CS664 Lecture #19: Layers, RANSAC, panoramas, epipolar geometry

Some material taken from:

- **David Lowe, UBC**
- **Jiri Matas, CMP Prague**
http://cmp.felk.cvut.cz/~matas/papers/presentations/matas_beyond-ransac_cvprac05.ppt

Announcements

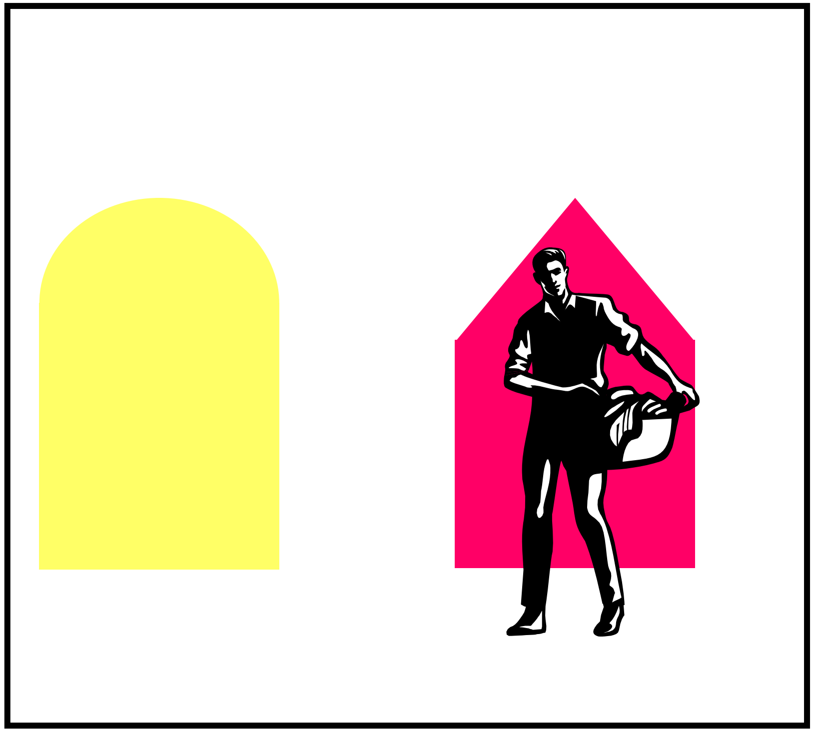
- Paper report due on 11/15
- Please choose a final project soon
  - Email me a proposal after you get your paper report graded
  - Which will be soon after 11/15!
- Project must have a research component
  - Talk to me if you have questions
- Next quiz Thursday 11/3
  - coverage through last lecture
- PS#2 due November 8

Handling large motions

- None of these optical-flow based techniques work well for large motions or for really textured scenes
  - Need “just right” amount of texture!
- A standard solution for larger motions is to do this “coarse to fine”
  - Run on a low resolution version of the image
  - Apply this as a warp, then increase resolution
  - These methods have some ugly properties
    - But a number of people think they work

Layered motion estimation

- Suppose there are multiple motions
  - Think of “Bugs Bunny” style animation



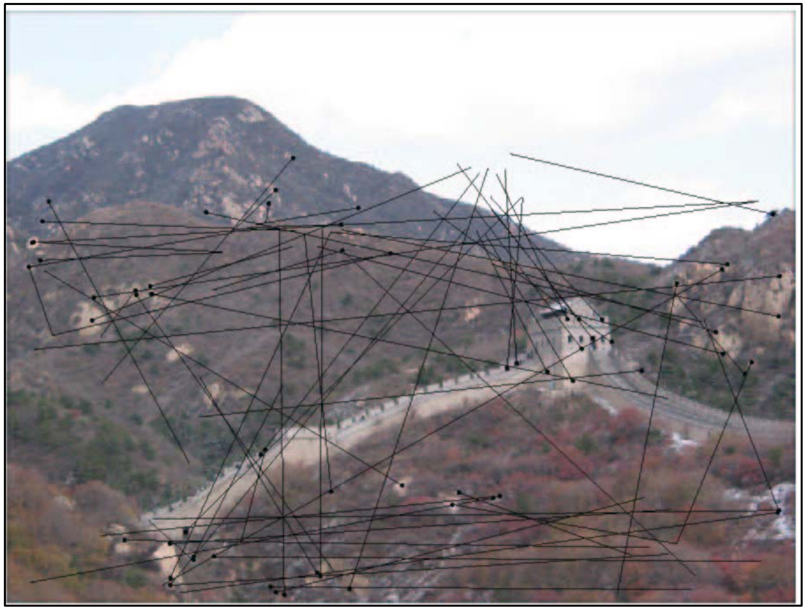
Layered motion algorithms

- Global affine fit with IRLS should give us the dominant motion
  - Assuming it's >50% of the image
  - Outlier pixels (low IRLS weights) are doing something else, so we can focus on them
- Need to find what the motions are, which pixels belong to each region
  - If we know one, we could compute the other
  - Classical application of EM
  - To initialize, compute local affine fits and cluster in 6-dimensional space

