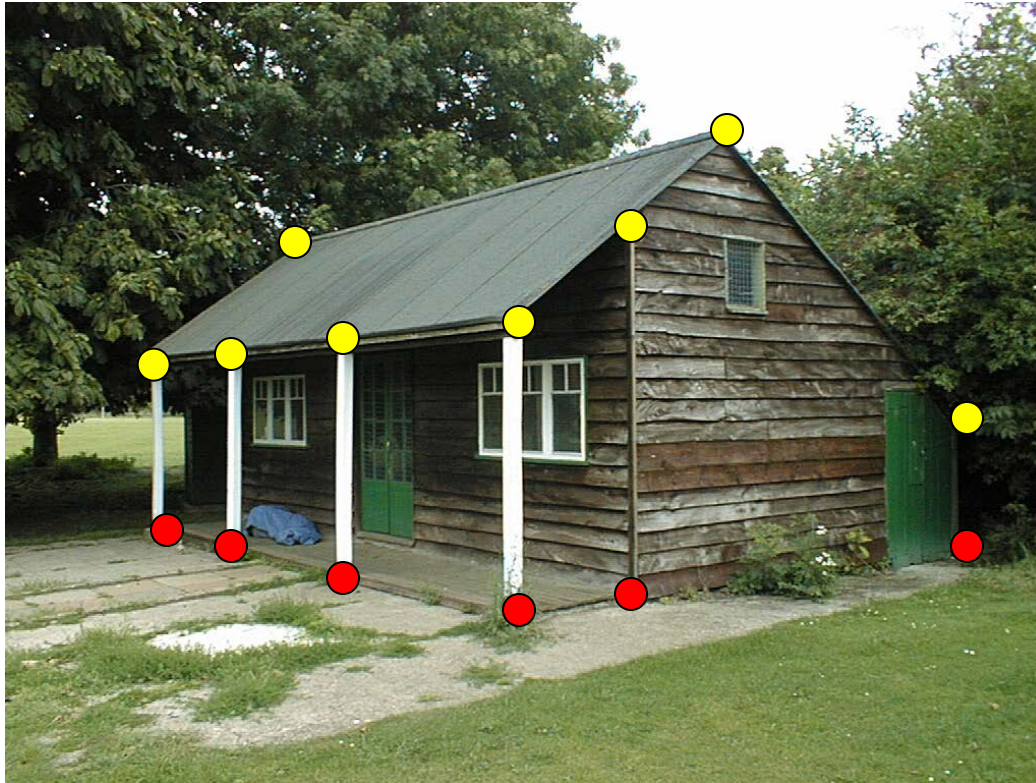
$$p = (x, y)$$

$$p' = (X, Y, 0)$$



# Finding world coordinates (X,Y,Z)

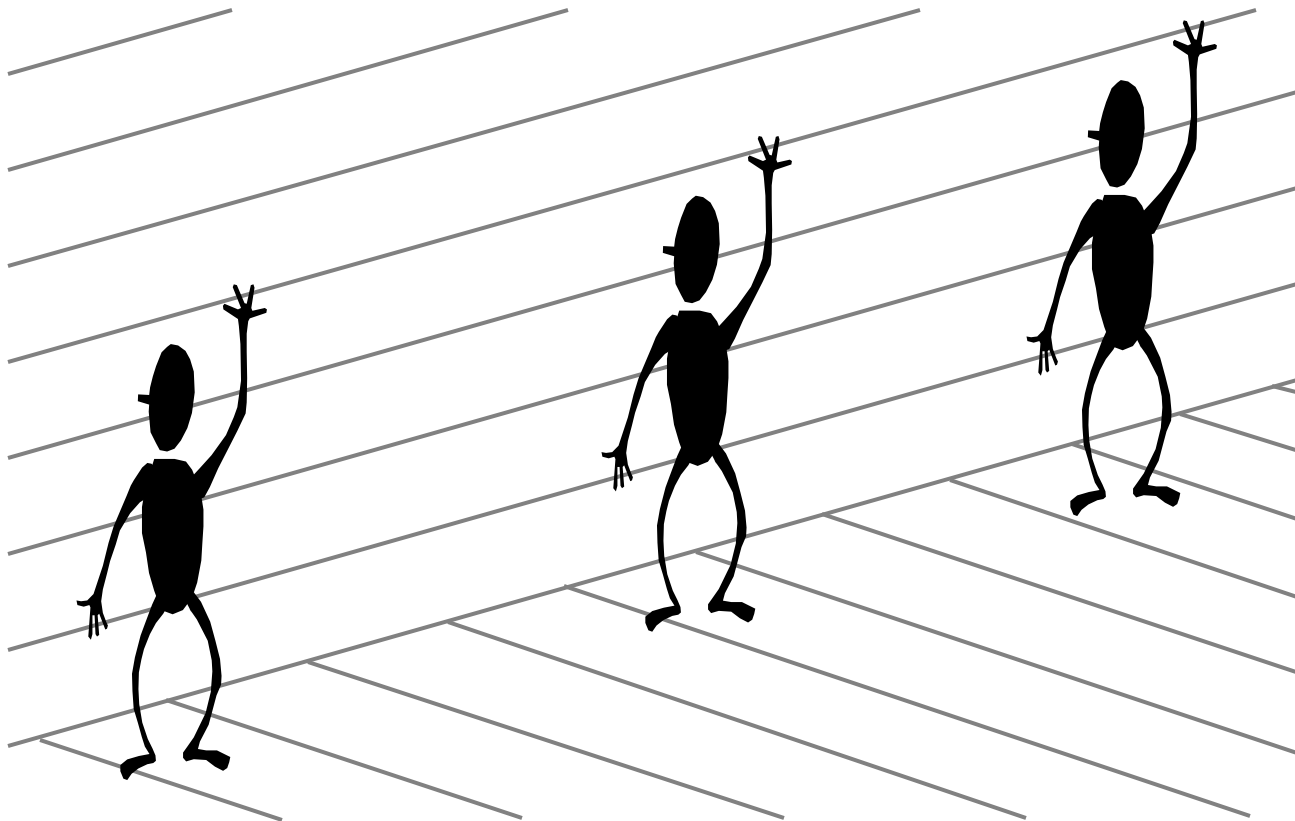
---



1. Define the ground plane ( $Z=0$ )
2. Compute points  $(X,Y,0)$  on that plane
3. Compute the *heights*  $Z$  of all other points

