

The Preprocessing Method of Control Points in Geometric Correction for UAV Remote Sensing Image

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Abstract. This paper focuses on the preprocessing method of control points in geometric correction for UAV (Unmanned Aerial Vehicle) remote sensing image. Control points preprocessing refers to find out the calibration points from the selected control points, so as to use the calibration points to fit the geometric correction function. Because in traditional K-means algorithm, clustering results have a strong dependence on initial clustering centers, so selecting initial clustering centers randomly will lead to the clustering results instability when preprocessing control points with traditional K-means algorithm, and it will influence the effect of the UAV remote sensing image geometric correction. Therefore, the paper imports the thought of Huffman tree to traditional K-means algorithm, aiming at optimizing the selection of initial clustering centers and improving the effect of UAV remote sensing image geometric correction ultimately.

1. Introduction

UAV has the advantage of flexibility, high efficiency, low cost, and it can shoot high-resolution low altitude remote sensing images, because of these, UAV is widely used in various fields, such as mapping, land resources survey, environmental monitoring and disaster monitoring, etc [1]. However, due to the small volume, weak wind resistance and poor stability of UAV, the images will be distorted during shot by UAV, so the geometric correction is needed for distorted UAV remote sensing image.

In the process of UAV remote sensing image geometric correction, control points which are used for the geometric correction must be selected at first, then based on the selected control points, the geometric correction model for the remote sensing image can be established to complete remote sensing image geometric correction. However, it is wrong that the more control points used, the higher accuracy will be got in the remote sensing image geometric correction. Conversely, the appropriate numbers and uniform distribution of the control points can help to improve the geometric correction accuracy of remote sensing. In order to make the control points of UAV remote sensing image geometric correction distribute uniformly, they should be preprocessed in advance. Control points preprocessing means that finding out the calibration points from the selected control points to fit the function of UAV remote sensing image geometric correction.

Traditional K-means clustering algorithm is the typical algorithm which is used to preprocess control points of UAV remote sensing image geometric correction. The general process of using traditional K-means clustering algorithm to preprocess control points of UAV remote sensing image geometric correction is described as follows: at first, setting the number of the calibration points which will be used to fit the function of geometric correction as the clustering number, then selecting the initial clustering centers randomly and getting the final clustering centers by repeat iteration, after that, selecting the control points which are the nearest with the final clustering centers as calibration points, and the algorithm ends.

However, determining the final clustering centers is largely dependent on the selection of initial clustering centers, selecting the initial clustering centers randomly will lead to the final clustering result instability, and then influence the effect of UAV remote sensing image geometric correction. Aiming at this problem, many scholars have conducted in depth researches. In the literature [2], it adopts density function to obtain a plurality clustering center of a sample data space, and it is also

combined with small class merge operation in order to avoid falling into local minimum. In the literature [3], it uses distance cost function to test the validity of the clustering, and when the distance cost function reaches the minimum, the spatial clustering result is optimal. In the literature [4], it proposes a method which is based on density estimation to select the initial clustering centers, and through iteration to find out k data as initial clustering centers.

The paper imports the thought of Huffman tree to traditional K-means algorithm, aiming at optimizing the selection of initial clustering centers. Through this method, the stability of the clustering results will be ensured, and the effect of UAV remote sensing image geometric correction is also improved.

2. K-means clustering algorithm for preprocessing control points of UAV remote sensing image geometric correction

K-means algorithm is usually adopted to preprocess control points when doing geometric correction for UAV remote sensing image. Through clustering control points, the control points which are nearest with the clustering centers can be selected out as calibration points, and with the calibration points, the function of geometric correction will be fitted; then the rest of control points are used as check points to calculate fitting correction error which is used to assess the effect of geometric correction, aiming at comparing the effects of different geometric correction models for UAV remote sensing image, and through comparing the effects, the best model for UAV remote sensing image geometric correction will be found out. By preprocessing the control points, not only the uniform distribution of the selected calibration points is ensured, but also in the geometric correction model, we need only input the selected calibration points to fit the geometric correction function so as to shorten the time of UAV remote sensing image geometric correction and improve the efficiency of geometric correction.

The general principle of K-means algorithm is that: at first, select k numbers of data from the preprocessed data randomly as the initial clustering centers, then calculate the distance between every data and each initial clustering center, classify the data to the class in which the nearest clustering centers is located. After that, calculate the average of each newly formed subclass, and select the average as the new clustering centers so that a new clustering can be conducted. Then compare new clustering centers and clustering centers on time, if the two cluster centers are same, the clustering ends, otherwise, the reclustering for the data is needed.

