CS364/AM792 : Computer Vision 12 August 2019

Assignment 2: Projective Geometry and RANSAC

Please prepare a single, condensed and neatly edited document for submission. For each problem include a short description of what you did, results, and a brief discussion/interpretation. It is not necessary to include any code in your document, unless a snippet helps to explain your method. Upload a zip-file containing your document and code to SUNLearn (under "Assignment 2") **before 17:00** on 26 August. Also hand in a printed copy of the document, at the latest during class on Tuesday 27 August.

You are free to use any programming language. I recommend Matlab or Python. If you are asked to implement a specific technique, the idea is that you do so from scratch; do not simply use a function from an image processing or computer vision library. Collaboration is restricted to the exchange of a few ideas, and no form of plagiarism will be tolerated. All code, results, and write-up that you submit must be your own work.

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1. Suppose we'd like to rotate an image about its centre by an angle θ, and scale the result by a factor s. This operation can be expressed as

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = s\left(R\left(\begin{bmatrix} x \\ y \end{bmatrix} - \begin{bmatrix} x_0 \\ y_0 \end{bmatrix}\right) + \begin{bmatrix} x_0 \\ y_0 \end{bmatrix}\right), \quad \text{with } R = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}.$$

Here (x, y) are coordinates in the input image, (x', y') are corresponding coordinates in the output image, and (x_0, y_0) are the coordinates of the centre of the input image.

(a) Rewrite this expression in homogeneous coordinates, as $\underline{x}' = H\underline{x}$ where $\underline{x}$ and $\underline{x}'$ are elements of $\mathbb{P}^2$ and H is a 3×3 homogeneous matrix that you need to specify in terms of θ, s, x_0 and y_0.

(b) Apply the homography H from part (a) to a colour image of your choosing, for two or three different choices of θ and s. You will find a document in the accompanying material detailing how an image can be transformed with a given homography.

(c) If the procedure in that document is followed, why would different values for the translation component in H (the last column's first two entries) have no effect on the output image? Also, if $\theta > 0$, why is the image rotated clockwise even though the form of R suggests counterclockwise rotation?

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2. Paste a poster of your favourite movie onto the side of the building in `griest.jpg`. More specifically, manually select the four corners of the building to which the corners of the poster image should map, calculate the appropriate homography, apply the homography to the poster image, and overlay the result.


The transformed image will contain parts with no image data that we want to ignore, and the image origin may shift. Explain how you addressed these two issues.

Also, if we follow the interpolation procedure in that document on applying homographies to images, it turns out that our input (untransformed) poster image should be more-or-less similar in size to the desired output (the transformed image). If the input is much larger, we may get unwanted "aliasing" artefacts in the output. Experiment with this idea, and include in your report a short description of the issue of aliasing in image interpolation.

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p.t.o.

3. The file `fifaimages.zip` contains a template image, and 12 test images of that template undergoing various distortions. Let's assume that the nonlinear distortions, e.g. due to the nonrigid warping of cloth, are negligible and that the template image can be transformed with a homography to fit each test image. The task is to find those homographies. The file also contains 12 text files. Each of these has an $n \times 4$ matrix that gives the SIFT feature matches between the template and a particular test image. A row in this matrix is of the form $[x \;\; y \;\; x' \;\; y']$ and indicates that point (x, y) in the template matches with point (x', y') in the test image. Note that coordinates are (x, y)-pairs, not $(\text{row}, \text{column})$-pairs.

(a) Display every test image and plot the given matches on top of it. A possibility here is to display the template in the top-left corner of a test image, as in *Fig. 1* below.

(b) Implement a RANSAC based approach to find a set of inlier feature matches and a homography calculated from them, for each test image. Display for every test image the inlier matches found, as in *Fig. 2*. Also map the four corners of the template with your calculated homography and draw the resulting quadrilateral on top of the test image, as in *Fig. 3*.

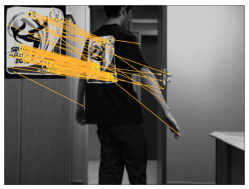

Fig. 1

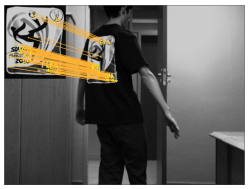

Fig. 2

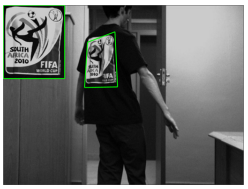

Fig. 3

Hand in: 26 August 2019