# Comparing heights

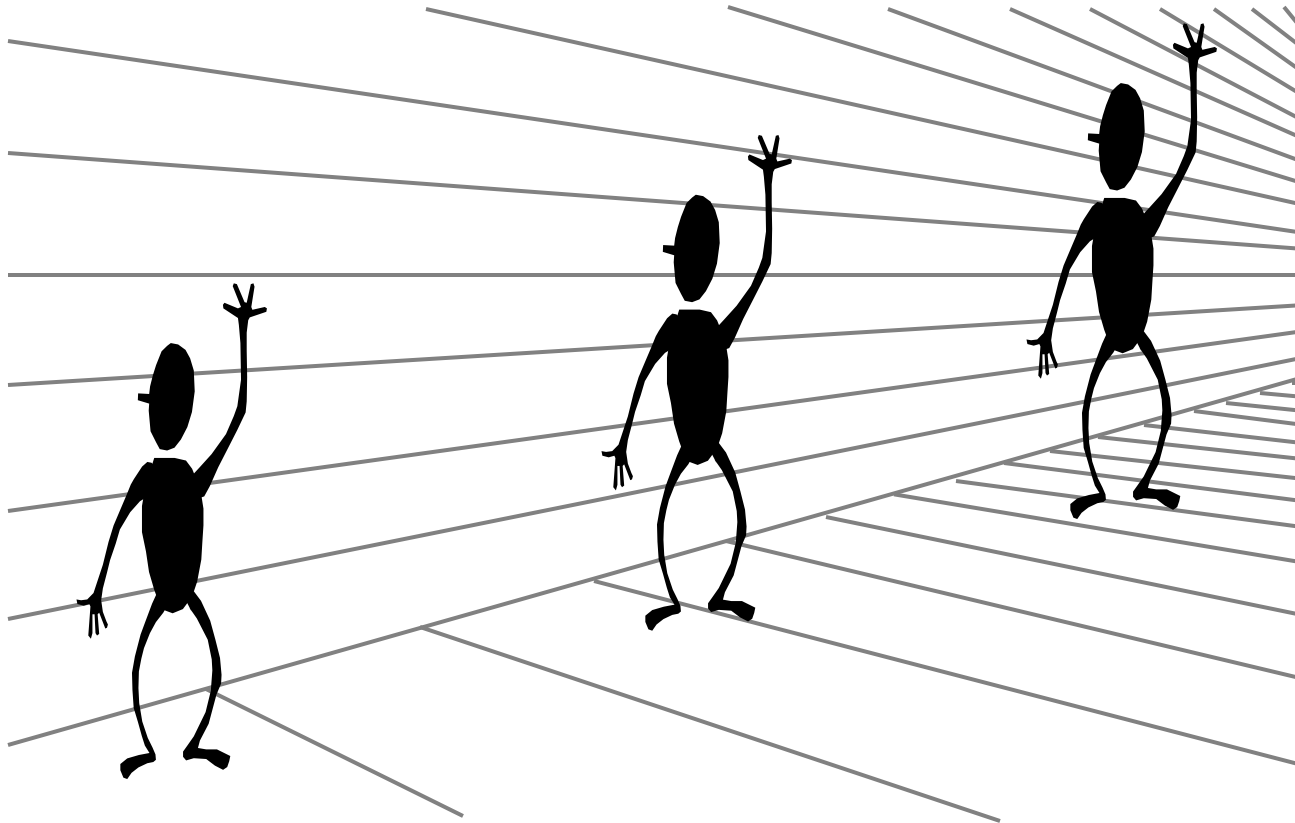
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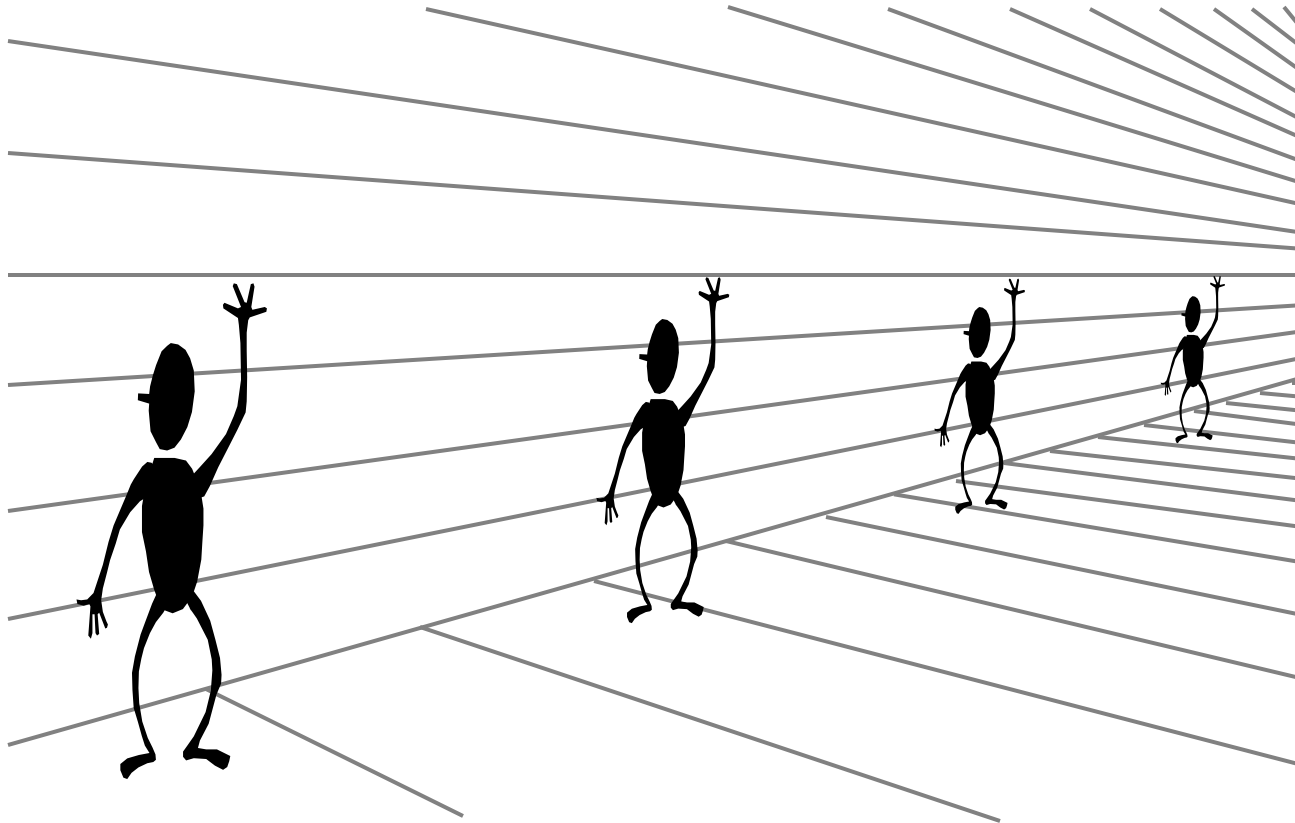
# Perspective cues

