A fast detection method for changed land using UAV remote sensing image

Hongfei Huang[1], Xiaoguo Zhang[2,a], Jiadong Lv[1] and Meijiao Xu[2]

[1]School of Mechanical Engineering, Southeast University, Nanjing, China
[2]School of Instrument Science and Engineering, Southeast University, Nanjing, China

Abstract. This paper proposes a fast detection method for changed land using UAV remote sensing image. Firstly, a series of SURF feature points on the old time phase orthoimage are retrieved and stored into a matching database. Secondly, through the establishment of coarse - fine double matching recursive model to quickly match the new and old time phase images, Whether the change of land use is preliminarily determined by the matching of feature points. Finally, it can be accurately determined whether the suspicious land is appeared through comparative analysis which based on the spectrum and texture of the dual mode comprehensive contrast detection method .Compared to the traditional technology, this method does not need to lay a large number of ground control points, and does not need to splice the UAV images, but can realize the rapid automatic discovery of suspicious objects, which is not only high precision but also saves time and effort.

Keywords: UAV remote sensing image; SURF algorithm; recursive matching; change detection.

1 Introduction

Since ancient times, land is a precious natural resource for human survival and development. The sustainable use of land is the cornerstone of the sustainable development of human society. Our country is in the crucial moment of urbanization and social transformation, the land under great pressure, increasingly tense relationship between man and land, there are also many outstanding issues between villages and towns in the new construction land use, such as occupation, random approval, serious abuse of land, which directly restricts the sustainable development of the economy of our country. Therefore, the party and the state attach great importance to them and take a series of measures, the strengthening of land management, clearly put forward the strengthen supervision of land, the establishment of land survey system and national land statistical system, the establishment of the national land management information system, the dynamic monitoring[1] of the condition of the land.

The current land monitoring method in China can be simply concluded as “Observing in Space”, “Surveying on the Earth” and “Managing Online”. “Observing in Space” means land monitoring by satellite remote sensing [2], which covers a large range of areas. However, it can’t get the real-time satellite images of regions under detected with the restriction of satellite access periods. In cloudy

[a] Corresponding author : zxg519@sina.com

areas or the weather condition is poor, it is hard to obtain satellite images that are clear enough. In addition, the process of fetching and handling satellite images costs too much. So it is not satisfactory to use satellite remote sensing. “Surveying on the Earth” means land monitoring by Land patrol car and artificial patrol, whose agility and flexibility have be increased compared with satellite remote sensing. However, it is restricted by basic road construction. In most cases the land monitoring can not be completed without suitable roads, such as mountains, hills, etc. And the present road condition and service condition must be taken into account. The land monitoring has a lot of restrictions and the real-time performance is difficult to achieve. The method of “Managing Online” not only costs a lot of manpower and material resources, its accuracy may be not enough. Its period from reporting to the on-the-spot investigation, validation, and then the data update is too long to get enough real-time performance.

Generally speaking the present splicing detection technology of UAV remote sensing images[3] can be used in land and resources administration with three processes, “flight in the air”, “monitor on the earth” and “indoor mapping” , each of them are indispensable. “Monitor on the earth” needs large quantity of professionals to investigate on-the-spot using professional test device. In the areas such as mountains, rivers, forests, which ground features are not obvious, personnel cannot reach or accurate positioning. Thus it is difficult or impossible to fetch ground control points[4],with time and energy waste and little effect.

2 Overall technological process

The fast detection method for changed land [5-9] using UAV remote sensing image mainly include three modules: the retrieval and organization of large-scale old time phase image feature points, recursive matching model of UAV image and old phase orthoimage [10],changed land detection algorithm, so as to quickly and accurately determine whether there is a suspicious land .

In the first module, the retrieval and organization of large-scale old time phase image feature points, which make a retrieval of SURF feature points on the old time phase orthoimage and store the feature points with an easy matching pattern into a matching database. This moudle can provide a strong basis for fast matching of the subsequent use of real-time shooting from UAV image and old time phase orthoimage, so as to ensure the smooth implementation of the monitoring of land use of land law enforcement.

In the second module, through the establishment of coarse - fine double matching recursive model to quickly match the new and old time phase images. It is divided into two steps: firstly, quickly matching the geographic coordinate information provided by POS system with the geographic coordinate information of old time phase image to form a small range of comparison domain, which is coarse matching. Secondly, A series of feature points based on feature retrieved in the comparison region to quickly match the feature points in the historical big matching database , which is fine matching, so as to to ensure the rapid and real time of land law enforcement.

In the third module, a reasonable change detection algorithm and a suitable evaluation system should be designed when the new and old time phase images’ matching accuracy is not high. First by pre judgment, and then using a dual mode comprehensive comparison test and comprehensive utilization of spectrum and texture information, which can effectively reduce the risk of a single information, so as to greatly improve the accuracy of detection.

