

HUE ADJUSTMENT METHOD OF LARGE-SCALE IMAGE DATABASE

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ABSTRACT:

This paper analyzes the reasons causing hue (or gray) differences of large-scale image database. Then based on the comparison of some general methods, the paper presents a new hue (or gray) adjustment and smoothness transition method according to the characters of image neighboring and correlative. Meanwhile, in order to reduce spatial transfer errors caused by adjusting large-scale images, an innovative multi-time adjustment algorithm based on quad tree is provided.

1. PREFACE

Image data as a main carrier of spatial data is playing an increasingly important role in the field of geographic information System (GIS). It provides foundational data and information for constructing National Spatial Data Infrastructure (NSDI). Meanwhile digital orthophoto quadrangle (DOQ) is a core component of digital earth (DE) which was constructed on the base of spot image with 1-meter resolution. The construction of NSDI and DE imminently need a large-scale image database to efficiently manage the multi-scale and multi-resource mass image data. At present, large-scale seamless image database based on commercial database management systems (such as ORACLE, SQL Server) has made significant theoretic contributions and successful applications both on the management of mass image data and on the matching and mosaic image in terms of spatial location information. However, there still exists serious non-equilibrium and deviance of the hue (or gray) in the large-scale image database due to different obtaining condition of original images. For example, different obtaining time of original image data will lead to different reflecting feature of objective and different sunshine conditions. Furthermore, even the obtaining time is simultaneous, the image data themselves will appear local deviance of hue (or gray) due to the influence of various factors such as terrain (the shade water area of mountain reflects and absorbs beam with different angles) etc. Seamed and mosaicked according to every single image's spatial locations information the whole image will look like "a big clout" in large-scale (such as in a province or in the whole national area) seamless image database. Even though various hue (or gray) transition methods were performed on the seam line when images combined, the large range image still looks like "a big flower-cloth" for the hue (or gray) differences exist in every image. It is very difficult to maintain the consistent hue of a whole image in large-scale seamless image database. The existence of hue (or gray) deviance leads to the same object has different hue. And it badly affects objective recognition in full digitalize measure system and 3S (Global Position System (GPS), GIS, Remote Sensing (RS)). And also affects the whole appearance of output map of large range images. So how to guarantee equilibrium of

large-scale images in practice becomes one of the key technologies of image mosaics in the construction of large-scale image database.

2. GENERAL METHOD OF IMAGE HUE BALANCE

Most methods for image hue balance are based on the overlap areas of neighboring images. Various methods of smoothness transition are used to eliminate artificial spurious margins and mosaic seams existed in images.

2.1 Hue Balance Based on Image Histogram

Gray-level histogram of images reflects their gray distribution characters. Under the ideal condition the gray-level histogram of the overlap area among neighboring images should be consistent.

2.1.1 Hue Adjustment Through Moving the Histogram Horizontally

The average values of gray of left and right images are represented as: \bar{g}_L , \bar{g}_R . If we set the histogram of left image the reference and move the histogram of right image horizontally along the gray axis. Then we will have the formula:

$$g'_{R(i,j)} = g_{R(i,j)} + (\bar{g}_L - \bar{g}_R) \quad (1)$$

An obvious advantage of this method is its minimal computation quantity. And it can achieve better result if the histograms of the overlap area of neighboring images have similar shapes.

2.1.2 Hue Adjustment Through Rejection of "First Order" Histogram

The main character of this method is linear transform on gray-level according to gray distribution characteristics of

neighboring images. Mapping histogram of one image to histogram of another, thus making the gray histogram of the overlap area between neighboring images have more similar shape. The maximum and minimum value of left imagery and right imagery labeled as: g_{Lmax} , g_{Lmin} , g_{Rmax} , g_{Rmin} . The average value of gray-level of the two images marked by: \bar{g}_L , \bar{g}_R . If we set the gray histogram of left imagery reference and linearly map the histogram of the right imagery to the histogram of the left, then the formula of linear mapping will be:

$$g'_{R(i,j)} = INT[(g_{Lmax} - g_{Lmin}) * g_{R(i,j)} / (g_{Rmax} - g_{Rmin})] + (\bar{g}_L - \bar{g}_R) \quad (2)$$

