LINE SEGMENTS MATCHING ALGORITHMl C0MBINING MSLD DESCRIPTION AND CORRESPONDING P0INTS CONSTRAINT

Xue Zhang[a], Jing Zhang[b]

[a,b]School of Geomatics, Liaoning Technical University,123000, Fuxin, Liaoning, China-670010240@qq.com

KEY WORDS: Mean-Standard Deviation Descriptor, Corresponding points, Pixel support region, Euclidean distance, Nearest Neighbor Distance Ratio

ABSTRACT:

Aiming at stability of line descriptor in the process of line segment matching, MSLD mean-standard deviation descriptor with corresponding points constraint method is proposed.The method is based on close-range images corresponding points matching and line extraction, in the beginning, determined the points which have the closest distance between the both sides of the target lines on the reference images, virtual line is composed by connecting corresponding points on the search image, and the line which intersects virtual line on the search image is defined as the candidate line segment. Then calculating the MSLD description of the straight lines and the candidate lines respectively, the specific construction steps are as followed: (1) gradient direction and normal direction of the straight line should be determined firstly; (2) for each pixel on the straight line, a rectangular area which is defined as Pixel Support Region (PSR) is established along the gradient direction and the normal direction, and the PSR is decomposed into several same size sub-regions in the normal direction; (3) recording each sub-region the gradient vectors of four directions to obtain a four-dimensional feature vector, and the gradient description matrix of straight line L is composed of all sub-regions feature vectors; (4) mean and standard deviation of the description matrix should be calculated by the row vector, then mean and standard deviation vectors should be normalized to obtain the normalized mean-standard deviation description. Finally, the similarity between the target lines and each candidate lines descriptor is calculated based on the Euclidean distance, using the nearest neighbor distance ratio to determine the corresponding line. Typical region image is selected to perform line matching experiment in this paper, results show that the proposed method has great stability and matching accuracy.

1.INTRODUCTION

[1]Line matching plays an important role in many applications, such as computer vision, object recognition, image registration and 3D reconstruction(Ok et al, 2012).compared with points, straight lines include more rich geometry informations, such as length, direction, gray, gradient, etc, specially in man-made environments,and they may be used where occlusions occur. However,line matching is more difficult than point matching because the end points of the extracted lines is not reliable. Besides that, there is not geometrical constraint, like the epipolar, for lines in two images.So existing line matching research focuses on two aspects: on the one hand is to find effective geometric constraints used to determine the matching candidates, the common constraint conditions include triangulation constraint(Wu, et al, 2015;Zhu,et al, 2005;Zhang,et al, 2013;Wu,et al,2012), corresponding points constraint(Fan, et al, 2010; Fan, et al, 2012), homography matrix constraint(Lu, 2010;Lou, et al, 2011), epipolar constraint(Yi, et al, 2008; Chen, et al, 2016; Schmid,et al, 2000) and so on. Those constraints make candidate lines of the search image limited into setting the range of conditions, reduces

global scope matching search time,improves the matching efficiency.Lou et al.(2011) used homography matrix constraint and neighborhood window gray similarity to determine corresponding lines;Liang et al(2014) used corresponding points constraint and neighborhood window gray similarity to determine corresponding lines.However, those methods more focus on geometric constraints and neighborhood gray window information,this directly uses image gray level information similarity method can not obtain reliable matching results for perspective changes larger or texture complexity of the images.On the other hand is the construction of a linear descriptor,linear descriptors become research hot in recent years. Similar to SIFT (Lowe, et al, 2004) used gradient information of points in the linear neighborhood build line descriptor. Wang et al (2009) proposed four Means-standard descriptors which is highly distinctive for line matching under translation, rotation, illumination under the condition of without any geometric constraints: Gray Feature Mean-Standard Deviation Descriptor (FMSD), Magnitude Mean-Standard Deviation Descriptor (MMSD), Gradient Mean-Standard Deviation Descriptor (GMSD), Mean-Standard deviation line Descriptor (MSLD), this method can obtain the better linear matching results for different image types, but it takes long time for the big photographic angle of complex texture images because of no-constraints.

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[11] Corresponding author: Xue Zhang
E-Mail: 670010240@qq.com

So, in this paper, we propose line segments matching algorithm of MSLD description based on the corresponding point constraint. Using linear neighborhood corresponding point to determine matching candidates on the basis on corresponding reliable points, and then building MSLD descriptor on the center of goal lines and candidate lines respectively, achieves great straight line matching results.

