Report for Lab Session in Image Registration

Group 3: Xareni Galindo, Daria Kruzhinskaia, Yen-Ting Lee
Date of the lab: 7 March 2018

Prepared for: Advanced Color Image Processing
Cours: COSI
Course instructor: Eva Valero

Case 1. Registration for Panorama Image stitching

The most likely transformation for these two images is translation (image is moved horizontally by a factor "h" or/and vertically by a factor "k").
For this task a Phase correlation approach is relevant. Phase correlation is an approach to estimate the relative translative offset between two similar images or other data sets. It is usually calculated by fast Fourier transforms. To implement this method Registration Estimator App (build-in in Matlab) was used.

The resulting panorama image obtained by registration and stitching of both images (reference and sensed) you could see at Figure 1.
The quality of registration method was evaluated by computing RMSE = 12.7526 and **RMSE_relative = 0.05** that is about 5 % of incorrect founded intensity.

Figure 1. Panoramic image after registration.

Q1) Because the primary transformation is quite easy, it is enough to apply Intensity based methods. Time consumption in this case is much less than that of regular algorithms based on image feature.

Another method to achieve similar result is to calculate the Euclidean distance between each possible common area in the images and then find minimum among them. This approach is possible because we surely know about the same orientation of scenes.

Also registration can be done by sequential similarity detection algorithm (SSDA).

Case 2

Likely transformation: Affine transform (translation + rotation + scaling + shearing). We can make this decision due to the fact that sides of sensed image are parallel (Figure 2).

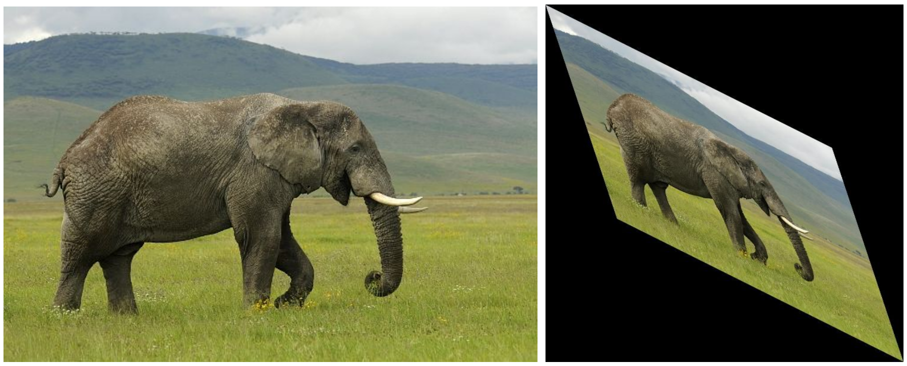

Figure 2. Reference and sensed images

These two images were registered using Matlab standard automatic intensity-based registration. For this approach we need to identify a transformation type wich was applied to the reference image (called the fixed image) to obtain the misaligned image (called the moving image). The process is iterative and the algorithm try to determine transformation matrix. In our case maximum number of iterations was 600.

Before applying imregister() function we created the optimizer and metric (with imregconfig() function) to set parameters such as InitialRadius, GrowthFactor, etc. After selection of the most suitable parameters result from Figure 3 was obtained.

Figure 3. Registered image over reference. (green + cyan)

The quality of registration method was evaluated by computing intensity-based metric
RMSE = 5.3328, **RMSE_rel = 0.0211**
Relative RMSE very close to zero so our registration is successful.

Q2) We also can evaluate quality of registration by features-based (CP-based) method.

Although features extraction and matching were not used for registration, they could be helpful in the assessment of quality.

The results of this metric vary a lot in dependance of chosen build-in features extraction method. For current task FAST algorithm is more impressing (according to results in Table 1).

Feature extraction method	MSERF	SURF	**FAST**
CP Location error	1.6945	3.1024	**0.2941**

Table 1. CP-based evaluation for case 2.

Maximum horizontal and vertical errors are equal to 1 (so the deviation is 1 px at maximum).

For relative RMSE we could implement acceptability threshold because this measure in percent. From our visual assessment, humans could not notice the difference if relative RMSE ie less than 7% (or <0.07). For control points based evaluation this threshold will depend of the size of image. But according to most researchers the error must be less than 1. So we can can filter different registered images base on this metric.

Link to the code:
https://drive.google.com/open?id=1GTJVJ42LEO7otkTXMUm9swWAm5M1Ymfs

Case 3

When we observed the images of case 3, we thought the transformation functions may be projective (homegraphy), so we tried to estimate the transform by Registration Estimator App in Matlab at first. The registration methods that we tested shows SURF and MSER (feature-based registration) can get the better results. The quality of using SURF and MSER are 0.715 and 0.819 respectively but FAST and Harris shows couldn't detect feature points in projective image. Therefore, we used SURF and MSER to estimate the transform and then register the image. The result as Table 2 shows.

Table 2. The register results of case 3

Reference image	SURF	MSER
		

To evaluate the quality, we considered MSER can higher quality than SURF, since the image right side (border) of SURF result has more errors than MSER by visual observation. To prove out thought, we used RMSE and CP extraction to evaluate the quality and we found the MSER is better than SURF, as Table 3 lists. When we observed the registration image, it's obvious that its resolution is worse than reference image, which causes the larger RMSE values. To increase the quality, we can try to decrease the resolution of reference image and registration image and then calculate the REMS values.

