Remote Sensing Image Correction of Geometric Distortion
By Using Outer Corners

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ABSTRACT
In the current research work produce the development and performance evaluation of techniques for an automatic image registration and image geometric distortion. A feature point extraction method based on determined the outer corners in the reference and scene images, is proposed. This feature point extractor can handle images at different scaling, rotation and translation, by comparison image by image. Experimental results show that the extracted feature points are invariant to image scaling, rotation and translation. This algorithm is implemented for automatically registration of geometrically distorted images. Three main steps constitute the algorithm: extracting feature point (outer corners) by dividing the image into four parts and search every part by window 5×5 to obtained the corner, obtained the correspondence between the outer corners of the reference and the scene images, and estimating the affine transformation parameters between the first and the second images. Experimental results show that the proposed algorithm leads to sufficient registration accuracy using several types of skewed images.

INTRODUCTION
Registration is a fundamental task in image processing used to match two or more pictures taken, for example, at different times, from different sensors, or from different viewpoints. Registration can be performed either manually or automatically. Virtually all large systems which evaluate images require the registration of images, or a closely related operation, as an intermediate step. Specific examples of systems where image registration is a significant component include matching a target with a real-time image of a scene for target recognition, monitoring global land usage using satellite images, matching stereo images to recover shape for autonomous navigation, and aligning
images from different medical modalities for diagnosis. Image registration, is an important step for a great variety of applications such as remote sensing, medical imaging and multi-sensor fusion based target recognition. It is a prerequisite step prior to image fusion or image mosaic. Its purpose is to overlay two or more images of the same scene taken at different times, from different viewpoints and/or by different sensors. 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 [1].

Geometric distortion is an error in an image, between recorded image coordinates and its actual earth coordinates even if projected theoretically with an ideal sensor under ideal conditions. These distortions are classified into internal distortions, resulting from the geometry of the sensor and external distortions resulting from the attitude of the sensor or the shape of the object. Geometric distortion in satellite imagery can rise when velocity and orientation are variable over the scanning period [2].

**STATEMENT OF PROBLEM**

1- Auto registration problem (Implementation automatic method).
2- Difference in illumination conditions.
3- Interest point detection in surrounding.
4- Matching two difference sets of points.
5- Image processing speeding problem for high resolution satellites images.

**PROPOSED SYSTEM DESCRIPTION**

The image registration is involved on three steps as shown in Fig. (1) image registration system can be considered a black box that receives a reference image and a sensed image then resamples the sensed image to spatially align with the reference image. This operation assigns the same coordinates to corresponding points in the images, defining both images in the same coordinate system.
OUTER FAR FOUR CORNERS FINDING

First advantage for choose outer corners of images as feature points to applied registration images, that salient and distinctive objects, this process for any size images, and the initial registration closer to optimal registration reduces computation time and increases accuracy, for that the present program include this steps:

1. Reset counters and variables.
2. Load Distortion Image (Img _D).
3. Read Width (w1), Height (h1), Pix (Pixels of Img _D).
4. Input of sensed image width (w2), height (h2).
5. Search (x, y) coordinates of corners, xx(1→4), yy(1→4) for Distortion Image (Img _D) by this demo programs (for 1st quadratic of Img _D), see figure- 2 bellow

for x = 0 to w/2-1
for y = 0 to h/2-1
if counter _corner=1 then 20
sum =0
for i = 1 to 5;for j = 1 to 5
sum = sum + pic1(x+i, y+j)
next :next
if (sum=0)or(sum=25*white _pixl) then
  go to 10
else
  counter _corner =1
Remote Sensing Image Correction of Geometric Distortion By Using Outer Corners
Firas, Faisel, and Suhaila

\[
\begin{align*}
    xx(\text{counter }_\text{corner}) &= x \\
    yy(\text{counter }_\text{corner}) &= y \\
\end{align*}
\]
end if
10 next :next
20 ....
6. Repeat to other corners.
7. Call sub-routine (Affine) to evaluate correction parameter.
8. Redraw correction image.

Figure-2: The scene divided into four parts with the coordinates.

