Image Registration using Discrete Cosine Transform and Normalized Cross Correlation

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ABSTRACT
In recent years, the accelerated growth in the field of computer vision, image fusion, medical imaging, military automatic target recognition, remote cartography and astrophotography has established the need for the development of good image registration technique for the efficient retrieval of interest point area. Image registration is the process of geometrically aligning one image to another image of the same scene taken from different viewpoints or by different sensors. The idea is to transform different sets of data into one coordinate system. It is a fundamental image processing technique and is very useful inintegrating information from different sensors, finding changes in images taken at different timesand inferring three-dimensional information from stereo images. Registration involves finding out area of interest by comparing the unregistered image with source image and finding the part that has highest similarity matching.This paper presents the image registration techniques based on extracting interest point area of satellite images using Discrete Cosine Transform and normalized cross correlation. The proposed algorithm is worked over various sizes of satellite images such as 256X256, 1024X1024 etc. The root mean square error is used as similarity measure. The experiment results show that the proposed algorithm can successfully process local distortion in high-resolution satellite images. The comparative study shows that DCT is faster and gives more accurate results.

General Terms
Algorithm, Experimentation, results, satellite images

Keywords
Discrete Cosine Transform (DCT), Normalized Cross Correlation, Interst Point Area Extraction, Image Registration

1. INTRODUCTION
Image registration is the process of geometrically aligning one image to another image of the same scene taken from different viewpoints or by different sensors.The idea is to transform different sets of data into one coordinate system [2].It is a fundamental image processing technique and is very useful in integrating information from different sensors, finding changes in images taken at different times and inferring three-dimensional information from stereo images. Registration involves finding out area of interest by comparing the unregistered image with source image and finding the part that has highest similarity matching.The accelerated growth in the field of computer vision, image fusion, medical imaging, military automatic target recognition, remote cartography and astrophotography has established the need for the development of good image registration technique for the efficient retrieval of interest point area [10].Before the development of image registration, there were difficulties in matching the images with angular distortion. As a result interest point matching result was poor.

Image registration involves following basic steps.
1. Detect Features
2. Match corresponding features
3. Infer geometric transformation
4. Align one image to other.

An image feature is any portion of the image that can potentially be identified and located in both the images for e.g. Points , lines or corners. Corresponding feature matching deals with matching features of one image with the corresponding features of the other image having common properties.Inference of geometric transformation function finds the correspondence between features in one image onto the location matching features in the other. For e.g. If two images are taken with the same angle but from different positions, possibly including a rotation about the axis.Image registration methods can be either manual or automatic depending upon whether feature detection and matching is human-assisted or performed using an automatic algorithm.
In this paper, the use of Discrete Cosine Transform (DCT) and normalized cross correlation is investigated.This paper presents the image registration techniques based on extracting interest point area of satellite imagesusing Discrete Cosine Transform and normalized cross correlation. Template matching is achieved by computing correlation coefficient and DCTbetween target unregistered image of any size and a source image of size NXN.The root mean square error is used as similarity measure.Image registration is achieved by extracting interest point area and placing it at the proper position over the transparent source image.

LITERATUREREVIEW
Image registration algorithms can be broadly classified into two categories according to matching method: area based methods (ABM) and feature based methods (FBM). In ABM algorithms, small window of pixels in the sensed image is compared statistically with windows of the same size in the reference image. The most commonly used methods are cross-correlation matching and least-squares matching. The centers of the matched windows are treated as control points, which can be used to solve for mapping function parameters between the reference and sensed images [2]. ABM is a classical matching method. Feature-based matching techniques do not use the gray values to describe matching entities, but use image features

derived by a feature extraction algorithm [1]. The form of the description as well as the type of feature used for matching depends on the task to be solved.

Interest-point matching is problematic and remains the subject of much research within the communities of photo grammetry, remote sensing, computer vision systems, pattern recognition, and medical image processing. Interest-point-matching algorithms can be grouped into two main categories: area-based algorithms and feature-based algorithms. In remote sensing, area-based algorithms are normally suitable for open terrain areas, but the feature-based approaches can provide more accurate results in urban areas. No single technique performs well in both circumstances [4]. Both algorithms have their own unique strengths and weaknesses. Neither type of algorithm can avoid the problem of dealing with ambiguity in smooth (low texture) areas. Feature-based algorithms face the additional problem of the effect of outliers (points with no correspondences) on the results [7].