The general flow chart of technology is shown in Figure 1:

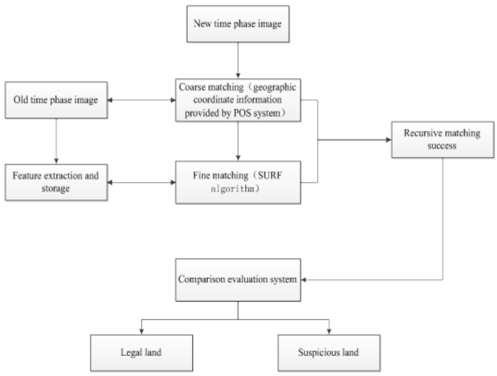

Figure 1. Technical general flow chart.

Figure 2. Large old time phase orthoimage .

3 Retrieval and organization of large-scale old time phase image's feature points

The method described in this paper can make a retrieval of feature points on the old time phase orthoimage (Old time phase orthoimage is archived in the Land Bureau's survey area map, satellite images, UAV images and so on.) and store the feature points into a matching database.

When UAV is shooting the area image, due to the impact of the external environment and the stability of UAV, the taken image may exist translation, rotation, scale transformation and other conditions. Therefore, it is required to detect the feature points with good robustness. SURF feature points[11],compared with Harris operator[12] and SUSAN operator[13], the translation, rotation, scale transformation and occlusion have better adaptability, so the SURF operator is used to detect the feature points in this paper. As shown in Figure 3, each feature point is represented as 128 dimensional vector with its own geographic coordinate information, which is stored by the K-D tree [14] for easy search. All those feature points are stored with an easy matching pattern into a matching database.

Figure 3. SURF feature point detection .

Figure 4. POS location map.

4 Establishment of coarse - fine double matching recursive model

The UAV images of aerial shoot used by UAV to get the all kind geography information. Because the phase amplitude of UAV image is small, and the old time phase orthoimage matched with UAV image is very large. In order to improve the analysis speed, at first, for each UAV image, quickly matching the geographic coordinate information provided by POS system with the geographic coordinate information of old time phase image to form a small range of comparison domain. In details: At first, it can find the longitude and latitude coordinates of the two points on one diagonal of the UAV image by using the geographic coordinate information provided by the UAV POS system [15], and calculate the distance D of these two points. Then a circle can be drew on the old time phase orthoimage with the geometric center of the UAV image as the center of the circle and the length of D/2 as the radius. At the same time on this circle to find another diagonal on the farthest two points and make the four points in the same circle to form a rectangular frame area corresponding to the UAV image which is the search matching domain(As shown in Figure 4).

After a series of feature points are retrieved for UAV image, and than matching exactly with the old time phase orthoimage's feature points in the matching database to complete the fine match. If the matching accuracy is greater than the threshold value A (The threshold value A generally takes 99% .), then it can determine that the UAV image corresponding to the area of the mainland has not changed, whereas the change detection algorithm will be used to further determine whether exist the suspicious land .

5 Change detection algorithm

When the fine matching accuracy of the UAV image and the old time phase orthoimage is less than the threshold A, it can make the comparative analysis which based on the spectrum and texture of the dual mode comprehensive contrast detection method. Taking the local new and old time phase images (As shown in Figure 5 and Figure 6) as an example, specific steps are as followings:

Figure 5. Local old time phase image.

Figure 6. Local new time phase image.

Step1. During the search matching domain of the old time phase orthoimage, the UAV image and the old time phase image at the same position are divided to some of the same size rectangular sub blocks(As shown in Figure 7) according to their own coordinate informations.

Figure 7. Rectangular sub blocks.

Step2. Each corresponding sub blocks of the new and old time phase images are conducted as the pre judgment. Gray Histogram can only reflect the frequency of each gray level in the image, and

Gray Level Co-occurrence Matr can also reflect the spatial correlation characteristics of gray level in the image. Therefore, Gray Histogram and Gray Level Co-occurrence Matr of the UAV image’s sub block and the old time phase iamge’s sub block are respectively extracted to calculate and get their similarity data of Gray Histogram R_a and similarity data of Gray Level Co-occurrence Matr R_b, and then the total gray similarity of the sub block is obtained by the weighted ratio calculated.

$$R_{ab}= \alpha_a R_a+\beta_b R_b \tag{1}$$

As shown in (1) formula, R_{ab} represent total gray similarity of two rectangular sub blocks, α_a and β_b respectively representative weighted proportion. When compare new and old time phase images, because the spatial correlation characteristics of the frequency of gray scale appear to have little influence on the spatial correlation characteristics, so α_a generally takes 0.3and β_b generally takes 0.7.

