2-view Alignment and RANSAC

CSE P576

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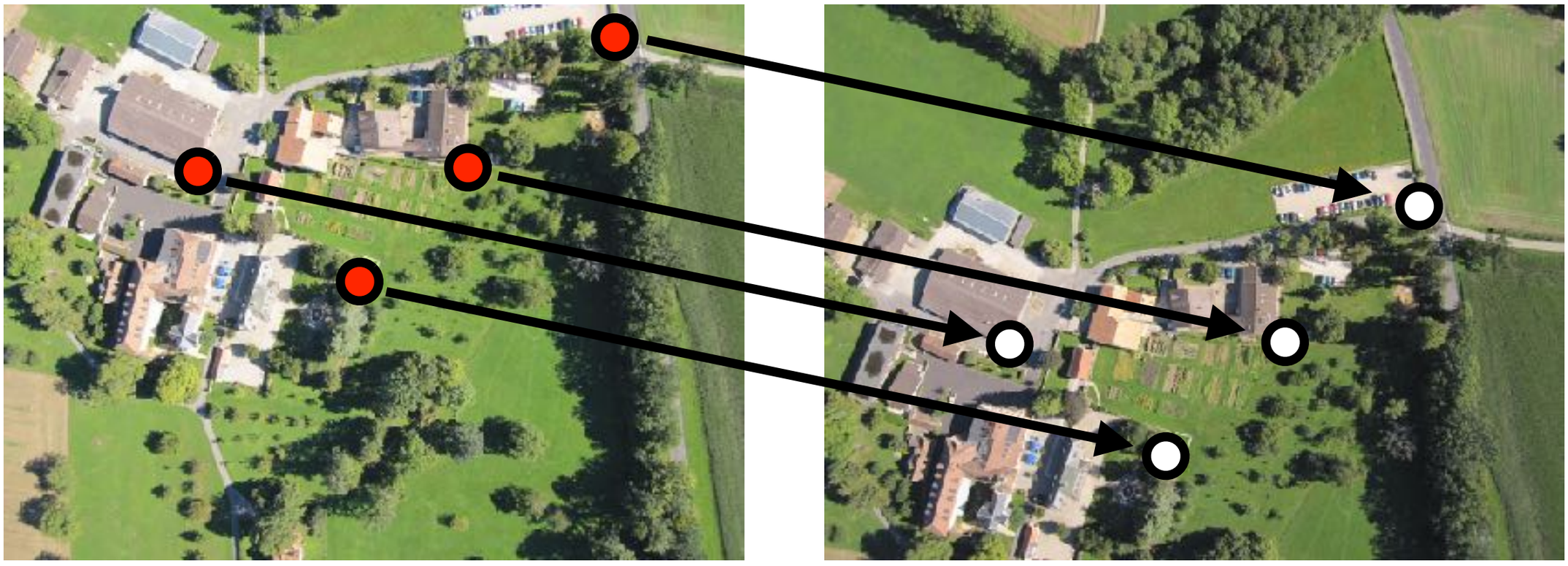
2-view Alignment + RANSAC

- 2-view alignment: linear equations
- Least squares and outliers
- Robust estimation via sampling

[Szeliski 6.1]