Because of the large number of feature-based algorithms used in interest-point matching, there are many classification methods for describing these algorithms. Normally, feature based algorithms can be categorized into rigid and non rigid (according to the transformation between images), global and local (according to the image distortions), or corrected and uncorrected (according to the image variations) [1].

In addition, most of the feature-based algorithms search for correspondences and also address the refinement of a transformation function. Therefore, feature-based algorithms can also be grouped into three additional categories [3]. They eithersolve the correspondence only, solve the transformation only, or solve both the correspondence and the transformation. Although numerous feature-based algorithms have been developed, there is no general algorithm which is suitable for a variety of different applications. Every method must take into account the specific geometric image deformation [6].

For non rigid local distortions, more complicated transformations are developed. TPS was proposed initially for global transformations, but it was improved for smooth local distortions for medical image registration [1], [2], [5].

1. METHODOLOGY

The proposed algorithm aims upon using normalized cross correlation and DCT for the purpose of image registration.The algorithm works by dividing the source image into non overlapping blocks of predefined size. The interest point area extraction is achieved by computing normalized cross correlation between each block of source image and the unregistered target image. The second approach used for interest point area extraction deals with finding DCT of unregistered target image and each block of source image.The minimum root mean square error criterion is used as a similarity measure.

1.1 Normalized cross correlation approach

Area-based methods put emphasis on the feature matching step rather than on their detection. No features are detected in these approaches so the first step of image registration is omitted. Area-based methods, sometimes called correlation-like methods or template matching merge the feature detection step with the matching part. These methods deal with the images without attempting to detect salient objects. Windows of predefined size or even entire images are used for the correspondence estimation during the second registration step.

Correlation coefficient can be calculated using equation (1).

Correlation Coefficient - 1

$$r = r_{yx} = \frac{S_{yx}}{\sqrt{S_{yy}S_{xx}}} = \frac{\sum_{i=1}^{n}\left(y_i - \bar{y}\right)\left(x_i - \bar{x}\right)}{\sqrt{\sum_{i=1}^{n}\left(y_i - \bar{y}\right)^2 \times \sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}}$$

$$r = r_{yx} = \frac{C(yx)}{\sqrt{V(y)V(x)}} = \frac{\frac{1}{n}\sum_{i=1}^{n}\left(y_i - \bar{y}\right)\left(x_i - \bar{x}\right)}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(y_i - \bar{y}\right)^2 \times \frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}} \quad (1)$$

3.1.1 Procedure for computing correlation between the images

1. Calculate cross-correlation in the spatial or the frequency domain, depending on size of images.
2. Calculate local sums by pre computing running sums.
3. Use local sums to normalize the cross-correlation to get correlation coefficients.

3.1.2Algorithm

1. Resize the target image to M X N pixels.
2. Partition source image into non overlapping blocks of size M X N by taking block size manually according to the size of source image.
3. Correlation coefficient is computed between the target image and each block.
4. The region having maximum correlation is extracted from source image.
5. Source image is now blended with the extracted block using suitable color transition methods.
6. All the intermediate images generated i.e. block sequences, are displayed along with the output overlapped image to show the result of registration.