2.EXPERIMENTAL PRINCIPLE

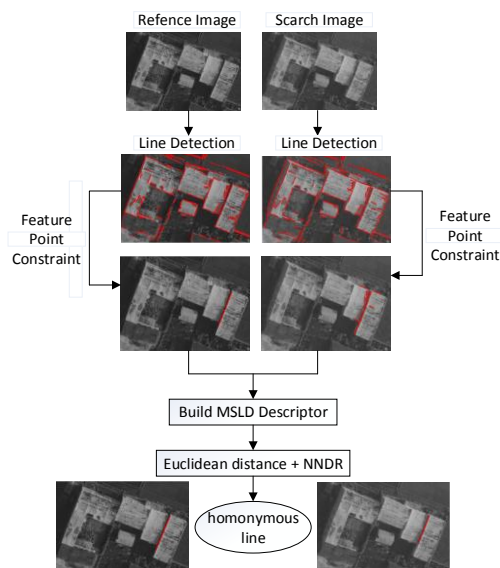MSLD in the paper line matching process as shown in figure 1:

Fig.1 line matching flow chart

1) First of all, the two images are matched by using SIFT operator, and RANSAC algorithm eliminates error matching the results to obtain initial reliable corresponding points, extracts reference and search image lines by LSD algorithm at the same time;

2) corresponding points which the closest distance on both sides of the goal lines to determine the matching candidates, shrink candidate lines search scope;

3) Establishing MSLD descriptor on the goal line and each candidate straight respectively. First, determined gradient direction and normal direction of the straight lines; second, for each pixel on the line segment, its pixel support region (PSR) is defined and then the PSR is divided into non-overlapped sub-regions; Third, Line gradient description matrix (GDM) is formed by characterizing each sub-region into a vector; the last, MSLD is built by computing the mean and standard deviation of GDM column vectors. To calculate Euclidean distances between target lines and all candidate line descriptors respectively, and then using nearest neighbor distance ratio(NNDR) determine corresponding lines.

3.LINE MATCHING

3.1 corresponding points constraint

As shown in figure 2,the points i、 j、 k、 u、 v and i_1、 j_1、 k_1、 u_1、 v_1 are corresponding points of reference and search image respectively. Assuming that a goal line L in the search image, as shown in figure 2(a),finding corresponding points u、 v which have the closest vertical distance on both sides of L.   Connecting the corresponding points u_1、 v_1 in the reference image, as shown dotted line in figure 2(b), line segments which are intersected with dotted line in the reference image, so line segments L_1、 L_2、 L_3 are candidate lines lists as it shown in figure 2(b).

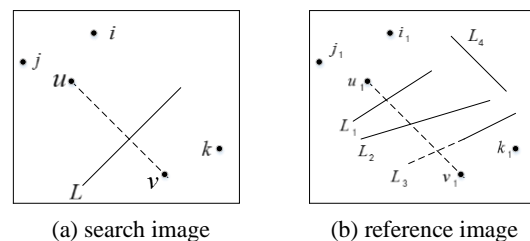(a) search image   (b) reference image

Fig.2 corresponding points constraint

3.2 MSLD descriptor

Given a line segment L according to chapter 3.1, firstly two directions are introduced: the average gradient direction $d_\perp$ of pixels on the line and its anticlockwise orthogonal direction d_L .For each pixel on the line L, a rectangular region centered at it and aligned with the directions $d_\perp , d_L$ is defined as the PSR. The PSRs of the pixels on the line along the direction d_L are denoted as, G_1、 G_2、 …、 G_N assuming L consists of N pixels. In order to give a more distinctive description for the PSR, each PSR is divided into M non-overlapped sub-regions with the same size along the direction $d_\perp$: $G_i = G_{i1} \cup G_{i2} \cup ...... \cup G_{iM}$, $i \in [1,n]$ .As shown in figure 3, each of the PSR is divided into three sub-regions, $M = 3$.
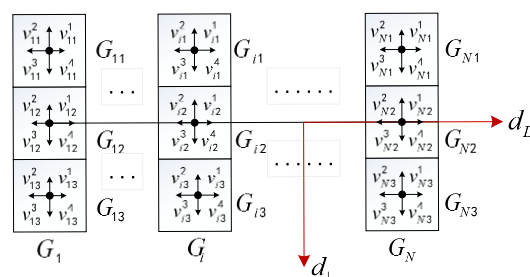

Fig.3 MSLD construction

Counting each sub-region gradient vector of four direction: $0°$ 、 $90°$ 、 $180°$ 、 $270°$, get a 4D description vector:

$$V_{ij} = (V_{ij}^1, V_{ij}^2, V_{ij}^3, V_{ij}^4)^T \in R^4 \qquad (1)$$

By stacking the description vectors of all the sub-regions associated with a line segment, a 4M × N matrix called line gradient description matrix(GDM) is formed as:

$$GDM(L) = \begin{pmatrix} V_{11} & V_{21} & ... & V_{N1} \\ V_{12} & V_{22} & ... & V_{N2} \\ ... & ... & ... & ... \\ V_{1M} & V_{2M} & ... & V_{NM} \end{pmatrix} \overset{\Delta}{=} (V_1, V_2, L , V_N) \quad (2)$$