RANSAC

- Extremely popular way to do model fitting in the presence of noisy data
  - One of the best algorithms in the vision toolkit
- Algorithm:
  - Select a random sample of data points
  - Find model that best fits these points(LS)
  - Find all other data points that like this model
    - Consensus set
- Parameters: number of iterations, sample size, consensus set “tolerance”

Example: registration

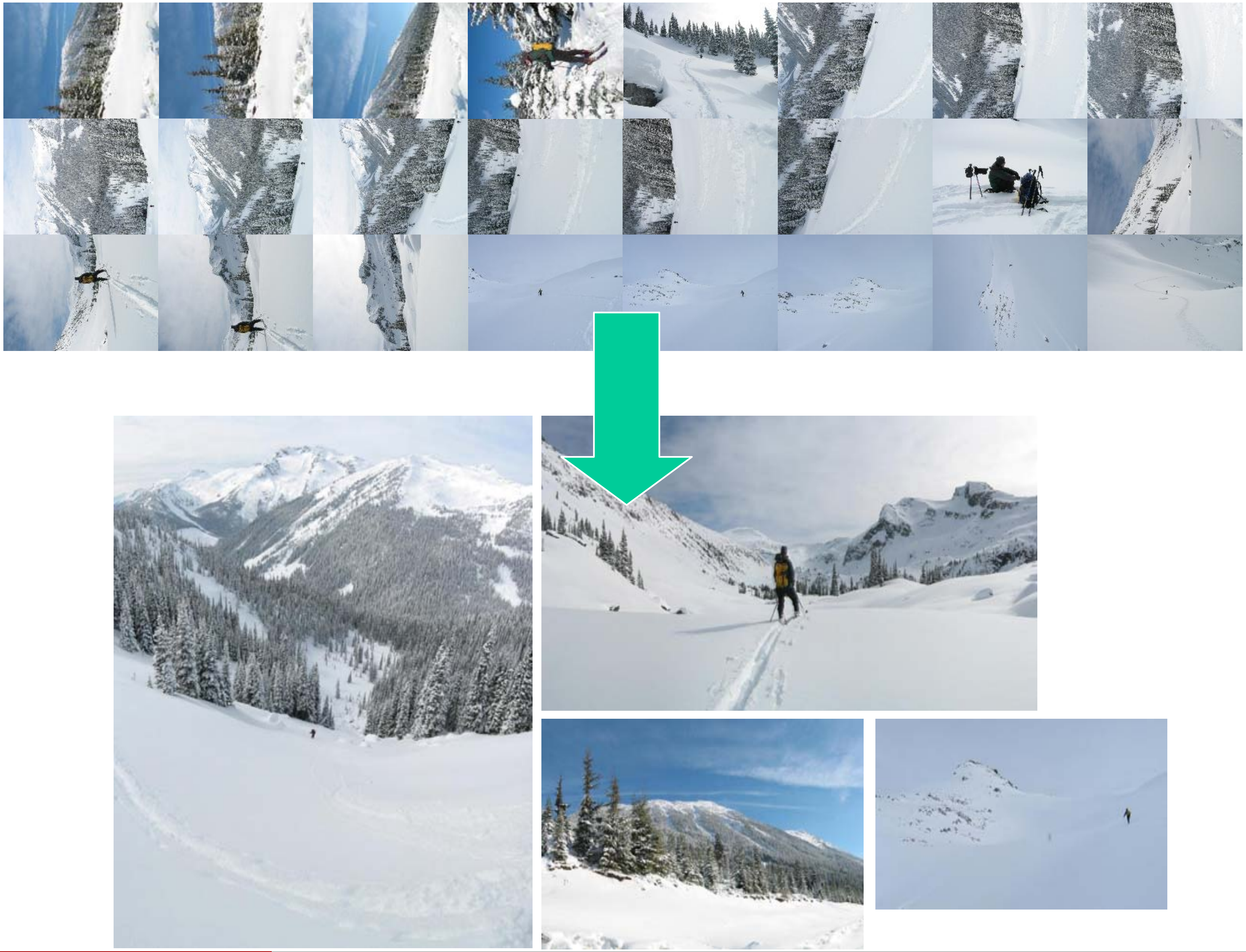


