IMAGE REGISTRATION IN THE MATLAB ENVIRONMENT

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Abstract

The paper is devoted to possibilities of geometric modifications of images to enable connection of separate scenes of overlaying images using their selected features. Results of various image transforms verified in the Matlab environment are compared with standard software tools. Final algorithms are verified for simulated images at first and then applied to real images.

Keywords: Image Registration, Image Stitching, Alpha Blending, Spatial Transformations

1 Introduction

Image registration [5, 7, 6] is an important part of image restoration that use objective criteria and prior knowledge to improve pictures. This method processes distorted images the pixels of which are shifted from their correct position. Another picture of the same object taken from a different camera position often serves as a control image. This situation is very common in the remote sensing [2] where image registration method helps to find the corresponding points in two images of the same region taken from the different viewing angles. The paper describes the application of image registration in the image stitching.

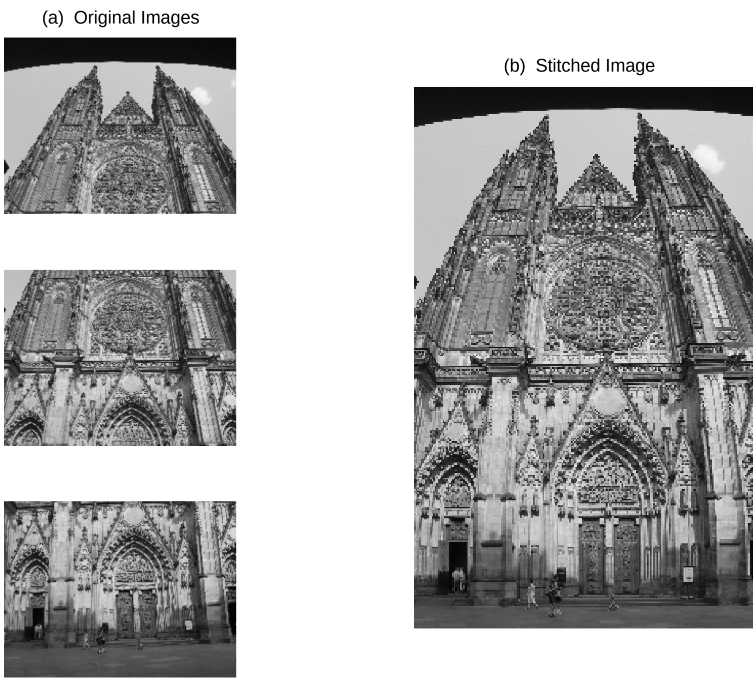

Figure 1: Process of image stitching presenting (a) three overlapping original images of St. Vitus cathedral, (b) the final stitched image obtained by the Canon company software

Many new digital cameras including their professional software provide the possibilities of stitching images - that means joining the partially overlapping snaps to create panoramas. But - after taking suitable photos - it is possible to use any other image processing software as well [3]. Various algorithms producing desired picture from original photos can be implemented in the similar way. The goal studied in the paper is in stitching of images by means of the Matlab system and its Image Processing Toolbox [1]. Three snaps of St. Vitus Cathedral in Prague (Fig. 1a) were taken with the Canon PowerShot G2 camera and then processed by Canon ZoomBrowser software (version EX 2.8.0.4) and its PhotoStitch utility to obtain a standard result (Fig. 1b) for further comparative studies. Unfortunately, it was possible to save photos in the JPEG format only so that the minimum compression level was chosen.

2 Image Registration Principle

The goal of image registration is removing of image distortion according to some prior information. The pixels in the incoming distorted image are shifted from their correct position caused by various reasons. The fact of making only the planar projections of three dimensional objects or various viewer's positions belongs to the most common causes of distortion. Moreover, various optical systems can produce various types of distortion. The spatial transformations constitute a basic mathematical tool for mapping receiving distorted image into correct system. The prior information about proper positions of pixels is often given by another (base) picture of the same scene taken from the different point of view. The coordinate system in one of the images usually is not Carthesian (see Fig. 2). Even, the curves describing the system need not to be linear. It is obvious that the shapes of the areas inside one image are quite different from the shapes of the same areas in the second one.