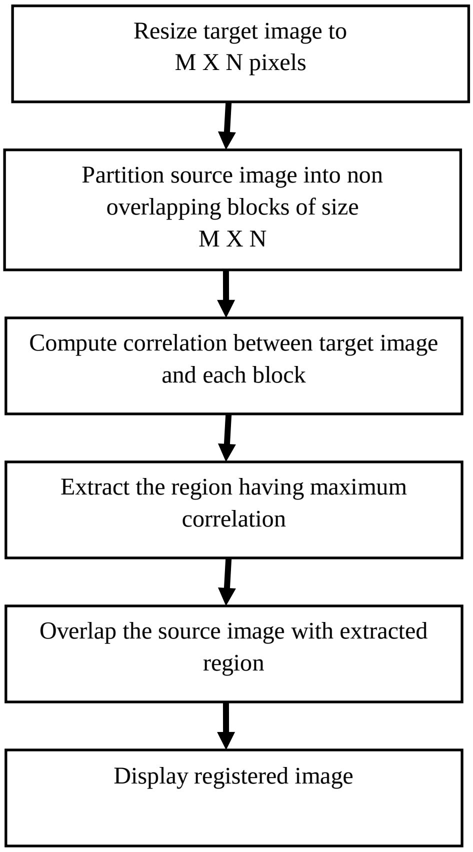

Figure1:Flowchart forimage registration using correlation

1.2 Discrete cosine transform approach

The discrete cosine transform (DCT) is closely related to the discrete Fourier transform. It is a separable linear transformation; that is, the two-dimensional transform is equivalent to a one-dimensional DCT performed along a single dimension followed by a one-dimensional DCT in the other dimension [11].Two dimensional DCT transform can be calculated using equation (2).

$$F(u,v) = \frac{C_u}{2}\frac{C_v}{2}\sum_{y=0}^{7}\sum_{x=0}^{7} f(x,y)\cos\left[\frac{(2x+1)u\pi}{16}\right]\cos\left[\frac{(2y+1)v\pi}{16}\right]$$

with:

$$C_u = \begin{cases} \frac{1}{\sqrt{2}} & \text{if u} = 0, \\ 1 & \text{if u} > 0 \end{cases} ; C_v = \begin{cases} \frac{1}{\sqrt{2}} & \text{if v} = 0, \\ 1 & \text{if v} > 0 \end{cases}$$

(2)

The basic operation of the DCT is as follows:

- The input image is N by M
- f(i,j) is the intensity of the pixel in row i and column j
- F(u,v) is the DCT coefficient in row k1 and column k2 of the DCT matrix.

3.2.1Algorithm

1. Resize the target image to M X N pixels.
2. Partition source image into non overlapping blocks of size M X N by taking block size manually according to the size of source image.
3. Compute the two dimensional DCT of the target image and each block of source image starting from the leftmost top first block.
4. Calculate root mean square error between DCT of target image and each block of source image.
5. The block having minimum RMSE is extractedfrom source image.
6. Source image is now blended with the extracted block using suitable color transition methods.
7. All the intermediate images generated i.e. block sequences, are displayed along with the output overlapped image to show the result of registration.

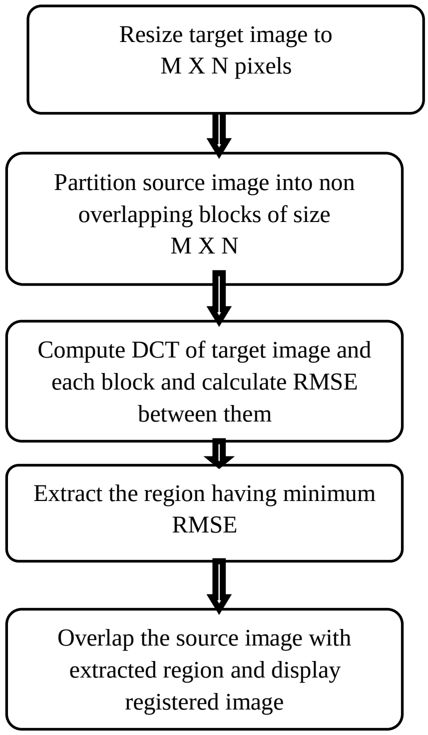

Figure 2: Flowchart for image registration using DCT

2. RESULTS AND DISCUSSION

The implementation of the proposed algorithm is done in MATLAB 7.8 using a computer with Intel Core2 Duo Processor (2.20GHz) and 2 GB RAM. The algorithm is executed with various satellite images of different sizes. The DCT and correlation approach is tested on each of them. The results obtained are shown in the following figures.