Image Alignment

- Find corresponding (matching) points between the images

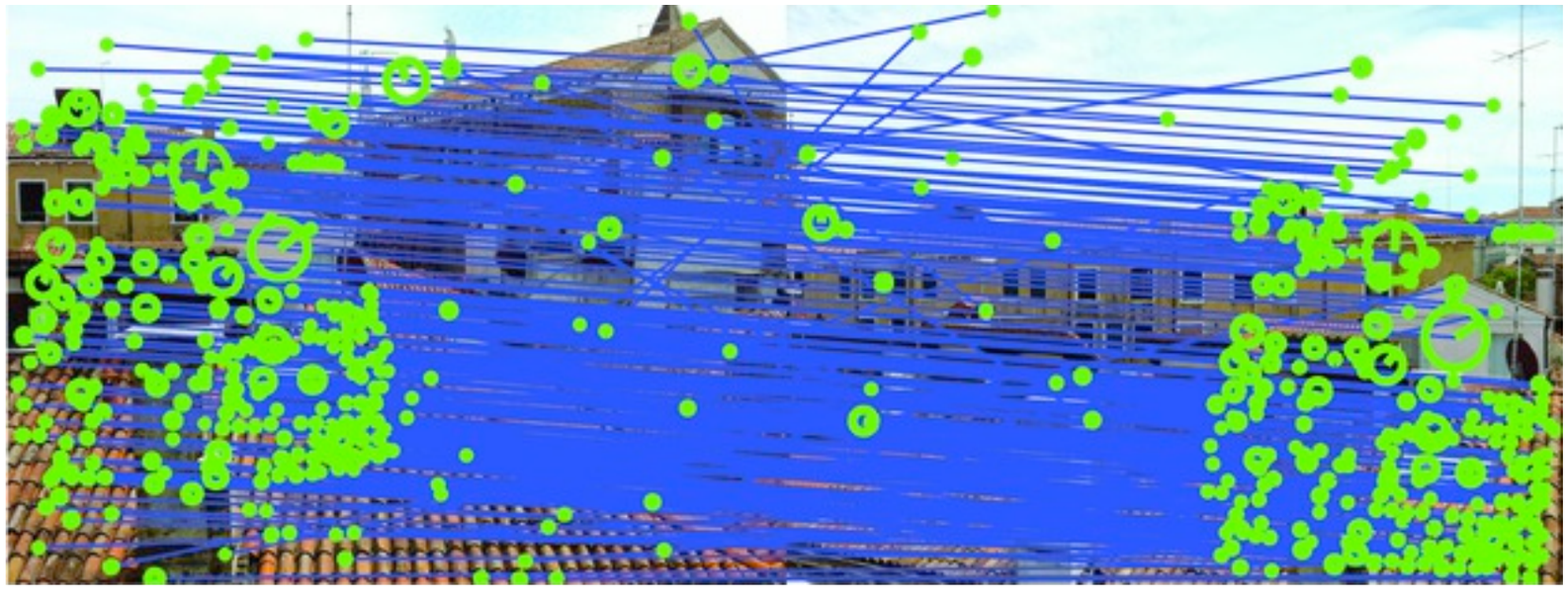


$$\mathbf{u} = \mathbf{H}\mathbf{x}$$

2 points for Similarity
3 for Affine
4 for Homography

Image Alignment

- In practice we have many noisy correspondences + **outliers**



Linear Equations

- e.g., for an affine transform we have a linear system in the unknown parameters **a**:

$$\begin{bmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x_1 & y_1 & 1 \\ x_2 & y_2 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x_2 & y_2 & 1 \\ x_3 & y_3 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x_3 & y_3 & 1 \\ \vdots & & & & & \end{bmatrix} \begin{bmatrix} a_{11} \\ a_{12} \\ a_{13} \\ a_{21} \\ a_{22} \\ a_{23} \end{bmatrix} = \begin{bmatrix} x'_1 \\ y'_1 \\ x'_2 \\ y'_2 \\ x'_3 \\ y'_3 \\ \vdots \end{bmatrix}$$

- It is **overconstrained** (more equations than unknowns)
- and subject to **outliers** (some rows are completely wrong)

Let's deal with these problems in a simpler context..

Robust Line Fitting

- Consider fitting a line to noisy points

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

4 inliers (red, yellow, orange, brown),

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

4 outliers (blue, light blue, purple, pink)

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

4 inliers (red, yellow, orange, brown),

4 outliers (blue, light blue, purple, pink)