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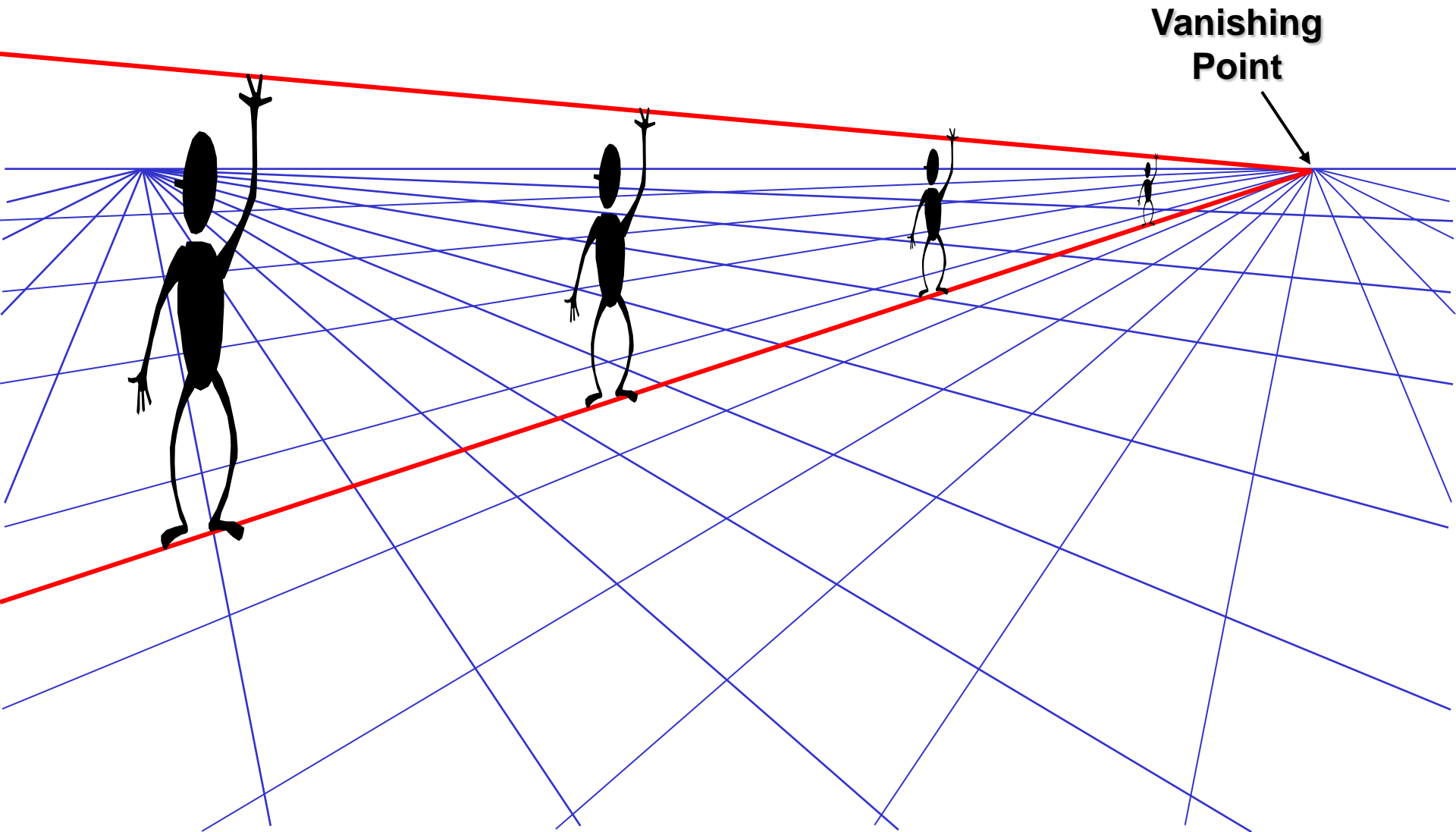
# Perspective cues

