

## Exercise 2 – Part I: Theory

### Group members:

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### 1. Which conditions on the image acquisition have to be fulfilled in order to model the image transformation successfully as a 2D homography?

- One must secure a circular motion around a projection center while taking a picture.
- Have a picture of a planar object.
- To create a panorama/stitching multiple images together, images must overlap at least 30%

### 2. How many corresponding point pairs do you need to reconstruct a 2D homography?

- If  $n$  is the dimension of a general projective transformation, then the number of required point pairs is  $n+2$ . Here, we have a 2D projective transformation, so we need at least 4 point pairs to compute the homography.

### 3. Why should the homogenous points be normalized before creating the design matrix?

- Conditioning guarantees numerical stability of the solution. If computed algebraically only, this would not be a big problem. However, the application of homography transformations in the real world implies all sorts of errors (e.g. mismatch between coordinates, rounding errors) which are avoided through the normalization of points.

### 4. What are possible reasons why the images don't perfectly align?

- Symmetric transfer error: there is no perfect transformation between input and output coordinate systems, as every point measurement in both coordinate systems comes with some measurement noise. There is always a little distance between the position we find by transforming the point in the input coordinate system into the output coordinate system ( $H*x$ ) and the point  $x'$ , which we know corresponds to the initial point  $x$  in the input coordinate system (the same error occurs if we transformed  $x'$  back to its original coordinate system with the inverse of our 2D homography matrix). To minimize this error, a non-linear optimization is required.
- If not taken over rotating projection center, images may present a translation caused by the back-and-forth movement of the camera.
- Radial distortions from the camera.
- Not precise enough point picking.
- The more point pairs chosen, the better.