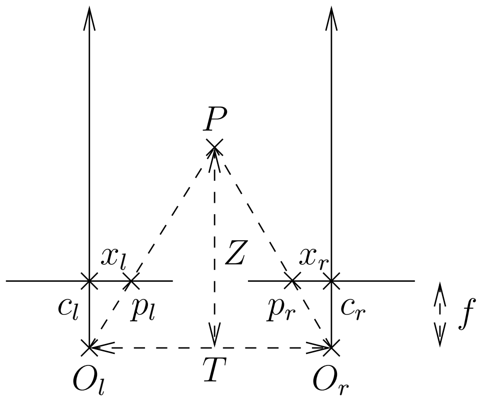
Camera Calibration and Stereo Systems

1 Simple stereo system and accuracy of stereo systems

Consider the stereo system as displayed on the right. O_r and O_l denote the optical centers of both camera systems. T is the baseline of the stereo system, i.e., the distance between the optical centers. P is a point which is projected onto its image point p_r in the right camera and p_l in the left camera. x_r and x_l denote the distance between the projections of P and the principal points of the cameras c_r and c_l. The depth Z of P is computed as $Z = f\frac{T}{d}$ where the disparity $d = x_r - x_l$.



1. Estimate the accuracy of the stereo system assuming that the only source of noise is the localization of corresponding points in the two images. Discuss the dependence of the error in depth estimation as a function of the baseline width and the focal length.
2. Using your solution to the previous exercise, estimate the accuracy with which features should be localized in the two images in order to reconstruct depth with a relative error smaller than 1 %.
3. Check what happens if you compute the *sum of squared differences* (SSD)

$$\psi_{\text{SSD}}(u, v) = -(u - v)^2 ,$$

and the *cross-correlation* (CC)

$$\psi_{\text{CC}}(u, v) = uv ,$$

between an arbitrary pattern and a perfect black pattern over a window W,

$$\psi = \sum_W \psi(u, v) .$$

Discuss the effect of replacing the definition of cross-correlation with the *normalized cross-correlation* (NCC)

$$\psi_{\text{NCC}}(u, v) = \frac{(u - \bar{u})(v - \bar{v})}{N_u N_v} ,$$

where $\bar{u} = \sum_W u$, $\bar{v} = \sum_W v$, $N_u = \sqrt{\sum_W u^2}$, and $N_v = \sqrt{\sum_W v^2}$. Discuss the advantages of NCC vs. CC vs. SSD. Can you precompute parts of ψ_{NCC} to speed up the computation?

4. Design a correlation-based method that can be used to match edge points.

Elli Angelopoulou — Pattern Recognition Lab
Simone Gaffling — University of Erlangen-Nuremberg
simone.gaffling@cs.fau.de — **www5.cs.fau.de/lectures/ss-14/computer-vision-cv**