DENOISING OF AUTOMATIC IMAGE REGISTRATION USING CONVOLUTIONAL NEURAL NETWOEK

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Abstract

Image registration plays an important role in many practical problems in diverse fields such as medical, remote sensing, and computer vision. The basic purpose of image registration is to obtain the finest geometrical and radiometrically aligned image from temporal or multi-modal image sensors. In this project, a novel stable shape feature-based image registration method has been proposed by matching the stable region with a set of rotations, scale invariant features, and multi-scale image segmentation is used to obtain the matching areas. Noise present in the image gives adverse effect to the image, hence denoise is performed using CNN. The removal of noise provide adequate and accuracy for various range of applications. The PSNR values will be calculated. The Experiment results are obtained using Matlab software tool.

Keyword*: image registration, multi-scale image segmentation, De-noising, Convolutional Neural Networks.*

1. INTRODUCTION

Multi-sensor image registration has been widely used in remote sensing and medical image field, and it is usually necessary for integrating information taken from different sensors or from different viewpoints, finding changes in images taken at different times or under different conditions [1]. It is difficult to automatically register due to the complexity of images which maybe have different resolutions, different orientations, and different imaging conditions and so on. The task of automated image registration can be divided into two major steps: one is the extraction of features from images and another is the search among the extracted features for the matching pairs that represent the same object in the field of view of the images to be matched. Image registration algorithms can be categorized into intensity-based and feature-based methods [2]. In the case of multi-sensor image registration, the large diverse nature of the represented information results in the failure of the prevalent intensity-based registration approaches. Compared to intensity-based methods, feature based methods have proven to be more suitable for multisensor image registration [3]. Points, lines, and regions are some of the most commonly used image features.

Due to the different resolutions, orientations, or different imaging conditions, region based registration strategy is rarely used compare with points and line registration because shape and intrinsic features of image regions obtained by segmentation are so instable and overly depended on the parameters set in regions extraction that it is difficult to find a corresponding region in another image [4]. But it is undeniable that region has own inherent advantages as it aims to characterize the global structural properties of related graphs of two images. Automatic image registration based on convexity

model and full-scale image segmentation is propsed in [5] where the rotating of image registration is not found be perfect. In order to overcome the region matching disadvantages talked above, this paper proposed a new automatic image registration based on stable shape features and multi-scale image segmentation. A multi-scale segmentation algorithm is introduced to find stable matching regions, and then an approach of automatic images registration based on shape features of image object regions is discussed.

2. IMAGE REGISTRATION

Image registration is used to match two or more partially overlapping images and stitch them into one panoramic image of the scene. To register two images, the coordinate transformation between a pair of images must be found from class of transformations. The optimal transformation depends on the types of relation between the overlapping images. To find the relationship between two images we rely on the estimation of the parameters of the transformation model. The number of parameters depends on the chosen transformation model. A common assumption is that the coordinate transformations between two images are rigid planar models. Rigid planar transformation is composed of scaling, rotation, and translation changes, which map the pixel $(x1, y1)$ of image $f1$ to the pixel $(x2, y2)$ of another image $f2$:

$$\begin{bmatrix} x_2 \\ y_2 \end{bmatrix} = sR\begin{bmatrix} x_1 \\ y_1 \end{bmatrix} + T = s\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}\begin{bmatrix} x_1 \\ y_1 \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

The rigid transformation is sufficient to match two images of a scene taken from the same viewing angle but from different position. That is, the camera can rotate about its optical axis. In the case of remote sensing, where the distance approaches infinity, the transformation between the captured images behaves like a planar rigid transformation.

