Building Contour Detection Based on Straightness Level Set

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Abstract. Traditional level set algorithm is not automated enough to extract buildings in UAV remote sensing images. This paper proposes an improved level set algorithm to solve this problem. Firstly, it combined the traditional level set and chain code, then it introduced the parameters of straightness. Finally, it could automatically detect whether the segmentation curve is a building by calculating the straightness. The experimental results show that the straightness of building contour calculation can reach more than 95%, which meets the requirement of straightness judgment, and the value of non-building straightness is relatively low. The algorithm is more automated than the traditional level set, and can automatically eliminate the segmentation curve of the UAV remote sensing image that does not belong to the building.

Introduction

In recent years, China’s urbanization has been progressing continuously, and the building area has been growing. Therefore, the specific status of land use has attracted more and more attention. How to accurately and quickly extract building information in cities has become one of the foundations for dynamic monitoring of land. However, traditional land surveys and statistics are quite complicated, which is time consuming and labor intensive, and relies on artificial digitization to extract building area. It is time-consuming and laborious, and has certain requirements for the relevant professional knowledge of the operators. So how to automatically extract the building area is very important.

The UAV remote sensing system has the advantages of high maneuverability, low cost, flexible data acquisition, strong real-time performance and high spatial resolution compared with the traditional space remote sensing system, which makes up for the shortcomings of satellite remote sensing affected by climatic conditions and long acquisition period [1-3]. However, there are still some shortcomings in the existing literature on the method of building contour detection for UAV remote sensing images: (1) the segmentation accuracy does not meet the requirements. (2) Strictly demanding remote sensing data. Most methods only apply to certain types of data.

Aiming at the limitations of the research results of building contour detection for existing UAV remote sensing images, this paper proposes an algorithm that combines the level set with the chain code and introduces a straightness parameters to automatically segment the outline of the building in the image, and automatically complete the building detection.

Related Method

Level Set

The core idea of the level set is to transform the curve that evolves on the plane into a high-dimensional surface and represent it as a zero-level set function [4].

Chain Code

Suppose that on an image, there is an initial point and a series of chain codes indicating the trend between adjacent pixels, then a curve can be represented on the image according to the chain code. This is the chain code curve [5]. This method of representing the chain code is called Chain code notation.
Chain Code to Judge the Straightness

(1) Corner detection of curves. The existence of partial fold lines in the evolution curve affects the results of the line detection. In order to eliminate the influence of the fold line, it is necessary to separate the fold lines by finding the corner points in the curve. In image recognition, the corner point generally serves as a high curvature point on the curve, so to detect the corner point in the image contour curve, it is required to find a point with a higher curvature on the curve. This paper obtain the curvature properties of a point on the curve by calculating the chain code difference between the chain codes. Setting a threshold $P_c$, and if the calculated curvature which is greater than $P_c$, then the point is treated as a corner point and the curve is truncated from that point. (2) The line detection of Chain code. The complete curve is divided into a plurality of chain code segments according to the corner points, and then the line segment is detected to determine whether the line segment is a straight line. This paper used a chain code histogram determine if the acquired chain code segment is a straight line [6]. And on the basis of the traditional judgment method, a new condition for judging the linear chain code is selected [7]. When the segment chain code satisfies the following three conditions at the same time, the segment chain code is a linear chain code:

\[
\begin{align*}
\left\{ \begin{array}{l}
a_{f_{\text{max}}} = a_{b_{\text{max}}} \quad \text{or} \quad a_{f_{\text{max}}} = a_{b_{\text{sec}}} \quad \text{and} \quad a_{f_{\text{sec}}} = a_{b_{\text{max}}} \\
\frac{f(a_{f_{\text{max}}}) + f(a_{f_{\text{sec}}})}{n} + \frac{b(a_{b_{\text{max}}}) + b(a_{b_{\text{sec}}})}{n/2} > \mu_1 \\
\frac{f(a_{f_{\text{max}}}) + f(a_{f_{\text{sec}}})}{n} - \frac{b(a_{b_{\text{max}}}) + b(a_{b_{\text{sec}}})}{n/2} < \mu_2
\end{array} \right.
\]

In Eq.1, $\mu_1$ and $\mu_2$ are threshold values, $a_{f_{\text{max}}}$ and $a_{b_{\text{max}}}$ represent specific chain code values corresponding to the maximum value of the chain code histogram of the forward and backward of the chain code center point, and the $a_{f_{\text{sec}}}$ and $a_{b_{\text{sec}}}$ represent the second largest value.