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# Comparing heights

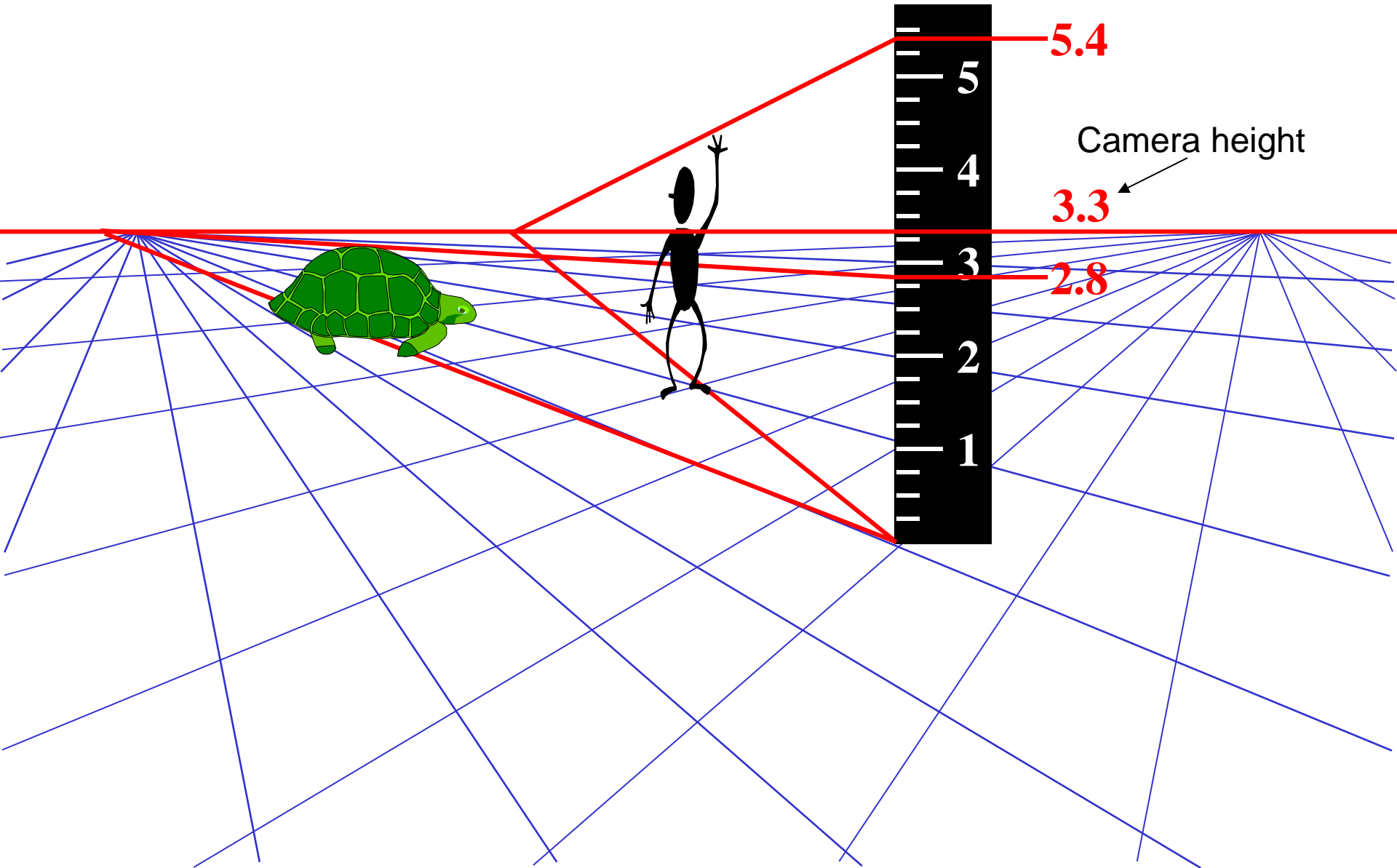
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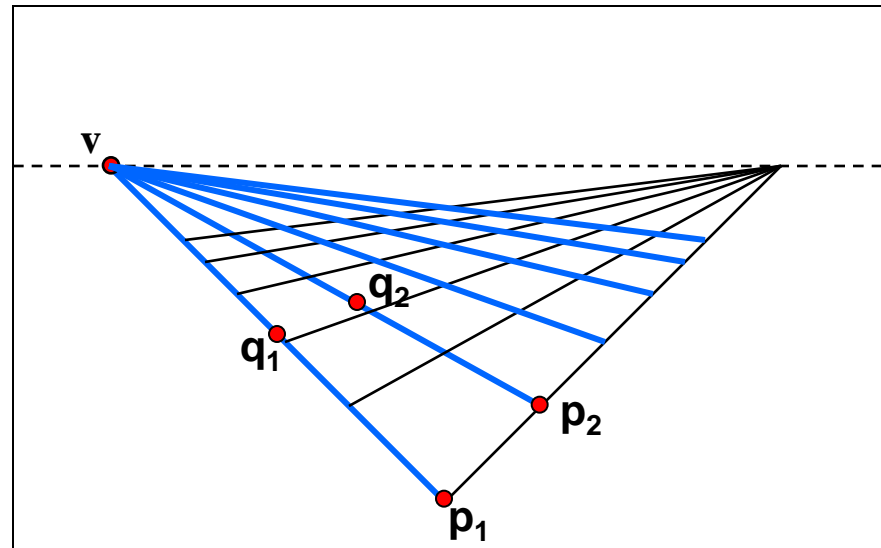
# Measuring height