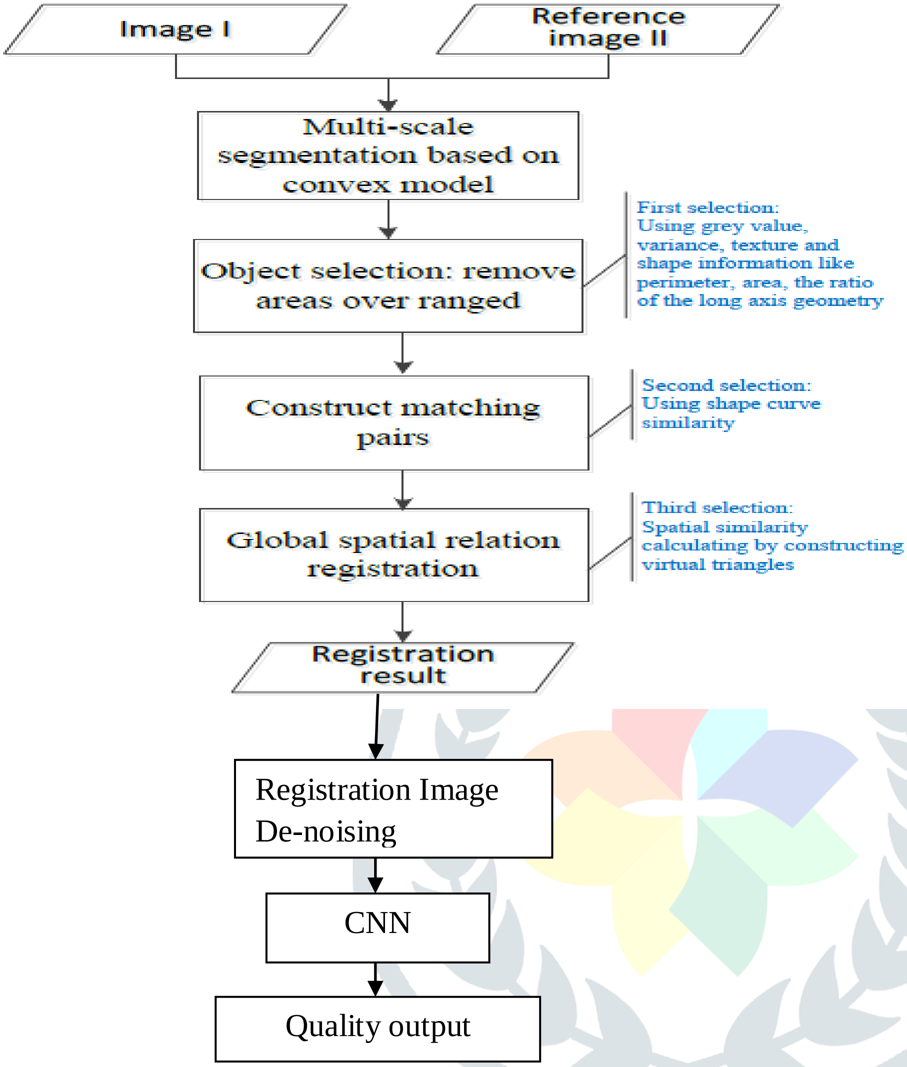

Figure 1. Framework of the proposed method.

3. DESIGN FLOW

Firstly multi-scale segmentation algorithm are used to divide image into many image objects by spatial clustering. In the course of segmentation, all image objects which accord with the convexity model are extracted. In this way, we get some homogeneous regions whose inner features are even relatively and different to surrounding heterogeneous regions in one image and there is a corresponding region which stands for the same ground region in another image, and multi-scale image segmentation is expected to ensure that the two regions exist of the two images no matter what parameters used. Figure 1 show the design of the work.

Then, s set of features such as grey value, variance, texture and shape information like perimeter, area, the ratio of the long axis geometry are applied to eliminate the over ranged areas. After this step, the region based shape feature described by the shape curve similarity is employed in object matching. Each object is both a regional target and feature point (the centroid of the region). Successively selecting 3 pairs of rough matching objects and then constructing virtual triangles to calculate spatial similarity. At last, according to the similarity of spatial correlation, the transformation parameters can be obtained.

4. METHODOLOGY

A. Multi-Scale Image Segmentation

Concept of convexity model

In remote sensing (RS) images, inside of the region which stands for one homogeneous ground object is even relatively and its features are different to its surrounding heterogeneous regions. If the gray value of image is used as altitude, the image can be regarded as a DEM or a convex surface of which the smooth parts stand for homogeneous ground regions and the rough parts stand for heterogeneous ground objects [5]. Small targets and noise in images performance on the intensity surface corresponding to a sharp general convex or concave surface of the cell, and the target background is relatively smooth. In the paper [6], Sun describes this target and background surface characteristics as convex models.

Multi-Scale Image Segmentation

Segmentation itself is not the goal and the resulting objects are just information carrier. The only purpose of segmentation is to facilitate the subsequent image analysis [7]. The multi-scale analysis method integrates the image information of different scales, and the precision of the fine scale is unified with the multi-scales.

