ENG301 - Computer Vision

Assignment 1

Demonstration deadline: 5 April 2023
Report submission deadline: 11:59 pm, 9 April 2023

Plagiarism note: *Students are free to discuss among the groups as well as learn from existing online codes. However, their programs should be written by themselves. If similarity is detected in their report or programs, heavy penalties will be applied.*

Theory

In many computer vision applications, the camera is not attached to a fixed frame but to a moving platform such as smartphones, cars, robots, drones, airplanes, etc. It is then important to calculate the relative position of the camera with respect to its surrounding objects as in the following question:

A workstation that includes a robotic arm and a camera has been set up as in Figure 1. The camera can see both the origin of the base coordinate system of a robot arm and the centre of the object to be manipulated by the robot.

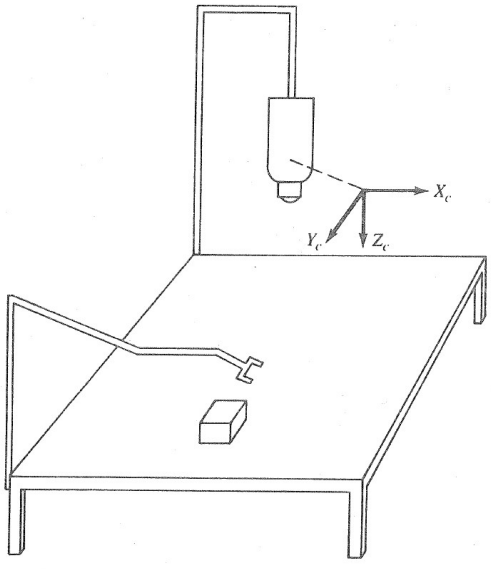


Figure 1: A workstation with a camera, a robot arm and an object.

If a coordinate system has been established at the centre of the object, then the object as seen by the camera can be expressed by the homogenous transformation matrix T_1.

$$T_1 = \begin{bmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 0 & 10 \\ 0 & 0 & -1 & 9 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Similarly, the origin of the robot base coordinate system as seen by the camera can be represented by the homogenous transformation matrix T_2.

$$T_2 = \begin{bmatrix} 1 & 0 & 0 & -10 \\ 0 & -1 & 0 & 20 \\ 0 & 0 & -1 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

a) After the equipment has been setup and these coordinate systems have been established, someone rotated the camera 90^0 about the *z* axis of the camera. What is the position and orientation of the camera with respect to the robot's base coordinate system?

b) After the rotation happened in a), the object is also rotated by 90^0 about the *x* axis of the object and translated by 4 units along the rotated y axis. What is the position and orientation of the object with respect to the robot's base coordinate system? What is the position and orientation of the object with respect to the rotated camera coordinate system?

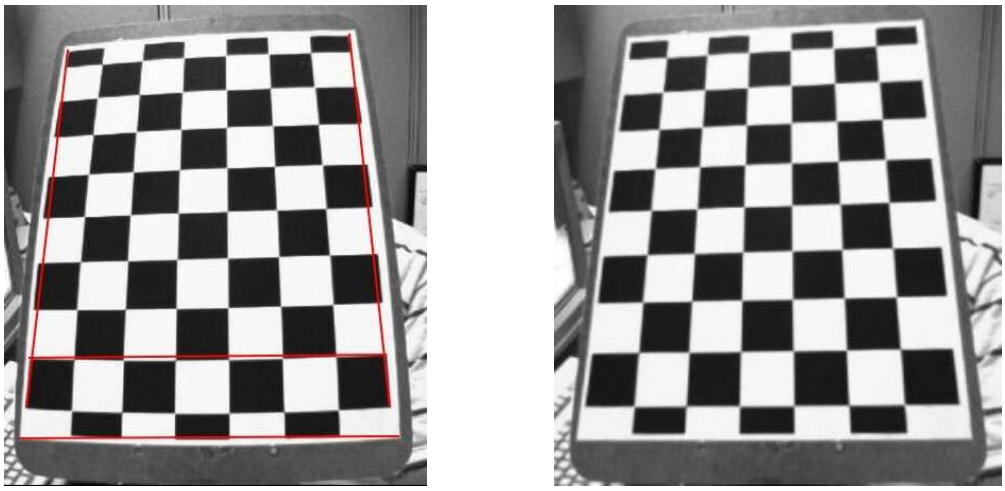
Note: The answer can be written in the **homogenous transformation matrix** form since retrieving the angles from a homogenous transformation matrix is not a trivial problem (see more: https://en.wikipedia.org/wiki/Rotation_matrix)

Programming

Lane marking detection plays a vital role in various applications such as autonomous driving, advanced driver assistance systems (ADAS), and road maintenance. The detection of lane markings involves identifying the boundaries of the lanes on the road, and this information can be used to guide the vehicle to accurately perceive its position on the road, maintain its lane, and avoid collisions.

In this task, students will work in groups of three (register here) to carry out the following tasks:

1. Collect a camera from the instructor and write a program to carry out the calibration. The obtained parameters are then used to correct the distortion of the captured images, as shown in Figure 2. Insert the result into your report.



a) Original image b) Corrected image

Figure 2. Camera calibration to undistort the image

2. Use the provided camera to record some videos of the lane markings at Maker Space and then write a program to carry out the following tasks:
   - Detect the lane markings and draw the lane area in front of the camera;

- Determine the midline of the lane markings and plot it;
- Calculate the position of the camera with respect to the midline, for example, “Left: 3 cm” or “Right: 1 cm”.

3. Deploy your program on a single board computer, such as Jetson Nano, Raspberry Pi, Intel Joule, etc. (The board will be provided if your group does not have it). Carry out a live demonstration using that board and the provided camera.
4. There are two options for this task:

   Option 1: Working with a mobile robot.

   Put the single board computer and camera on a mobile robot platform (to be provided). Write a program to control the robot to follow the lane.

   Note: The purpose of this task is to verify the robustness of your lane tracking algorithm as well as to provide you with experience on working with a real system. The robot control can be as simple as go straight, turn left, turn right. The performance of your lane tracking algorithm, not the robot, will be assessed.

   Option 2: Metric rectification

   Extend your program to measure the distance between the lane markings and display it when moving the camera along the lane.