First, to make the descriptor independent of the line length, we compute the mean vector and the standard deviation vector of GDM column vectors:

$$M(GDM(L)) = Mean\{V_1, V_2, ..., V_N\} \in R^{4M} \qquad (3)$$

$$S(GDM(L)) = Std\{V_1, V_2, ..., V_N\} \in R^{4M} \qquad (4)$$

Second, in order to make the descriptor invariant to linear changes of illumination, the mean vector and the standard deviation vector are normalized to unit norm, respectively. Then, by concatenating the normalized mean vector with the normalized standard deviation vector into a single vector, we obtain a line description vector with a dimension of 8M:

$$MSLD(L) = \begin{pmatrix} \dfrac{M(GDM(L))}{\| M(GDM(L)) \|} \\ \dfrac{S(GDM(L))}{\| S(GDM(L)) \|} \end{pmatrix} \in R^{8M} \qquad (5)$$

3.3 MATCHING STRATEGY

Euclidean distance as the matching measures in this paper, if the ratio of minimum and second minimum Euclidean distance NNDR less than the given threshold, candidate line which has the minimum Euclidean distance with goal line as corresponding

4. EXPERIMENT

In the experiments, we conducted two sets of experiments.1) MSLD description matching method in this paper.2) Gray similarity matching method on the condition with the same constraints. As shown in figure 4, we conducted three groups of close-range images to evaluate the stability and effectiveness of the MSLD description method. Two matching algorithm for line matching results are shown in table 1. Artificial visual interpretation method judged line matching results are correct or not, Table of MN (Matching Number) means total number of line matching, CM (Correct Matching) means the correct number, CR(Correct Ratio) means correct matching rate.
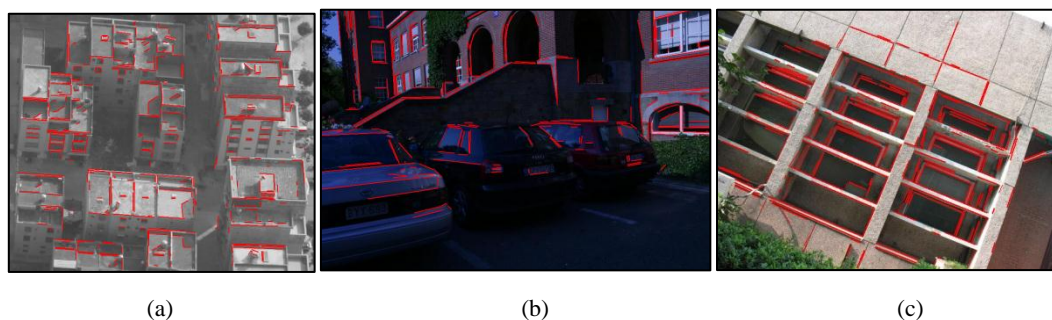
| (a) | (b) | (c) |

Fig.4 (a) Building area aerial close-range images and line matching results.(b) Different light close-range images and line matching results.(c) Rotating angle about 30° close-range images and line matching results.

Tab.1 Line matching result by different method

images	images size	line detection number	descriptor	MN	CM	CR
(a)	1084*918 963*860	(1222 / 1447)	gray correlation	403	391	97.0%
			no-constraint MSLD	456	409	89.6%
			MSLD+constraint	**430**	**426**	**99.1%**
(b)	900*600 900*600	(689 /884)	gray correlation	287	271	94.4%
			no-constraint MSLD	389	311	79.9%
			MSLD+constraint	**318**	**318**	**100%**
(c)	640*480 640*480	(488 / 518)	gray correlation	256	227	88.6%
			no-constraint MSLD	356	274	76.9%
			MSLD+constraint	**274**	**273**	**99.6%**

The building images are shown in figure 4(a),the number of line detection in search and reference images are 1222、1447 respectively; the number of line matching by using the above three methods are 403、456、430 and correct matching rate are 97.0%、89.6%、99.1% respectively.

The images with same building of different light are shown in figure 4(b),the number of line detection in search and reference images are 689、884 respectively; the number of line matching by the above three methods are 287、389 and 318 respectively. The number of correlation lines of proposed method more than the former and has no error matching, its correct matching rate has been achieved 100%.

The rotation images are shown in figure 4(c),the number of line detection in search and reference images are 488、518 respectively; the number of line matching by using the above three methods are 256、356 and 274, correct matching rate are 88.6% 、 76.9% 、 99.6% respectively. Through the above experiment results show that the MSLD descriptor in this paper is more reliability than gray correlation algorithm.

According to table 1, under the condition of same number line detection in the search and reference images, compared to the method of gray correlation matching, we proposed line segments matching of MSLD description based on the corresponding point constraint can get more corresponding lines、less error and high accuracy; under the condition of same matching strategy with MSLD, although no-constraint MSLD have more corresponding lines error, there are more error lines.

This method has low accuracy and spends a lot of time because of nothing constraints. To sum up, the method in this paper is reliable and effective.

5.CONCLUSIONS

MSLD description in this paper is based on each pixel on the lines built pixel domain support and divided into several sub-regions, it is stability by defining level and vertical direction for each sub-region; different from traditional gray correlation, MSLD characterizing each sub-region into a vector formed gradient description matrix, computing the mean and standard deviation of matrix column vectors to make description dimension has no impact on line length and light;Using NNDR matching strategy determine corresponding lines.The experiment proved that the method has great stability and robustness.

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