The Study on an Advanced Algorithm for Auto-generation of MOSAIC Seam Lines

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Abstract: In this paper an advanced algorithm for selecting a seam line automatically, which used to be selected by human operator for mosaicked images is presented. In addition to four factors proposed by automation theory, the FOM(Figure Of Merit) of tie point were taken into account to suggest the method to select a seam line applicatively and the algorithm was applied to mosaic test images..

Keywords: Mosaic, Seam lines.

1. Introduction

1) Scope and Purpose

Mosaicking is a series of processes of the combination of several image frames into an image mosaic covering a large area which maintains the continuity of features [1-2]. Mosaicking is essential to generate an spatial ortho-image covering large area from an spatial ortho-image frame [3-4].

In mosaicking, a seam line is mostly defined by human operator, which goes across the overlap area between tie points corresponding to the same point set of features in the two overlapping images. Performing image mosaicking commonly requires that a human operator identify pairs of tie points along the operator selected seam line, that is, pairs of points in the two images that represent the same feature. Automatic seam line selection algorithm is studying widely due to following problems.

Firstly, a seam line selection is always done by human operator, consumes lots of time and effort.

Secondly, a seam line can contain errors which are caused by human operator.

Thirdly, each human operator derives different seam line from other's, so that consistent results can not be provided.

This study suggests an advanced algorithm to select a seam line more practically through improving algorithm with which a seam line is defined manually.

2) Research Trends

The seam line selection using Dijkstra's shortest path algorithm is one of representative methods of automatic seam line selections [5]. To improve Dijkstra's algorithm which considers simply the distance, many researches include not only the distance between tie points but also more factors as follows [1].

1. Having short distances between adjacent points
2. Minimizing the distances of the points from the coarse seam line
3. Selecting tie points at areas of small geometric distortion
4. Selecting tie points with minimal variations of geometric distortion between adjacent pairs

Like above, researches to develop the algorithm of more practical selection of seam line are performed steadily [6]-[7].

2. Related Work

1) Automated Mosaicking Algorithm

Yehuda Afek and Ariel Brand proposed the algorithm in the paper of "Mosaicking of Orthorectified aerial Images" with which the problems which happen during mosaicking can be settled [1].

Firstly, it identified the overlapping region of the two input images, and sketched a rough line in whose neighborhood the final seam line would be located.

Secondly, the tie point selection phase extracted the tie points in the overlap area.

Thirdly, the seam line selecting phase performed the exact selection of the seam line.

Fourthly, the geometric correction phase performed the geometric correction. In the correction process, some area along the seam line was compensated by average seam line area.

Fifthly, the radiometric correction phase handled the radiometric corrections. The radiometric correction was the process of removing radiometric seam line which happened on average seam line.

Sixthly, the merge corrected images phase merged the image of the two unchanged regions of the input images and the two modified margin zones.

3. Suggested Algorithm

1) Summary of Algorithm

This paper suggests the method in which the figure of merit (FOM) of tie point as the fifth factor is taken into account. It is important in this algorithm how the FOM can be calculated. (1).

$$FOM = \frac{(correlation + direction)}{2} \times 100 \qquad (1)$$

The correlation and direction are considered to calculate FOM between tie point pair. That is, the arithmetic mean of the sum of correlation and direction is computed, then multiplied by 100, so that the FOM can score 1 to 100.

The procedure of obtaining the FOM is as follows.

Firstly, image patches of 8 points around tie point from original image and target image are taken.

Secondly, the mean μ and the standard deviation σ of two image patches are computed as below (2-3).

$$\mu_o = \frac{\sum_{i=1}^{9} O_i}{9}, \quad \sigma_o{}^2 = \frac{\sum_{i=1}^{9} O_i^2}{9} - [\frac{\sum_{i=1}^{9} O_i}{9}]^2 \qquad (2)$$

$$\mu_T = \frac{\sum_{i=1}^{9} T_i}{9}, \quad \sigma_T{}^2 = \frac{\sum_{i=1}^{9} T_i^2}{9} - [\frac{\sum_{i=1}^{9} T_i}{9}]^2 \qquad (3)$$

Thirdly, two image patches are normalized. That is the process of making the mean and the standard deviation of image patches into 0 and 1, respectively (4-5).

$$\forall_i = 1..9, \quad O_i = \frac{O_i - \mu_o}{\sigma_o} \qquad (4)$$

$$\forall_i = 1..9, \quad T_i = \frac{T_i - \mu_T}{\sigma_T} \qquad (5)$$

Fourthly, the correlation of image patches is calculated. The correlation of image patches (FOM_1) has the value 0 to 1 (6).

$$FOM_1 = \frac{\left| \sum_{i=1}^{9} O_i \bullet T_i \right|}{\sqrt{\sum_{i=1}^{9} O^2{}_i \bullet \sum_{i=1}^{9} T^2{}_i}} \qquad (6)$$

Fifthly, the direction of image patches is calculated. Also, The direction of image patches (FOM_2) has the value 0 to 1 (7-13).