(a) (b)

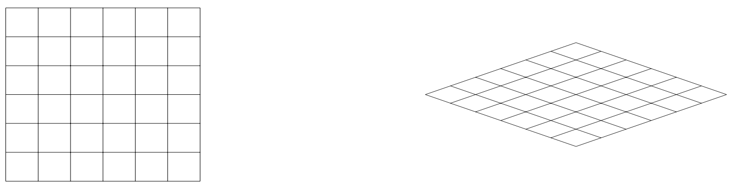

Figure 2: An example of the image distortion caused by various points of view. (a) Image of Carthesian grid viewed from the direction of z-axis. (b) The same grid distorted with selection of another viewer position

The result of application of spatial transformation to the distorted image $I(x, y)$ is a new image $J(\overline{x}, \overline{y})$ where every pixel $(\overline{x}, \overline{y})$ is evaluated by selected spatial transformation equations:

$$\overline{x} = F_x(x, y) \tag{1}$$

$$\overline{y} = F_y(x, y) \tag{2}$$

Forms of functions F_x, F_y are given by the selected type of transformation. Projective, affine, polynomial, linear conformal and other methods belong to the reasonable types of spatial transformations. The functions' parameters are estimated from the selected set of points for which we know the position in the new image. This information is taken from comparison of the base image in the case of image registration. As the pixel coordinates $\overline{x}, \overline{y}$ in the new image need not be integer, the use of an appropriate interpolation method is necessary to know the colour level exactly in the pixel coordinates. An example of image registration is shown in Fig. 3.

(a) (b) (c) (d)

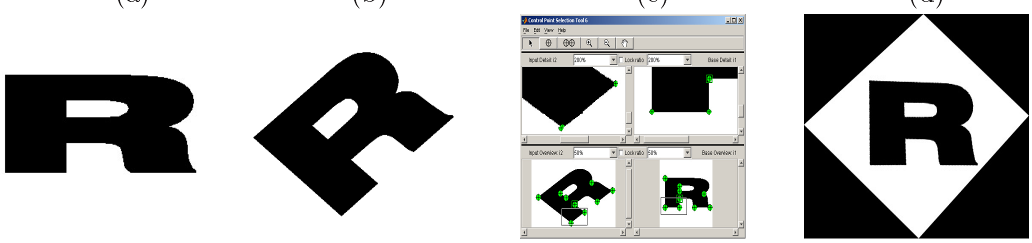

Figure 3: An example of image registration presenting (a) original image serving as a prototype image used as the base image in the registration process, (b) distorted image exported from 3D drawing system in sililar way as the base image, (c) selection of control points in the Matlab system, (d) resulting image after registration after the application of the affine transform and the nearest neighbour interpolation method

3 Real Image Stitching

Stitching images means joining several partially overlapped pictures into one panorama. In the digital photography there are some basic rules for taking incoming snaps described in [4] but in general it would be possible to join any two (or more) corresponding pictures resulting from various systems. The results of image stitching usually are not perfect, but depending on the used algorithms and quality of source pictures they can be good enough to not notice the joins. Two main problems must be solved to accomplish the satisfactory result:

- Source images registration by means of spatial transformations
- Mapping colour of source images using histogram adjustment

The following Matlab algorithm is focused on solving the first problem epecially. Its function was verified in joining of two upper photos of St. Vitus Cathedral (Fig.1a). It can be applied to the grayscale images or to the R,G,B colour layers separately in the case of true-colour images.

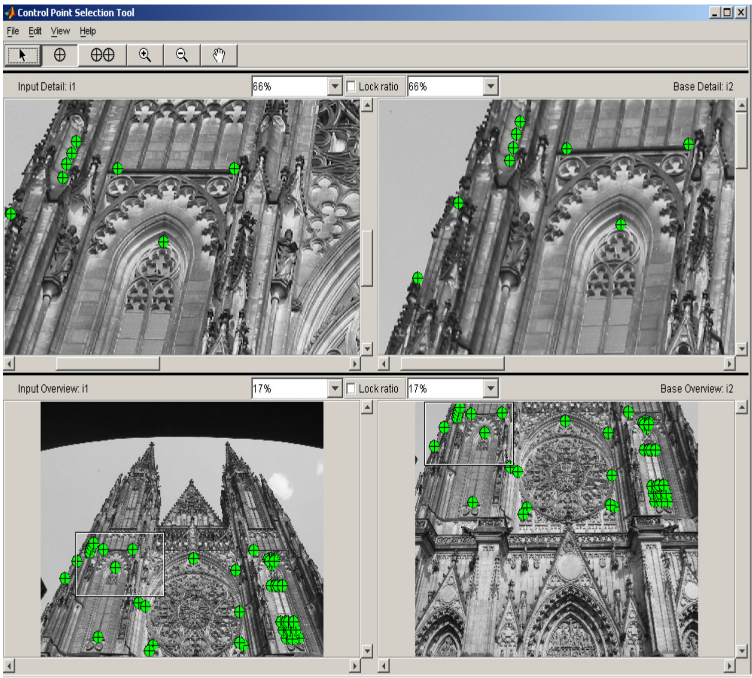

Figure 4: Selection of control points set for the given image registration. The important point pairs were selected in both images and corrected by means of correlation analysis

