Multidimensional Sensing Techniques
Assignment 4 – Lidar points projection
You can collect up to 22 points in this assignment
Deadline: 22.10.2021 at 23:55

The aim of this lab is to familiarize yourself with calibration data and apply it to project LIDAR data on a picture and one video. The goal of the provided code is to calibrate the point projection from lidar data onto the video camera image and overlay the two.

Tasks to be performed

1) Download the code and open it with either jupyter lab from anaconda (install opencv package if you do) or in google colab (https://colab.research.google.com/).

2) Import the image and lidar data into the project (need to be in the same folder if jupyter lab is used or imported if colab).

3) Run the first 2 tabs of the code and inspect the plots you get. What you should see is a 3d plot of the lidar points and its projection.

4) On the third tab there is a parameter camera_axis (3x3 matrix) which represents how the camera axes are rotated relating to the lidar axises. In other words, coordinate systems for camera and lidar are different. Opencv assumes that coordinates from 3d points show depth at z-axis, right on the x-axis and downwards on the y axis. You need to figure out what is the axis system for lidar data and input the corresponding rotation matrix.

As an example, if lidar data had stored depth at y axis, right on the x-axis and upwards on the z axis, then the rotation matrix would look like this (take note that to reverse the upward to downward, the value of rotation matrix is -1)

[[0,1,0],

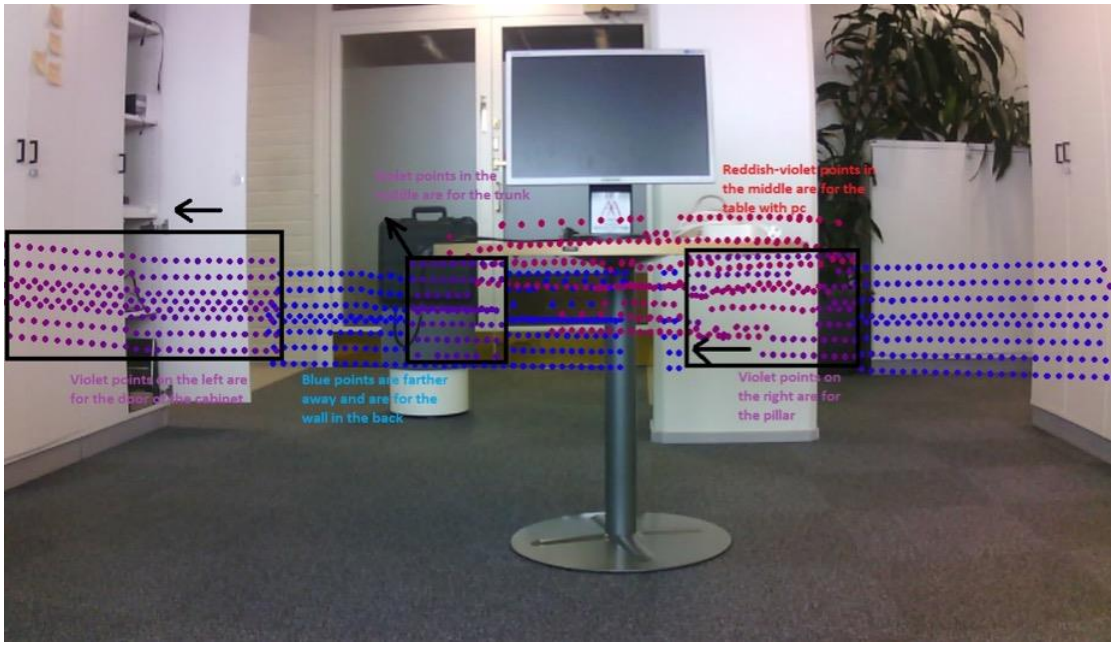
[1,0,0],

[0,0,-1]]

Find out what is the correct rotation matrix and apply it (supplementary materials contain more information on this). Should this succeed, you should see lidar points projected as horizontal lines like this:

5) You need to adjust the parameters of rotation, tvec and dist_coeffs (more detailed description about them below) so that the points in the image are properly overlayed on top of the objects present in the image. Use this to figure out the parameters. IMPORTANT: be sure to set variable is_colab to False in case you are using anaconda opencv (this is preferable, because it makes the calibration process easier)

Information about the code: Third tab in the code initializes variables and shows the projected points. Since the variables are uninitialized, nothing is projected properly. Your task is to find out parameters that are most suitable to perform as good of a projection as possible. Here is an example of how the process should look like midway (the color of the points depends on the distance, red corresponds to close distance and blue corresponds far away dustance.)



Here is a bit of information regarding the parameters that need to be edited:

tvec and rotation - contain parameter showing how much camera is rotated (rotation) and displaced relating to the lidar. These need to be properly adjusted so that projection doesn't show just a line, but actually overlays points on top of the objects that these points represent. The camera is slightly tilted downwards and to the side, the displacement is slightly below the lidar (10-20 centimeters) and a few centimeters to the sides (The calibration is using meters as a unit of measurement).

dist_coeffs = [d1, d2, d3, d4, d5] - This coefficient shows how much the camera distorts the image. Originally one should perform camera calibration with chessboard to figure out these parameters for the lens used. For this exercise you can assume that values of d3 and d4 equal zero. For d1 try values -0.2, -0.3, -0.4. For d2 try values 0.5, 0.6, 0.7. For d5 try values -0.1, 0.0, 0.1. Figure out which combination is the best and try to explain how the result changes based on the changes to d1, d2 and d3. Note: If you figure out combination of parameters that provides better result, then you can use that instead of the values provided.

General Advice: Since there are a lot of parameters that need to be changed and tested in (5), it could save some time/work if you wrote a script to go over them in a loop rather than rerun the program. For anaconda users, you can just link the keyboard input to the parameters (for example 'd' could increase tvec[0] by 0.01 and 'a' decrease it by the same amount and other keys could change other parameters in similar manner). For google colab users you unfortunately cannot give proper input to the program so for you it would make more sense to iterate through a set of values with small delays and record which seemed to fit best (for example tvec[2] could go from 0.1 to 0.2 by increments of 0.01 every 0.5 seconds).

Questions:

- (2 point) What are the axises for the lidar (depth, vertical, horizontal)?

- (6 points) What is the camera_axis matrix between lidar and camera. Describe what it means.

- (10 points) What are the displacement parameters for the camera (translation and rotation), what does it mean. Feel free to illustrate your answer with a figure.

- (4 points) How are different parameters of lens distortion affecting how the points are projected? (Feel free to experiment and use more outlandish values)

More information regarding projectPoints function:
https://docs.opencv.org/4.5.3/d9/d0c/group__calib3d.html#ga1019495a2c8d1743ed5cc23fa0daff8c

Misc information about projection:

https://learnopencv.com/geometry-of-image-formation/

Report

The report document should contain:

- Your full name and student number at ÅA
- **Screenshots of the part of the source code you need to modify**
- Each page of your submission should have a page number
- **Pay attention to the readability of your report!**

You should write a report documenting the work performed during the exercise. The report should contain information on:

- What you did
- How you did it
- Why you did it this way
- The results of your work
- How your solution could be improved/generalized

You are encouraged to provide pictures, graphs, screenshots, diagrams etc. Anything that help understanding your solutions should be included in your report. If you use content (pictures, graphs, etc.) from other sources, remember to properly cite and provide a reference to the used external source(s).

At the end of the report you should also provide a reflection on what you learned during this exercise. This section could provide answers to the following questions:

- What did you learn?
- Did anything surprise you?

- Did you find anything challenging? Why?
- Did you find anything satisfying? Why?

The expected size for this report is 2-5 pages of content.

Name you report file Assignment4_YourName.pdf and upload your report in PDF format on moodle before the deadline.