DODGING RESEARCH FOR DIGITAL AERIAL IMAGES

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ABSTRACT:

Analysis two main influences of orthophoto mosaic quality, one is geometric mosaic quality and another is the colour mosaic quality. The uneven lightness distribution inside aerial image and the colour differences between aerial images are two factors which lead the colour mosaic problems. Homomorphic filter can change the distribution of lightness inside image and Wallis transform can adjust the colour difference between images. Using low frequency convolution algorithm to eliminate seam lines in mosaic orthophoto. The finally result of DOM is showing that the dodging method mentioned in this paper is useful for solving the colour problems in orthophoto mosaic.

1. INTRODUCTION

1.1 DOM Quality's Influences

As an production of photogrammetry, Digital Orthophoto Map (DOM) has become more and more important because of its visual, truthful and high automatically produce. The quality of DOM is decided by geometric precision and colour mosaic quality. The details are showing in figure 1.

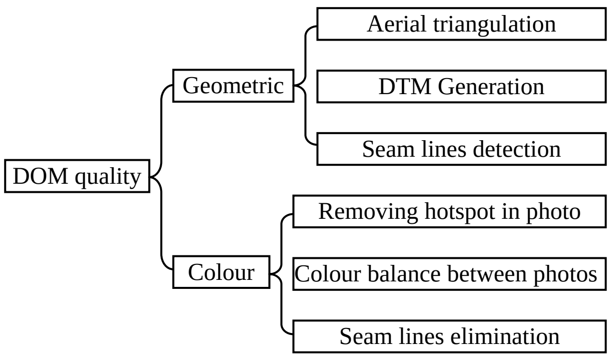

Figure 1. DOM quality's influences

1.2 Geometric Influences

The precision of aerial triangulation and DTM decide the precision and geometric quality of DOM. With the development of POS technology, full automatically aerial triangulation becomes true. Such as MATCH-AT (Inpho Company) and Stereo Softcopy Kit (Intergraph Company) can aerial triangulate automatically with POS data. Using Multi-view matching algorithms or Lidar data, the DTM is easy to get.

Seam lines of orthophoto mosaic can't cross buildings, trees etc which higher than ground and can't cross areas which exist big gray difference between overlapping orthophotos. Researches about Automatic seam line detection have got achievements.

1.3 Colour Problem

Colour processing in orthophoto mosaic is important for DOM quality, include local illumination (hotspot) removing in single image, radiometric slope elimination between images and seam lines elimination in mosaic orthophoto. The following content of this paper discuss method of colour processing in orthophoto mosaic in detail.

2. COLOUR PROCESSING IN ORTHOPHOTO MOSAIC

2.1 Hotspot Removing with Homomorphic Filter

Big frame of aerial cameras and remote sensors leads light illumination in cent and dark illumination in edge when imaging (Figure 2.A). Special ground (such as water, desert and metal house roof) also leads illumination problems (Figure 2.B). The angle between sensor director and sunshine caused top of the photo is light and under of the photo is dark (Figure 2.C, or reverse this case). Hotspot problem is very familiar in digital aerial photos and it lead list scene in final mosaic orthophoto, see Figure 3.

The low frequency of image is related distribution of lightness and basic colour, high frequency of image is related texture characters. See Figure 4, high pass filter remove the lightness of image. Filtering operation can be used in space field or frequency field, the lightness distribution is the global information for images (very low frequency singles), so space field filtering operation need big size filter. Computer time in space field is related to the size of filter and big filter size lead more costing time, so frequency field filtering operation is common select.

Homomorphic filtering is a change of high pass filtering; it split the irradiation information and reflection information from image, and filtering operation for irradiation information. The

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workflow of homomorphic filtering is showing in Figure 5. The function of filtering as follows (Formula 1).
In transfer function *H(u,v)*, r_L <1.0 and r_H >1.0, D_0 is the cut off frequency of highness filtering. For most digital aerial images, r_H=3, r_L=0.5 and D_0=14. The section diagram of filtering is showing in figure 6, and figure 7 is the result of homomorphic filtering operation of figure 3.

$$z(x,y) = \ln f(x,y)$$
$$H(u,v) = (\gamma_H - \gamma_L)[1 - e^{-c(D^2(u,v)/D_0^2)}] + \gamma_L \quad (1)$$
$$r_0(x,y) = e^{r(x,y)}$$

A. light illumination in cent

B. water lead hotspot

C. sunshine caused top light

Figure 2. Example of hotspot problems in aerial images

Figure 3. Two images in left is digital aerial photo, the top of image is light, bottom of image is dark, the seam line between photos is clear in mosaic orthophoto

Figure 4. Left is aerial photo, middle is the low frequency singles of image (result of low pass filtering), right is the high frequency singles of image (result of high pass filtering)

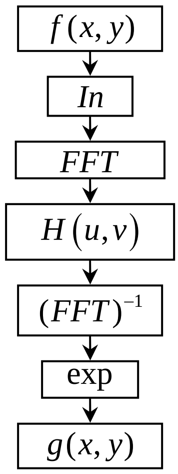

Figure 5. The workflow of homomorphic filtering

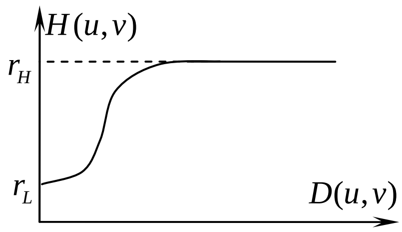

Figure 6. The section diagram of homomorphic filtering

Figure 7. Mosaic result after homomorphic filtering

2.2 Colour balance with Wallis Transform

Digital aerial camera is easily to deviate colours than simulation camera because the CCD's charge deviation (Figure 8), it leads blocks in final mosaic orthophoto (Figure 9).

