3D Computer Vision TP1

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1. Introduction

The aim of this coursework was to construct a panorama from two given images, as seen in Figure 1. The main objectives were the following:
1. Let the user click at least 4 corresponding points in left and right images
2. Compute the homography matrix by solving the linear system $Ax = b$
3. Compute the bounding box of the panorama
4. Stitch the two images by averaging colors for corresponding pixels in the overlapping area

Figure 1. The two images used for the panorama construction.

2. Keypoint Correspondences

The first task was for the user to manually click on a keypoint in one image, then to identify the corresponding point in the second image. Figure 2 shows how the implemented code allows the selected matching points to be visualized as red circles on the image. In addition, a command line prompted the user to chose at least 4 pairs of matching points since this is the minimum number of correspondences required to estimate the homography matrix in $\mathbb{P}^2$[1].

Figure 2. Example of keypoint identification in one image.

3. Homography Estimation

In this part, we assume that the scene is flat or that we are rotating the camera to estimate the homography. Therefore, we use two independent linear equations per matching pair of points (x,x') to solve for $x_i' * (Hx_i) = 0$ and $A_i h = 0$ [1], with:

$$A_i = \begin{pmatrix} x_i & y_i & 1 & 0 & 0 & 0 & -x_i'x_i & -x_i'y_i & -x_i' \\ 0 & 0 & 0 & x_i & y_i & 1 & -y_i'x_i & -y_i'y_i & -y_i' \\ -x_iy_i' & -y_iy_i' & -y_i' & x_i'x_i & x_i'y_i & x_i' & 0 & 0 & 0 \end{pmatrix}$$

The matrix can be further simplified by discarding the third line which is a linear combination for the first two, and by supposing that $h_9 = 1$. Finally, the coordinates of the matching points are used to fill each A_i matrix entries.

4. Panorama Construction

In the last part, the estimated homography is applied so that two images are stitched together. The method used employs the inverse homography matrix H^{-1} to pull pixels from the original image by interpolation. The color of the overlapping pixels is averaged to obtain a smoother rendering, as seen in Figure 3.

Figure 3. Resulting panorama.

5. Conclusions

To conclude, we have seen how a panorama can be constructed by manually selecting point correspondences in two images and using the coordinates obtained to correct homographies. Even if the result is visually appropriate, the non-straightness of certain lines, blurred areas as well as an uneven change in color at boundaries can be observed. This could be caused by the a slightly inaccurate selection of point correspondences or the fact that the assumption of pure camera rotation is inexact. Nonetheless, this method has proved efficient for panorama construction with two images. However, automatic methods for keypoint identification would enable a higher quantity of points to be rapidly found, which is therefore more practical for processing large numbers of images, but perhaps at the expense of quality. Lastly, further image processing could be investigated to get a smoother panorama overall.

References

[1] P. Monasse. 3d computer vision session 1: Projective geometry, camera matrix, panorama, 2022. http://imagine.enpc.fr/ monasse/Stereo/1CameraCalib.pdf.