CSCI 677: Advanced Computer Vision - Fall 2021

Instructor: Prof. Nevatia

Assignment 1

Due on September 16, 2021 before 17:00 PDT

Submit a PDF file on course page; you may scan the hand-written solution and need not format the mathematical expressions.

Problem 1. (4 points) Consider a line l in the image, given by parameters (a, b, c), in the image coordinate system. We know that the corresponding 3-D line casting this image lies in a plane. Derive the equation of this plane (in the camera coordinate system). You may assume that the intrinsic calibration matrix, $\boldsymbol{K}$, is given.

Problem 2. (11 points) Suppose that we have a right-handed camera coordinate system (X_c, Y_c, Z_c) associated with its origin at the lens center (or the pinhole), as in the examples discussed in class. Suppose that the imaging plane is at a distance of 50 millimeters from the lens center, the imaging surface (a planar patch) is 1200×1200 pixels, each pixel is .04 millimeters in each dimension, and that the principal ray intersects the imaging surface in the center. Let the image (or retinal) coordinate system have its origin at the upper-left corner of the imaging sensor, the x-axis along the top-row, and the y-axis points downward at an acute angle of 88 degrees to the x-axis). Assume that the x-axis in the image plane is parallel to the x-axis in the normalized image plane.

- For these conditions, derive the intrinsic matrix K, which helps map a point, specified in the normalized image coordinate frame to the image coordinates $(x, y, 1)^T$ expressed in pixel units (ignore the issue of rounding off pixel coordinates to integers).
- Now suppose that the camera is placed in a world coordinate system (O_w, X_w, Y_w, Z_w) such that O_c is at location $(4, -3, 2)$ in the world coordinate system (all distances expressed in meters); X_c is parallel to X_w and then the camera is rotated by 15 degrees about the X_c axis in a clockwise direction (visualize as a person taking a picture with camera pointing down slightly). Compute the final projection matrix, M.
- Consider a set of parallel lines in the horizontal plane (i.e. the $X_w - Z_w$ plane). Find the vanishing point, in the image coordinates, of this set of lines in terms of the direction of the lines for the above configuration.