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# Computing vanishing points (from lines)

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Intersect  $p_1q_1$  with  $p_2q_2$

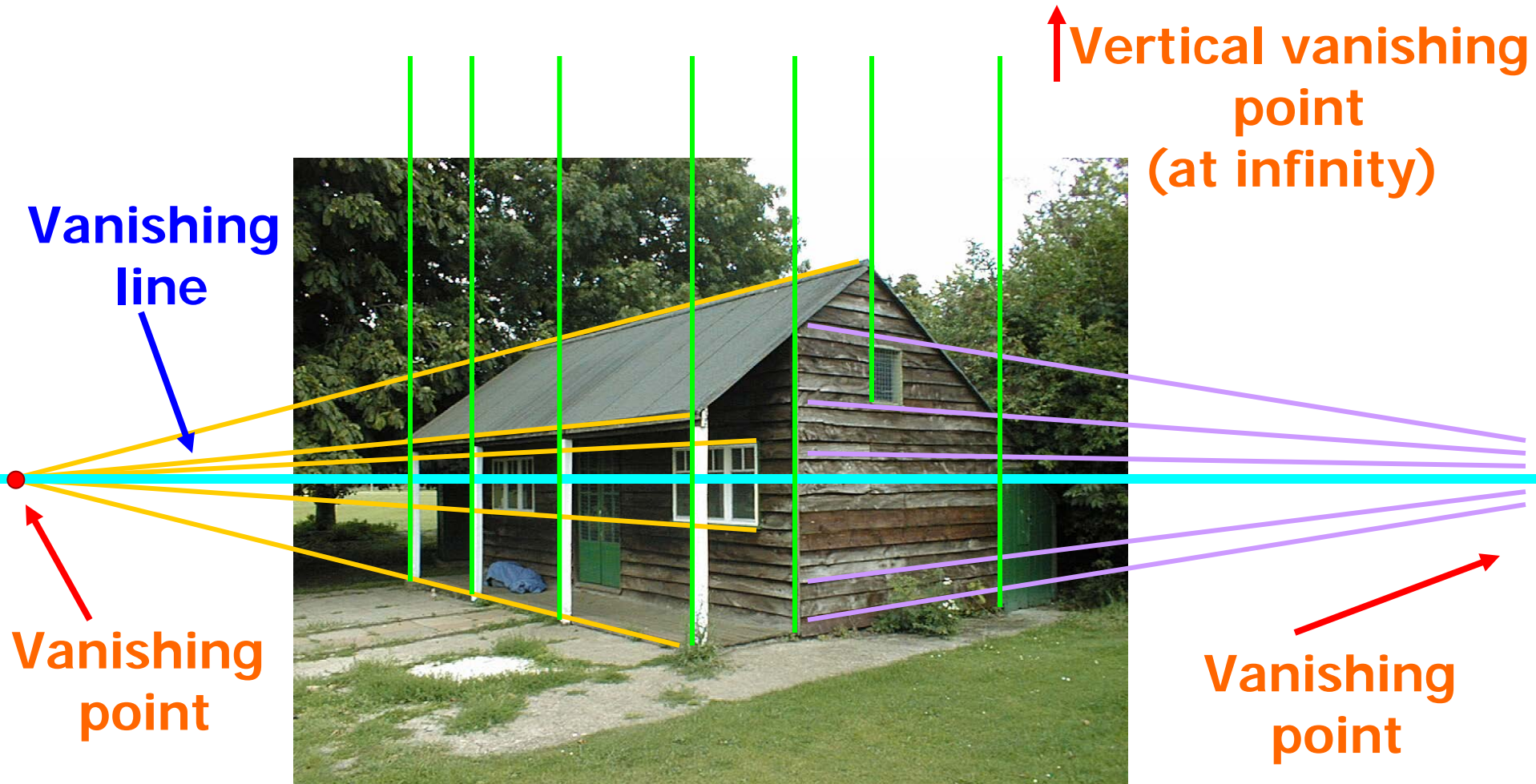
$$v = (p_1 \times q_1) \times (p_2 \times q_2)$$

Least squares version

- Better to use more than two lines and compute the “closest” point of intersection
- See notes by [Bob Collins](#) for one good way of doing this:
  - <http://www-2.cs.cmu.edu/~ph/869/www/notes/vanishing.txt>

# Criminisi '99

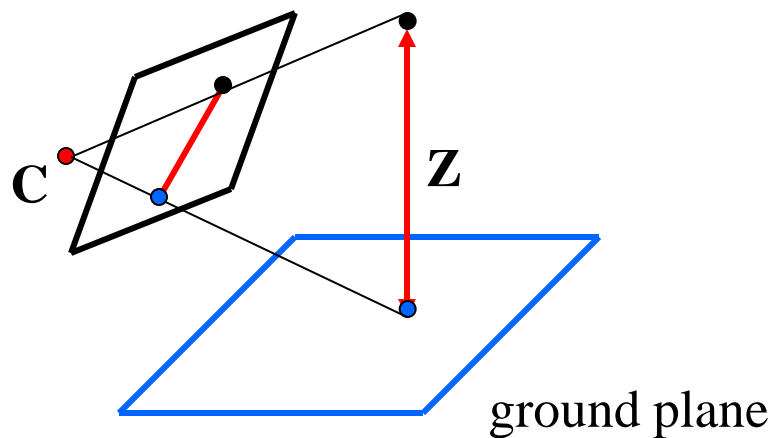
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# Measuring height without a ruler