Example: multiple motions

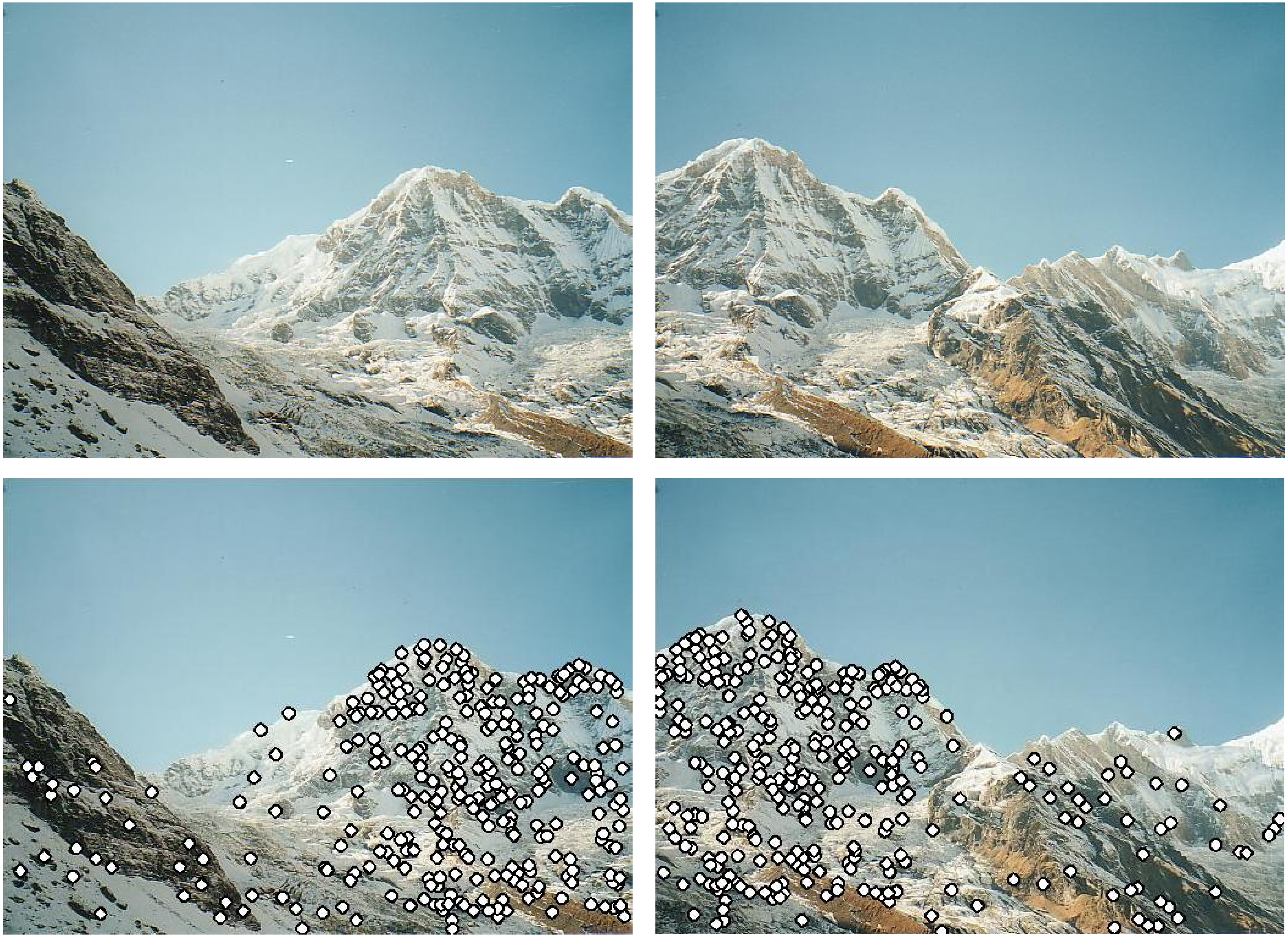
RANSAC for sparse registration

- Given an interest-point operator
  - Corner detector, or SIFT (we will cover this)
- Assume we're looking at a plane
  - Planar homography
    - Homography = projective transformation
    - Planar homography = 2D affine homography
  - Application: recognizing panoramas
    - Brown & Lowe, ICCV 2003
      http://www.cs.ubc.ca/~mbrown/panorama

