Geometry for Computer Vision
Written Examination

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This exam consists of six topics, each worth 2p, and thus the maximal score is 12p. Each topic should be answered on a separate paper. At the top of the page: Write your name, and the number of the question(s), e.g. "1A", or "2" if both answers A and B fit onto one page.

1 Homographies

A 2D homography can be used to relate two sets of corresponding points on two planes in 3D.

A Homographies are often estimated using the DLT algorithm. How many corresponding points are needed to estimate a 2D homography using DLT? What is the minimal number of points needed to uniquely define a 2D homography?

B For a non-minimal correspondence set it is important that the DLT algorithm is accompanied by a data normalization. Explain why!

2 Fundamental Matrices

The fundamental matrix relates two images of a static 3D scene.

A Why is the epipolar constraint not sufficient for determining the correspondence between two projections of a 3D point?

B The fundamental matrix has 7 degrees of freedom. Explain why!

3 Camera Calibration

A popular technique for calibration of the intrinsic camera parameters is the calibration plane method by Zhang.

A Zhang's method starts with a linear solution, which is then refined by Maximum Likelihood(ML). What cost is minimised in the ML step of Zhang's method?

B What are the free parameters in this step? List, and describe each parameter.

4 Motion Segmentation

A popular method for motion segmentation is based on multi-body factorisation.

A This method assumes an affine camera model. Explain what this is, and when you can expect it to be valid.

B In the algorithm, the data matrix $\mathbf{W}$ contains one point trajectory in each column, and is constructed by stacking the observed image coordinates. In the case of two objects with separate motions, each column of $\mathbf{W}$ thus belongs to either of the two objects. If we were to construct a sub-matrix consisting only of trajectories from one of the motions, it would satisfy certain algebraic properties. Describe these!

5 Multiple View Geometry

A In multiple view geometry, *Bundle Adjustment* is a popular technique. Describe what problem Bundle Adjustment solves! Characterise the cost function used, and what inputs are needed in the algorithm.

B Degeneracy: In the uncalibrated case, the fundamental matrix is used to describe the epipolar geometry. If the fundamental matrix is estimated from seven points, where five are on a common plane, the resulting matrix is unique, but it is still said to be $\mathbf{H}$-degenerate. Explain what this means!

6 Rotations

A The most straight-forward way to represent a rotation is in terms of a matrix $\mathbf{R} \in \mathbb{R}^{3\times3}$. It is sometimes preferrable to instead represent the rotation using unit quaternions. List (at least two) advantages of the latter representation.

B Explain what problem is solved by the SLeRP algorithm in terms of geodesics. You should also define the concept of a geodesic.