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University of Bonn
Institute of Computer Science II
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Computational Photography

Assignment Sheet 3

– due by 12 May 2025, 12:15 pm –

1 Practical Part: Focal stacking (12 Points)

A common problem in macrophotography and microscopy is the shallow depth of field associated with large apertures. For stationary objects, this can be circumvented by recording a stack of exposures and combining them into an image that is sharp everywhere.

Use the provided Python skeleton and JPG images to solve the following tasks.

- Complete the Python script so that it fuses the focal stack into a single image. We suggest that you use the following procedure: **(8 Points)**
  - Load all images into a 4-dimensional matrix stack with dimensions (D, H, W, C).
  - Compute a contrast matrix `contrast(D,H,W,C)` that contains the response to a local contrast filter. Obtain this response by convolving the 2-dimensional image for each z slice and each color channel c with the discrete Laplacian

    $$K = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

    or any other edge detection filter (Sobel, Prewitt, Roberts, Scharr), and summing up, for each pixel, the absolute values across color channels.
  - Compute a depth map `depth(H,W)` where each entry indexes the layer where the pixel is sharpest.
  - Create a 3-dimensional matrix `fused(H,W,C)` that takes the sharpest input pixel for each (x,y) coordinate, according to the depth map.
- The result is not as good as one could expect, since the depth map is noisy. Denoise it (e.g., using a 5×5 median filter), and try again. **(2 Points)**
- Name at least two reasons why this dataset is not optimal for this type of task, and how you would capture better data. **(2 Points)**
- Bonus task 1: Use the depth map to create a pseudo-3D animation of the object **(n Points)**
- Bonus task 2: Develop a more advanced fusion technique to get rid of the remaining artifacts. **(n Points)**

As always, explain what you do, and provide your solution in a form that is ready to run.

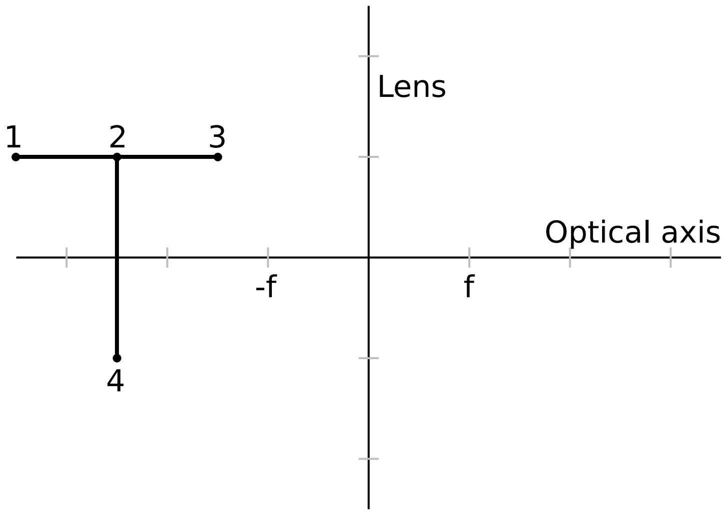
2 Theoretical Part (8 Points)

2.1 Glasses (2 Points)

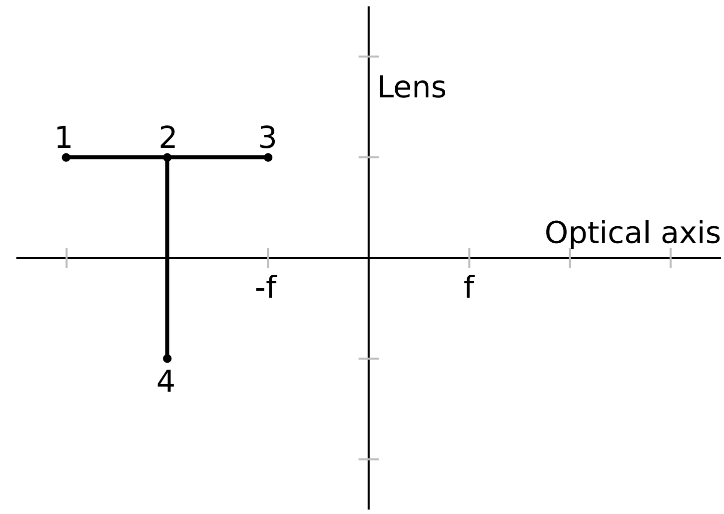
You are having dinner with someone who wears glasses. As an optics fan, you are curious about the condition of his/her eyesight - is the person far-sighted or near-sighted? Of course, you want to avoid talking about this sensitive topic. How can you find out without risking to offend your company?

2.2 Image construction (6 Points)

Suppose you have an ideal converging lens with focal length f and an object as shown in the sketch. What does the image of the object look like? Consider two cases a and b as shown in Figure 1. Using Gauss' ray-tracing method, construct the image for every case, and explain what you do.



(a)



(b)

Figure 1: Image formation through an ideal lens.