Practical Work - Creating a panorama with several images

Julie Digne

September 2020

The matlab code *vgg_warp* permits to compute an image deformed through an homography H. Please read carefully the appendix A before beginning.

Data from J. Ponce, I. Laptev, C. Schmid, J. Sivic, A. Efros, S. Lazebnik, A. Zisserman, available here : *https://perso.liris.cnrs.fr/julie.digne/cours/regression_data.zip*

1 Image registration with hand-picked pairs of points

This first part is done on images keble_a.jpg (image A) and keble_b.jpg (image B).

— Open the two images and select manually 4 pairs of corresponding points (such as the corner of a window that is seen in both images...), store their coordinates. Each pair consists thus of a pixel in image A and a pixel in image B.
— Compute the homography linking both images (see appendix A)
— Use vgg_warp to transform image A to match image B, display the obtained panorama.
— What kind of artefacts do you observe ?

NB : if you cannot make it work by selecting points manually, you can try : [658 287 366 289 ; 642 360 347 361 ; 681 359 386 361 ; 342 56 50 39] (syntax : a matched pair per line).

2 Image registration with detected pairs of feature points

This section requires the file matchesab.txt which contains the set of all matched feature points detected by the SURF algorithm (to be detailed later in the course), using its IPOL implementation `http://demo.ipol.im/demo/69/`.

— Implement the RANSAC algorithm on the SURF points, compute the homography H between the two images.
— Build the resulting panorama.
— Add random pairs to the set of matched feature points and measure the impact on the number of iterations to get the right transformation.
— What do you observe ?

3 BONUS : Panorama with 3 images

— Build a panorama with 3 images : keble_a.jpg (image A), keble_b.jpg (image B) and keble_c.jpg (image C).

A Appendix : homographies

An homography is a transform linking two pictures of the same planar surface. Itis generally used as a good estimate for registering two images of a distant object. From 4 pairs of points one can estimate the homography linking the two images.

Each point A of image I_1 is matched to the point A' of image I_2 such that :

$$A' = H \cdot A$$

Assume that pixel A has coordinates (x, y) and pixel A' has coordinates (X, Y). In homogeneous coordinates, this yield $(x, y, 1)$ and $(X, Y, 1)$. However we have :

$$\begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = H \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

Hence $X = \frac{x'}{z'}$ and $Y = \frac{y'}{z'}$.

$$A = \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}, A' = \begin{pmatrix} x' \\ y' \\ z' \end{pmatrix}$$

$$X = \frac{x'}{z'} = \frac{H_{11}x + H_{12}y + H_{13}}{H_{31}x + H_{32}y + H_{33}}$$

$$Y = \frac{y'}{z'} = \frac{H_{21}x + H_{22}y + H_{23}}{H_{31}x + H_{32}y + H_{33}}$$

These equations can be rewritten

$$r_x \cdot h^T = 0\,;\, r_y \cdot h^T = 0$$

with

$$h = \begin{pmatrix} H_{11} & H_{12} & H_{13} & H_{21} & H_{22} & H_{23} & H_{31} & H_{32} & H_{33} \end{pmatrix}$$

$$r_x = \begin{pmatrix} x & y & 1 & 0 & 0 & 0 & -Xx & -Xy & -X \end{pmatrix}$$

$$r_y = \begin{pmatrix} 0 & 0 & 0 & x & y & 1 & -Yx & -Yy & -Y \end{pmatrix}$$

Hence for each pair of points, we have two equations. For n pairs of points, we have a matrix $2n \times 9$ such that :

$$M \cdot h^T = \begin{pmatrix} r_x^1 \\ r_y^1 \\ r_x^2 \\ r_y^2 \\ \vdots \\ r_x^n \\ r_y^n \end{pmatrix} h^T$$

Let us look for h such that $M \cdot h^T = 0$. This is a least squares problem (homogeneous since the right hand side is 0) solved by taking the right singular vector of A and reshaping it to a 3×3 matrix form. In matlab, the svd is done using $[USV] = svd(M)$ and h corresponds to the last column of V.