According to the general principles of K-means algorithm above, we should require the number of calibration points which are used in correction model as the number of clustering, and take the number of iterations as the clustering ending condition, then the specific algorithm flow is described as follows:

Step1: Input the n selected control points of UAV remote sensing image geometric correction, the clustering number k and the iterations number T ;

Step2: Select k control points from the n control points as the initial clustering centers ($k \leq n$);

Step3: Calculate the distance between every control point and each clustering center, and then classify the control points to the classes according to the minimum distance;

Step4: In every newly formed subclass, recalculate the center of the control points, and take it as a new clustering center of the subclass;

Step5: Determine whether the number of iterations is T or not, and if so, go to Step6, if not, go to Step3 and go on;

Step6: Find out the control points which are the nearest from the final clustering centers, then output them and take them as the calibration points of UAV remote sensing image geometric correction. At this time, the algorithm ends.

In summary, the flow chart about using K-means algorithm to preprocess the control points of UAV remote sensing image geometric correction can be drawn, and it is shown in Fig.1:

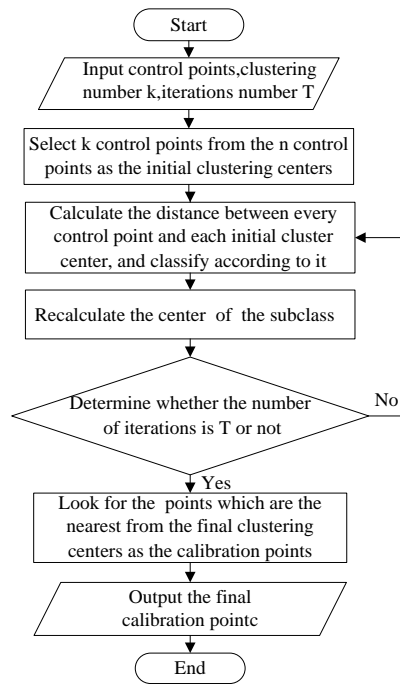


Fig.1 The flow chart about preprocessing control points with K-means algorithm

In this paper, the UAV remote sensing image used in the experiments is shot by UAV of the author' institution, and the location is located in Tianjin. Fig.2 is the UAV remote sensing image which needs geometric correction and the distribution of selected 60 control points, and (a) is the distribution of the control points in the image, (b) is the distribution of the control points in the coordinate map. Do the experiment three times in a row about preprocessing the selected control points with K-means algorithm described above, and set the parameters $k = 14$, $T = 30$, then the results of the experiments are shown in Fig.3, and(a)(b)(c) are respectively the results of three experiments about calibration points distribution.

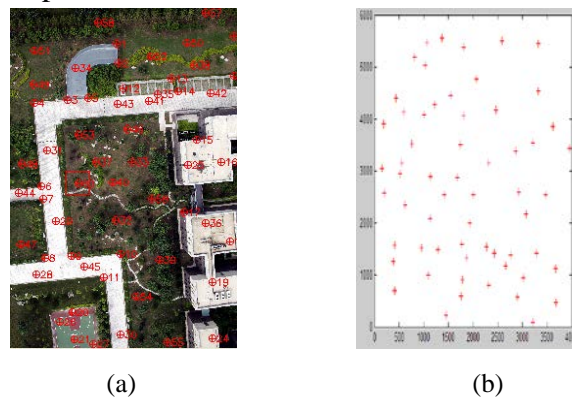


Fig.2 The control points distribution of the UAV remote sensing image

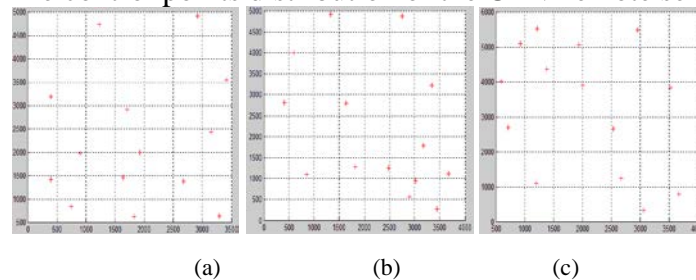


Fig.3 The results of the experiments

Fig.3shows that when preprocessing control points of UAV remote sensing image geometric correction with traditional K-means algorithm, the result obtained is unstable. It has a great influence on fitting the function of UAV remote sensing image geometric correction in the

subsequent, and also affects the effect of UAV remote sensing image geometric correction. The following will conduct a research on the issue and give solutions.

