Photogrammetric Computer Vision
Final Project

Winter Semester 21/22

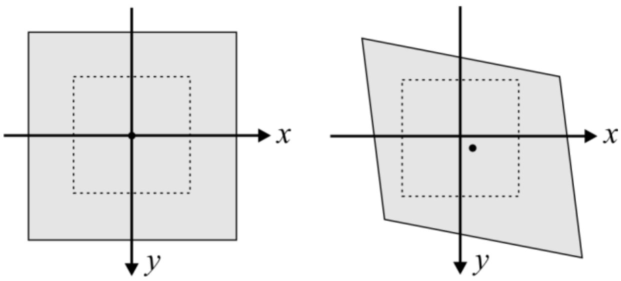
Submission Deadline: 13.03.22 13:30 pm

Least Squares Correlation

Due to diverse perspective distortions, a surface-based relation of homologeous image points is quite difficult. A *geometric transformation* can help to reduce these distortions.

This project focusses on **geometric alignment using an affine deformation model:**

1. Select (or capture) a well textured, small (approx. 150 x 150 pix.), g*reyscale image*. Transform this image by applying an arbitrarily chosen *affine transformation* $\mathbf{H}$. For the application of $\mathbf{H}$ to an image, a function is provided (Moodle): *geotrans.m*



$$\mathbf{H} = \begin{bmatrix} 1+d_1 & d_2 & d_5 \\ d_3 & 1+d_4 & d_6 \\ 0 & 0 & 1 \end{bmatrix}$$

   Your task is to compute the six *parameters* $d_1,\ldots,d_6$ that enable a transformation of the distorted image **back to its initial state**. The idea is to use grey value differences of the two images for this computation. In order to avoid problems in image border regions, you may use the central image area (e.g. 100 x 100 pix).

2. Implement an Octave / MATLAB function for a ***least squares correlation***. In each iteration, a linearized inhomogeneous equation system has to be solved. Use the Moore-Penrose-Pseudoinverse (`pinv`) and centered image coordinates here. For the computation of image gradients in *x*- and in *y*-direction, the function *gradient.m* can be used.

3. *Quantitatively* compare the estimated deformation parameters with the initially applied parameters and *qualitatively* describe the visual effect of the geometric adjustment. Compare the results after different numbers of iterations.

4. In addition to the evaluation performed in *task 3*, you should now test your implementation with a different target image. In the folder ***evaluation_images*** (Moodle), you will find one target image (*target_img.png*) and three differently distorted source images. For each of the three source images, use your *least squares correlation* function in order to find the affine transformation matrix, which can align as best as possible the particular source image to the given target image.

Computer Vision in Engineering – Prof. Dr. Rodehorst

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Document and analyze the achieved results. Are the results satisfactory? Did you use the same number of iterations in each of the three cases? Try some (small) variations of the size of the central image area used for the least squares correlation computation. Do you notice any significant differences in the achieved results?

5. In the context of stereo matching, explain how *least squares matching* is applied and why it can be useful.

6. Explain the geometric meaning of the of the six parameters of a general *2D affine transformation*. Judging by the visual appearance of the three distorted images (see folder: ***evaluation_images***) compared to the target image, are you able to (roughly) determine how the three distortion transformation matrices that were independently applied to the target image in order to produce each of these distorted images could have looked like? Motivate your answers. (Hint: *Please keep in mind that after applying each of the three transformations, the resulting images have been cropped to match the original size of the target image of 135 x 135 pixels*.)

7. Provide a detailed documentation of your work. Any external sources that you use should be included in the reference section of your documentation. Specify if you have used an input image that you captured, or one from an external source. Include figures showing the initial image distortion, some intermediate alignment results, as well as your final results. Discuss your choice of optimal number of iterations. In a similar manner, report the results from *task 4*. Your answers to all theoretical questions from *tasks 4* to *6* should also be included in the same documentation file.

Remark: For this mini project, you should work in small groups with up to 3 members. These groups do not need to correspond to the work groups formed at the beginning of the semester. Therefore, please, include in your documentation full information (i.e. names, student IDs, and study program) about all group members. Your final submission should comprise of source code, documentation and at least one input image.