Computer Vision – Camera Calibration

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1) Camera calibration

Try calibrating a webcam or smartphone camera yourself. Either OpenCV (with some programming effort) or Matlab calibration (a tool including visualization) can be used.

- You can generate a calibration sample here:
  https://calib.io/pages/camera-calibration-pattern-generator

- You can find an OpenCV tutorial with Python here:
  https://docs.opencv.org/4.10.0/dc/dbb/tutorial_py_calibration.html

- A local installation is required to use Matlab; the software is paid for by the TH Rosenheim and made available to all students free of charge. You can find installation instructions here:
  https://intranet.th-rosenheim.de/einrichtungen/rechenzentrum/it-services/software/allgemeine-software
  There are extensive extensions (toolboxes) for Matlab, not all of which need to be installed; the calibration tool is located in the Computer Vision Toolbox. You can find instructions here:
  https://de.mathworks.com/help/vision/ref/cameracalibrator-app.html

If you have a data sheet of your camera: Convert the computed focal length to mm and compare it to the focal length given in the data sheet. Does it appear to be correct?

Why is the above procedure for calibrating a smartphone camera unsuitable for practical purposes?

2) Intrinsic camera parameters

A digital camera (including a lens) has the following properties:

Sensor type:	CMOS
Sensor format:	1"
Sensor size:	1921 pixels x 1201 pixels
Pixel size:	5 µm x 5 µm
Focal length:	7 mm

The principal point is exactly in the center of the image, the axes of the sensor coordinate system are perpendicular to each other.

What is the 3x3 calibration matrix of the intrinsic camera parameters?

3) Camera parameters: System design using the example of driver assistance in vehicles

Consider the following situation: The camera from question (1) is installed in a car that has stopped at a road junction. Another vehicle is driving from left to right along the crossroads at a distance of 10 m at 50 km/h.

You can make the following assumptions for the subsequent questions:

- the origin of the world coordinate system is in the optical center of the camera, the camera is not rotated
- the crossing vehicle moves exactly parallel to the image plane
- all pixels on the sensor are exposed at the same time
- lens distortions can be neglected

a) What does the complete 3x4 projection matrix from homogeneous world coordinates to homogeneous image coordinates look like?
b) How far does the crossing vehicle move in the image between two images if the camera takes 20 images per second?
c) What frame rate is required so that the crossing moves by a maximum of 20 pixels between two images?