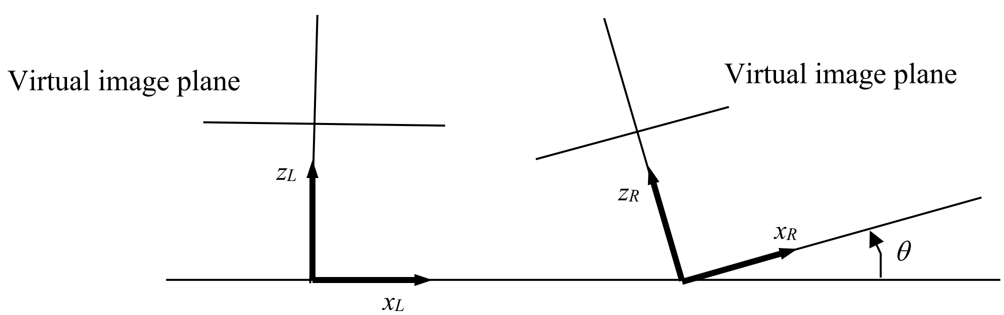
ECE 4554 / 5554: Computer Vision: Homework 4

Fall 2021

Instructions

- The assignment is due at Canvas on December 6 before 11:59 PM. Late submissions are allowed at the cost of 1 token per 24-hour period, but only up the end of Dec. 8.
- Please review the Honor Code statement in the syllabus. This is an "individual" assignment, not a "team" assignment. The work that you submit for a grade must be your own.
- This assignment is shorter than previous assignments. It will be weighted proportionately less when final course grades are computed.
  - Problem 1 is the only analytical problem, and it is worth 10 points.
  - Problem 2 is a programming assignment, and is worth 20 points.
  - Problem 3 is also a programming assignment. It is worth 10 points, and is required for 5554 students but is optional (extra credit) for 4554 students.
- For problem 1, please submit a single PDF file that shows your work and contains your answers. Use file name `Homework4_P1_USERNAME.pdf`, with your own VT Username. Handwritten solutions are permitted, but they must be easily legible to the grader.
- Problems 2 and 3 should be submitted together as one Jupyter notebook file. Details are provided at the end of this assignment. For any coding problem, the notebook file that you submit must be compatible with Google Colab. Your code should execute after the grader makes only 1 change to your file, which is the location of the working directory. If the notebook file does not execute, then the grader will be tempted to assign a grade of 0 for the coding problems.
- After you have submitted to Canvas, please take care to download the files that you submitted and verify that they are correct and complete. *The files that you submit to Canvas are the files that will be graded.*

Problem 1. (10 points.) The diagram below shows a stereo camera arrangement, as viewed from above. This arrangement is similar to the common stereo imaging set-up that we have discussed in lectures, except that the camera on the right has rotated inward by an angle θ. The two optical axes are coplanar, and both cameras have the same focal length *f*. Vertical axes for the two cameras, y_L and y_R, are not shown, and are perpendicular to this page. When the right camera rotates, the baseline *B* does not change.



a) Solve for the <u>essential matrix</u> that relates these two cameras.

b) If possible, solve for the locations of the two epipoles.

Problem 2. (20 points.) You have been given a Jupyter notebook file named `Homework4_USERNAME.ipynb` and a file `hotel_images.zip`. Replace "`USERNAME`" with your Virginia Tech Username. Unzip the other file, and examine the files inside folder `hotel_images`. Then upload the notebook file and the intact folder to Google Drive. Open the `ipynb` file in Google Colab. Follow the instructions that you will find inside the notebook file.

Problem 3. (10 points. For 5554 students, this problem is required. For 4554 students, this problem is optional and can be submitted for extra credit.)

Near the end of your Jupyter notebook file for the previous problem, append new code blocks and text blocks in which you implement your own keypoint detector, and then track those keypoints over the "hotel" image sequence. Do not change your answers for Problem 2, but instead add new blocks at the end of the notebook file.

Essentially, you should copy your solution for Problem 2 and then update your `getKeypoints` function so that it does not depend on `cv2.goodFeaturesToTrack`. (Possibly you only need to re-define `getKeypoints` and then run `mainFunction`, but this depends on your implementation for Problem 2.)

It is suggested that you use either Harris-corner criteria or Shi-Tomasi criteria. Referring to packet 9 of the lecture slides and rewriting slightly, we have

$$\det(H) - k\big(\mathrm{trace}(H)\big)^2 \geq R$$

If you use the Harris criteria, it is good to choose $k \in [0.01, 0.06]$. Choose R so that simple (non-corner) edges and noisy patches are ignored. It is good to perform local non-maxima suppression over a 5x5 window centered at each point. Try to generate at least 100 keypoints, and track them in the same way as you tracked other keypoints for Problem 2. Generate the same type of output as you did for Problem 2.

What to hand in: After you have finished your work, please upload your solutions to Canvas. This homework has been set up as a Canvas "quiz". You will need to upload your answers in different files for some of the problems. The purpose is to help the graders work more efficiently, with fewer errors in grading and with better feedback to you.

- Problem 1: upload your answer in file `Homework4_P1_USERNAME.pdf`.
- Problem 2 and (possibly) Problem 3: Create the following 2 files and upload both of them to Problem 2 of the Canvas "quiz". (Later, a separate Canvas gradebook entry will be created to hold grades for Problem 3.)
    - Upload `Homework4_Code_USERNAME.zip`, which contains your one Jupyter notebook file, for Problem 2 and (possibly) for Problem 3.
    - Upload `Homework4_Notebook_USERNAME.pdf`, which contains a PDF version of your Colab session for Problem 2 and (possibly) Problem 3.