Figure 8. The deviate colour problem in digital aerial image

Figure 9. Colour is different between aerial photos, some of them are green, and others are yellow, the result of mosaic orthophoto has blocks

Wallis filter can adjustment the colour different between images, it adjust the gray mean and variance to a given mean and variance. The gray mean of image define hue and light information, and variance of image define the range of gray values (contrast information). Select a stand image from aerial images and get mean and variance information about red band, green band and blue band of stand image as the stand values of mean and variance. All images operated with wallis filtering and adjust the means and variances to stand values.
The formula of wallis filtering as follows.

$$g(x,y) = m_S + v_S(g_C(x,y) - m_C)/v_C \qquad (2)$$

m_S is stand image's mean, v_S is stand image's variance, m_C is current image's mean, v_C is current image's variance, $g_C(x,y)$ is the gray value of current image, $g(x,y)$ is the gray value after wallis filtering operation. The mean value m and variance value v of image is computer with formula 3.

$$f_i(x,y) = \begin{cases} 0 \cdots\cdots g(x,y) != i \\ 1 \cdots\cdots g(x,y) == i \end{cases}$$
$$h_i = \sum_{x=0}^{w} \sum_{y=0}^{h} f_i(x,y)$$
$$m = \frac{\sum_{i=0}^{k} h_i * i}{w*h} \qquad (3)$$
$$v = \sqrt{\frac{\sum_{i=0}^{k} (i-m)^2 * h_i}{w*h}}$$

w, h is the image width and height, k is the colour resolution per pixel, for example k=255 if the resolution is 8bits per colour channel.

The wallis filtering result of images in figure 8 is showing in figure 10. Figure 11 is the mosaic orthophoto result after wallis filtering operation with the stand image in figure 10 left.

Figure 10. Left is stand image, middle and right is the wallis filtering result of image in figure 8

Figure 11. The result after wallis filtering, the blocks in figure 9 is removed after wallis filtering

2.3 Seam Lines Elimination

Seam lines elimination is a necessary processing step after seam lines detection in orthophoto mosaic. Even though the hotspot removing and colour balance is very good effect, the contrast in seamline is also clear between two mosaic orthophotos (see figure 12). Feathering process is a useful method for seamline elimination when the seam line is simple, but its hard elimination for complex form of seamline.

Template operation is suit for any form of seamline. The first step of template operation is determined mosaic areas which decided by seamline and create a template (figure 13, left top). Then median filter operation in template (figure 13, right top, filter size is 9 pixels). Finally mosaic two images with template operation. Figure 14 is the seamline elimination result with median filtered template operation.

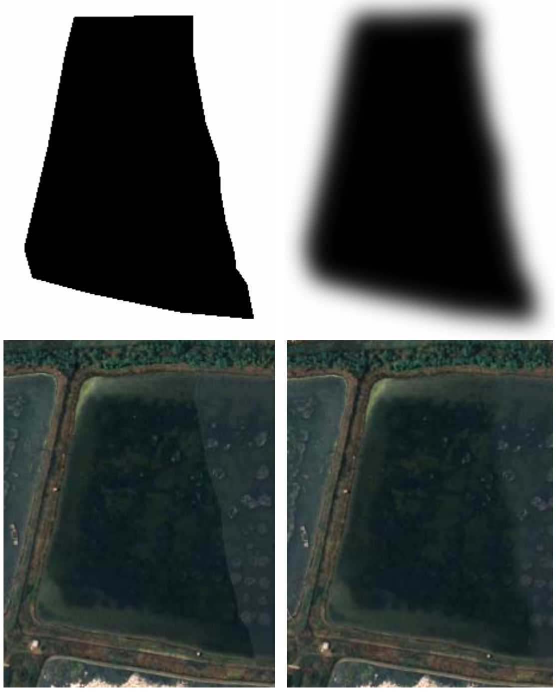

Figure 13. Left top image is oral template of mosaic area, right top is median filtering result of oral template, left bottom is the mosaic result with oral template, and right bottom is the mosaic result with right top template

3. CONCLUSION

This paper introduced the colour problems and their processing method in orthophoto mosaic, include hotspot removing with homomorphic filtering, colour balance with wallis filtering and seam lines elimination with median filtered template operation. Experiments proved the methods mentioned in this paper are useful and it has been used in DPGrid system (Digital Photogrammetry System Based on Grid Computation).

Figure 12. The seamline between mosaic orthophoto

Figure 14. Seam lines elimination result of figure 12

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