Lecture 11: Homography Estimation using DLT - Short Notes

Homography Estimation - Question Bank

Q: What is a homography?

A: A homography is a 3×3 matrix that defines a projective transformation between two views of a planar surface. It maps points from one image to another using homogeneous coordinates: $x' \sim Hx$.

Q: Why use homogeneous coordinates?

A: Homogeneous coordinates allow translation, rotation, scaling, and perspective transforms to be represented as linear matrix operations. They make projective geometry computations easier.

Q: How many point correspondences are needed to compute a homography?

A: At least 4 pairs of corresponding points are required, because each point pair contributes 2 equations, and there are 9 unknowns in the homography matrix.

Q: Why is the solution of the homography only determined up to scale?

A: In homogeneous coordinates, any non-zero scalar multiple of a point represents the same location. Therefore, the homography matrix H is also determined up to a non-zero scale factor.

Q: What is a degenerate configuration?

A: A degenerate configuration is a setup of points (e.g., 3 collinear points) that does not provide enough independent constraints to compute a unique homography matrix.

Q: Why are collinear points problematic for homography estimation?

A: Collinear points lie on the same line and lack the geometric diversity needed to constrain the transformation. This leads to a rank-deficient matrix A and unreliable estimation.

Q: What is DLT (Direct Linear Transform)?

A: DLT is a method to compute homographies from point correspondences. It involves building a linear system $Ah = 0$, solving it via SVD, and reshaping the result into a 3x3 matrix H.

Q: Why normalize points before applying DLT?

A: Normalization improves numerical stability by translating points to have zero mean and scaling them to have average distance ?2 from the origin. This avoids large value ranges in matrix A.

Q: What does normalization involve?

A: Normalization centers the points around the origin and scales them. This is done using a transformation matrix T such that the average distance from the origin becomes ?2.

Q: How is the homography recovered from SVD?

A: The homography is found by taking the right singular vector of matrix A corresponding to the smallest singular value. This vector h is reshaped into a 3×3 matrix H.

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Q: How do we denormalize the homography?

A: To get the real-world homography, we apply the inverse of the normalization matrices: $H = T'?^{1} \times H \times T$.

Q: How do we check if H is correct?

A: Apply H to each point x to get x?'. Normalize x?' by dividing by its third coordinate and compare it to x'. If the reprojection error is small, H is accurate.

Q: What is reprojection error?

A: Reprojection error is the Euclidean distance between the predicted point (H x) and the actual point x'. It indicates how well the homography maps the points.

Q: Why use more than 4 point correspondences?

A: Using more points helps avoid degenerate configurations and makes the estimation more robust to noise. It creates an overdetermined system solved in a least-squares sense.

Q: What is the advantage of SVD in DLT?

A: SVD helps find the best least-squares solution to an inconsistent system (due to noise). It ensures the most stable solution by minimizing ||Ah|| under the constraint ||h|| = 1.