A New Method of Automatic and Accurate Image Registration through Histogram Based Image Segmentation

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Abstract

Image registration is the process of transforming different sets of data into one coordinate system. Automatic image registration is still an actual challenge in several fields like computer vision and remote sensing applications. In this project, a method for automatic and accurate image registration through histogram-based image segmentation is proposed. This new approach mainly consists in combining the pair of images to be registered are segmented, according to a relaxation parameter on the histogram modes delineation (which itself is a new approach), followed by a consistent characterization of the extracted objects through the objects area, ratio between the axis of the adjust ellipse, perimeter and fractal dimension and a robust statistical based procedure for objects matching. The main aim of this proposed methodology is illustrated to simulated rotation and translation. The first dataset consists in a photograph and a rotated and shifted version of the same photograph, with different levels of added noise. This allows for the registration of pairs of images with differences in rotation and translation. An accuracy below 1^{o} for rotation and at the sub pixel level for translation was obtained, for the most part of the considered situations.

Keywords:

Histogram, image registration, image segmentation, matching, Wiener filtering.

1. Introduction

IMAGE registration is the process of matching two images by transforming different sets of data into one coordinate system. This data may comprise of multiple photographs, data from different sensors, from different times, or from different viewpoints. For the analysis of two or more images of the same scene often requires registration of images. Hence the main goal of image registration is to establish the correspondence between the two images taken by different sensors, images taken by same sensor at different times and determine the geometric transformation that aligns one image with the other. It becomes a classical problem in various image processing applications where it is necessary to match images of same scene.

AUTOMATIC image registration (AIR) is still a present challenge regarding image processing related applications. Reviews concerning image registration methods can be found in [1] and [2]. Remote sensing applications are one of the fields where further research on AIR methods is required. Under this scope, there are particular difficulties so that AIR methods suitable for many computer vision applications will present limited performance. One challenging problem of registering remote sensing images can be the determination of translations and a small rotation parameter.

In relation to computer vision applications, the rigid-body model may be a simple problem to be solved. However, in remote sensing applications [3], [4], the most challengeable problems are connected to the radiometric content due to multisensory or multispectral pairs of images. Over the last few decades, a plenty of articles has been published related to image segmentation and their application in several fields such as military, medicine, remote sensing, among others [5], [6], [7], [8],[9] etc. Image Segmentation is the process of partitioning the digital image into multiple regions that each element in the region satisfies some predefined criteria. IS plays a vital role in identification of objects on a scene.

Classifying image segmentation methods [7], [10], based on their nature: feature based approaches, region-based approaches, histogram thresholding, edge detection approaches, fuzzy approaches, physics-based approaches and any combination of these. Image segmentation is used as a step in image registration whose methods are used to transform any image to a binary image: objects and background.

Typically, Our Proposed Method comprises of three stages:

1) Identifying modes of the histogram,

2) Finding the valleys between the identified modes and

3) Finally applying thresholds to the image based upon the valleys identified.

Most of the well known methods are subjected to unimodal, bimodal or multimodal histogram thresholding technique for segmenting the images, [11], [12], where it is analyzed that each of the object corresponds to a certain class of objects. However, this is not appropriate for remote sensing applications.

The work by Liang *et al.* deals with a robust multiscale segmentation algorithm for automated registration of images related by rigid-body transformations. This algorithm comprises a new region-based similarity segmentation technique, where minimization of the metric is carried out by Powell direction set optimization method to find the peak. The images taken here do not include additive noise neither remote sensing images, which are widely associated with particular difficulties in registration process.

The work done by Goshtasby *et al.* presents a major contribution to a region-based approach where an algorithm is designed to refine region boundaries so that similar corresponding regions are obtained. Here centers of gravity of corresponding regions are determined, which are used as control points, up to sub pixel accuracy. Automatic registration is carried on TMS and MSS images in this region based approach. The work from Dare and Dowman is another example, where the authors state that the image registration method handled is fully automatic, but in practice the method requires a manual alignment initially to remove gross differences in scale and rotation. Moreover, the segmentation methods proposed by Dare and Dowman are more adequate to images containing homogeneous objects such as larger water bodies, but with limited performance on datasets such as satellite images used in remote sensing applications.

