University at Buffalo
Department of Computer Science and and Engineering
CSE 473/573 - Computer Vision and Image Processing

Fall 2020
Project #1
Due Date: 10/12/20, 11:59PM

1 Rotation Matrix (5 points)

Figure 1 illustrates the transformation from coordinate xyz to XYZ: 1)rotate around z axis with $\alpha = 45°$; 2) rotate around $x\prime$ axis with $\beta = 30°$; 3) rotate around $z\prime\prime$ axis with $\gamma = 50°$. (You are allowed to use any function of the imported library in "task1.py".)

- Design a program to get the rotation matrix from xyz to XYZ. (3 points)
- Design a program to get the rotation matrix from XYZ to xyz. (2 points)

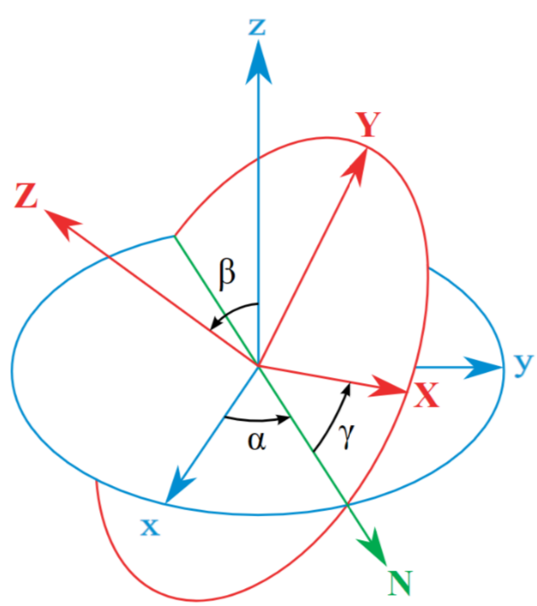

Figure 1: Illustration of Eular angles

2 Camera Calibration (5 points)

Figure 2 is an image of the checkboard, where XYZ is marked as the world coordinate and xy is marked as the image coordinate. The edge of each grid on the checkboard is $5mm$ in reality. Suppose one pixel of the image is equivalent to $1mm$. You can calculate the projection matrix from world coordinate to image coordinate based on the 32 marked points on the checkboard (It is suggested to use Direct Linear Transformation). From the projection matrix you can get the intrinsic matrix which is indicated as $\begin{bmatrix} f_x & 0 & o_x \\ 0 & f_y & o_y \\ 0 & 0 & 1 \end{bmatrix}$ (f_x and f_y are not necessarily be equal).

- Design a program to get the intrinsic parameters f_x, f_y, o_x, o_y. (4 points)
- If the defination of world coordinate changed, would the intrinsic parameters be different? (1 point)

In this task you are only allowed to use the library and library function already imported in the script "task2.py".