In this project, the multi-scale segmentation based on convex model method is similar to the fractal evolution method [8] (FNEA, Fractal Net, Evolution Approach). It is a bottom-up region growing technology, the convex model criterion is used in the control of object merging, and the convex model criterion and heterogeneity criterion in FNEA are applied to determine whether the end of the segmentation.

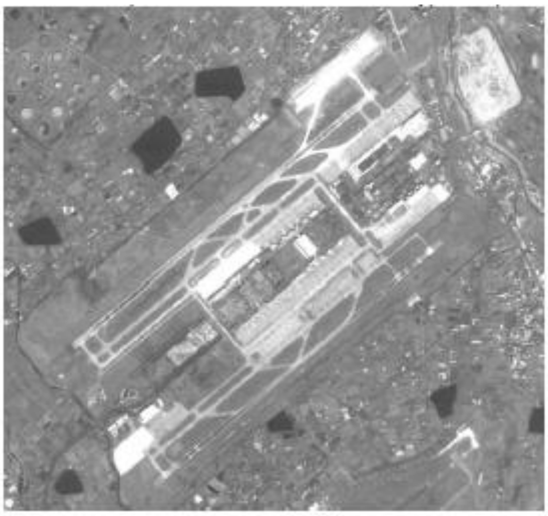

Figure 2. Original image

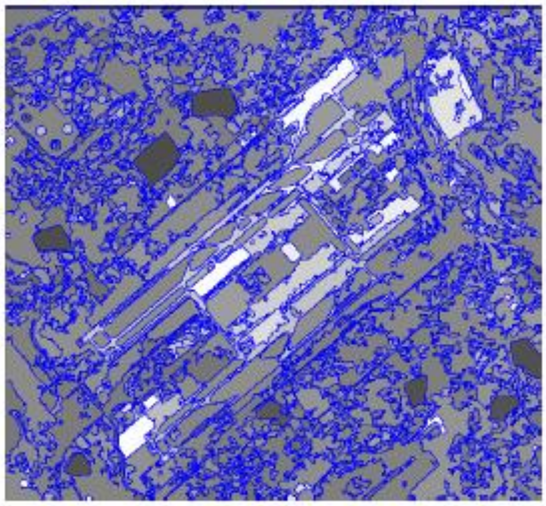

Figure 3. Segmentation result

Fig.2 display the segmented result (the scale parameter is 150). After segmentation, we can get relatively abrupt interest objects from backgrounds. Then the spectral features and the geometric features of the target objects are extracted, for the further matching analysis.

B. Automatic Image Registration Method Based on Shape Features

After getting the target objects, each object according to convex model is an area and also can be seen as a feature point (region centroid). In this paper, the region based image registration is realized by a coarse-to-fine strategy. First of all, the object selection process is used to eliminate the targets of large differences and complex, and so that can retain the conjugate regions.

In the second phase, shape curve features are employed to measure regional similarity of the conjugate regions. After this step, we can get a series of the corresponding conjugate region pairs according to the similarity in descending order. Finally, this paper combines spatial relations and feature similarity organically and makes sure that its global maximum can be reached when the sensed image is aligned with the reference image completely. The constraint of the spatial relation is realized by constructing the virtual triangle using the centroid of the conjugate regions.

Conjugate regions selection

At the first step, some of the areas which too small (less than 50 pixels) or too large (more than 1/2 of the whole image) are filtered out to improve the stability of registration. Then mark the object according with the convex model, as the feature objects.

The essence of image registration is to find a subset $R_r' = \{R_1', R_2', R_3', \ldots\ldots, R_m'\}$ from the set R_r with a set of similarity metrics to establish a one-to-one correspondence between the subset $R_r' = \{r_1', r_2', r_3', \ldots\ldots, r_m'\}$ from the set R_s.

A set of invariant local features are applied to select the conjugate regions.

(1) Spectral features: Including gray mean value and standard deviation of objects.

(2) Geometric features: Including the area, centroid, circumference, compactness, eccentricity of areas.

