ADVANCED TOPICS IN COMPUTER VISION

Image Stitching

Francesc Moreno-Noguer
Institut de Robòtica i Informàtica Industrial, CSIC-UPC

May 24, 2016

The goal of this assignment is to automatically stitch two images acquired by a rotating camera following the steps discussed at class:

1. Compute interest points in both images
2. Estimate potential matches
3. Estimate the homography relating the two images using RANSAC
4. Project each image onto the same image plane

1 FEATURE EXTRACTION

For detecting interest points in both images I considered the SIFT detector [1] based on the maxima of a Difference of Gaussians function. I used the following code available online:

`http://www.vlfeat.org/~vedaldi/code/sift.html`

Yet, for detecting interests points you can use any other interest point detector, such as Harris, FAST, a Laplacian of Gaussian, MSER, etc.

2 ESTIMATE POTENTIAL MATCHES

You will need to find pairs of features that look similar and are thus likely to be in correspondence. We will call this set of matched features "potential" correspondences.

For this, I considered the SIFT descriptor, and computed the initial set of matches for each point in image I_1, taking its closest neighbor (in Euclidean space) in the second image I_2. On top of this, I used the simple approach used in [1] of thresholding based on the ratio between the first and the second nearest neighbors. That is, a potential match between a point $\mathbf{u}_i(I_1)$ in I_1 and a point $\mathbf{u}_j(I_2)$ in I_2 is rejected if:

$$r = \frac{\|\mathrm{SIFT}(\mathbf{u}_i(I_1)) - \mathrm{SIFT}(\mathbf{u}_j(I_2))\|}{\|\mathrm{SIFT}(\mathbf{u}_i(I_1)) - \mathrm{SIFT}(\mathbf{u}_k(I_2))\|} > 0.8 \tag{2.1}$$

where $\mathbf{u}_k(I_2)$ is the 2nd closest correspondence in image I_2, of $\mathbf{u}_i(I_1)$

Again, if you used other descriptors or representations of the interest points different from SIFT, you will have to use the corresponding criteria to select the initial set of potential matches.

The second row of Figs. 1, 2 and 3 shows the initial set of potential matches I obtained using SIFT.

3 ROBUSTLY ESTIMATE HOMOGRAPHY USING RANSAC

Use RANSAC to robustly estimate the homography relating the two images. For RANSAC, a very simple implementation performing a fixed number of sampling iterations is sufficient. You should output a single transformation that gets the most inliers in the course of all the iterations.

For the various RANSAC parameters (number of iterations, inlier threshold), play around with a few "reasonable" values and pick the ones that work best. For the number of iterations use the table discussed during the class for ($s = 4$, $p = 0.99$ and an expected percentage of 50% of outliers). For randomly sampling matches, you can use the Matlab `randsample` function. Finally, after you find the set of inliers using RANSAC, don't forget to re-estimate the homography from all inliers.

For the homography use the algorithm discussed in class, based on applying DLT with 4 correspondences. Remind that in order to compute the entries in the matrix $\mathbf{H}$, you will need to set up a linear system of $n = 2\times4$ equations (i.e. a matrix equation of the form $\mathbf{Ah} = \mathbf{0}$ where $\mathbf{h}$ is a vector holding the 8 unknown entries of $\mathbf{H}$). The solution to the homogeneous least squares system $\mathbf{Ah} = \mathbf{0}$ is obtained from the `SVD` of $\mathbf{A}$ by the singular vector corresponding to the smallest singular value. In Matlab: `[U,S,V]=svd(A); h = V(:,end);`.

4 PROJECT EACH IMAGE ONTO THE SAME IMAGE PLANE

Warp each image into the reference frame using the estimated homography and composite warped images into a single mosaic. I provide a matlab function for doing this:

```
imgout=make_mosaic(I1,I2,H);
```

where $\mathbf{H}$ is assumed to map the points from image I_2 to image I_1, i.e, $\tilde{\mathbf{u}}_1 = \mathbf{H}\tilde{\mathbf{u}}_2$.

5 TEST IMAGES

I provided 3 images to test the algorithm. The results I obtained are shown in Figures 1,2, and 3.

Also run your code on a new set of at least one homography related images, which you capture yourself using a digital camera or download from the Internet. To capture the images, shoot from the same point of view but with different view directions, and with overlapping fields of view. Make sure the images have enough overlap (e.g. at least 40%). In addition, make sure that you only rotate the camera.