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

choose random points

check inliers, distances

light blue, purple

#inliers = 2

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

check overlap in image spaces

blue pink

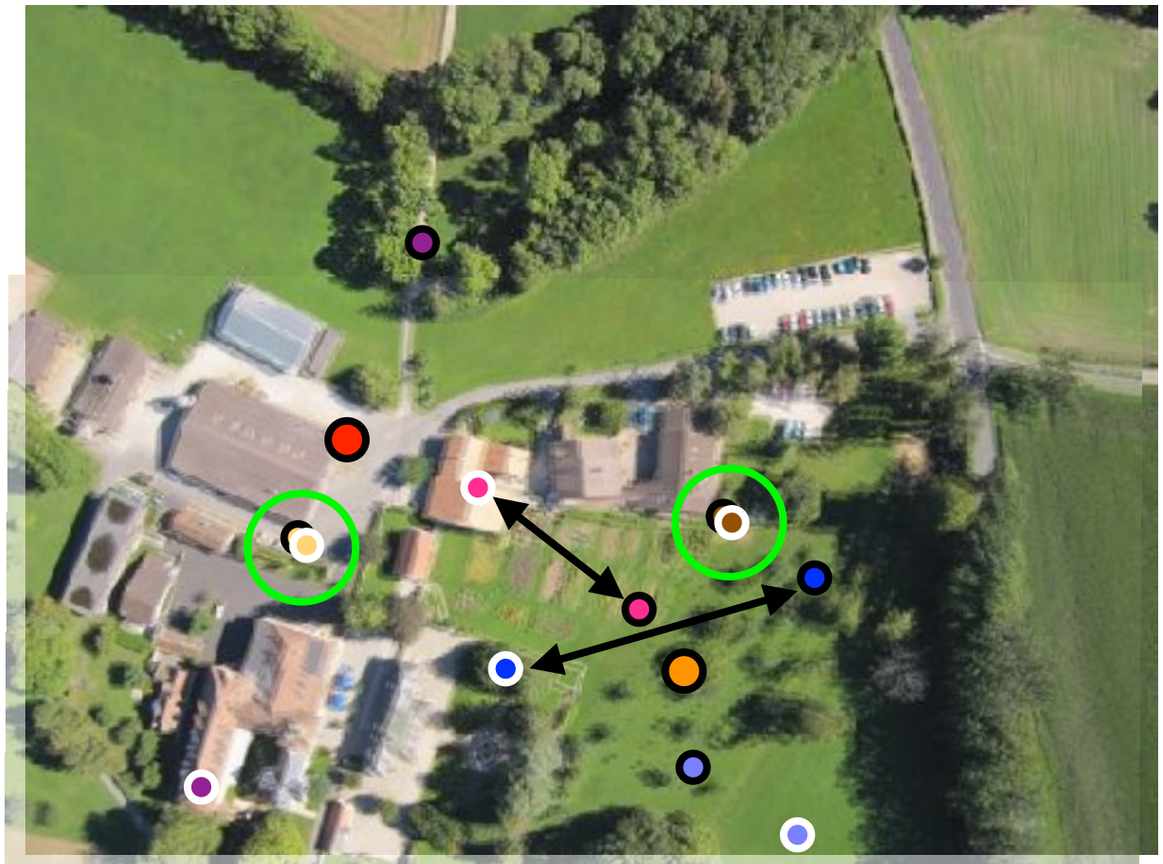
#inliers = 2

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)



choose a pair, align

check other points

#inliers = 4

RANSAC Example

- RANSAC solution for Similarity Transform (2 points)

RANSAC algorithm

1. Match feature points between 2 views
2. Select minimal subset of matches*
3. Compute transformation T using minimal subset
4. Check consistency of all points with T — compute projected position and count #inliers with distance < threshold
5. Repeat steps 2-4 to maximise #inliers