2.2 Hue Balance Based on Information Entropy of Images

The overlap area between neighboring image represents the same image, so its average information quantity (entropy) should be equal. In fact, the actual hue deviance could be adjusted through mapping the entropy. Suppose the maximum value of gray-level, minimum value of gray-level and entropy of left image and right image are denoted separately by: g_{Lmax} , g_{Lmin} , H_L and g_{Rmax} , g_{Rmin} , H_R . The percent of the i th gray-level of the left and right images denoted as: $P_L(i)$, $P_R(i)$. Then we have:

$$H_L = - \sum_{g_{Lmin}}^{g_{Lmax}} P_L(i) * \log_2 P_L(i) \quad (3)$$

$$H_R = - \sum_{g_{Rmin}}^{g_{Rmax}} P_R(i) * \log_2 P_R(i) \quad (4)$$

Set the left image reference, map the right image, then we have the mapping formula:

$$g'_{R(i,j)} = \frac{H_L}{H_R} * (g_{R(i,j)} - g_{Rmin}) + g_{Lmin} \quad (5)$$

2.3 Hue Balance Based on Average Value and Standard Deviation

Suppose the two neighbored images are: $f(i, j)$, $g(i, j)$. Then compute the average value, standard deviation and covariance of the two imageries. The formula formed as:

$$\left\{ \begin{array}{l} Mg = \frac{1}{S} \iint_S g(x,y) dx dy \\ Mf = \frac{1}{S} \iint_S f(x,y) dx dy \end{array} \right. \quad (6)$$

$$\delta_{ff}^2 = \iint (f(x,y) - Mf)^2 dx dy \quad (7)$$

$$\delta_{fg}^2 = \iint (g(x,y) - Mg) * (f(x,y) - Mf) dx dy \quad (8)$$

Using the following formula compute the left image, the result should consistent with the right image on the hue.

$$f'(x,y) = \frac{\delta_{fg}^2}{\delta_{ff}^2} (f(x,y) - Mf) + Mg \quad (9)$$

All of the above discussed methods based on the selection of the mosaic seam between the neighboring images. They do useful when used to eliminate mosaic seams of neighboring images at the case of the overlap area of them is considerably large. But they cannot really eliminate the hue deviance of large-scale image database.

3. HUE BALANCE BASED ON CHARACTERS OF NEIGHBORING CORRELATIVE IMAGES

Both aerial and space remote sensing obtain images by flying along air lane that was preplanned. The image at the same air lane marked as left or right image, while image at different air lanes marked as up and down image. The relationship illustrated at figure 1. Just because orthophotoes are spotted according to different strips, the hue of images achieved from the same strip takes on similar hue. Neighboring images represented considerable relativity not only between left and right image, but also between up and down image.

Hue balance method based on characters of neighboring and correlative image can be described as: at first, adjusting local hue deviance existed in individual images. Moreover, to those images that have obvious internal hue deviances brightness unifying can be done. Then, do smoothness transition at the combining area for large-scale orthophotoes. Use the overlap area as standard to make them have consistent colors. Then extend the smoothness transition from the area to outer until reach the goal of mosaic margin smoothly. On the other hand in order to reduce the spatial transfer of adjustment errors, we use quad-tree repeatedly. The processes are detailedly described as follows.

1. Set correlative relationship of each image block according to meta data file of images.

The meta data file has the format which was ruled by national earth spatial data exchange standard. The relationship represented at figure 1. Applying brightness unifying to single image which has obvious internal hue deviance and adjusting lightness and contrast of each image, thus making the same image has evenly internal hues. f_{max} , f_{min} denote the maximum and the minimum gray-level values of image, the formula will be:

$$f'(x, y) = \frac{255}{f_{\max} - f_{\min}} (f(x, y) - f_{\min}) \quad (10)$$

2. Adjusting according to separate strips

Images at a same aviation strip have left-right relationships. The seam line of images can be determined according to the metadata file formatted by national earth spatial data exchange standard. The selection of seam line can directly use the margin of image or actual geodetic coordinate edge. See figure 2. Set the left image as reference. Adjust the right image. $f(i, j)$, $g(i, j)$ denote the corresponding mosaic line of left and right image. k denotes adjusting width. And d denotes distance from mosaic line. Then the formula will be represented as (11). Through above process, the hues of multi-images at a same aviation strip will keep consistent.

$$f'(x, y) = \frac{\sum_{i=0}^k f(x, y)}{\sum_{i=0}^k g(x, y)} (f(x, y) - f_{\min}) + \frac{k-d}{k} * ((\sum_{i=0}^k f(x, y) - \sum_{i=0}^k g(x, y)) / k) \quad (11)$$

3. Smooth transition process of mosaic seams

Mosaic seam consists of left-right seams or up-down seams. Due to the existence of overlap area of neighboring image, represented as up-down overlap or left-right overlap, the overlap areas have consistent hue (or gray). Smooth transition is performed from the overlap area to outer to obtaining smooth margins. The sequence of smooth transition listed at figure 1. The used smooth algorithm included value averaging method and mid-value filtered method