Table 3. Quality evaluation of case 3

	SURF	MSER
RMSE	7.0916	6.4579
CP extraction	0.6946	0.3720

Case 4

The images in case 4 are multimode. One of images is cut off the visible portion of the spectrum, and the other is cut off the NIR portion of the spectrum so it's difficult to estimate the good transform by using feature-based registration or intensity-based registration if we don't do any image reprocessing. In this case, we selected matching points manually by using Matlab built-in function, "cpselect". We measured 15 matching points which are uniformly distributed, as Figure 4 shows. Ten of them are selected to be control points to estimate transform and the other five matching points can be checkpoints to evaluate the quality.

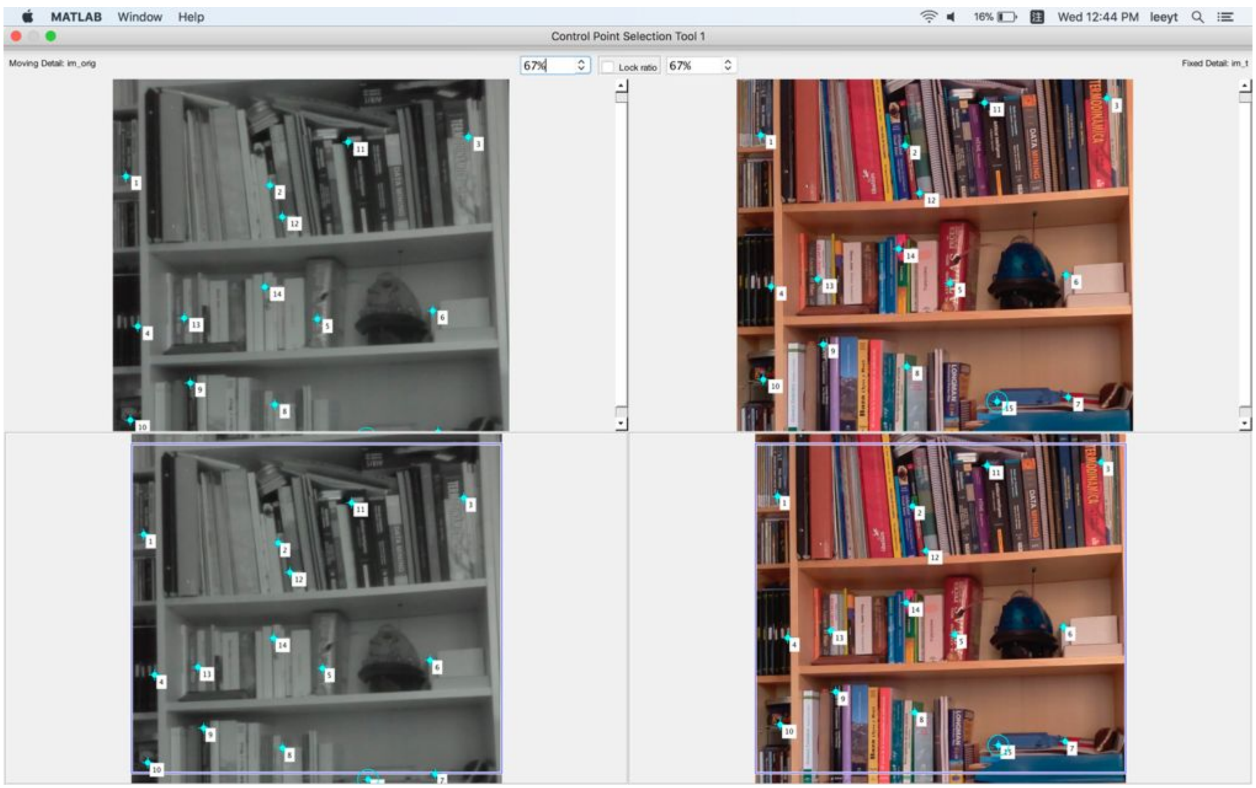

Figure 4. The results of manually select matching points

We used ten control points to estimate the transform and then Figure 5 shows the registration results. To evaluate the quality, firstly, we utilized five check points in sensed image and transform to get the position of check points in registered image. Secondly, we calculated mean Euclidean distance of check points in reference image and registration image. The value that we got is 3.9391 and it also indicates the accuracy of manual measurement, so we believe that's why the accuracy is larger than 1 pixel.

Figure 5. The register results of case 4

Comparing the quality of previous cases, we known that the result in case 4 is not good. In reference image, the image is blur due to cutting off visible portion of the spectrum; on the other hand, the sensed image cut off the NIR portion, which means only visible portion can pass through the filter. If we just look the images at a first glance, we might think the transformation function between this two images is translation or similarity, but after trying to solve this case, we understood it's easier to underestimate the complexity of registration images.

In addition, we also tried to improve our results by doing image preprocessing, RGB to gray value and histogram equalization, to enhance the contrast of image. After that, using Registration Estimator App estimated the transform and it indicated SURF with similarity transformation function got better results. Figure 6 shows the register results and the RMSE value and CP extraction are 10.0769 and 0.4022 respectively.

Figure 6. The register results of case 4 when doing image preprocessing