Computer Vision

Test conditions: All documents and reference materials are authorised. You may NOT communicate with anyone other than the exam Proctor or the course professor. You must answer all questions in INK on the official exam forms. You may use scratch paper to prepare your answer. You may respond in English or French (or both), but you MUST write legibly. Illegible text will not be graded. Duration : Maximum 3 hours.
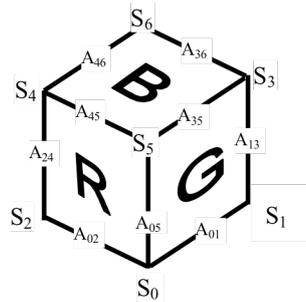
You are to use a multi-colored cube of size 1 meter^3 as a calibration object for a camera. In the calibration image you see three faces of the cube painted saturated colors of red (R), green (G), and blue (B) as shown above. The cube is placed on a light colored surface, whose boundaries are outside the image. In the calibration image you can see seven corners (S_0, S_1, S_2, S_3, S_4, S_5, S_6), three interior edges (A_{05}, A_{45}, et A_{35}), and six exterior edges (A_{01}, A_{02}, A_{13}, A_{24}, A_{46}, et A_{36}) as shown above. Your camera provides an RGB image with 24 bits per pixel (8 bits per color).

1) (4 points) Explain how to transform your image into 4 color-opponent images: Red–Blue (RB), Red–Green (RG), Blue–Green), and White–Black (BW). How many values are possible for each pixel in each of you color opponent images RB, RG, BG, BW?

2) (4 points) Explain how to use a Sobel edge detector and a Hough Transform to determine the parameters of the line equations for each of the interior edges (A_{05}, A_{45}, et A_{35}), using the images RB, RG and BG, as well as the 6 exterior edges (A_{01}, A_{02}, A_{13}, A_{24}, A_{46}, et A_{36}) using the image BW. How precisely can you determine the line parameters from the Hough transform? How can you exploit the gradient direction to reduce the computation time?

3) (4 points) Explain how to determine the position of the corners (S_0, S_1, S_2, S_3, S_4, S_5, S_6) of the calibration cube in the calibration image from the line equations of the edges (A_{01}, A_{02}, A_{05}, A_{35}, A_{45}, A_{13}, A_{24}, A_{46}, et A_{36}).

4) (4 points) Explain how to compute the projection matrix $\mathbf{M}_S^i$ for the camera from the position of the corners in the image. What is the minimal number of corners required? How would you use ALL the corners? Which gives a more precise answer? Why?

5) (4 points) Explain how to calculate the homographic transformation $\mathbf{H}_G^I$ that is needed to map an image "I" so that it appears as if it were on the Green face of the cube in the calibration image.

The image I
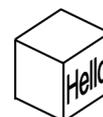
The image I mapped onto the face G of the cube.