Mobile Robotics End Sem Exam

27 Nov 2024

Open Book, Laptop, Notes

NO INTERNET

1. What are the 3 different homography relations used in Computer/Robotic Vision ? You need to be clear what geometric entities get related through these homographies **(1.5 points).** Derive these relations between those entities for each such homography **(4.5 points).** Out of these 3 homography relations which two were discussed at length in class and for solving what problem **(1 point)**

2. Derive the relation between depth and disparity in the context of stereo reconstruction. **(2 points)** What is stereo rectification and what does it accomplish **(1 point).** Prove that for rectified cameras that the image of a point in the left camera lies on the same horizontal line in the right camera **(2 points).** In the stereo rectification process the left camera is subject to one rotation while the right camera is subject to two rotations. What are these rotations each of this camera is subject to. Describe clearly by representing the two camera frames what does each such rotation accomplish **(6 points)**

3. In the figure below the camera is at a height h above the ground plane and has a pitch of θ with respect to the ground or a plane parallel to the ground plane. Let such a camera observe a point on the ground plane through its projected image pixel $\boldsymbol{x} = [x\ y\ 1]^T$. Let the normal to the ground plane be $\mathbf{n}$ as mentioned in the figure. What will be the coordinates of the point x in 3D? Assume known calibration matrix K. **(5 points)**

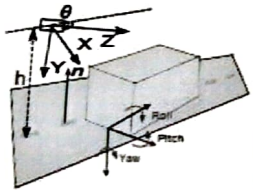

Figure 2. Geometry of ground plane estimation and object localization. The camera height h is the distance from its principal point to the ground plane. The pitch angle is θ and $\mathbf{n}$ is the ground plane normal. Thus, the ground plane is defined by $(\mathbf{n}^\top, h)^\top$.

4. Local feature matching methods learn a descriptor for a pixel and use some kind of distance metric to match features between two images. How would epipolar constraints or homography based constraints help in improving feature matching? **(2 points)**

5. What is loop detection in SLAM? **(1 point).** What is Loop Closure in SLAM? **(1 point).** How does loop closure in SLAM give rise to additional relations that improves the trajectory estimate. You need to be precise and argue with the relevant equations **(2 points)**

6. Given a calibrated camera what is the nature of the Reconstruction Ambiguity that occurs in a two view reconstruction? Prove analytically that such an ambiguity exists? **(1+3 = 4 points)**

7. What is the central challenge that arises when given a sequence of camera views, the R, t estimation between two successive views is computed by decomposing the Essential Matrix? What are the two ways discussed in the class to ensure that the reconstructed 3D

points from a sequence of such camera views differ from the original 3D points by a single scale (**1 +2 = 3 points)**

8. How would you pose the camera resection problem through reprojection error minimization formulation? **(1 point).** Derive the Jacobian that relates a point in the image plane to its corresponding 3D point. Assume that the camera pose is the only variable and not the 3D point as typical of a resection formulation **(4 points).** What will be the structure of the Jacobian for ***n*** such 3D – 2D correspondences. (**2 points**)