Figure 3: Source Image 1

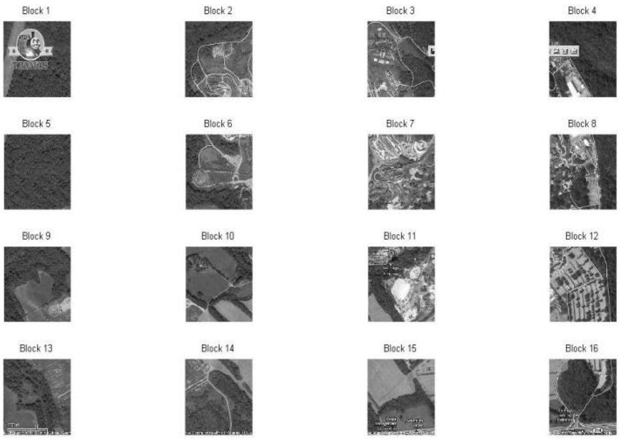

Figure 4: Blocks Source Image 2

Figure 5: Template 1 to be registered

Figure 6: Registered image using correlation

Figure 7: Source Image 2

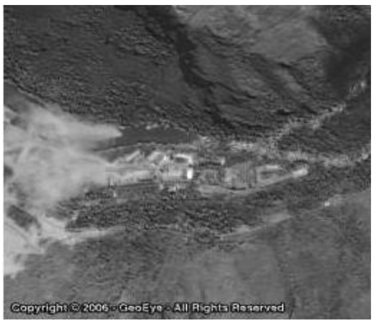

Figure 8: Template 2 to be registered

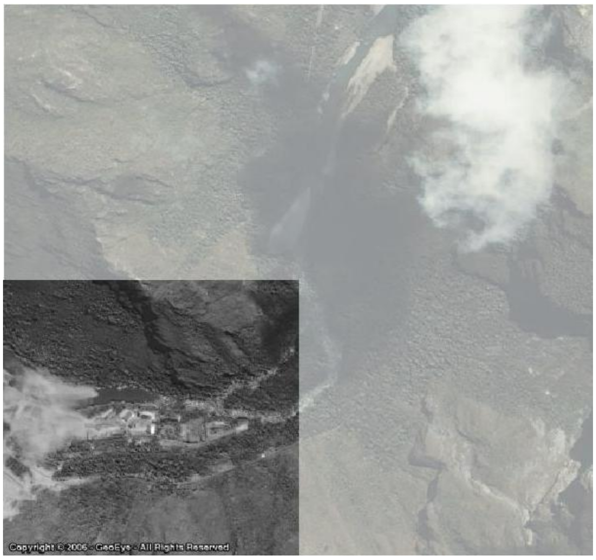

Figure 9: Registered image using correlation

Figure 10: Template 3 to be registered

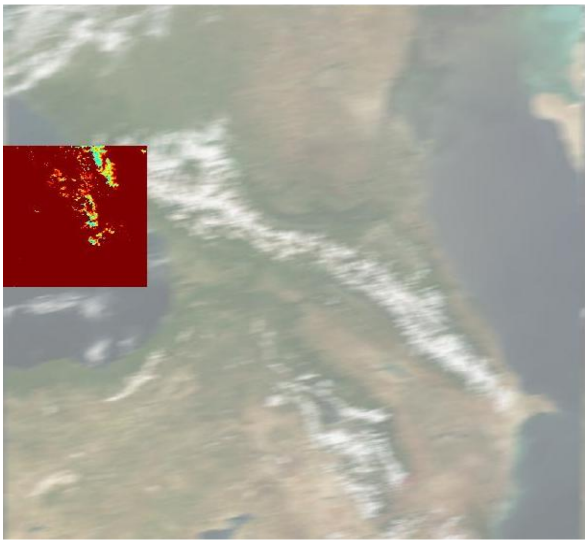

Figure 11: Registered image using DCT

Feature	Correlation	DCT
Computational complexity	High	Low as compared to correlation
Speed	Slow	Faster than correlation

Table 1: Comparative study

3. CONCLUSION

Image registration plays an importance role in the alignment of two or more images of the same scene taken from different angles or different times. This time difference can be in terms of months and years as satellite detect environmental changes over a long time period.

In this paper, a simple but effective algorithm of Image Registration is presented which uses Discrete Cosine Transform (DCT)and Normalized Cross Correlation. The algorithm works with the idea of dividing the source image into non overlapping blocks of size same as that of unregistered target image.

The image registration method of this paper is for the field of satellite imaging.Experimental results on various images in image registration shows that transparently overlapping source image with the extracted interest point area computed using DCT and Normalized Cross Correlation provides an easy and efficient way of image registration.

The comparison of DCT and Correlation shows that as computational complexity of Correlation is more than DCT, DCT provides the resultsfaster than correlation.

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