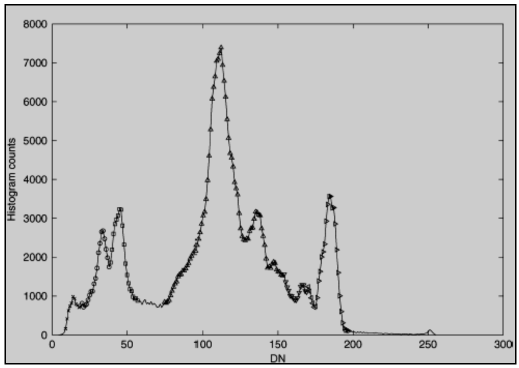


Fig.1. Histograms

The work by Hui Li represents a method known as contour- based approach to multisensor Image registration where two methods are described which use region boundaries and strong edges as matching elements. These methods work well on collection of contour information and accurate contour locations of images such as optical images with SAR images from Landsat and Spot satellites.

During my work, I have proposed an excellent method for automatic image registration of pair of multi-spectral/multi-temporal images with different values of added White Gaussian noise through histogram-based image segmentation, which leaves a way for an accurate image registration rather than the traditional methods. Our proposed technique involves in estimating the rotation and/or translation parameter between two images (reference and referred)— which could be different because were taken at different times, using different devices (multi modal) and from different angles in order to have 2D or 3D (multitemporal or multisensor)— with small differences in their spectral content.

2. Proposed Method Description

A pair of images in the same scale (same pixel size with respect to the scene), is taken. Where one of them is "static" (image 1) and the other (image 2) is to be registered onto the "static" image. Assuming that are the coordinates of the "static" image and are the (Pixel, Line) pair of the image to be registered. It begins with a preprocessing stage in order to reduce unnecessary detail on the images content, important for the subsequent histogram-based image segmentation phase (which includes a relaxation parameter). It begins with a preprocessing stage in order to reduce unnecessary detail on the images content, important for the subsequent histogram-based image segmentation phase (which includes a relaxation parameter). The objects extracted from the segmentation stage are characterized and matched according to some related properties, which finally allows for the statistically-based rotation and translation parameters estimation.

$$\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ \sin\theta & -\cos\theta \end{bmatrix} \begin{bmatrix} P \\ L \end{bmatrix} + \begin{bmatrix} \delta_x \\ \delta_y \end{bmatrix} \qquad (1)$$

Where the origin is considered to be the upper left corner of the "static" imageθ, is the orientation difference, and (δ_x, δ_y) is the shift between the two images. The proposed methodology of automatic image registration is schematically represented in Fig. 1.It begins with a preprocessing stage in order to reduce unnecessary detail on the images content, important for the subsequent histogram-based image segmentation phase (which includes a relaxation parameter α). The objects extracted from the segmentation stage are characterized and matched according to some related properties, which finally allows for the statistically-based rotation and translation parameters estimation. In the following, the several steps involved in our proposed method are explained, where the main objective is to estimate θ , (δ_x, δ_y)

2.1 Preprocessing

Preprocessing stage in order to reduce unnecessary detail on the images content, By image enhancement (which is itself a largely subjective process), it is intended to obtain an image with less detail than the original version, nearest to the "object" identification which is performed by the human eye. The Wiener filter is one of the most used filters under the scope of image restoration methods. However, it may also be used for image enhancement, with the aim of reducing the detail on an image. A "pixel-by-pixel processing" approach may become quite computationally expensive, in opposition to a "sub image-by-sub image processing" where we divide the image into a certain number of tiles. The latter is typically considered for sub images with size between 8x 8 and 32x32 pixels. Since the objective of the Wiener filter employment is different from restoration, it is advisable to consider the conservative smallest possible square tile size of 3x 3 pixels. Although this latter approach might induce the so-called "blocking effect, "In delineating the objects boundaries, an edge-sensitive adaptive image restoration version of the Wiener filter is adequate. This method is based upon the idea of reducing more noise near edges without additional edge blurring through a cascade of 1-D adaptive filters. Additionally, in order to overcome significant differences between the histograms of the images to be registered, an histogram equalization of image 2 using the histogram counts of image 1 is performed, prior to the application of the Wiener filter.

$$H(\omega_1, \omega_2) = \frac{P_f(\omega_1, \omega_2)}{P_f(\omega_1, \omega_2) + P_v(\omega_1, \omega_2)} \qquad (2)$$

Where $P_f(\omega_1, \omega_2)$ stands for the original image and $P_v(\omega_1, \omega_2)$ power spectra and for the additive random noise power spectra. Additionally, in order to overcome significant differences between the histograms of the images to be registered, a histogram equalization of image 2 using the histogram counts of image 1 is performed, prior to the application of the Wiener filter. In this way, the Wiener filtering on image 2 allows both for the reduction of the image detail, as well as to the smoothing of the histogram, which becomes spiky due to the histogram equalization step.