3. Optimize the selection of the initial clustering centers for K-means algorithm

As shown in Fig.1, when preprocessing control points in UAV remote sensing image geometric correction with traditional K-means algorithm, the selected k initial clustering centers have a great impact on clustering results, and the reason of this is that the selected k points as the initial clustering centers is random in the step 2 of the algorithm. When randomly selected initial clustering centers, there are two influences on the clustering results as follows:

① Randomly selecting the initial clustering centers easily lead the clustering results to fail into local optimum;

② K-means algorithm has severe dependence on the initial clustering centers, randomly selecting the initial clustering centers easily lead to the clustering results instability.

Therefore, in order to maximally eliminate the influence of these two aspects, the paper introduces the thought of Huffman trees to optimize the selection of the K-means algorithm's initial clustering centers, so as to not only improve K-means algorithm, but also ensure the accuracy and stability of the selected calibration points which will be used for UAV remote sensing image geometric correction.

Based on the construct method of Huffman trees, construct the set S_n with n control points, select two control points whose distance is minimum from S_n and calculate the midpoint coordinates of these two points, then remove the two points from S_n and add the midpoint into it, so a new set S_{n-1} is gotten. Do the same process to the data in set S_{n-1} until the number of data in set S_k reduces to k , the k control points is the selected initial clustering centers[5].

The specific algorithm process of selecting initial clustering centers is as follows:

Step1: Input the set S which consists of n control points of UAV remote sensing image geometric correction and clustering number $k(k \leq n)$;

Step2: Calculate the Euclidean distance between any two points in S and constitute the distance matrix H ;

Step3: Find out the minimum distance from the matrix H , and determine which two points (p_1 and p_2) correspond to the minimum distance;

Step4: Calculate the midpoint p_{mid} of p_1 and p_2 ;

Step5: Add the point p_{mid} into the set S , and remove p_1 and p_2 from S , so as to update S ;

Step6: If the number of control points in set S is less than or equal to k , the algorithm simply ends; otherwise, turn to Step2 and go on.

It can obtain the better initial clustering centers by the algorithm above. After that, use K-means algorithm to preprocess the control points, the selected calibration points will be stable and uniformly distributed and thus improve the effect of UAV remote sensing image geometric correction.

Similarly, take an example of Fig.2, preprocess the control points of UAV remote sensing image geometric correction, the result is shown as Fig.4.

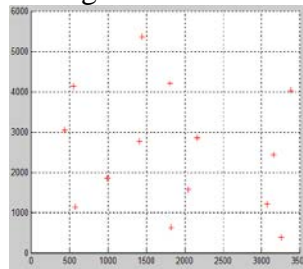


Fig.4 The results of the improved K-means algorithm

The result of the experiment shows that adopting the K-means algorithm which the initial clustering centers are optimized to cluster data, the clustering results obtain stable and avoid failing into local optimum, thus the purpose of the paper is achieve.

To further validate the improved K-means algorithm is effective for preprocessing the control points, the experiment about doing geometric correction for the UAV remote sensing image shown in Fig.2 has been done in the paper, and in the experiment, use the improved K-means algorithm to select 30 calibration points from 60 control points, then use the general quadratic polynomial to do geometric correction and use bilinear to do re-sample, the result is shown in Fig.5, and (a) is the uncorrected UAV remote sensing image, (b) is the corrected UAV remote sensing image. As can be seen from Fig.5, it achieves a good result in UAV remote sensing image geometric correction, and further illustrates that the improved K-means algorithm is effective on preprocessing the control points of UAV remote sensing image geometric correction.

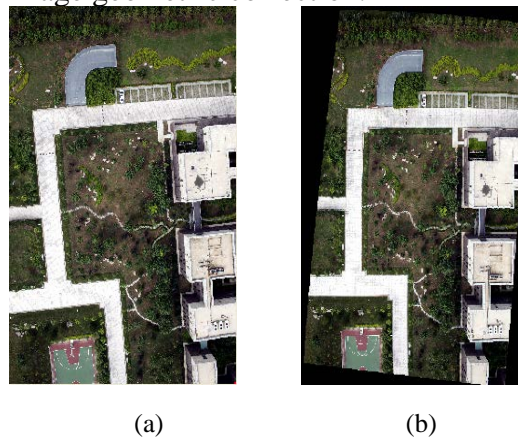


Fig.5 The comparison between uncorrected and corrected UAV remote sensing image

4. Summary

In this paper, it has optimized the selection of initial clustering centers for K-means algorithm by reference on the construct method of Huffman trees, and the experiments show that the optimization result is stable and avoids falling into local optimum, thus the calibration points of good quality and uniform distribution can be found out, it also lay a good foundation for UAV remote sensing image geometric correction at the same time. The work in the paper is preprocessing the control points of UAV remote sensing image, based on the result of the paper, the geometric correction for UAV remote sensing image will be done next.

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