Assuming that there are two objects sets I_R and I_S, which I_R is the reference image, I_S is to be registered image. Then they should meet the following conditions in terms of regional shape characteristics:

$$\left|\overline{M_A}-\overline{M_B}\right| \le T_m \ \&\& \left|\sigma_A-\sigma_B\right| \le T_\sigma$$

Where *A M* and *B M* are the gray mean value of object in image I_R and I_S ; σ_A and σ_B are standard deviation respectively. T_m is the threshold value of the gray mean (here pick 30), T_σ is the standard deviation of the threshold (here chose 12).

At the same time, the difference between the shape compactness of the object from R_r and R_S is not larger than T_{C_1} and T_{C_2} :

$$\left|C_{1A}-C_{1B}\right| \le T_{C_1} \ \&\& \left|C_{2A}-C_{2B}\right| \le T_{C_2}$$

Where C_{1A} and C_{2A} are the roundness value of object from I_R , the same for C_{1B} and C_{2B} For the object from I_R , calculated the most similar goals from I_S according to the above principles for each target, recorded on the set Ω_R; for the object from I_S , calculated the most similar goals I_R for each target, recorded on the set Ω_S. So the jointly elements of Ω_R and Ω_S, mark $\Omega_0 = \{(R_A^1, R_B^1)_1, (R_A^2, R_B^2)_1, \dots, (R_A^m, R_B^m)_1\}$, are the conjugate object sets.

Region shape matching using shape curve features

In order to improve the reliability of registration based on regions, a further verified method based on object contour shape feature is employed. The shape curve [9] is a way to get the marker map based on the distance. The polygon is described as a circumference cycle curve, and it can describe the external shape characteristics of the target area very good, also keep the invariance of rotation, scaling and translation.

For each pair of regions in Ω^0, the vector outer boundary is extracted, and then the maximum similarity of the shape curve and the rotation difference value of the angle θ between the two targets are calculated. The formula for calculating the similarity between shape curves is:

$$pCor\_shape(A,B) = \max\left(\frac{\sum_{i=1}^{n}(d_i^A-\overline{d^A})(d_{ji}^B-\overline{d_j^B})}{\sqrt{\sum_{i=1}^{n}(d_i^A-\overline{d^A})^2\sum_{i=1}^{n}(d_{ji}^B-\overline{d_j^B})^2}}\right), j=0,1,2\dots n)$$

Where d_i^A is distance between the sampling point *i* of the outer of polygon boundary *A* and the centroid of polygon *A*. $\overline{d^A}$ is the mean value of all d_i^A . Same way of d_{ji}^B and $\overline{d_j^B}$ is the starting point of polygon *B*. θ is the included angle between $\overline{O_r \cdot j_{max}}$ (j_{max} is the sampling point of polygon *B* when the similarity is the maximum, O_r is the the centroid of polygon *B*) and $\overline{O_0 \iota_0}$o (i_0 is the starting point of the base polygon *A*, and O_o is the centroid of polygon *A*).

In the initial matching group, there will be a target object that corresponds to multiple targets and multiple targets, so if $pCor\_shape(A,B) \ge 0.5$, keep this match pair, else remove it. After this $\Omega_0$update as a new collection matching set of ,and elements are arranged in descending order of the shape curve similarity.

After the region shape feature matching, we need to go further for the global spatial relation constraint. It is found that in the course of the experiment, when there are multiple shapes of the same or similar features in the image, it is easy to cause the algorithm to fail. In order to overcome this problem, the algorithm is introduced for the global spatial relation consistency criterion.

5. CONVOLUTIONAL NEURAL NETWORKS

CNN is now the go-to model on every image related problem. In terms of accuracy they blow competition out of the water. It is also successfully applied to recommender systems, natural language processing and more. The main advantage of CNN compared to its predecessors is that it automatically detects the important features without any human supervision.

CNN is also computationally efficient. It uses special convolution and pooling operations and performs parameter sharing. This enables CNN models to run on any device, making them universally attractive. All in all this sounds like pure magic. We are dealing with a very powerful and efficient model which performs automatic feature extraction to achieve superhuman accuracy (yes CNN models now do image classification better than humans).