6 WHAT TO HAND-IN

1. Show the final mosaic of the provided test images (similar to the last row of figures 1,2,3).
2. Show the visualization of the set of potential matches and the set of inliers for one image pair (similar to rows 2 and 3 in Figures 1,2,3).
3. Give the parameter values you have used (e.g. the threshold for descriptor matching, number of iterations and the inlier threshold for RANSAC).
4. Show the input images and the final mosaic for your new image set

Instructions for formatting and handing-in assignments

At the top of the first page of your report include (i) your name, (ii) date, (iii) the assignment number and (iv) the assignment title.

The report should be a single pdf file and should be named using the following format: `A#_lastname_firstname.pdf`, where you replace # with the assignment number and "firstname" and "lastname" with your name, e.g. `A2_Moreno_Francesc.pdf`. Zip your code and any additional files (e.g. additional images) into a single zip file using the same naming convention as above, e.g. `A2_Moreno_Francesc.zip`. I do not intend to run your code, but I may look at it and try to run it if your results look wrong.

Send your report (a single pdf file) and code with your two additional test images (in a single zip file) to Francesc Moreno <fmoreno@iri.upc.edu>, before May 31st, 11.59 pm.

REFERENCES

[1] D. G. Lowe. Distinctive image features from scale-invariant keypoints. *International Journal of Computer Vision*, 60(2):91–110, 2004.