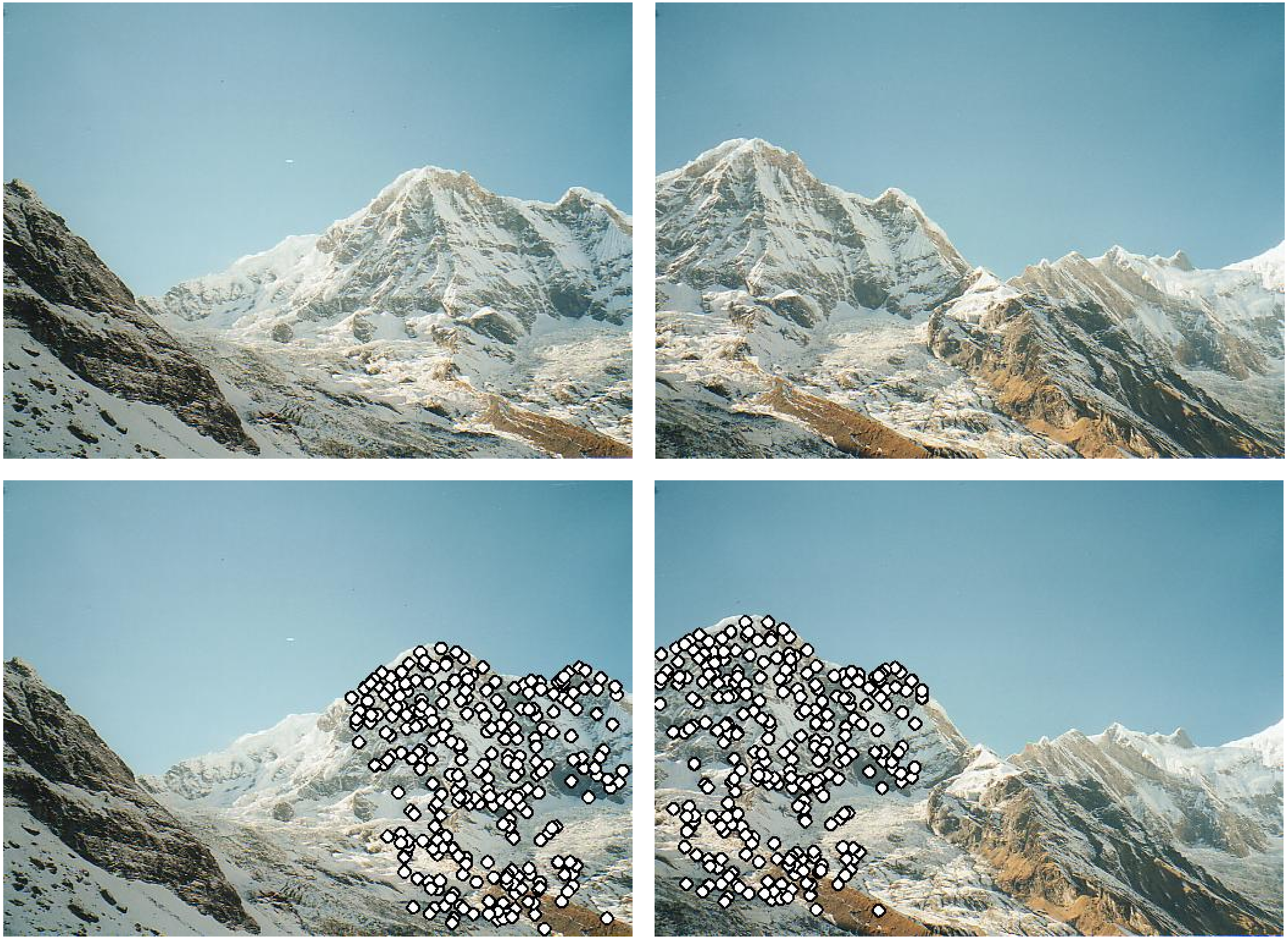
Recognizing panoramas



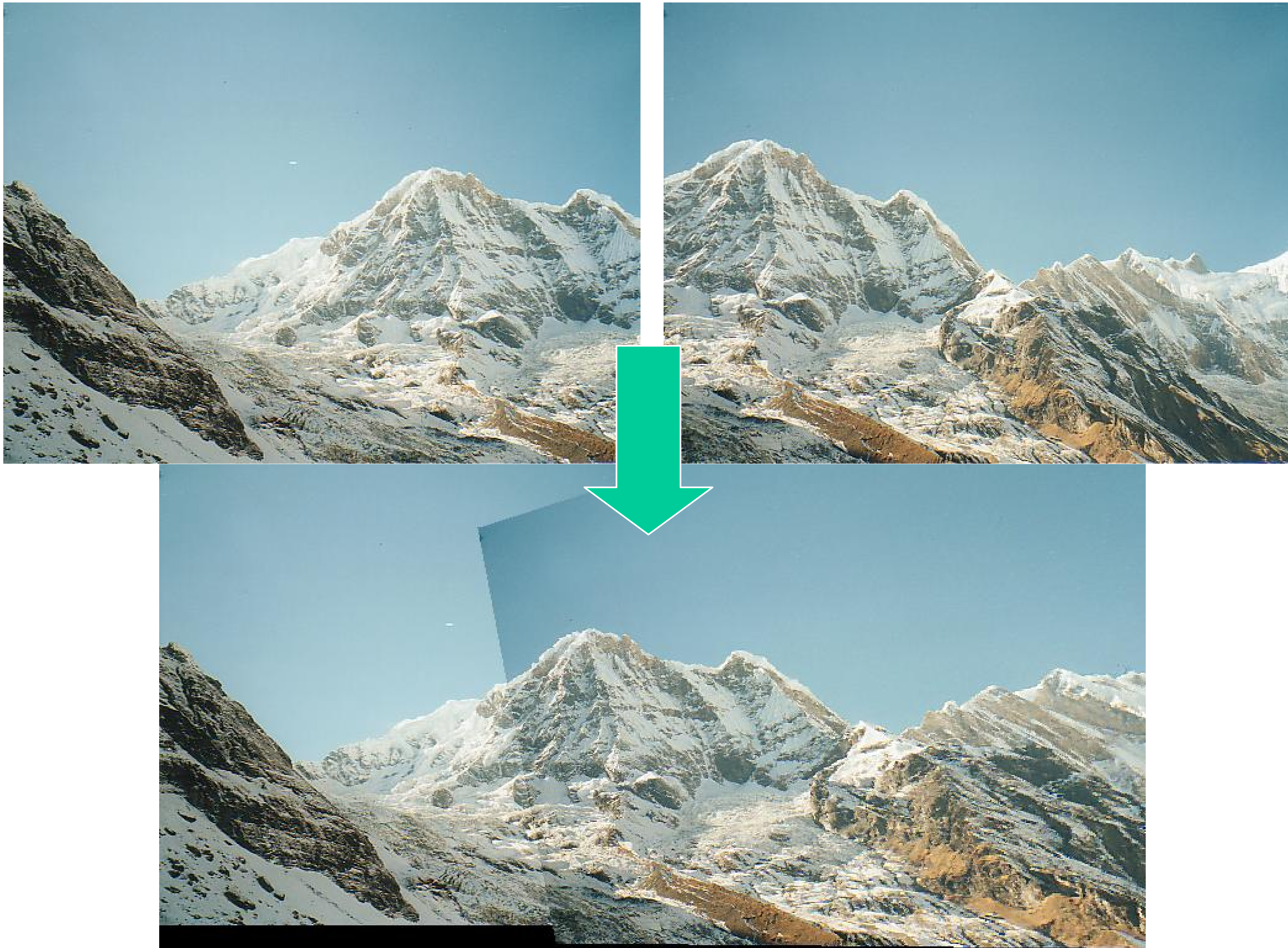
Feature extraction (SIFT)



Consensus set



Panorama



Completing the panorama

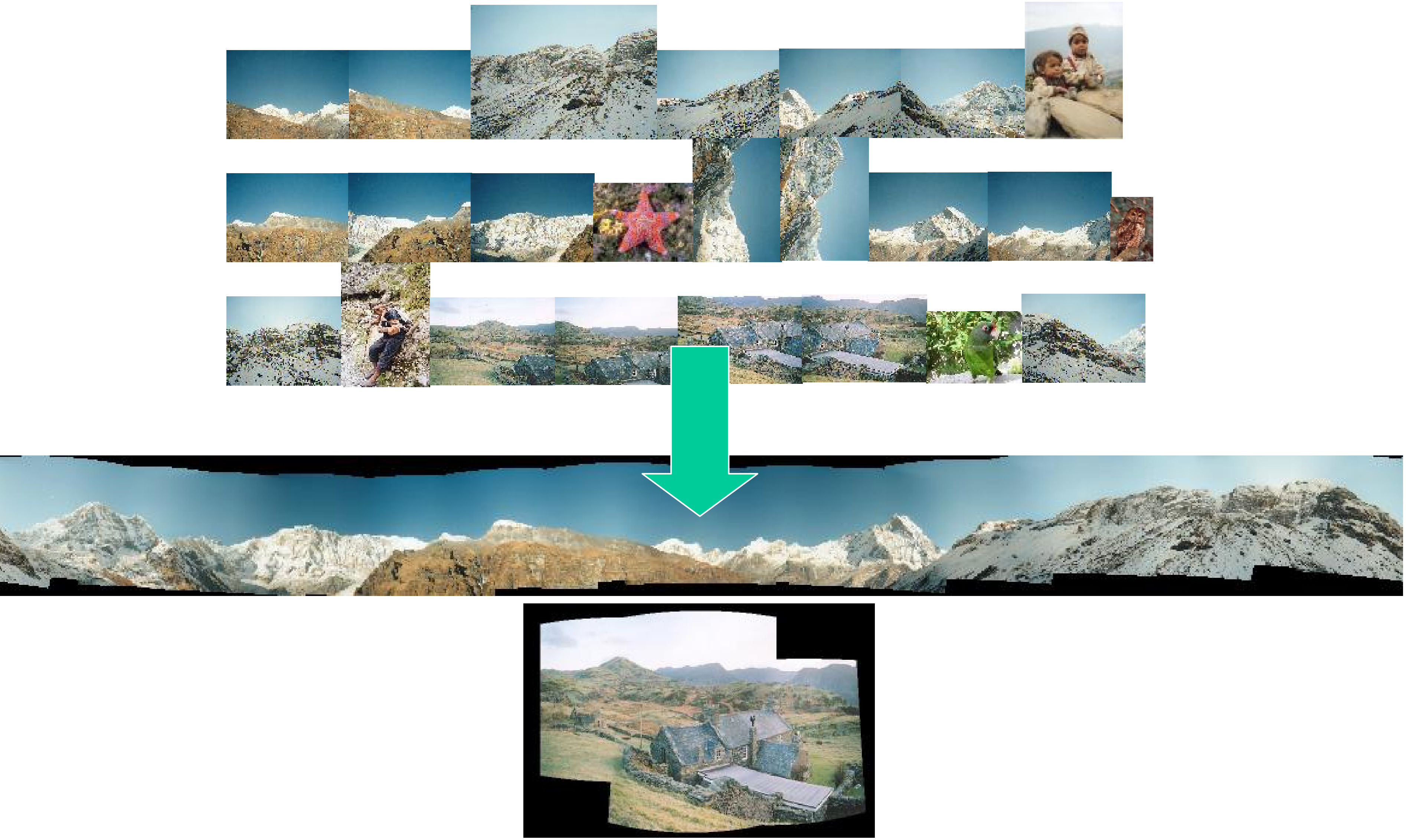
- We have a lot of pairwise panoramas
  - How do we create a complete panorama?
  - A connected set should be a panorama
- How to create the image?
  - Pairwise registrations aren't globally consistent
- Camera parameters come in two classes
  - Intrinsic: focal length, pixel size & spacing
  - External: rigid body motion (6 d.o.f.)
  - For a given panorama, we will assume the parameters are only rotation & focal length

