

# IMS – Assignment 4

## Image Alignment and Stitching

November 28, 2013

Students should work on this assignment in a group of two. All files should be zipped and sent to **f.alnajar@uva.nl** before 05-12-2013, 23:59 (Amsterdam time).

### 1 Image alignment

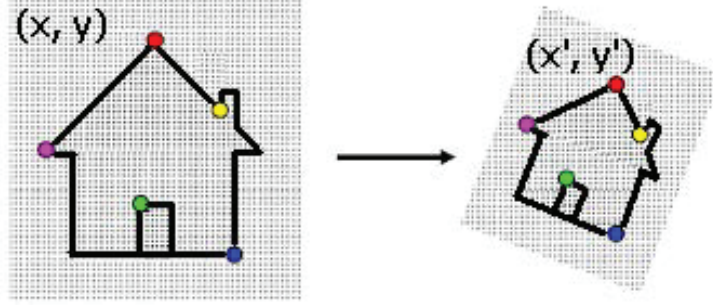
In this assignment you will write a function that takes two images as input and computes the affine transformation between them. You will work with supplied boat images. The overall scheme is as follows:

1. Detect interest points in each image.
2. Characterize the local appearance of the regions around interest points.
3. Get the set of supposed matches between region descriptors in each image.
4. Perform RANSAC to discover the best transformation between images.

The first three steps can be performed using David Lowe's SIFT. You can use the functions `[frames,desc] = sift(im)` and `[matches] = siftmatch(desc1, desc2)` from Andrea Vedaldi's sift implementation (to download check <http://www.vlfeat.org/vedaldi/assets/sift/versions/>, you need the latest version 0.9.19).

The final stage, running RANSAC, should be performed as follows:

- Repeat  $N$  times:
  - Pick  $P$  matches at random from the total set of matches  $T$ .  
How many matches do we need to solve an affine transformation which can be formulated as shown in Figure 1? Please, write the answer in the comments.
  - Construct a matrix  $A$  and vector  $b$  using the  $P$  pairs of points and find transformation parameters  $(m1, m2, m3, m4, t1, t2)$  by solving the equation  $Ax = b$ . Hint: Equation  $Ax = b$  can be solved using pseudo-inverse:  $x = (A^T A)^{-1} A^T b$ , or `x = pinv(A)*b` in Matlab.



$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} m_1 & m_2 \\ m_3 & m_4 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} t_1 \\ t_2 \end{bmatrix} \quad (1)$$

It can be rewritten as

$$\begin{bmatrix} x & y & 0 & 0 & 1 & 0 \\ 0 & 0 & x & y & 0 & 1 \end{bmatrix} \begin{bmatrix} m_1 \\ m_2 \\ m_3 \\ m_4 \\ t_1 \\ t_2 \end{bmatrix} = \begin{bmatrix} x' \\ y' \end{bmatrix} \quad (2)$$

or

$$Ax = b, \quad A = \begin{bmatrix} x & y & 0 & 0 & 1 & 0 \\ 0 & 0 & x & y & 0 & 1 \end{bmatrix}, \quad x = \begin{bmatrix} m_1 \\ m_2 \\ m_3 \\ m_4 \\ t_1 \\ t_2 \end{bmatrix}, \quad b = \begin{bmatrix} x' \\ y' \end{bmatrix} \quad (3)$$


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Figure 1: Affine transformation.

- Using the transformation parameters, transform the locations of all  $T$  points in image 1. If the transformation is correct, they should lie close to their counterparts in image 2. Plot the two images side by side with a line connecting the original  $T$  points in image 1 and transformed  $T$  points over image 2.
- Count the number of inliers, inliers being defined as the number of transformed points from image 1 that lie within a radius of 10 pixels of their pair in image 2.
- If this count exceeds the best total so far, save the transformation parameters and the set of inliers.

- End repeat.
- Finally, transform image 1 using this final set of transformation parameters. If you display this image you should find that the pose of the object in the scene should correspond to its pose in image 2. To transform the image, implement your own function based on nearest-neighbor interpolation. Then use the build-in Matlab functions `imtransform` and `maketform` and compare your results.

How many iterations in average are needed to find good transformation parameters? Please, write the answer in the comments.

## 2 Image Stitching

In this assignment you will write a function that takes two images as input and stitch them together. You will work with supplied images *left.jpg* and *right.jpg*. The overall scheme can be summarized as follows:

1. As in previous task you should first find the best transformation between input images.
2. Then you should estimate the size of the stitched image. Hint: calculate the transformed coordinate of corners of the *right.jpg*.
3. Finally, combine the *left.jpg* with the transformed *right.jpg* in one image.

## 3 Deliverables

Two demos with image alignment and image stitching (using Matlab's image transformation functions) should be submitted. Image transformation implementation based on nearest-neighbor interpolation should also be included in the submission. The code should run without any adjustments once it is unpacked (please, check all paths and make sure all files are in place). Additionally, the figures showing the initial, transformed and target boat images together with the combined *left.jpg* and *right.jpg* image should also be submitted. Provide resultant images using both Matlab's and your image transformation implementations.

The code should be clearly commented, explaining what each line is doing. Also, you should submit a report including your names and student identification numbers. All files should be zipped and sent to **f.alnajar@uva.nl** before 05-12-2013, 23:59 (Amsterdam time).