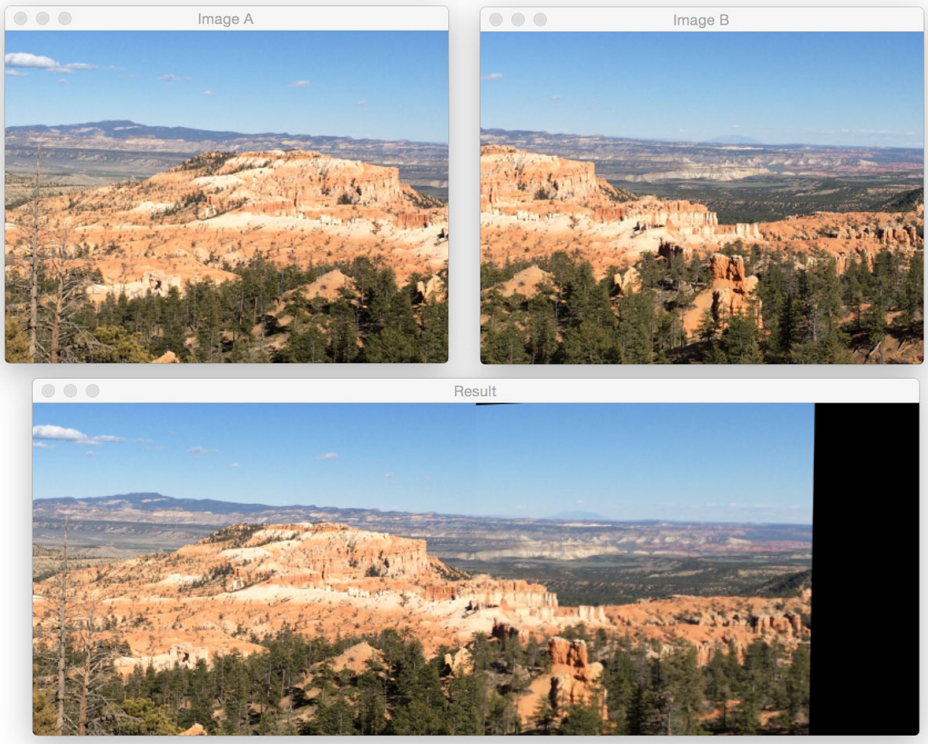
Assignment 3: Feature matching and image stitching
Vision and Image Processing

Søren Olsen and François Lauze

December 5, 2019



This is the third mandatory assignment on the course Vision and Image Processing. The goal for you is to get familiar with image feature extraction, feature matching, and use of this in simple image stitching.

This assignment must be solved in groups. We expect that you will form small groups of 2 to 4 students that will work on this assignment. You have to pass this and the other mandatory assignments in order to pass the course. If you do not pass this assignment, but you have made a SERIOUS attempt, you will get a second chance of submitting a new solution.

The deadline for this assignment is Wednesday 8/1, 2020 at 22:00. You must submit your solution electronically via the Absalon home page. For general information on relevant software, requirement to the form of your solution including the maximal page limit, how to upload on Absalon etc, please see the first assignment.

1 Detecting interest points (Features)

In the first part of the assignment you should implement a feature detector, apply it on a few images (see later) and illustrate that it works.

We recommend that you use either a blob detector, such as either Difference of Gaussians (DoG) or the Laplacian of a Gaussian (LoG), or the Harris corner detector. You are allowed to use any kind of library function that you find useful. This includes routines that directly gives you the point detections.

To visualize your results, plot the detected points on top of a typical image and include this as a figure in your report. Use a small image (or a subimage) to increase visibility. Remember to comment the result. **Do not expect me to see what you see**. What should I see where in the images ?

2 Feature matching

The second part of the assignment is to establish point matches/correspondences between different images of the same physical scene. First, for each extracted point you attribute a descriptor. Then, you select matches as the pair of interest points that have most similar descriptors.

For the **descriptor** you should extract a small square patch, with side length N, of intensity values centered at the detected point. You should then normalize the values to have zero mean and a standard deviation of 1.0.

For dissimilarity measure you should use **The sum of squared descriptor differences**. A low value signals a good match. Please report what value of N, you find best to ensure you a high number of correct matches.