The algorithm consists of 4 steps:

1. Import input images into Matlab environment using command `imread`
2. Registration of the upper image according to the lower one. The set of 42 control points (Fig. 4) was selected using command `cpselect` for estimation of the parameters for following spatial transform. These manually selected points were corrected using correlation analysis (`cpcorr` command). The projective transform and bicubic interpolation method seems to be the most suitable modification in the case of these pictures. Result of its application is shown in the Fig. 5. The modified picture serves as an input image into the following part of the algorithm
3. Selection of the cutting line in both images. The vertical line (at the similar position as at the Canon panorama) has been selected in the upper image. The corresponding line in the low image was found by means of correlation of lines color profile (The same resolution must have been ensured by previous resampling of images)
4. Joining selected parts of both images into one. The method of alpha blending has been used in the surrounding rows for removing some little errors in details. This procedure is the simplest solution of histograms disparity of input images as well.

(a) (b)

Figure 5: An example of an image transform presenting (a) the upper original image of St. Vitus Cathedral and (b) the same image modified with projective transform

4 Results

Fig. 6 compares results of real images stitching achieved by standard Canon software and resulting from the Matlab algorithm described above. The cutting line has been selected according

(a) (b) (c)

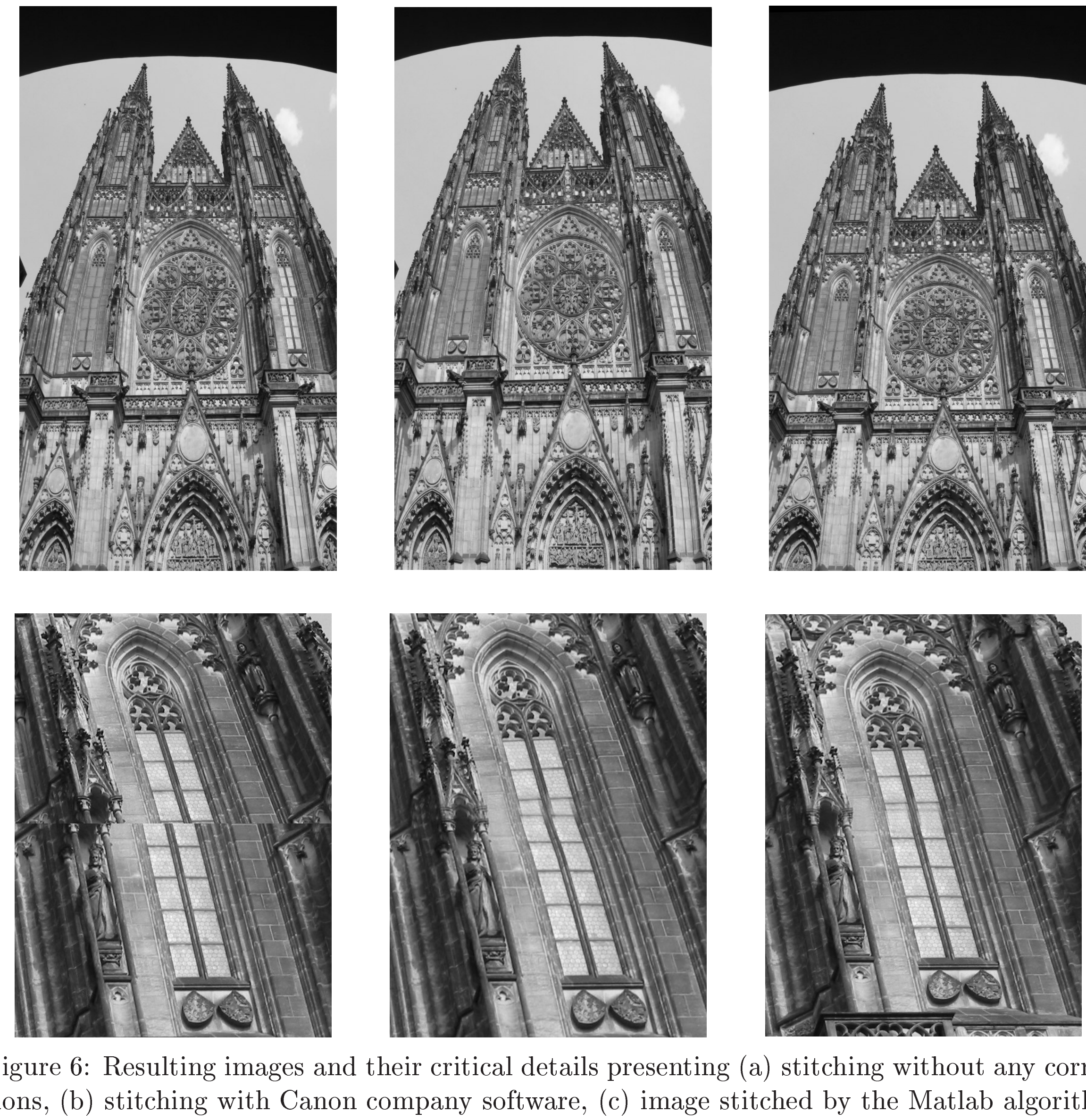

Figure 6: Resulting images and their critical details presenting (a) stitching without any corrections, (b) stitching with Canon company software, (c) image stitched by the Matlab algorithm

to the Canon procedure in this case. Joining these two pictures could seem better using other cutting line selection - as pictures are joined in the vertical direction, the line going through a remarkable horizontal line can be more applicable. This fact is documented in the Fig. 7.

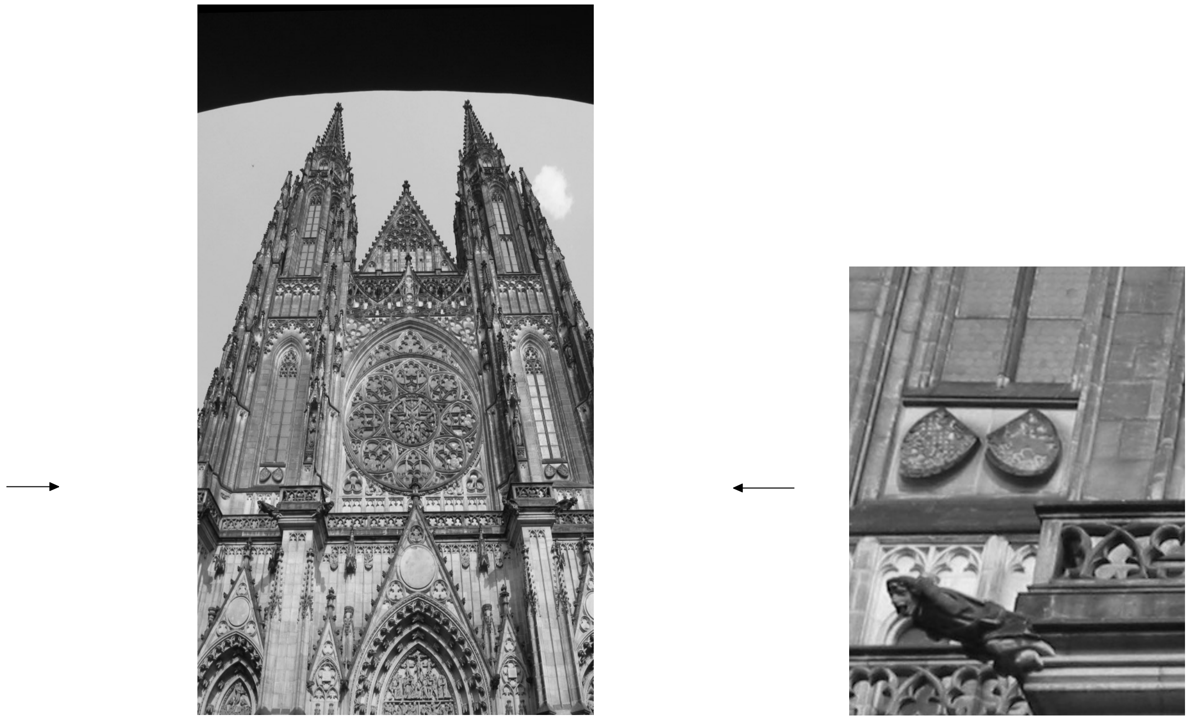

Figure 7: The real image od St. Vitus cathedral and its critical detail stitched in the Matlab environment at the selected horizontal profile

5 Conclusion and Suggestions for Further Investigation

It is possible to summarize that the Matlab system including its Image Processing Toolbox provides large possibilities of spatial transformations and image registration. Achieved results documents wide possibilities of application of Matlab tools in the stitching process of given images. The presented algorithm can be completed with a better solution of colour mapping. The appropriate algorithm for automatic finding the same details in the overlapped parts of the stitched images will be further studied as well.

Acknowledgments

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