

## Exercises in 3D Computer Vision I

### Exercise 1      **Depth estimation**

- Derive the formula for calculating the depth  $Z$  of an image point  $\mathbf{x}$  given its disparity  $d$
- Assume a stereo rig with the following properties:  $R = I$ ,  $\mathbf{C}_L = (0, -H, 0)^T$  and  $\mathbf{C}_R = (B, -H, 0)^T$ . The distance is computed from the disparity values, but in practice the disparity is estimated with a certain error  $\Delta d$  (depending on the stereo algorithm). Derive the range error  $\Delta Z$  depending on the distance  $Z$  to the point and the disparity error  $\Delta d$ .
- Derive the formula for transforming a 2D image point  $\mathbf{x} = (x, y)^T$  to its corresponding 3D world point  $\mathbf{X} = (X, Y, Z)^T$  given the distance of the point  $Z$  to the camera center  $C$

### Exercise 2      **Stereo matching**

- How can the similarity between two regions  $I_1(u, v)$  and  $I_2(u + d, v)$  be measured given the disparity value  $d$ , where  $u \in [0, \text{width}]$  and  $v \in [0, \text{height}]$ .
- What is the underlying assumption of these methods? When is this assumption violated?
- What happens to these measures if the illumination between the two images changes? How can one remove the influence of illumination changes?
- Compare the advantages and disadvantages of local and global methods

### Exercise 3 (H)      **Stereo matching**

In this exercise we are going to implement several local stereo matching algorithms. Download one or more of the Middlebury benchmark datasets from <http://vision.middlebury.edu/stereo/data/> (for example the Tsukuba dataset, which you know from the lecture).

- Implement a Matlab function that computes a disparity map from two images using intensity based matching (the AD and SD matching criteria). The function should take as arguments the left and the right image, the maximum disparity and the algorithm to be used.
- Implement a Matlab function that computes a disparity map from two images using region based matching (SAD, SSD and NCC). The function should take as arguments the left and the right image, the maximum disparity and the algorithm to be used. Experiment with different window sizes and maximal disparities.