Bundle adjustment

- We have a set of cameras with their parameters θ_{old}, and need to add a new image and estimate its parameters θ
  - Find the θ that makes the feature points line up as closely as possible
    - Minimize the "reprojection error"
    - Robustify this, to handle outliers
  - Actually, we minimize both θ_{old} and θ
- Non-linear least squares problem
  - Usually solved with Levenberg-Marquadt

Bundle adjustment in action

Results

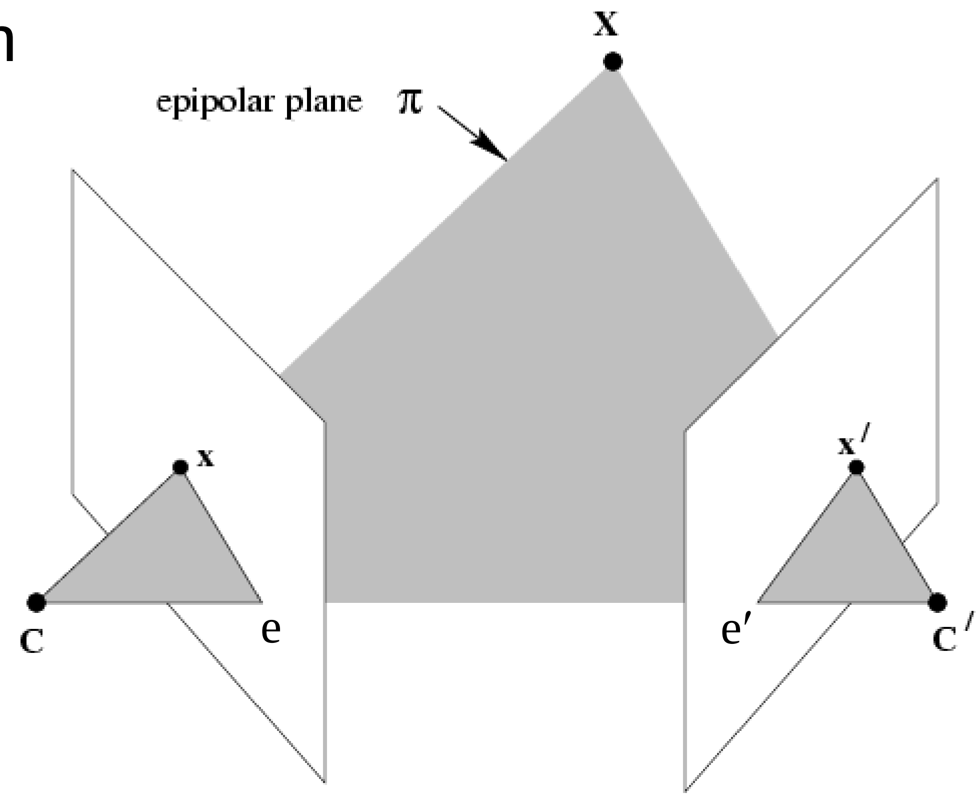


Epipolar geometry

- Where could a point in I1 appear in I2?
  - Motion: anywhere nearby
  - Stereo: anywhere horizontally nearby
    - Why just horizontal?
  - Assume a stationary scene

