Robotics: Assignment III

(Team Assignment)

Robot Vision

Due: 2023/11/20 13:00 pm

Cameras are one of the most commonly used sensors for a robot to gather visual/spatial information of its environment. With the help of image processing, a robot can analyze the image of the immediate environment imported from the camera and use the result to determine the appropriate action to take.

In this assignment, you will learn how to model the relationship of an image and the real environment with camera calibration and how to use the camera model to estimate the position of an object in the real world.

Part A: Camera Calibration

Camera calibration is the process of estimating the parameters of a pinhole camera model, including the focal length and principal point. This process is essential before conducting any image processing. In this section, you should become acquainted with the camera model and the meaning of each camera parameter.

0) For this assignment, you will extensively utilize the OpenCV library. We recommend using Python as your primary language for completing this assignment. While C/C++ are also acceptable, please be aware that you'll be responsible for managing OpenCV installation and handling any I/O problems.

1) Print the image '**`AssignmentIII/PartA/checkerboard.png`**', which displays the checkerboard pattern, onto a sheet of paper. Then, measure the physical size of the squares.

2) Select a camera for calibration, such as your phone's camera or a webcam. Capture 20 images of the checkerboard for calibration, ensuring that you vary the shooting angles for each image. Please include a clear description of the camera you used.

   Note: Typically, commercial cameras, like those in cell phones and laptops, come with an autofocus feature that can dynamically alter the camera's intrinsic parameters. To achieve a satisfactory calibration result, it's important to disable this feature when capturing images for your calibration dataset. If your default camera app on Android devices doesn't provide an option to disable autofocus, you can consider using the Camera FV-5 Lite app.

3) Follow the steps outlined in the provided tutorial [1] for conducting camera calibration. Record the intrinsic parameters you derive and briefly describe the process used to obtain them. Additionally, explain the physical meaning of each intrinsic parameter in your own words.

4) Utilize the camera parameters you acquired in the previous step to remove distortion from the 20 images you've taken, as well as a new image of a different object. Include all 21 pairs of original and undistorted images in your report and try to observe and describe the impact of this transformation.

Part B: Object Detection

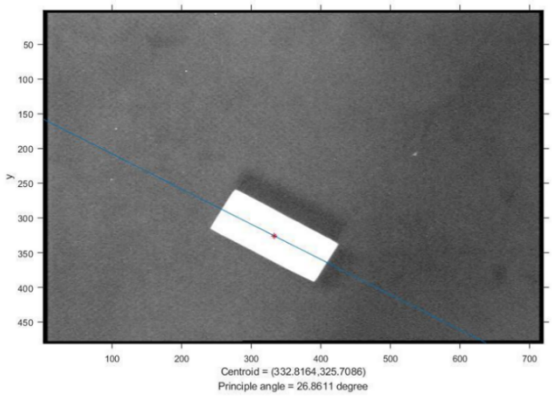
Given an image taken from a camera, apply the algorithms you learned in the binary machine vision section of Lecture 6 to develop a program to identify foreground objects. Specifically, your goal is to find the centroid and the principal angle of each object in the image. We've included sample code (main.cpp) for fundamental image processing functions in OpenCV to assist you.

Input Image:

We provide 4 images in **"`AssignmentIII/part_b/images`"** for testing. Your program should take the file name of the image from the standard input.

Output Results:

Your program should display the **centroid** and **principal line** for each object on the given image. Additionally, it should provide the **centroid's coordinates** and the **principal angle**. You have the option to present this information either through standard output or by marking it directly on the output image. Run your program on the provided four images and include the results in your report.



example output

Submission

Create a zip file named 'hw3_team*[team number]*.zip' that includes the following items and upload it to NTUCOOL:

- The source code for Part A, which can be 'hw3_a.cpp' or 'hw3_a.py,' demonstrating how you obtained your camera's intrinsic parameters.
- The source code for Part B, which can be 'hw3_b.cpp' or 'hw3_b.py.'
- Your team's report in PDF format, named 'hw3_report.pdf.'

Please ensure that your code can be successfully built and executed before submission. **Only one member per team should submit this zip file**.

Evaluation Criteria

- Report in English
- Brief and concise
- Define the division of work within your team

Reference

[1] Camera Calibration and 3d Reconstruction in OpenCV
http://docs.opencv.org/master/d4/d94/tutorial_camera_calibration.html
[2] "A very brief Introduction to OpenCV.ppt" in Files/AssignmentIII/ on NTU COOL