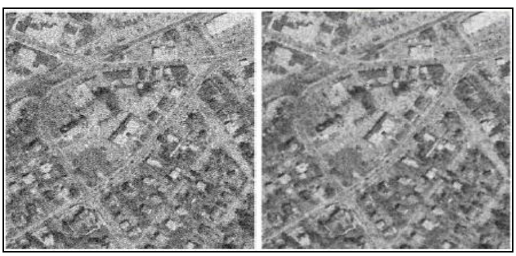
Below procedure indicates the removal of noise in image by using adaptive wiener filter and regarding images are also shown. First take original color (RGB) image and convert the image into gray image by using matlab command rgb2gray

Example:

```
OriginalRGB = imread (image1.bmp);
        Gray image=rgb2gray (originalRGB);
```

Fig. 2.1: original RGB image and its gray image

Add Gaussian noise with variance 0.025 and mean 0 in gray image using imnoise command and remove that noise using adaptive wiener filter.



Example:

```
J = imnoise (Gray image, 'gaussian', 0, 0.025);
 H=wiener2 (J, [3 3]);
```

2.2 Use of Histogram Equalization of image:

It enhances the contrast of images by transforming the values in an intensity image so that the histogram of the output image approximately matches a specified histogram.

Fig. 2.3: Original Gray Image and Its Histogram Equalization Image

2.3 Histogram-Based Segmentation and De-lineation

The method used for mode delineation is based upon the analysis of the consecutive slopes of the histogram. Let be the image histogram counts m =0,………,M and the sequence of the consecutive slopes, where is the number of histogram levels (M=255 for an 8-b image).

$$y(n) = x(n) - x(n-1), \quad n = 1, \ldots, M \qquad (3)$$

The idea behind this approach is to choose an adequate threshold for considering whether or not one is in the presence of a mode, which is characterized by a significant increase and/or decrease on the slopes sequence. A relaxation parameter α is considered on the mode delineation, which in theory is a continuous parameter, defined on the space [0, 1], and has to pass through a discretization process in practice. The inclusion of this parameter leads to the obtention of several different segmentation results, which allows for the subsequent stages of the proposed methodology to be more robust.

2.4 Image Segmentation:

Generally image segmentation means separating background and foreground image. Below procedure indicates the general image segmentation procedureFirst of all take gray image (black and white image) and calculate threshold using graythreshfunction.Second segment the gray image using im2bw command.

For Example:

```
A=imread(„grayimage.bmp‟);
Threshold=graythresh (A);
 Segmented Image=im2bw (A, Threshold);
```

In this, Segment the image using threshold i.e. deepest valley that is in between two highest modes (or) peaks, but not graythresh.

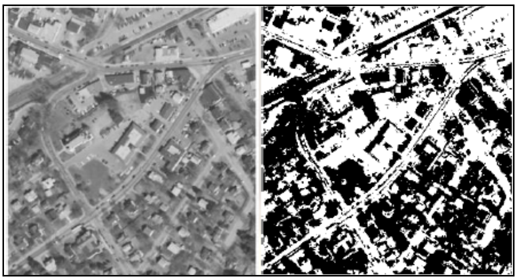


Fig. 2.4: Original Gray Image and Its Segmented Image

2.5 Characterization of the Extracted Objects

The extracted objects at the segmentation stage are characterized by four attributes which allow for their adequate morphological description: area (A_{rea}), perimeter (P_{erim}), and axis ratio (AR_{at}) and fractal dimension (D_b). The attribute area is merely obtained by the number of pixels which form an object, whereas the perimeter is obtained by calculating the distance between each adjoining pair of pixels around the border of the region. These two attributes allow for the evaluation of an object with respect to its size and compactness, respectively. The four previously described attributes are used for the later stage of objects matching. These four attributes are expected to be similar for corresponding objects. As stated at the beginning of proposed method description, it is assumed that the pair of images differs with respect to rotation θ and translation. With respect to translation (δ_x, δ_y), the centroid of each object is also stored

2.6 Initial Matching

The matching step begins with the evaluation of a cost function, between every possible two-by-two combination of objects obtained by the segmentation of the two images, for every possible combination of the alpha values considered for both images. This leads to a matrix with n1 rows and n2 columns, where n1and n2 correspond to the number of extracted objects from images 1 and 2, respectively. The cost function, evaluated for the values of the properties of the objects from images 1 and 2, is defined as follows

Cost function= (Area1-Area2)/Avg (Area) + (ARat1-ARat2)/Avg (ARat)+ (Perim1-Perim2)/Avg(Perim) + (Db1-Db2)/ Avg(Db).