Some feature points may have several good candidate matches. To choose the right one several heuristics may be used. Let A and B candidate feature points in the two images and $\mathbf{d}$ the displacement vector. You may use to accept the match $< A, B >$ if:

1. The dissimilarity measure for $< A, B >$ is much smaller that for the next best match $< A, B2 >$.

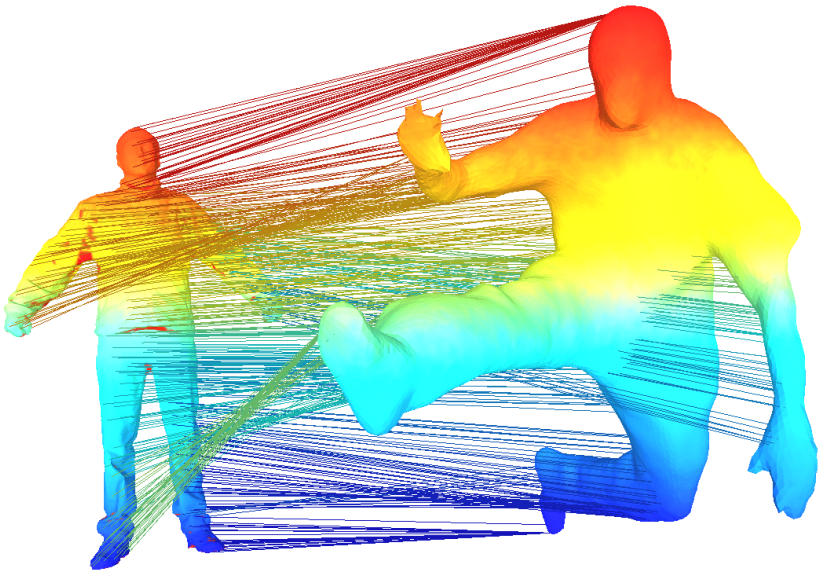
2. The best A-image match C to the B-image feature B, i.e. $< C, B >$ is identical to A. Thus the two feature points agree about being each others best match.

3. The displacement vector $\mathbf{d}$ is similar to the major part of other displacement vectors. Please note this only applies exact if the two images differ by a translation only. A robust estimate of the overall displacement vector is given by the median. To allow e.g. rotations a threshold on the displacement deviation should not be too tight.

4. The local density of correspondences should be sufficient high. In stitching, large image parts often is not visible in other images. Any match here will be false. Often such false matches are isolated. A simple approach (for horizontal stitching) will be to find the valid image columns by thresholding a count of accepted matches within $\pm P$ pixel broad vertical image strip, where P is a number that depend on the density of feature points.

In your report you should argue for your choice of match acceptance heuristics (if any). An example of use with/without heuristics may strengthen your report.

In your report you should show a single image of the best matching result. A popular approach to illustrate interest point matches between two images, is to put the two images beside each other and then draw lines between the matching interest points. Again, use images that is not too large and remember to comment on your results.



To solve this question you must program the matching part yourself, and not rely on library functions.

3 Image stitching

To glue images together, the geometric transformation between the images must first be estimated. We will assume that both images show a scene with an approximately planar surface. Thus (see lectures), the transformation is an homography $A = HB$. Based on the established set of matches you should estimate H as described at the lecture slides and in the text book. You should remember to normalize H to have $H_{33} = 1.0$. Please report your estimated H and comment on the type of transformation it describe.

An image C stitched from A and B have zones only visible in A or B, and a middle mutual zone (defined by the matches) that is visible in both. The colors

in corresponding A and B patches may differ. Thus the stitching seam-line may stand out. There are techniques to blur this difference, but you should NOT apply such approaches (in this assignment). Also, the stitching line may not be straight, but determined from the image. You should NOT apply such advanced seam-lines, but use a single straight vertical line. Please describe how you choose this line.

Your report should include a figure showing the final stitching result. Please comment on your success, and suggest the most obvious first step of an future improvement.

Your answer to this third part of the assignment must not rely on library routines that directly performs the stitching. However, you are welcome to compare your results with such applications.

4 Images

At the Absalon course page you may find two sets of image pairs. One is showing DIKU from two viewpoints, the other showing the skyline of a town. A lager part of the DIKU images show a planar surface. Thus these images might be easier. You must show your result on this image pair. You may supplement by showing your result on the skyline image pair or on two images chosen by yourself. If so, please ensure at least 50-60% overlap, and choose images with sufficient image texture distributed evenly within the images.

You are recommended to downsample or crop the images during program development to minimize processing time and to maximize the visibility of your results.