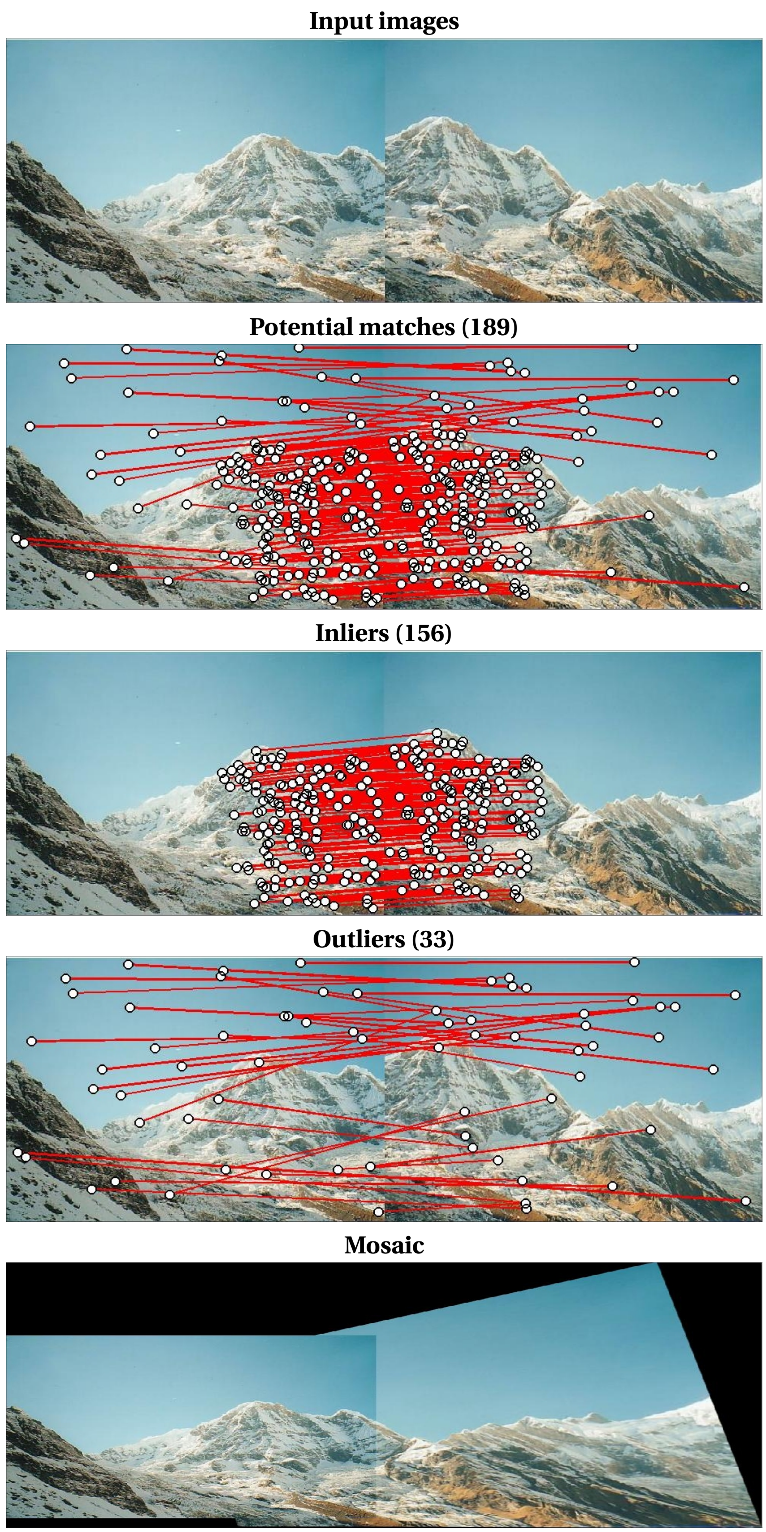

Figure 1: Sample results of image stitching. “Jungfrau” experiment.

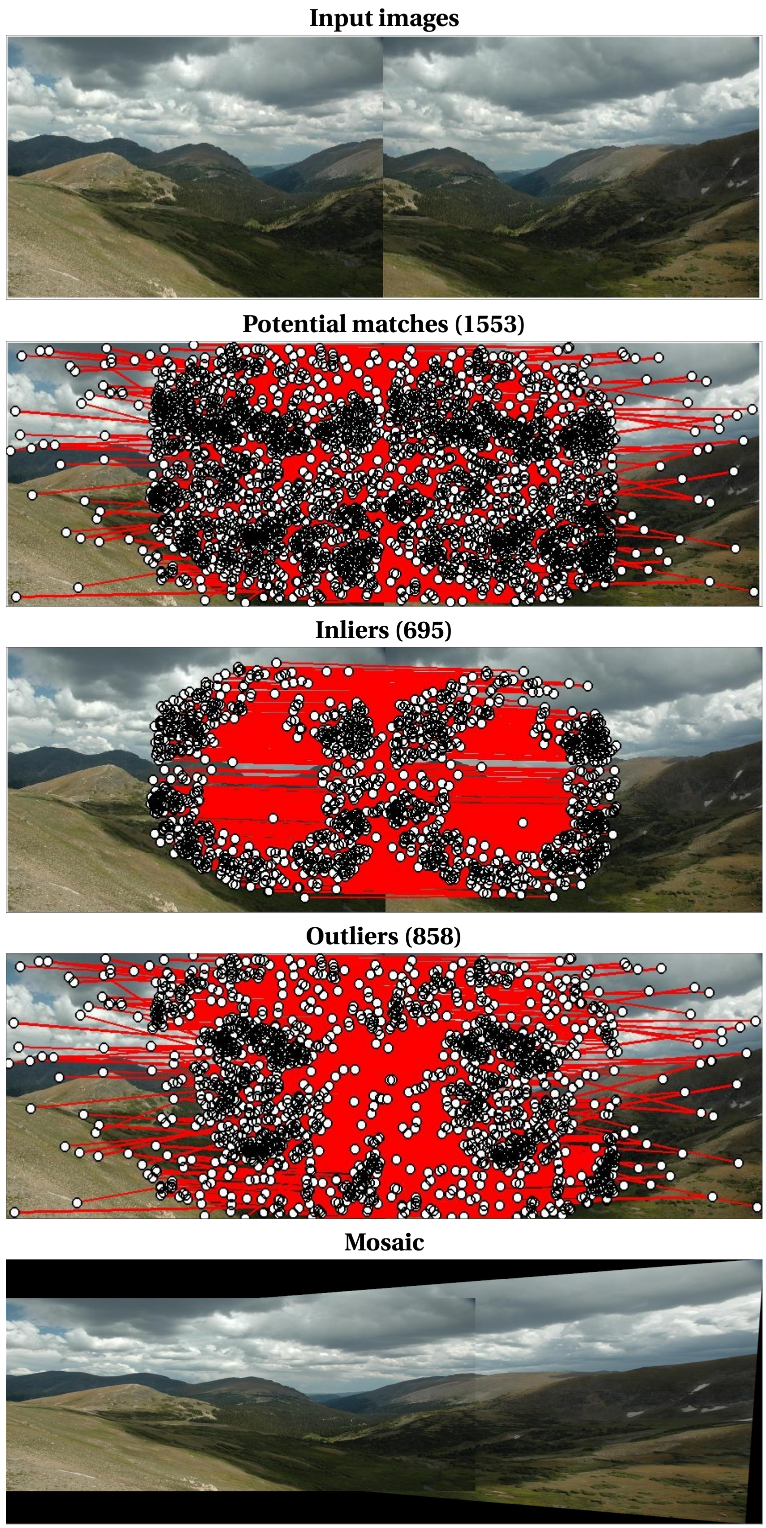

Figure 2: Sample results of image stitching. “Mountains” experiment.