Then, the cost function values are represented in the form of boxplots, with the image which led to the lower number of segmented objects corresponding to the horizontal ("categorical") axis. A valid matching between two objects should lead to the lower values of cost function, sufficiently far from the majority. This can be statistically evaluated through the outlier detection criterion used in the boxplots representation, where a point is considered an outlier (regarding the smaller values) if it is smaller than, Q1-K*(Q3-Q1) where Q1andQ3 are the first and third quartiles, respectively. Similarly where a point is considered an outlier (regarding the higher values) if it is greater than, Q1+K*(Q3-Q1). Although K is typically considered as 1.5, in this step the more flexible value of 1 is required (also commonly used in practice), in order to reduce the loss of eventual matching candidates.

2.7 Rotation Estimation and Translation Estimation

This rotation estimation is entirely statistical base procedure; first we obtain orientation of extracted objects from base and unregistered image and perform the difference of orientation between every possible two-by-two combination of objects obtained by the segmentation of the two images and estimate robust angle by using same boxplot procedure indicated in above module. This translation estimation is entirely statistical base procedure; First we obtain orientation of extracted objects from base and unregistered image and perform the difference of orientation between every possible two-by-two combination of objects obtained by the segmentation of the two images and estimate robust angle by using same boxplot procedure indicated in above module. General example for how to rotate and shift image

```
A=imread(„peppers.png‟);
B=rgb2gray (A);
C=Imrotate(B,angle);
figure(1),imshow(C);
```

Fig. 2.5: Illustrates Original and Its Rotated Image

Fig. 2.6: Illustrates transformed and transformed image with showing shifting location

$$xform= \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 60 & 40 & 1 \end{bmatrix} ;$$

```
shift_xdirection=xform(3,1);
shift_ydirection=xform(3,2);
tform_translate=maketform('affine',xform);
[trans_imagexdataydata]=imtransform(aa,
tform_translate); cb_trans2 = imtransform(aa,
tform_translate,'XData',[1(size(aa,2)+xform(3,
1))],'YData',[1(size(aa,1)+ xform(3,2))]);
```

3. Experimental Results

In this section we present a greedy histogram clustering algorithm which takes as input a partitioned image and obtains a histogram clustering based on the minimization of the loss of MI. That is, we group the bins of the histogram so that the MI is maximally preserved. From the perspective of the information bottle neck method, the binning process is controlled by a given partition of the image clustering algorithm has been previously presented.

Fig. 3.1 WIENER Filter Performed On Image1

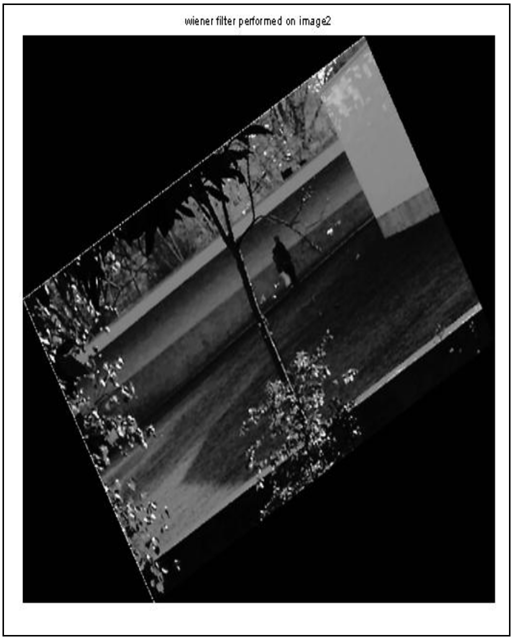


Fig. 3.2WIENER Filter Performed On Image2

4. Conclusion

In this paper, a new approach for automatic and accurate image registration through histogram based image segmentation is proposed, with clear advantages by joining these two main areas of image processing. Since this project does not require point selection in images through cp select that is used in previous method either for rotation or translation, it is a fully automatic procedure. In this project filtering step is an important preprocessing stage of the proposed methodology, for that reason several other filters had also been tested from different filter categories. The median filter, one of the most used filters, produces a blurred version of an original image, comparing to other filters, adaptive wiener filter is providing better results but it takes more computation time compared to non adaptive filter. Histogram based image segmentation is also new and simple technique compared to other procedures like clustering based image segmentation. Finally this project achieving better rotation and translation estimation and registering original image with registered image compared to previous methods. By using our proposed method, we can able to get best computational time at the segmentation stage compared with many existing methods for image registrations. Our Proposed method was performed computations in very less time compared to many existing methods.

5. References

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