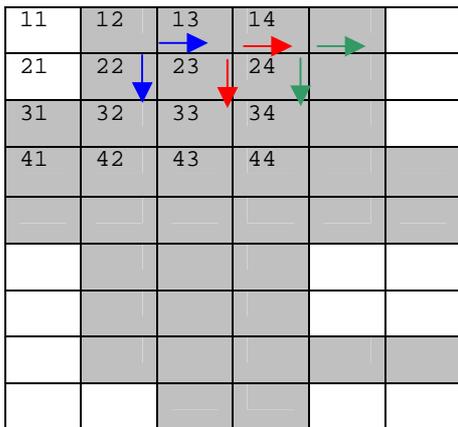


Figure 1. The adjusting sequence of image data

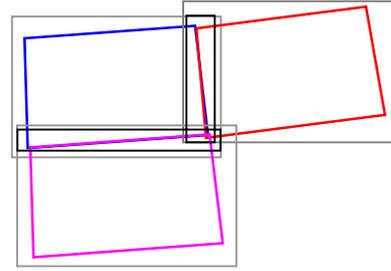


Figure 2. Selection of transition boundary

4. A novel multi-step adjusting approach based on quad-tree

Large-scale image database covering large range areas consists of mass images. If we always set the left imagery as reference standard for hue adjustment, then the interior of a whole large-range image still exists uneven hue with the increasing of spatial transferring adjustment errors. So to reduce the spatial transferring of errors this paper presents a novel multi-step adjusting approach based on quad-tree. The detail procedures exemplified at figure 3. First adjusts the small imagery, then looked the four small images as a single image and adjusts it with its left-right or up-down images. The rest may be deduced by analogy, until the hue of the whole image achieved equilibrium, and there are no mosaic spurious margins.

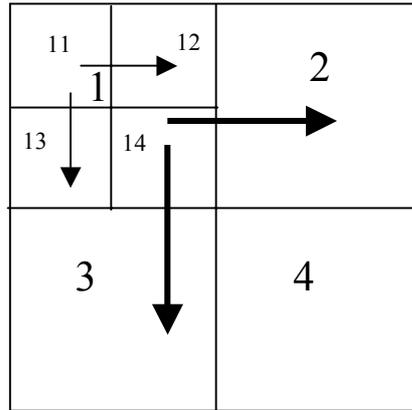


Figure 3. Adjusting sequence based on Quad tree

This method adjusts the hue deviance and eliminates mosaic lines completely according to the characters of neighboring and correlative of images, need not manned inference and can be performed automatically by computer. To save steps and times, the positional relationship of image was determined according to national earth spatial data exchange file format standard, and adjustment in separate strip and smooth transition process can be completed using batch process method.

4. EXPERIMENT AND CONCLUSION

In order to test the effectiveness of the method, the left-right neighboring image blocks, which have relatively obvious hue deviances, are selected. The original images listed at figure 4. Using method based on characters of neighboring and correlative images to adjust the two images, then the results are

represented at figure 5. It proved that this method could eliminate the hue deviance effectively.

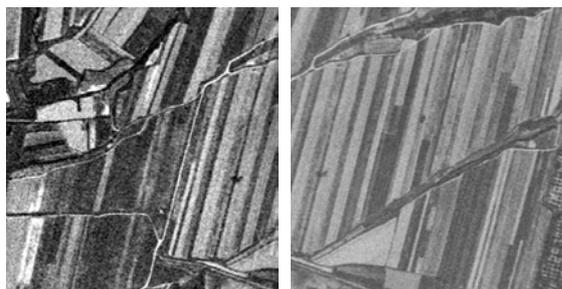


Figure 4. Border imagery before hue adjusting

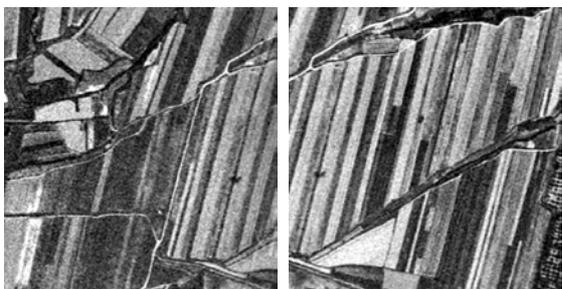


Figure 5. Border imagery after hue adjusting

When orthophoto image database were constructed, the quality of DOM must satisfy two main requirements. On one hand the images must have even hue, no fuzzy overlap, and smooth gray transition of each mosaic block. On the other hand the joint precision must satisfy the limit requirement. The above method has been used to some productive projects of orthophoto image database. And practice proved that when used to adjust hue deviance of large-scale images, this method produced better results.

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