# Assignment 2

Welcome to the second assignment of the lecture *Visual Computing* in summer term 2020. **Please read all instructions carefully!** The goal of this exercise is to familiarize you with the mathematical description of *cameras* and *camera calibration*. Submission is due on Monday, Mai 4th, 2020 at 12.00am. Please submit your solutions via `read.mi.hs-rm.de`.

Aufgabe 1. (1 point) Construct the size of the diameter of the *circle of confusion* created when the point **P** is mapped with the lens, aperture and image plane system shown below.
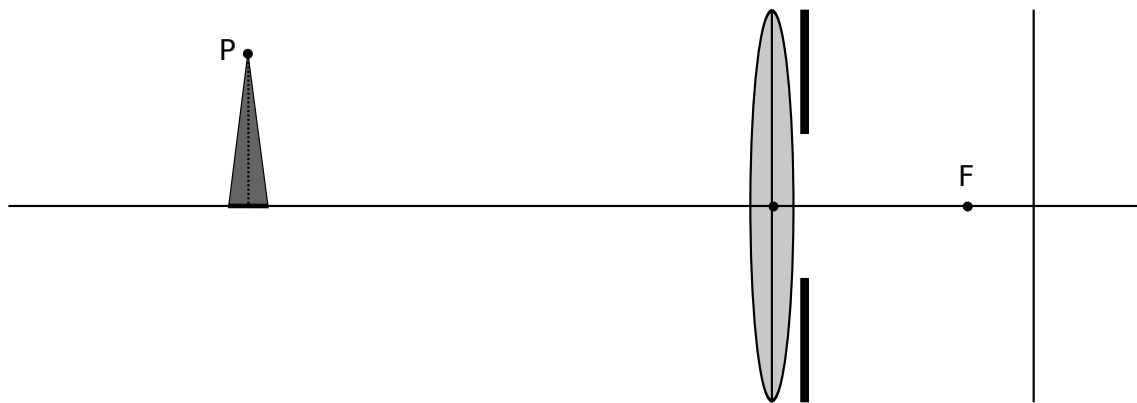
Aufgabe 2. (1 point) The sensor of a camera has a resolution of 2048×2048 pixels. The pixels are square and have a side length of $5.5\mu m = 0.0055mm$. How large must a suitable lens be to fully illuminate the sensor?

Aufgabe 3 (1 point)**.** Given is a CCD camera with focal length $f = 6mm$. The sensor has 640×480 square pixels with a side length of $5\mu m = 0,005mm$. The principal point is $\mathbf{h} = (310, 250)^T$. The optical center of the camera is at $\mathbf{C} = (100, 200, 300)^T$ and the orientation of the camera corresponds to the orientation of the world coordinate system. What is the camera matrix $\mathbf{P}$?

Aufgabe 4 (3 points)**.** Given is the camera matrix

$$\mathbf{P} = \begin{pmatrix} 490 & -390 & -1500 & 1300 \\ -590 & 1400 & -600 & 1300 \\ -0.5\sqrt{2} & -0.3\sqrt{2} & -0.4\sqrt{2} & 5 \end{pmatrix}.$$

Calculate

1. (1 point) the *camera center*,
2. (1 point) the corresponding *calibration matrix* and
3. (1 point) the *orientation* of the camera.

Aufgabe 5 (2 points)**.** Determine the parameters of a camera using the *GML C++ Camera Calibration Toolbox* mentioned in the lecture (see `http://graphics.cs.msu.ru/en/node/909`). You will also find a folder with sample images there.
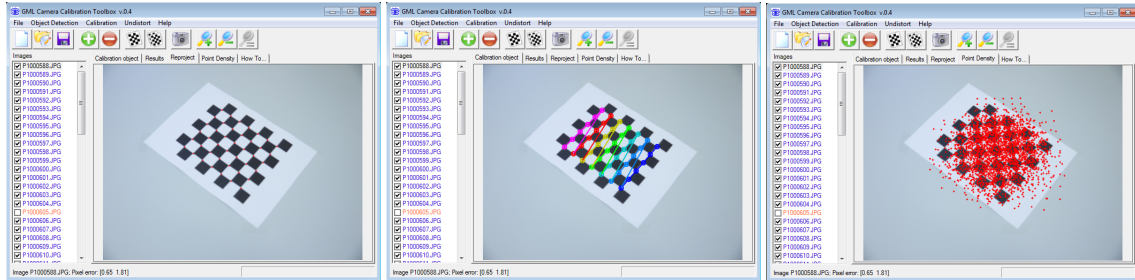
1. (1 point) What are the camera calibration matrix and the coefficients of radial distortion corresponding to the sample images on the website?

2. (1 point) Calibrate the camera based on the pictures contained in the archive `calibrationImagesCheckerboard.zip`, which you can find on the website of this lecture. In the aarchive you will find images of a 7×8 chessboard pattern with $25 \times 25mm^2$ in size.

Aufgabe 6 (2 points)**.** Write a simple OpenCV program that rectifies input images using the OpenCV function `undistort` and related calibration parameters – for example, as described in Task 5. In concrete terms, your programme should

1. (1 point) import an image together with the associated calibration parameters from a file, and

2. (1 point) display the *imported image* as well as the *image* that ist *rectified* using the OpenCV function `undistort`.

The adjacent figures show an example from the data set `calibrationImagesCheckerboard.zip`. Left the *(distorted) input image*, right the *same image after rectification*.