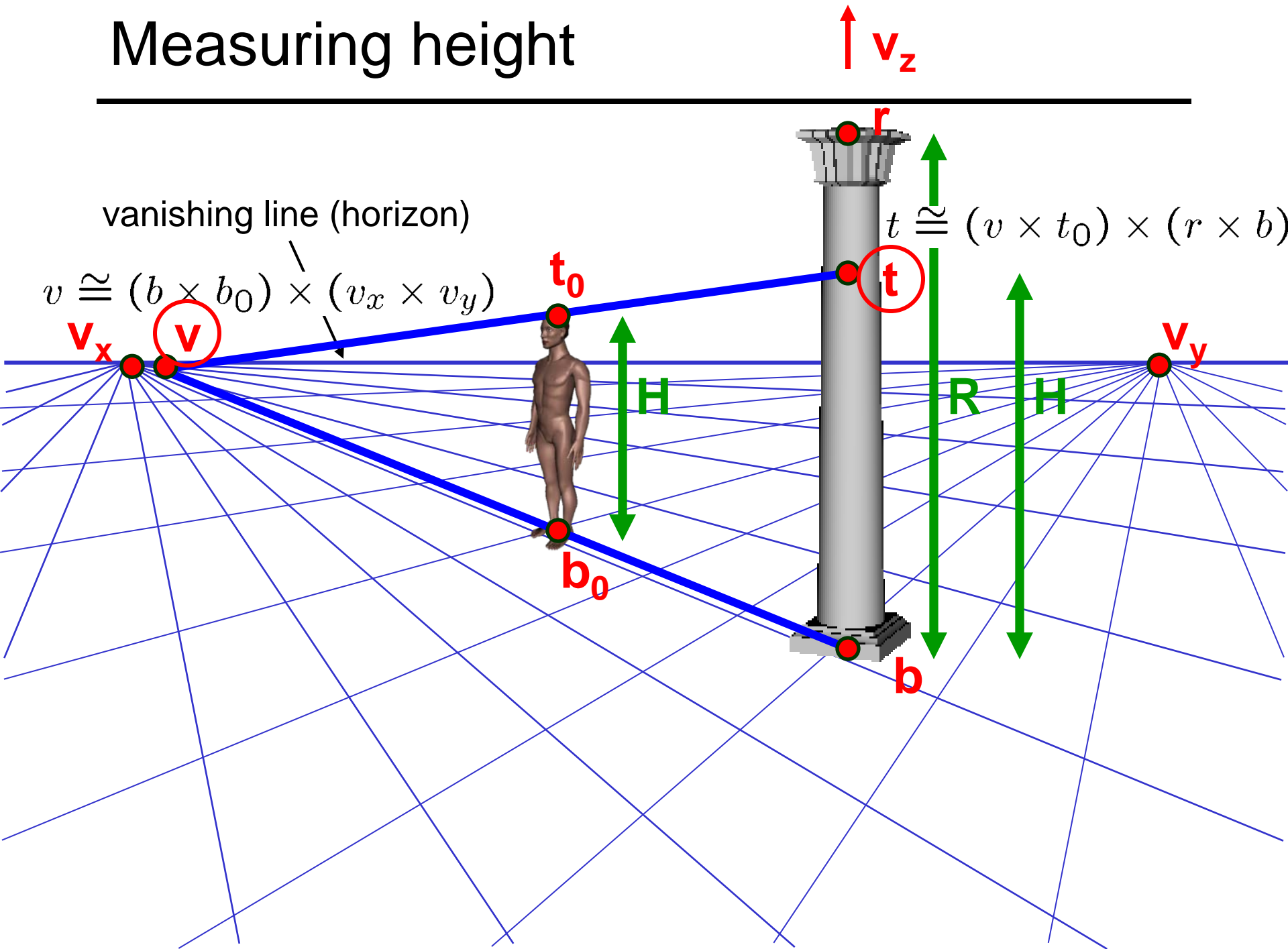
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Compute  $Z$  from image measurements