MATERIALS AND METHODS
The implemented method can automatically extract outer corners (feature points) from both images figure-2 and figure-3 then matching between them. This method can be summarized by following steps:
(1) Establishing a simple and effective program for correction satellite images which have geometric distortions (manually and automatically).
(2) Determined the feature points (outer corners) in both (reference image and scene image).
(3) Manual or automatically, corresponding between (reference and scene images).
(4) Selected the distorted ratio in the scene image before registration [3].
(5) Calculated the corrected ratio from the scene image after registration [3].
(6) Calculated the error pixel counter (EPC) from the scene image after registration [3].
(7) Calculated the error ratio \[ \text{Error\%} = \frac{\text{Sum} (|R - C|)}{\text{Sum}(R)} \], where \((R)\) is the reference image and \((C)\) is corrected image \[3\].

**RESULTS AND DISCUSSION**

Figure 3: Reference image, by Landsat (5), the resolution of thematic mapper (TM) = 30 meter, Japan, Hachirogata Lake, Akita prefecture at 28 Apr. 1988 \[4\].

Figure 4: Rotation
Distorted Ratio = 76.16%

Figure 5: Registrated Image
Error Ratio = 37.66%
Remote Sensing Image Correction of Geometric Distortion By Using Outer Corners
Firas, Faisel, and Suhaila

Figure 5: Rotation + High Scaling
Distorted Ratio = 81.6%

Registrated Image
Error Ratio = 46.58%

Figure 6: Low Scaling
Distorted Ratio = 63.35%

Registrated Image
Error Ratio = 31.43%

Figure 7: Scaling + Low Rotation
Distorted Ratio = 68.47%

Registrated Image
Error Ratio = 29.65%

Figure 8: High Scaling + Rotation
Distorted Ratio = 83.47%

Registrated Image
Error Ratio = 54.26%
First must now that we calculate distortion ratio for each case before corrected them by calculate the total volume for image by equation:

\[
\text{Total volume (v)} = \text{Width (w)} \times \text{Height (h)} \times 3
\]

After we calculate by counter the number of distorted pixels and divided them on the total volume then multiplying them by (100), as shown:

\[
\text{Distorted Ratio} = 1 - \left( \frac{\text{No. of distortion pixels}}{\text{Total Volume}} \right) \times 100
\]

In the other domain after corrected the distortion, we calculate the corrected ratio by make counter to calculate the corrected pixels from the total distortion and divided them on the total volume then multiplying by (100), as shown:

\[
\text{Corrected Ratio} = 1 - \left( \frac{\text{No. Of corrected pixels in registered}}{\text{Total Volume}} \right) \times 100
\]

Then will use the other equation:

\[
\text{Error Pixel Counter (EPC)} = 1 - \left( \frac{\text{No. Of distorted pixels in registered}}{\text{Total Volume}} \right) \times 100
\]

And finally, we used another equation to measure the error ratio in the corrected image by comprise it with the reference image as we shown

\[
\text{Error %} = \left( \frac{\text{Sum} \mid \text{Ref. image} - \text{Corrected Image} \mid}{\text{Sum of Pixels value in ref. Image}} \right) \times 100
\]

The total sum from the different between the pixels value in the reference and corrected images then divided into the total sum for pixels value of reference imagewill be the error ratio.
In the first case the distorted ratio equal 76.16% before registered image and after that the Error ratio become 37.66% , the second case distorted ratio equal 81.6% before registered image and after that the (Error ratio) become 46.58%, the third case distorted ratio equal 63.35% before registered image and after that the (Error ratio) become 31.43%, the forth case distorted ratio equal 68.47% before registered image and after that the (Error ratio) become 29.65%, finally the last case distorted ratio equal 83.47% before registered image and after that the (Error ratio) become 54.26%.

Some conclusions can be drawn from the foregoing results and discussions:
(1) The distorted ratio in the experiment results was decrease into a half value and more than in some hard scaling and rotation case.
(2) The method applied affine transform technique after extract feature points from the reference and the scene images, by using outer corners.
(3) The two sets of feature points (outer corners) can be compared.
(4) The correspondences between the feature points can be established.
(5) The registered image of input reference images can be obtained in an automatic way.

REFERENCES
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