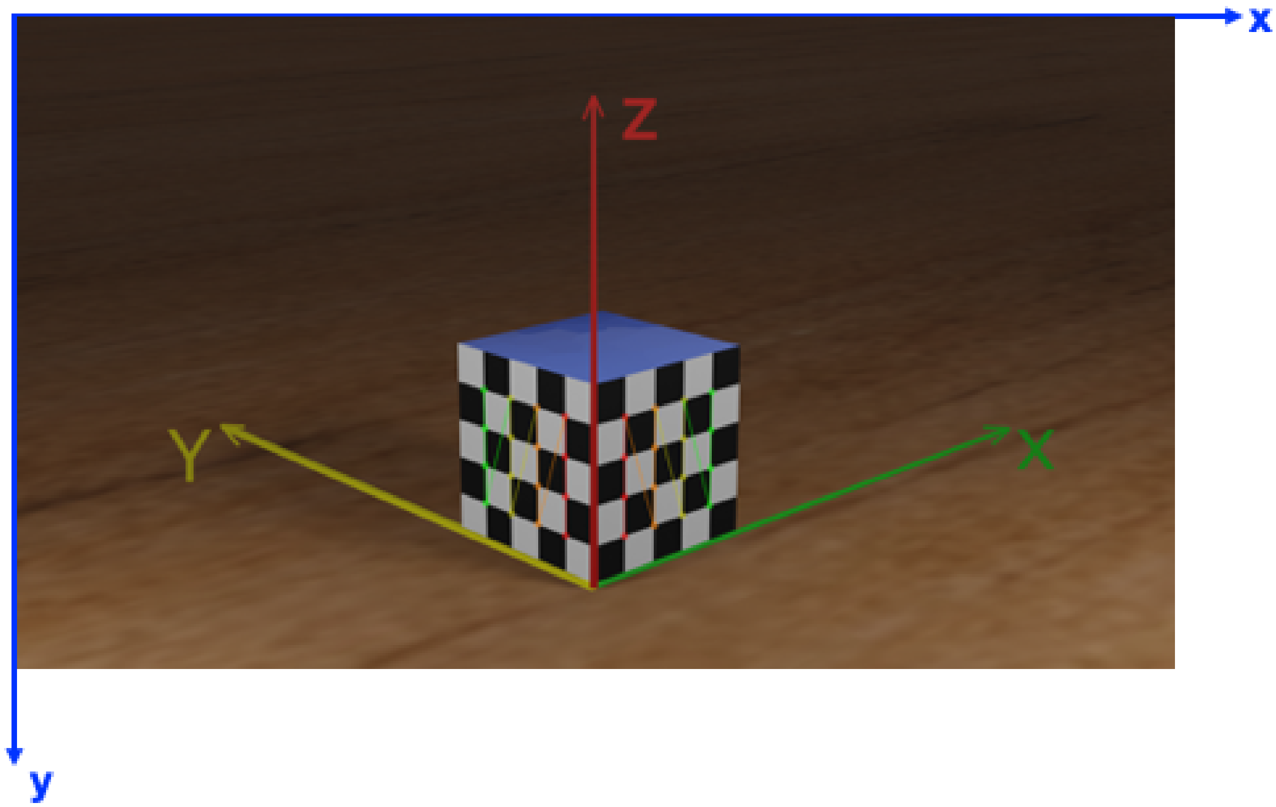

Figure 2: Image of the checkboard

3 Image Rectification (5 points)

Figure 3 shows two images of one object taken from different views, where xy are marked as the image coordinates. The relationship between the two image coordinates can be with the fundamental matrix **F**: $\begin{bmatrix} x_l & y_l & 1 \end{bmatrix} \cdot \begin{bmatrix} f_{11} & f_{12} & f_{13} \\ f_{21} & f_{22} & f_{23} \\ f_{31} & f_{32} & f_{33} \end{bmatrix} \cdot \begin{bmatrix} x_r \\ y_r \\ 1 \end{bmatrix} = 0$, where $[x_l, y_l]$ and $[x_r, y_r]$ are the coordinates of corresponding points on the left and right images. Figure 4 is an example of the epipolar line in epipolar geometry.

- Design a program to get the fundamental matrix **F** using eight points algorithm. (3 points)
- Following the example of Figure 4, draw the specific point and the epipolar lines of them on the two images (The two points are clarified in the script "task3.py"). (2 points)

See the hints for feature extraction and points match in the script . You are only allowed to use the library and library function already imported in the script "task3.py".

Figure 3: Left and right view

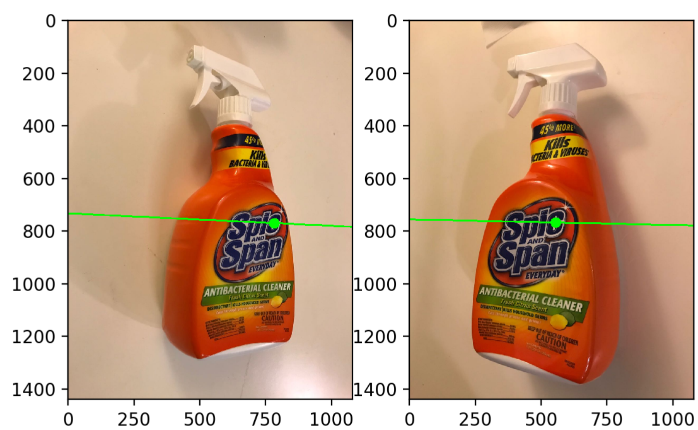

Figure 4: Example of epipolar lines on two images

Instructions:

- Compress the three python files, i.e., “task1.py”, “task2.py”, “task3.py”, the three given images (“checkboard.png”, “rect_left.jpeg”, “rect_right.jpeg”) into a zip file, name it as “UBID.zip” (replace “UBID” with your eight-digit UBID, e.g., 51399256) and upload it to UBLearns before the due. The zip file you upload should not contain files other than the six aforementioned files.
- Anyone whose code is evaluated as plagiarism, your grade will be 0 for this project.
- For all students whose code raise “RuntimeError”, your grade will be 0 for this task.
- Strictly follow the format in the scripts, i.e., “task1.py”, “task2.py”, “task3.py”. **Do Not** modify the code provided to you.
- **Do Not** import any library or APIs besides what has been listed. For task2 and task3, you are **ONLY** allowed to use the library and library function already imported in the script.
- Late submissions within 24 hours are allowed and will result in a 40% penalty. After one day, submissions will not be accepted.