- Need more than vanishing points to do this

# Measuring height



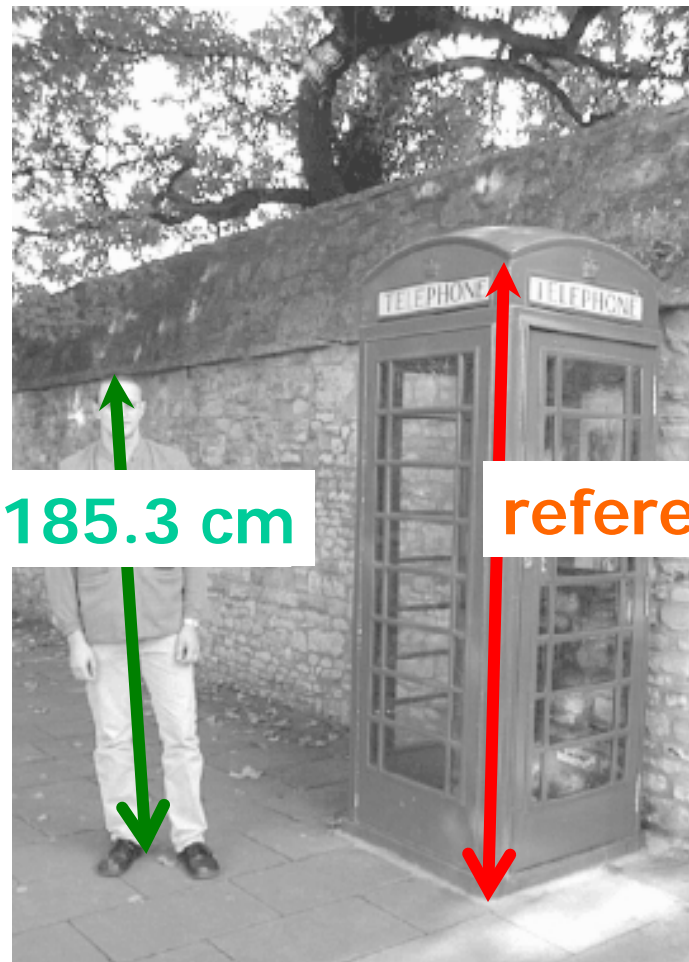




# Measuring heights of people

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Here we go !



185.3 cm

reference

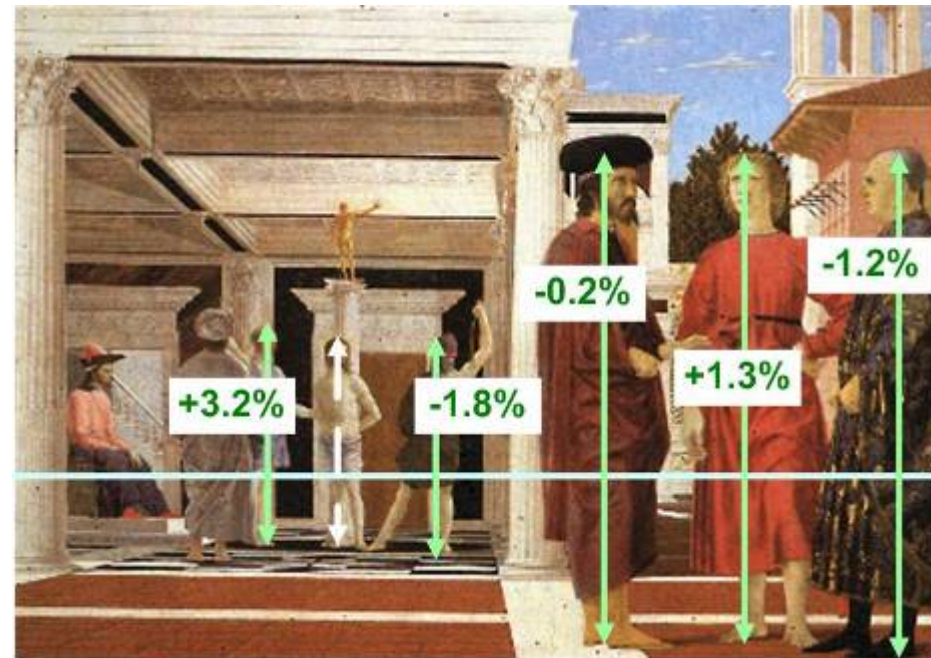
# Assessing geometric accuracy

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Are the heights of the 2 groups of people consistent with each other?