Step3. For each corresponding sub blocks of the new and old time phase images, if any total similarity of two rectangular sub blocks is greater than or equal to the threshold value B (The threshold value B generally takes from 0.95 to 1 .),then it can determine that the UAV image corresponding to the area of the region without suspicious land. Otherwise, the sub blocks which the total similarity is less than the threshold B will be respectively conducted the spectral and texture analysis. And specific steps are as followings:

A)The UAV image’s sub block and the corresponding old time phase image’s sub block are respectively conducted spectral variation method to get the spectral change rate R_s according to their sub blocks’ spectral features.

*B)*Appropriate texture features of the UAV image’s sub block and the corresponding old time phase image’s sub block are selected to get changed texture features of each wave band by subtracting band by band. Then it can count the number of texture- changed region’s pixels P_i and the total number of pixels P_j in the region. At last, texture change rate R_t can be calculated according to (2) formula.

$$R_t= P_i/P_j \tag{2}$$

C)The total change rate of the sub blocks is obtained by weighting the spectral change rate Rs and the texture change ratio Rt according to (3) formula. The sub block will be de determined the changed sub block if the total change rate is greater than the threshold value C(The threshold value C generally takes from 0.05 to 0.15.).

$$R_{st}= \alpha s Rs+\beta t R_t \tag{3}$$

As shown in (3) formula, R_{st} represent total variation rate of two rectangular sub blocks, α_s and β_t respectively representative weighted proportion. Because the spatial resolution of the UAV image is high, the structure and texture information of the object is rich, but the band is less, and the spectral resolution is relatively low. When compare new and old time phase images, spectral features have little influence on the texture features, so α_s generally takes 0.2 and β_t generally takes 0.8.

Step4. If there is a changed sub block, the corresponding area of the UAV image can be determined suspicious land.

The overall flow chart of change detection algorithm is shown in Figure 8:

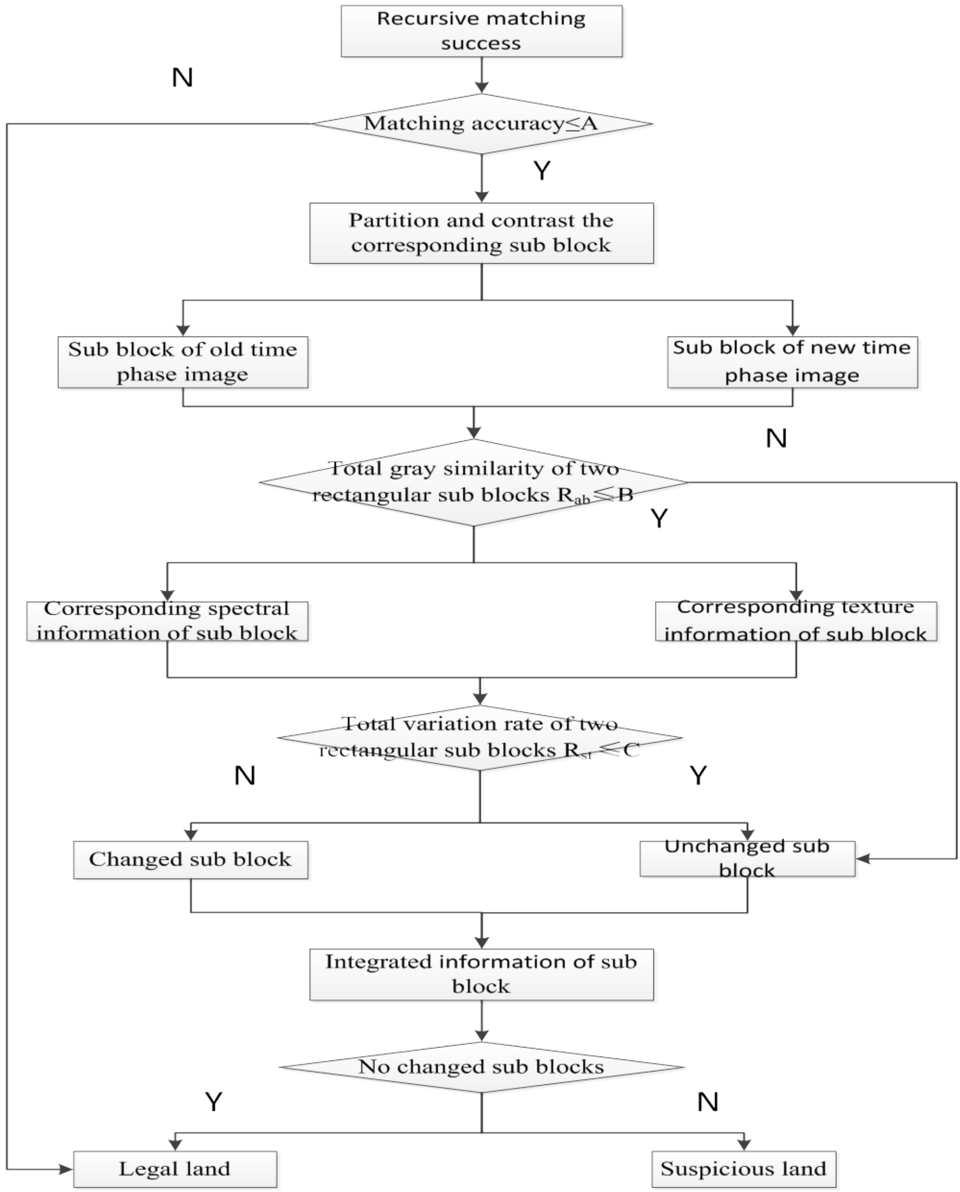

Figure 8. Change detection algorithm flow chart.

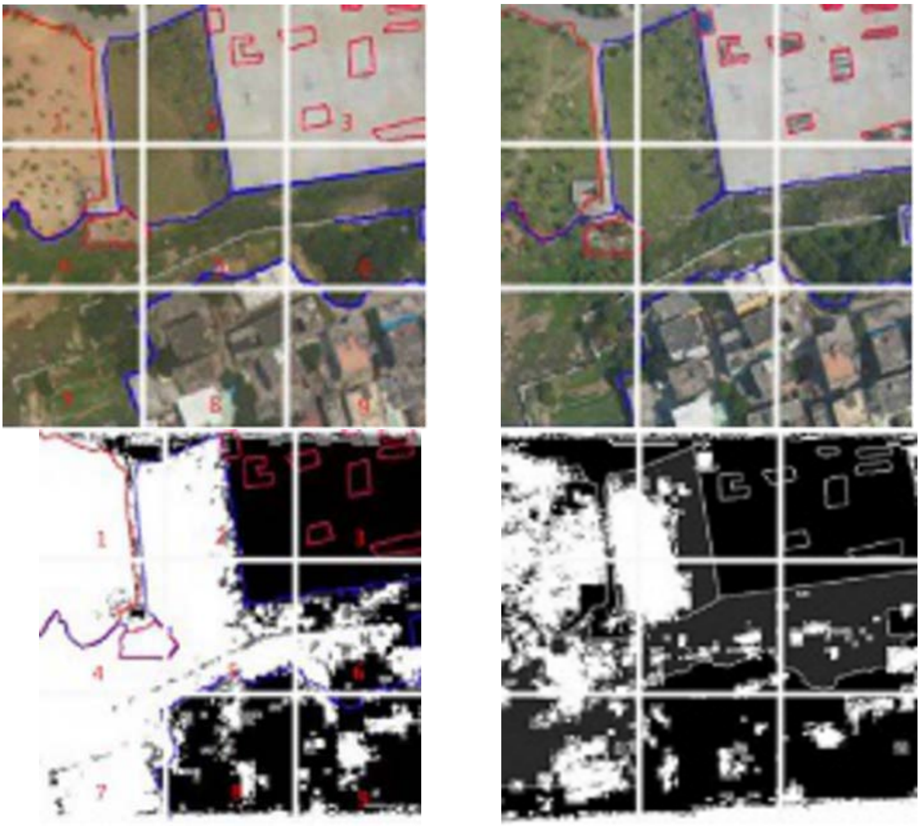

Figure 9. Changes in each sub block.

Table 1. Change rate data of each rectangle sub block.

NO.	1	2	3	4	5	6	7	8	9
R_S	0.561	0.093	0.192	0.377	0.021	0.073	0.035	0.073	0.109
R_T	0.193	0.205	0.471	0.298	0.072	0.094	0.082	0.091	0.127
R_{ST}	0.266	0.183	0.415	0.314	0.062	0.089	0.073	0.087	0.123

It can be drawn from the table 1 that No.1-No.4 sub blocks are changed sub blocks because their R_{ST} is greater than the threshold value C. Therefore, the corresponding area of the UAV image can be firmly determined suspicious land.

6 Conclusion

In the traditional UAV remote sensing image of land change detection process, it is required to complete the image stitching, and then to compare the new and old time phase images of the contrast detection, with time and energy waste and little effect. This paper proposes a fast detection method for changed land using UAV remote sensing image on the basis of previous studies. This method does not need to lay a large number of ground control points, and does not need to splice the UAV images, but can realize the rapid automatic discovery of suspicious objects, which is not only high precision but also saves time and effort, so as to to ensure the rapid and real time of land law enforcement. It also provides guarantee for land and resources management and monitoring with great theoretical significance and important engineering application values.

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