$$X_O = (O_3 + 2O_6 + O_9) - (O_1 + 2O_4 + O_7) \qquad (7)$$

$$Y_O = (O_1 + 2O_2 + O_3) - (O_7 + 2O_8 + O_9) \qquad (8)$$

$$Angle_O = a\tan^2\left(\frac{Y_o}{X_o}\right) \qquad (9)$$

$$FOM_2 = \left| Angle_O - Angle_T \right| \qquad (10)$$

$$IF\ FOM_2 > \pi, \quad FOM_2 = 2\pi - FOM_2 \qquad (11)$$

$$FOM_2 = \frac{FOM_2}{\pi} \qquad (12)$$

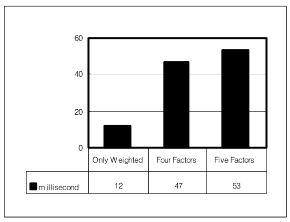
$$FOM_2 = 1 - FOM_2 \qquad (13)$$

Sixthly, the correlation FOM_1 and the direction FOM_2 are added to calculate the arithmetic mean. The arithmetic mean is multiplied by 100, so that FOM scores 1 to 100 (14).

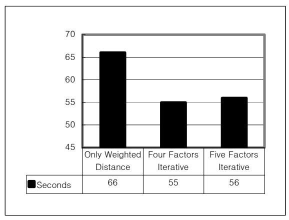
$$FOM = \frac{(FOM_1 + FOM_2)}{2} \times 100 \qquad (14)$$

4. Evaluation of Practicality

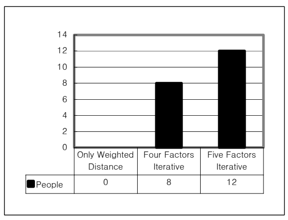
The practicality of an automatically selected seam line was evaluated according to the algorithm running time, the geometric correction speed and the mosaic result with regard to three cases of five factors iterative process proposed by this paper, four factors iterative process, and weighted distance process considering only weighted distance (Fig. 1.).



(a) Algorithm running time



(b) Geometric correction speed



(c)Preference of mosaicked images

Fig. 1. Result of evaluation

1) Evaluation of algorithm running time

Three algorithms were realized and the running times of each algorithm were estimated. Then the results were compared with each other.

「Weighted distance process」 selected the seam line by one iteration.

「Four factors iterative process」 and 「five factors iterative process」 selected the seam line by two iterations and three iterations, respectively (Fig. 1-a).

Also the paths of selected seam lines were different from each other. This meant that tie points selected by three algorithms were different from each other (Fig. 2.).

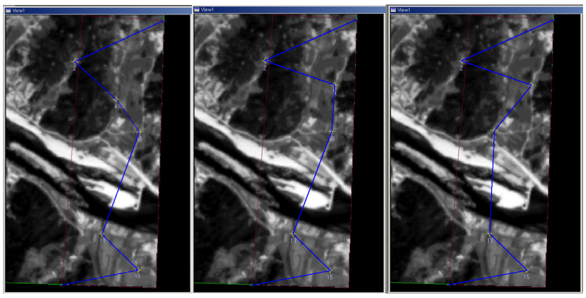


Fig. 2. Selected seam lines

2) Evaluation of geometric correction speed

The running times of geometric corrections were shorter, using seam lines selected through five factors iterative process, and four factors iterative process, which satisfied conditions for seam line selecting. The running time of geometric correction was longer, using seam line selected through weighted distance process without any condition (Fig. 1-b).

3) Evaluation of preference of mosaicked images

The user's preferences of mosaicked images were compared. (Fig. 1-c).

There was no user who evaluated the mosaicked image that was created by the weighted distance process excellently. Eight users preferred the mosaicked image that was created by the four factors iterative process. User who evaluate mosaicked image that was created by five factors iterative process was twelve.

According to examine above, there was only a little difference in algorithm running times and geometric correction speeds of the four factors iterative process and five factors iterative process. However, the mosaicked image using the seam line selected by the five factors iterative process was highly evaluated in the user's preference.

5. Conclusion

In this paper the FOM is taken into account as fifth factor to select the seam line practically. That is, in addition to four factors proposed by automation theory, the FOM(Figure Of Merit) of tie point were taken into account to suggest the method to select a seam line applicatively. This advanced algorithm is more efficient at higher spatial resolution image.

The practicality of an automatically selected seam line was evaluated according to the algorithm running time, the geometric correction speed and the mosaic result with regard to three cases of five factors iterative process proposed by this paper, four factors iterative process, and weighted distance process considering only weighted distance.

Flowing conclusions are induced from the evaluation:

1. The continuities of features are poor in the result image mosaicked using weighted distance process.
2. The advantage of this algorithm compared with four factors iterative process and weighted distance process is that a selected seam line is more practical. The Operator Satisfaction is higher in the image mosaicked using five factors iterative processing though there is little difference in the algorithm running time and the geometric correction speed of five factors iterative processing and four factors iterative processing.
3. The FOM of tie points is the significant factor for selecting a seam line.

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