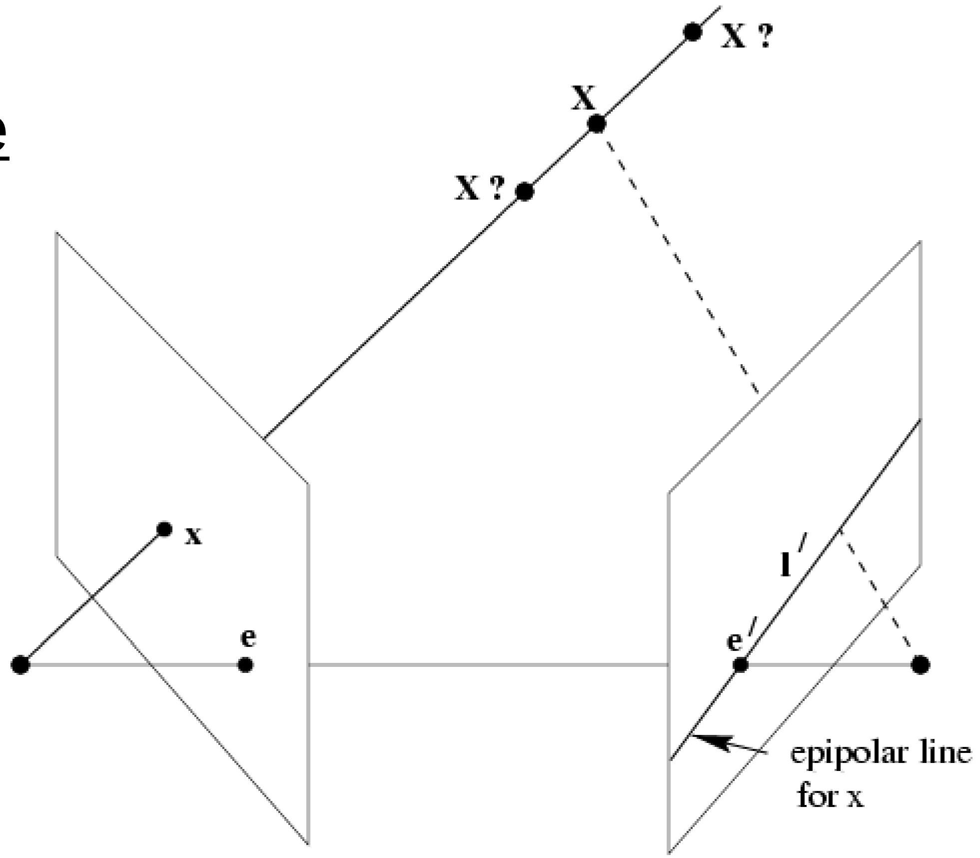
Two View Geometry

- Point X in world and two camera centers C, C' define the epipolar plane
  - Images x,x' of X in two image planes lie on this plane
  - Intersection of line CC' with image planes define special points called epipoles, e,e'



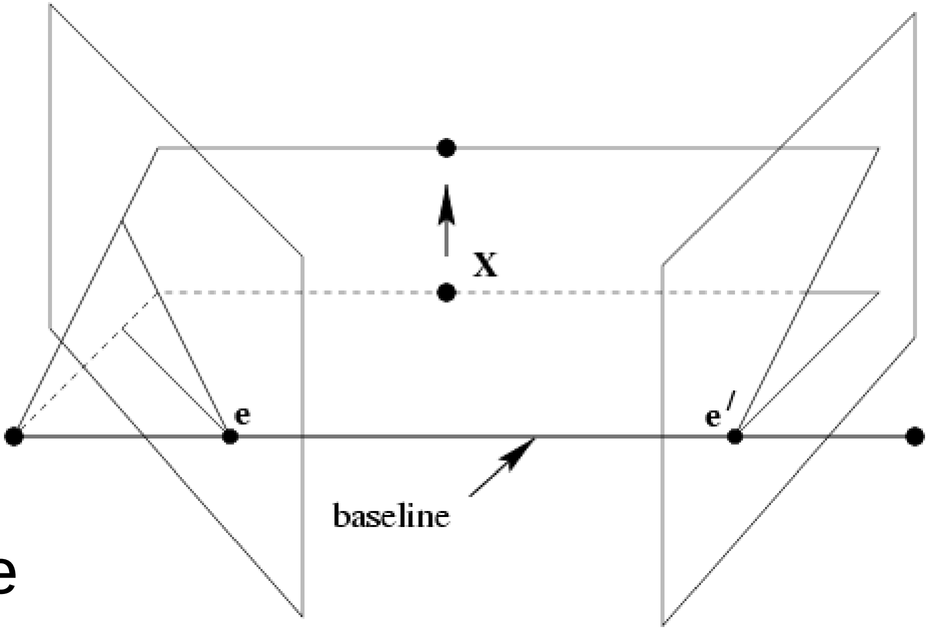
Epipolar Lines

- Set of points that project to x in I define line l' in I'
  - Called epipolar line
  - Goes through epipole e'
  - A point x in I thus maps to a point on l' in I'
    - Rather than to a point anywhere in I

