CS364/AM792 : Computer Vision 13 August 2018

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 14:00** on 28 August. Also hand in a printed copy of the document, at the latest during class on Wednesday 29 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. **(a)** If an image has m rows and n columns, and we index rows and columns from 1 (not 0), what would the (x, y) image coordinates of the image centre be? What would those coordinates be if we index from 0 (not 1)?

(b) The combined operation of rotating a colour image about its centre (x_0, y_0) by an angle θ, and scaling the result by a factor s, can be expressed as a single projective transformation in $\mathbb{P}^2$. Write out this operation in the form $\underline{x}' = H\underline{x}$, where $\underline{x}$ and $\underline{x}'$ are homogeneous 3-vectors and H is a 3×3 matrix that you need to specify in terms of θ, s and (x_0, y_0).

(c) Apply the homography H from part (b) 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.

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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 overly 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, why would it make sense to first resize the poster image to a suitable size, before we calculate and apply a homography to map the poster to the building? What would be a "suitable" size, in this case?

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3. *The Ambassadors* was painted by Hans Holbein the Younger in 1533. One of its most famous symbols is a skewed skull in the bottom centre. The viewer must approach the painting from the side to see this symbol morph into an accurate rendering of a human skull. Your task is to perform this perspective distortion by a homography. Crop the skull from the image `ambassadors.jpg`, pick four points that you believe should map to rectilinear coordinates, calculate a homography, and apply that homography to the cropped image to undistort the skull.

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4. 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

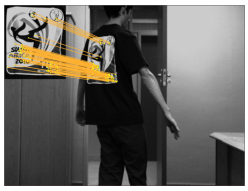

Fig. 2

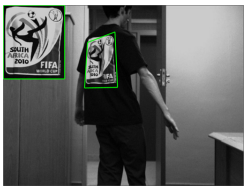

Fig. 3

Hand in: 28 August 2018