***Flagellation,***  
**Piero della Francesca**

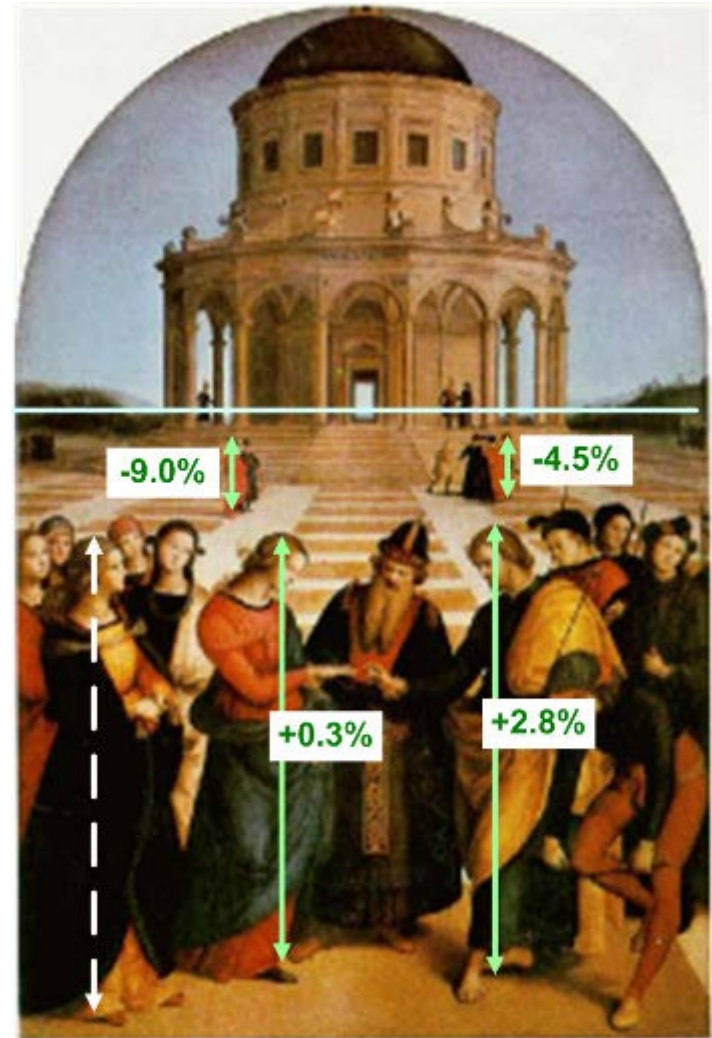


**Estimated relative heights**

# Assessing geometric accuracy



***The Marriage of the Virgin,***  
**Raphael**



**Estimated relative heights**



# Criminisi et al., ICCV 99

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## Complete approach

- Load in an image
- Click on lines parallel to X axis
  - repeat for Y, Z axes
- Compute vanishing points
- Specify 3D and 2D positions of 4 points on reference plane
- Compute homography H
- Specify a reference height
- Compute 3D positions of several points
- Create a 3D model from these points
- Extract texture maps
  - Cut out objects
  - Fill in holes
- Output a VRML model

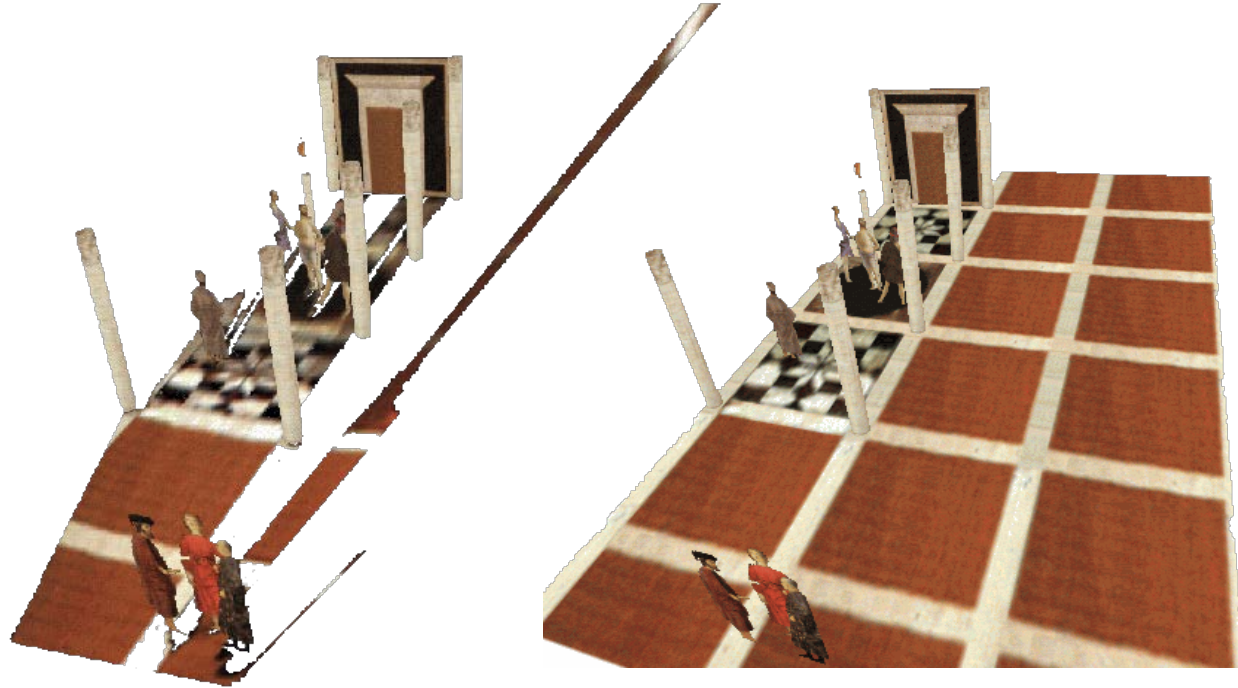
# Interactive silhouette cut-out

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# Occlusion filling

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Geometric filling by exploiting:

- symmetries
- repeated regular patterns

Texture synthesis

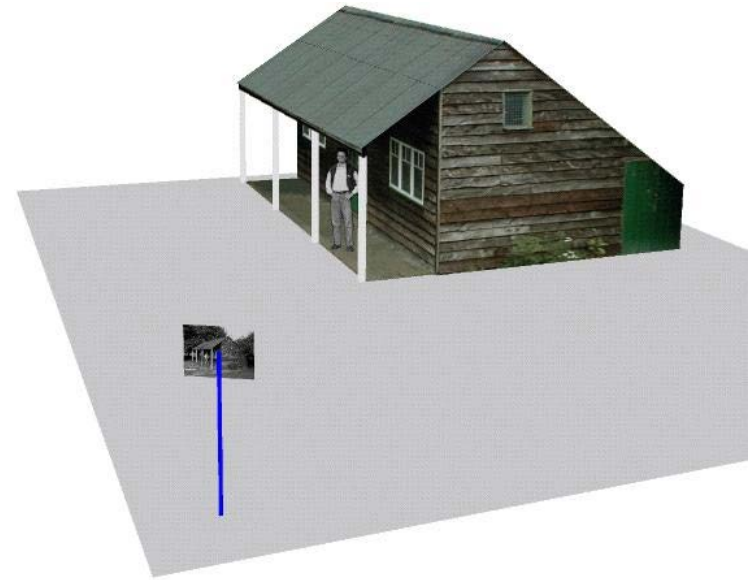
- repeated stochastic patterns

# Complete 3D reconstruction

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**Single  
View  
algorithms**



**Single  
image**



- Planar measurements
- Height measurements
- Automatic vanishing point/line computation
- Interactive segmentation
- Occlusion filling
- Object placement in 3D model



**3D  
model**



# A virtual museum @ Microsoft