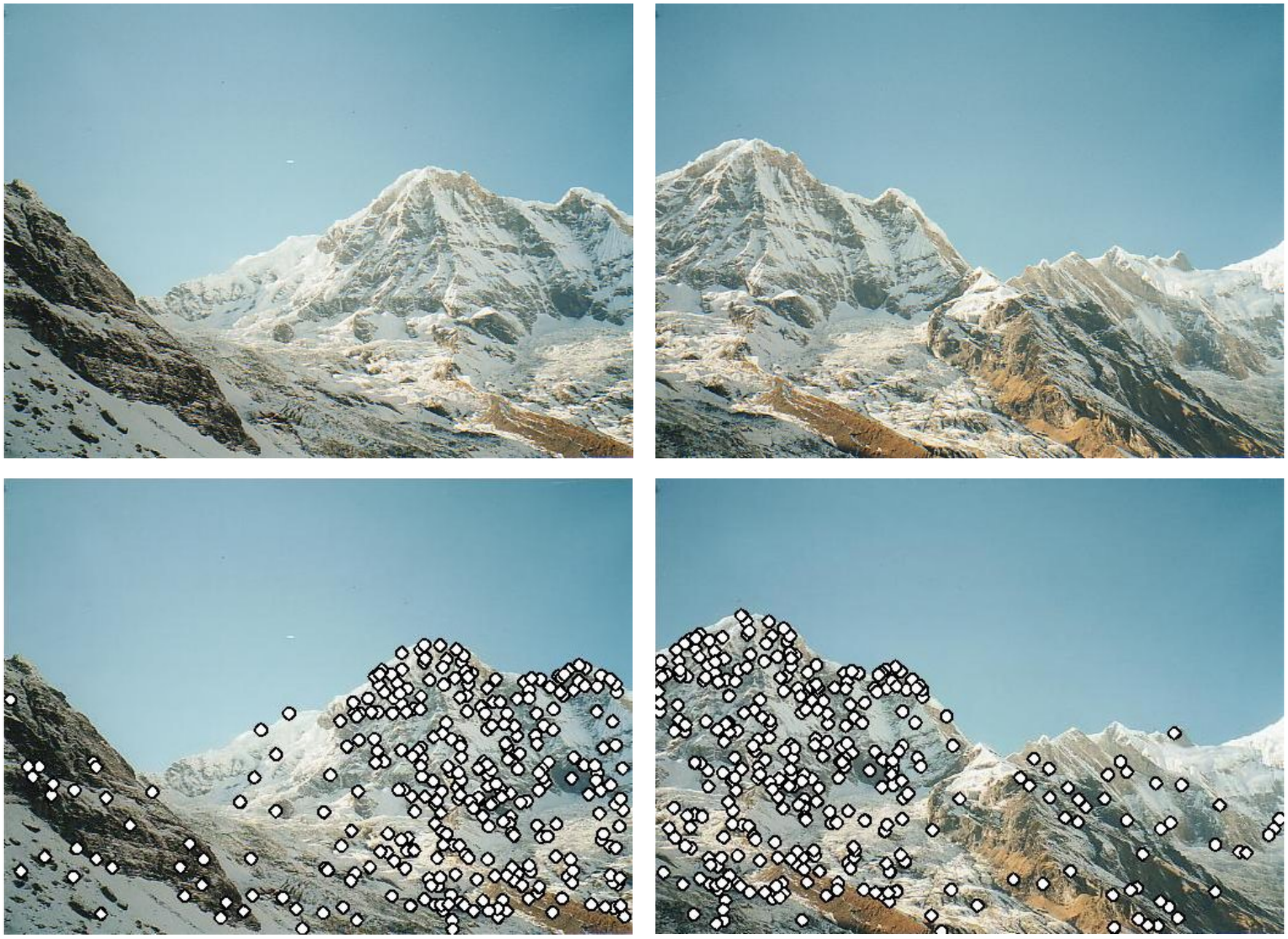
* Similarity transform = 2 points, Affine = 3, Homography = 4

Project 2

- Try out the **RANSAC Implementation** section in Project 2.

