IMAGE RECTIFICATION IN A GIS ENVIRONMENT

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ABSTRACT

The usual practice in geometric correction and registration of remotely sensed data is to fit the image onto a map base. In a geographic information system (GIS) with both vector and raster data handling capability, a map to image registration is also possible. This is the preferred approach when the two data types must only be in registration for the purpose of image analysis but a permanent georeferenced image file is not required. Both the image-to-map and the map-to image transformation has been implemented in a GIS at the University of New Brunswick. The design and implementation of this registration method is discussed.

KEY WORDS: Geometric registration, Rectification, Resampling, Georeferencing, Transformation, GIS.

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1. INTRODUCTION

Geometric correction and registration are essential elements of digital image processing and analysis.   Without georeferencing the exact spatial relationship of an image to the earth's surface is unknown. Without known spatial position of the information obtained from digital images has limited value.

Georeferencing of any raster data involves two transformations, a geometric and a radiometric. The geometric transformation defines the coordinates of every pixel in the new reference system. It is performed by one of the well known two-dimensional coordinate transformation functions such as the similarity, affine, projective or polynomial transformation. Radiometric transformation, which is usually referred to as resampling, means to determine the radiance value of every pixel in the transformed raster. It is an interpolation based on the radiance values in the unregistered scene. The three most frequently employed resampling techniques are the nearest neighbour, the bilinear and the bicubic interpolation.

2. EFFECTS OF RESAMPLING

Radiometric transformation is a computationally demanding task and is not without problems. The nearest neighbour method is reasonably fast and the new pixel values are copies of existing values from the input image. Thus the radiometric characteristic of the image remains unchanged. On the other hand, it does tend to produce a rather blocky, disjointed appearance in the output image.   Bilinear interpolation results in a smoother looking image because it is essentially an averaging process. This, however means that sharp boundaries in the input image become somewhat blurred in the output image. This technique introduces new radiometric values and problems may be encountered in subsequent spectral pattern recognition analyses of the data. The computational time required is longer than for the nearest neighbour method. The bicubic technique requires the longest computation time, but it tends to give the most natural-looking image. Again, some loss of high-frequency information occurs, as this interpolation is essentially a low-pass filter.

The following example illustrates the effect of resampling

Derenyi and Saleh, 1989]. Agricultural fields and water was classified on a Landsat TM, Band 5 subscene of 342 lines by 313 pixels. First, the classification was performed on the image in its original state. It was then repeated after a 9° and 35° rotation, followed by a nearest neighbour and bicubic interpolation resampling. The 9° rotation approximates the orbital inclination of earth observation satellites, while the 35° represents rotations which could occur when airborne data are georeferenced.

Table 1 shows the mean and standard deviation obtained in training areas for the two classes in the original and in each of the four resampled images. Table 2 shows the pixel count of each class after the maximum likelihood classification at 95% probability level of the five data sets.

The effect of resampling is demonstrated by the shift of the mean value, the expanded standard deviation and by the significant increase in the pixel count of both classes in the bicubic interpolation resampled image.

3. MAP-TO-IMAGE REGISTRATION

The lengthy processing time and the undesirable effects on the radiometric characteristic could be avoided if both the image and the map resides in a GIS with an integrated raster-image/vector-graphics handling capability. In this case, a temporary digital map-to-image registration is possible. All information extracted from the image can later be georeferenced by an inverse transformation . This map-to-image transformation scheme has been implemented in the raster image extension (RIX) of the Computer Aided Resource Information System (CARIS) GIS in two versions: For small sub-scenes the registration can be performed on-line interactively. For large data sets an off-line batch processing mode is available. Here, various two or three-dimensional transformation functions are provided as options.

3.1 On-line Georeferencing

It is not uncommon that large data sets still exhibit noticeable residual misregistrations in subregions, after georeferenceing. This may happen when relief displacement was ignored and when the number, distribution and accuracy of the ground control points (GCPs) or the transformation function used are inadequate for properly modelling the

geometric distortions. In order to remedy this problem, an iterative geometric correction module has been implemented in CARIS that allows the operator to interactively improve the map/image coregistration in a combined display without having to select GCPs. The operator incrementally translates, scales and rotates the vector graphics to match corresponding features in the map and in the raster-image backdrop. The graphics is redrawn after each adjustment step. Although the different adjustment parameters are introduced sequentially, their effects are accumulated to provide a complete affine (6 parameter) transformation.

Once the desired registration has been obtained, the operator can edit the map or extract new information from the image by digitization in the display. (The mouse and standard CARIS commands are used for these functions.) An inverse transformation of all new points assures proper registration with the original digital map base. This operation is now an integral part of the CARIS Primary Graphics module.

3.2 Off-line Georeferencing

The batch processing version of the map-to-image registration package in CARIS has three modules. PERSMAPS transforms points in a map or ground coordinate system into an image coordinate system. ORTHMAPS reverses the transformation performed by PERSMAPS. RECTMAPS can be used for either map to image or image to map transformation.

PERSMAPS and ORTHMAPS are designed for digitized aerial photographs. The collinearity equation is the transformation function. Both programs presuppose that the camera parameters (coordinates of the exposure station and the angular orientation of the optical axis of the camera) are known. This information can be obtained by space resection, may be available from previous photogrammetric operations or is provided by an inertial navigation system. A digital elevation model (DEM) is needed to obtain a rigorous solution. Failing this, the transformation is based on an average terrain height.

RECTMAPS is designed for non-photographic images such as Landsat, SPOT, MEIS, SAR imagery. DEM is not required. Affine, two-dimensional polynomial up to 5th order and projective transformations may be selected, as well as surface fitting with spline functions.

4. CONCLUSIONS

In a fully integrated raster-image/vector-graphics processing facility, the coregistration of image and map files may also be accomplished through a map-to-image transformation. This option is especially attractive when an image is only used for cartographic editing, map revision or transferring visually interpreted information into a map file. An inverse transformation assures that the new information is properly georeferenced. This approach avoids the potentially undesirable side effects of resampling on the radiometric characteristic of the image data and significantly reduces the computational load. This scheme has been successfully implemented and tested in the CARIS GIS.

REFERENCES

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Table 1: Training statistics before and after resampling.

α	Res.	Field		Water	
		Mean	σ	Mean	σ
0°	--	151.4	5.3	8.1	1.5
9°	NN	151.4	5.4	8.1	1.5
	BC	151.2	6.9	7.5	2.1
35°	NN	151.5	5.5	8.2	1.5
	BC	150.8	8.0	7.4	1.9

α = rotation angle, σ = standard deviation
NN = nearest neighbour, BC = bicubic

Table 2: Pixel counts after maximum likelihood classification.

α	Res.	Field	Water
0°	--	1532	4110
9°	NN	1540	4116
	BC	1876	5020
35°	NN	1562	4108
	BC	2302	5082