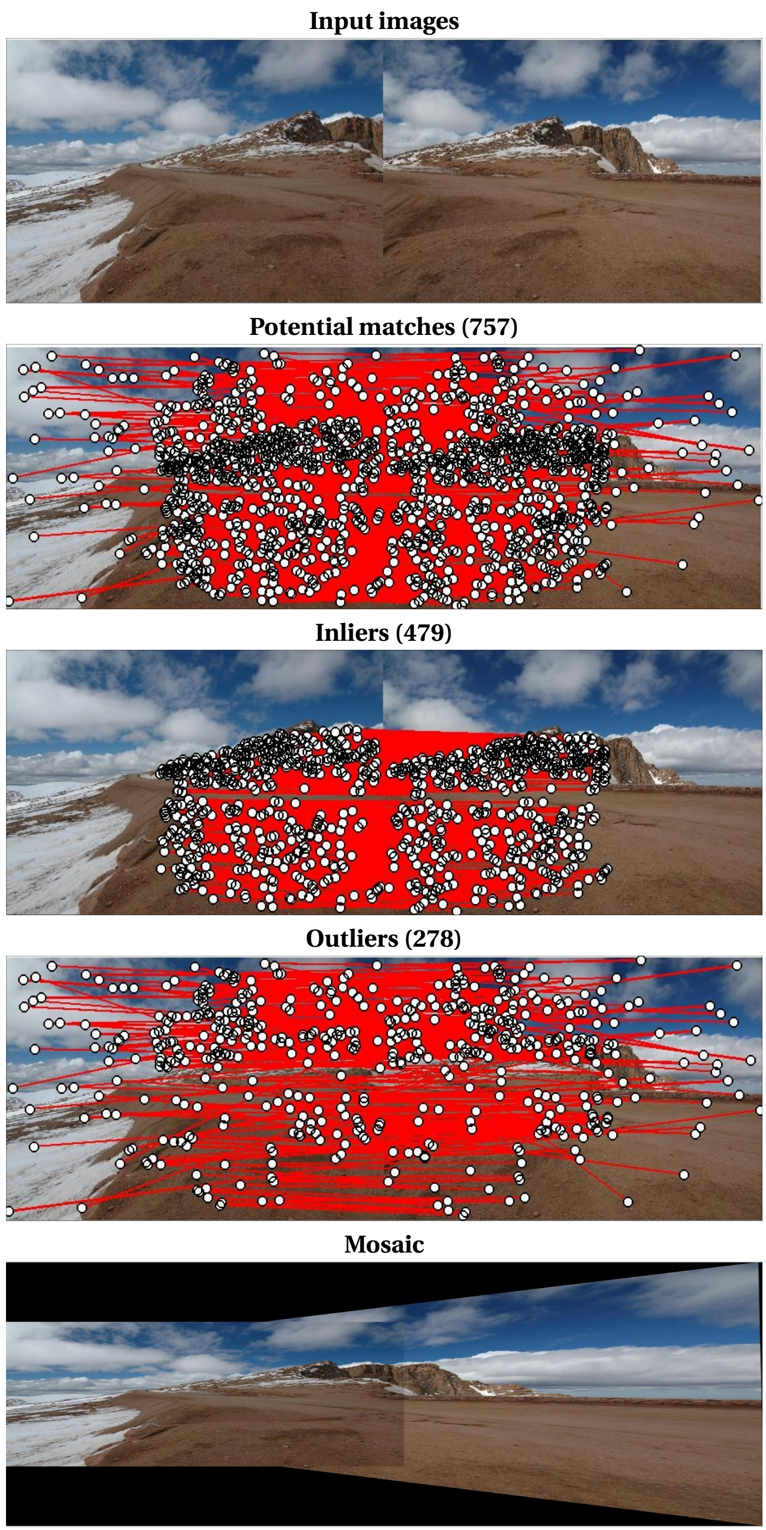

Figure 3: Sample results of image stitching. “Beach” experiment.