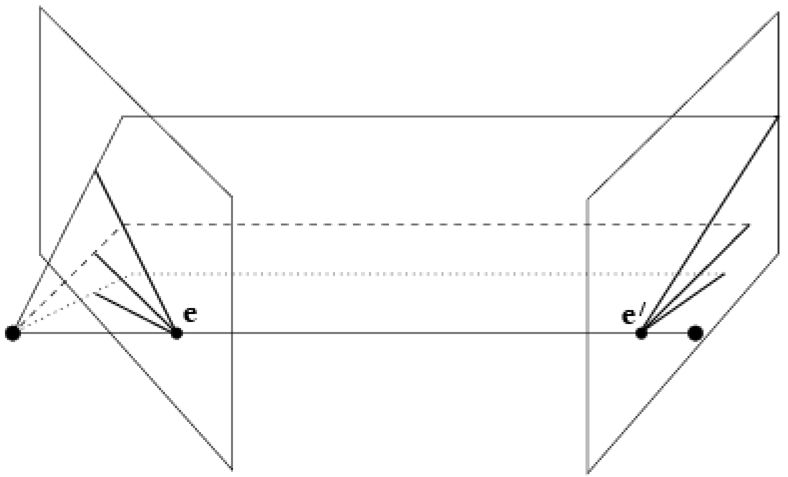


Epipolar Geometry

- Two-camera system defines one parameter family (pencil) of planes through baseline CC'
  - Each such plane defines matching epipolar lines in two image planes
  - One parameter family of lines through each epipole
  - Correspondence between images

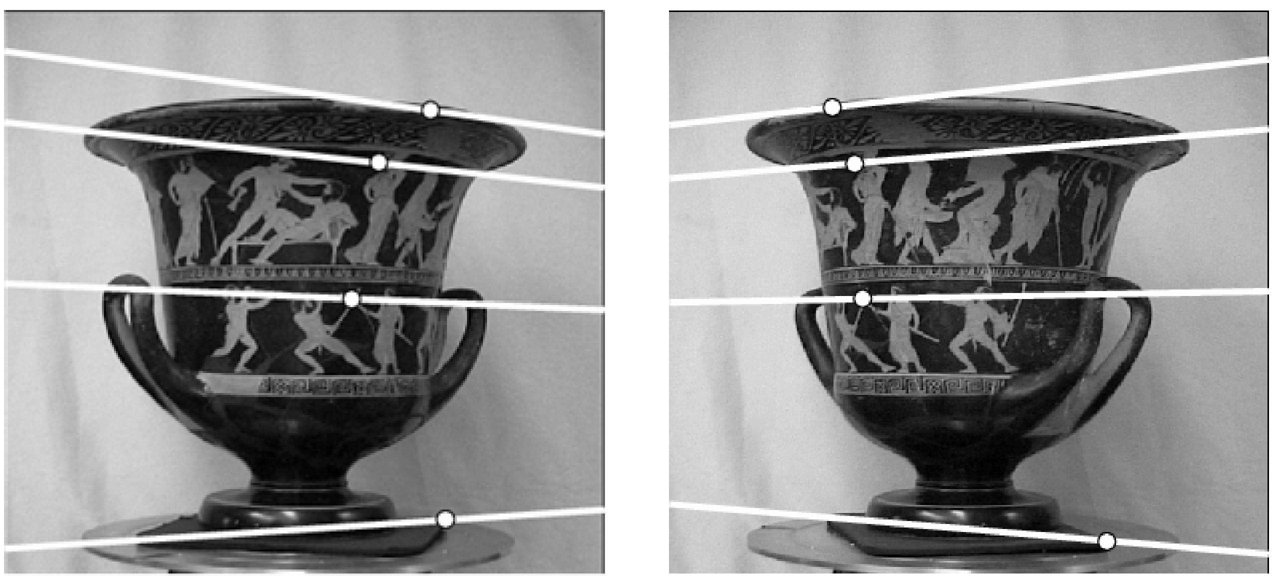


Converging Stereo Cameras



Corresponding points lie on corresponding epipolar lines

Known camera geometry so 1D not 2D search!



Epipoles in direction of motion