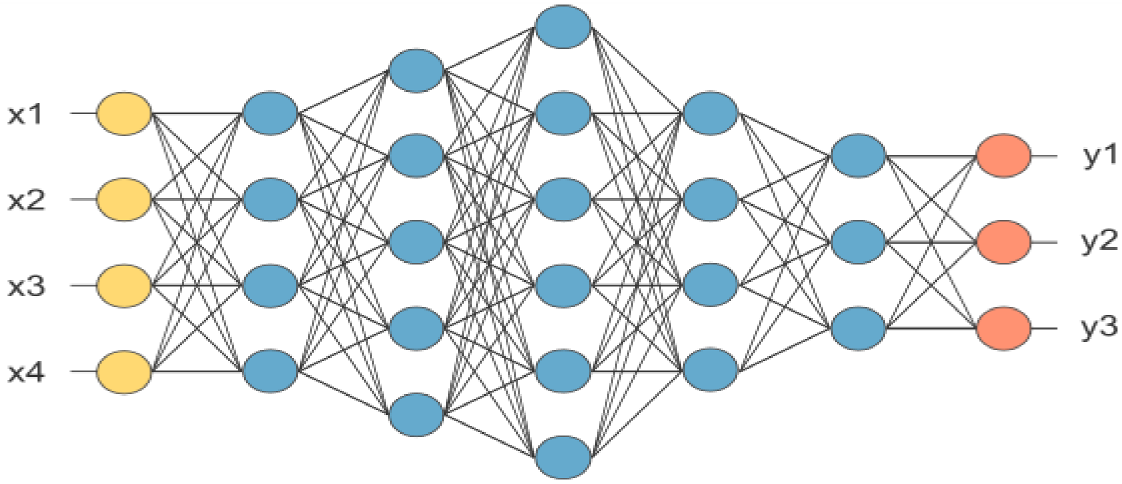

Figure 4. Convolutional Layers

In the above diagram, feature map matrix will be converted as vector (x1, x2, x3, …). With the fully connected layers, we combined these features together to create a model. Hence by extracting the information of image using layers helps in denoise the image. Denoising involves the application of some filtering technique to get the true image back.

6. RESULTS AND DISCUSSION

we experimentally verify the performance of the proposed schemes by applying them to real images. In order to check the accuracy of matched image, a root-meansquare error (RMSE) is used to evaluate the performance of the proposed method. The RMSE is defined as:

$$\boldsymbol{RMSE} = \{\tfrac{1}{N}\sum_{i=1}^{N}[(\boldsymbol{x}_i - \boldsymbol{X}_i)^2 + (\boldsymbol{y}_i - \boldsymbol{Y}_i)^2]\}^{1/2}$$

The PSNR block computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed, or reconstructed image.

The *Mean Square Error (MSE)* and the *Peak Signal to Noise Ratio (PSNR)* are the two error metrics used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error.

To compute the PSNR, the block first calculates the mean-squared error using the following equation:

The experimental results are conducted by taking google images. The results obtained using mutli scale segmentation by extracting the feature of the image. The obtained RMSE , PSNR and MSE are shown below. The obtained values of registered image is compared with results of denoised registered image.

$$MSE = \frac{\sum_{M,N}[I_1(m,n) - I_2(m,n)]^2}{M*N}$$

In the previous equation, *M* and *N* are the number of rows and columns in the input images, respectively. Then the block computes the PSNR using the following equation:

$$PSNR = 10\ log_{10}\left(\frac{R^2}{MSE}\right)$$

The Experimental results obtained based on the input image are given below.

RMSE OF Registered Image = 1.215209

PSNR OF Registered Image = 6.437786

MSE OF Registered Image = 1.162985

The RMSE, PSNR and MSE values obtained after denoising the registered image by using convolutional neural networks. The denoising of the image helps in increase in the quality registered image.

RMSE OF DeNoised Registered Image = 0.856297

PSNR OF DeNoised Registered Image = 9.478318

MSE OF DeNoised Registered Image = 0.972432

7. CONCLUSION

In this project, a method for image registration based on shape features and multi-scale image segmentation, image de-noising using CNN is proposed . By multi-scale segmentation and convexity model restriction, we can convert images into image objects. By analyzing the shape features of image objects, a series of conjugate regions are obtained. After the region shape feature matching, global spatial relation constrain is introduced to constraint the global registration consistency. Experiments show the algorithm proposed in this project is not sensitive to rotation and resolution distortion, which can accomplish image registration automatically. This method's accuracy is strongly depended on the feature of outer contour region shape integrity and stability, so the effects of scale and target change on shape registration must be studied further. The result obtained consists of noise and the removal of noise is done using CNN. The reduced PSNR value in experimental result shown that image quality also improved.

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