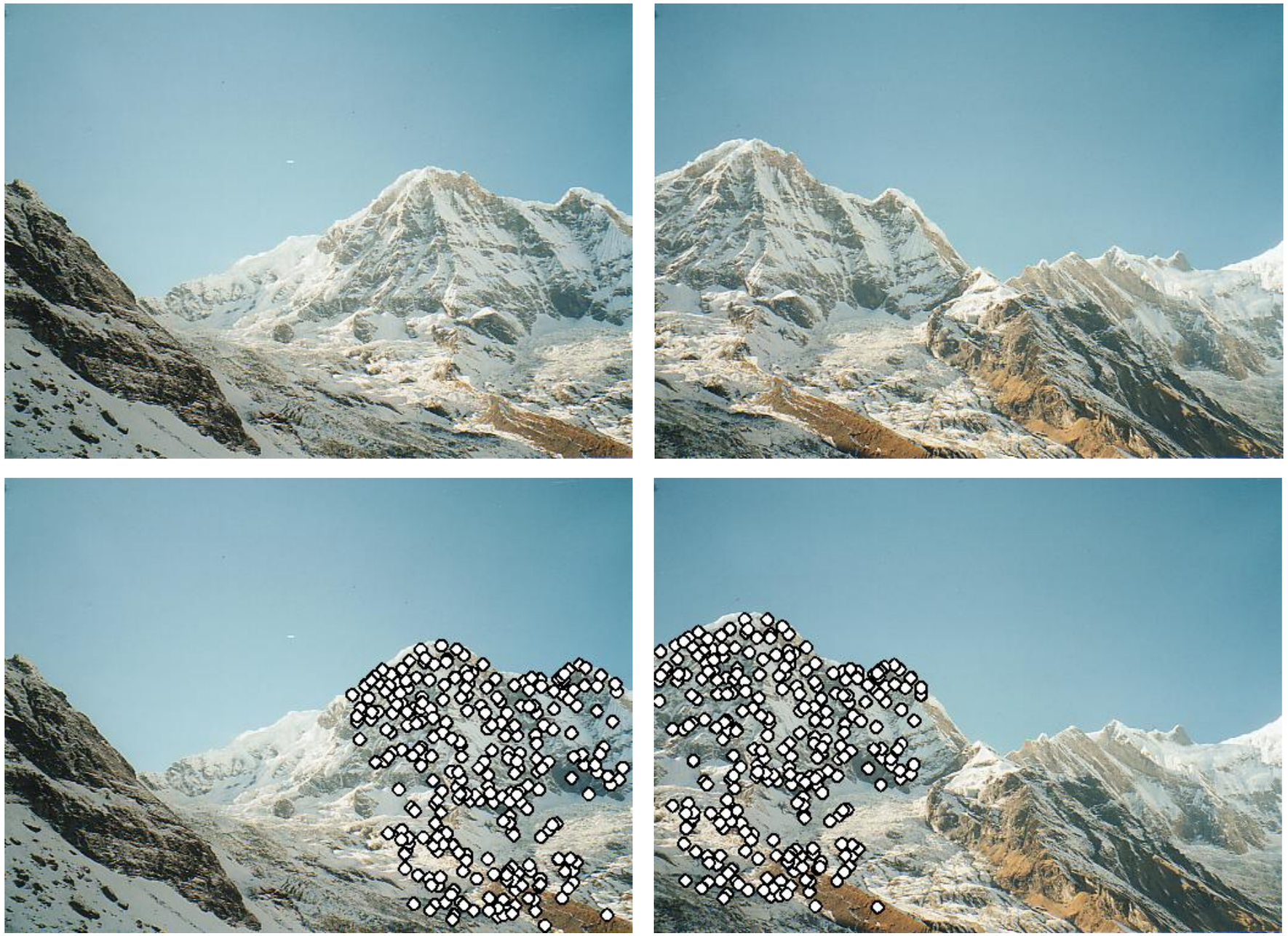
2-view Rotation Estimation

- Find features + raw matches, use RANSAC to find Similarity



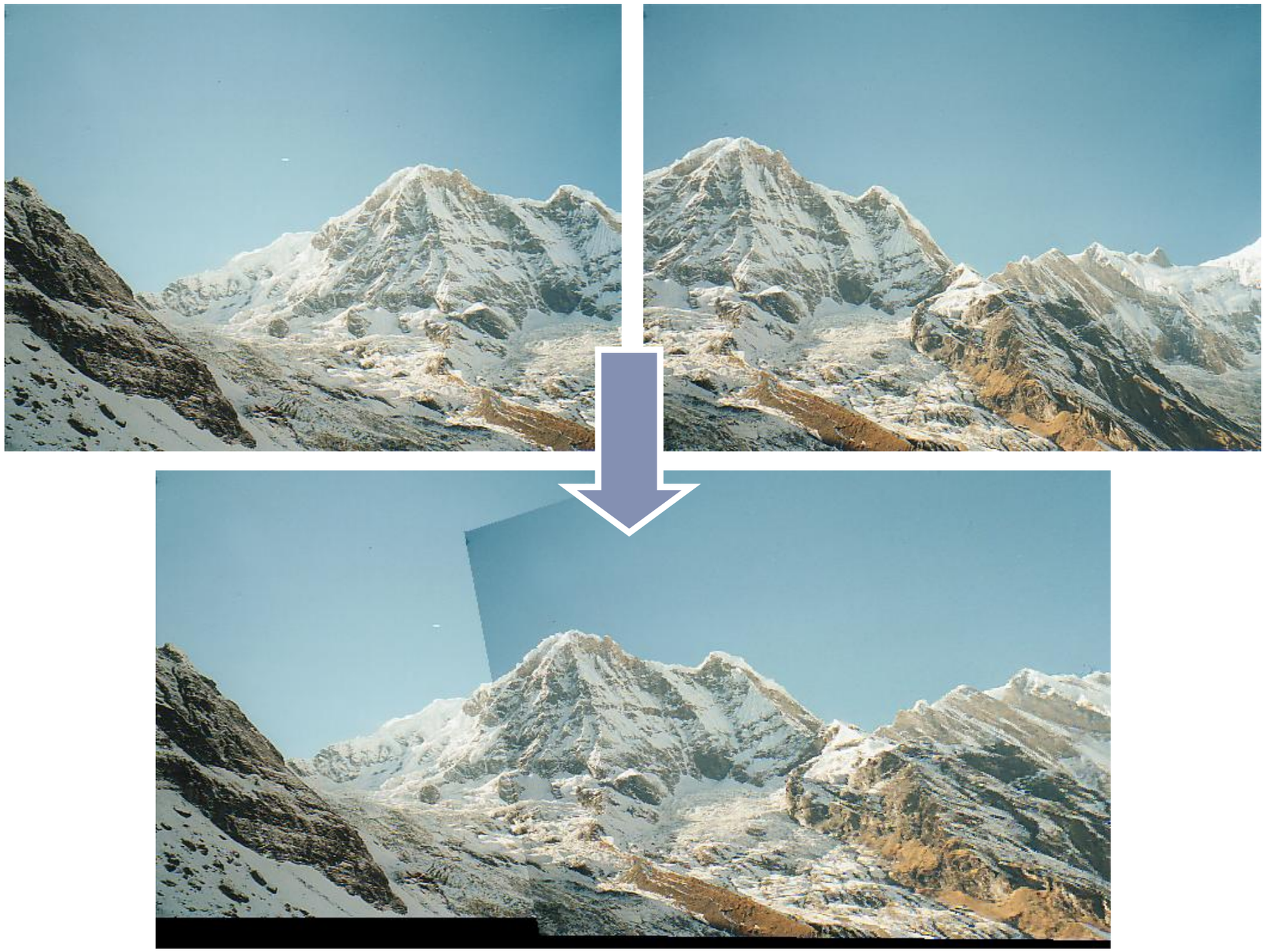
2-view Rotation Estimation

- Remove outliers, can now solve for R using least squares



2-view Rotation Estimation

- Final rotation estimation



Rotation Estimation

- We can solve for 3D rotation by forming a correlation matrix of corresponding rays (unit vectors in camera coordinates)

$$\boldsymbol{C} = \sum_i \hat{\boldsymbol{x}}' \hat{\boldsymbol{x}}^T = \boldsymbol{U}\boldsymbol{\Sigma}\boldsymbol{V}^T$$

$$\boldsymbol{R} = \boldsymbol{U}\boldsymbol{V}^T$$

- The solution for R minimizes the squared distance between corresponding rays, this is known as an "Orthogonal Procrustes Problem", see Szeliski p321, Arun et al 1987.

- You can use this to complete the **Rotation Estimation** section in Project 2

Next Lecture

- Epipolar Geometry, Multiview Reconstruction