Straightness Judgment Evolution Curve

In this paper, straightness is used as a condition for judging whether the curve profile of the level set is a building. The essence of straightness is to judge the proportion of the straight line on the whole contour curve. Therefore, this paper considers that the curve profile with high straightness has a high probability of being a building. Two methods are used to calculate the straightness. When the straightness of one of the conditions meets the threshold condition, the curve can be regarded as a building. (1) The ratio of linear chain code segments to the total circumference. Using the total length of the linear chain code segment as the numerator, the total perimeter of the final evolution curve is used as the denominator, and the ratio of the two is used as the first calculation method of the straightness, as shown in Eq. 2.

\[
L_d = \frac{C_l}{C_o}
\]

In the Eq.2, $L_d$ represents straightness, $C_l$ represents the sum of the lengths of all the chain code segments that belong to the line, and $C_o$ represents the circumference of the level set evolution curve, if the straightness which obtained is greater than the threshold $\mu_L$, then the curve Can be considered as a contour curve of a building. (2) Minimum circumscribed rectangle perimeter ratio. Based on the calculation of the straightness of the straight line ratio, another way of calculating the straightness is added, that is, the straightness is determined by calculating the ratio of the total circumference of the curve to the circumference of the minimum circumscribed rectangle.

\[
L_{ds} = \frac{C_o}{C_{\text{MER}}}
\]

In Eq.3 above, $L_{ds}$ represents the second calculated value of the straightness, $C_o$ represents the perimeter of the final evolution curve, and $C_{\text{MER}}$ represents the perimeter of the smallest
circumscribed rectangle of the evolution curve. The obtained straightness value is compared with the set threshold $\mu_L$ to determine whether the curve is a building.

**Analysis of Experimental Results**

**The Experimental Samples**

The experimental data selected in this paper is a 1:2000 digital positive photographic image of Danling County, Sichuan Province, and the pixel size of each test image is cropped to 256*256.

**Parameter Analysis**

In this paper, the parameter threshold $P_c$ for corner detection is chosen to be 0.5, and the size of this value will affect the number of corner points in the entire evolution curve. The threshold of the line detection is selected as $\mu_1=0.95$, $\mu_2=0.15$. The magnitude of the two values directly affects the number of straight lines. Finally, the detection curve is the straightness threshold $\mu_L=0.7$ of the building outline, which will affect the judgment accuracy of the building.

**Test results and Analysis**

The cut drone remote sensing image is imported into the algorithm, and selecting the parameter for detection, and representative experimental results are selected as shown in the following Fig.1.

![Figure 1. Recognition result.](image)

In the Fig.1, the first picture shows the curve of the selected image after the level set segmentation is converted into the specific value of the chain code, and it can be seen that the repeated chain code value accounts for a large ratio. The second picture is the straightness value of the contour. The value is close to 1, indicating that the large probability of the curve is the outline of the building; the third picture is the final result. And the contour segmentation effect of the building is very ideal. In addition, it is judged by the threshold of the straightness, which is the contour curve of the building, so the curve is displayed in one color. The other three pictures are the curve chain code value, the straightness value and the final test result of the another test image. The chain code of test image has a low degree of repeatability, so the value of straightness is low, and the final result is detected as a non-building which is displayed on the image in another color.

**Summary**

In this paper, it combines the level set and the chain code, the processed UAV remote sensing image is firstly segmented by the traditional level set, and then converted into a chain code for line detection. Finally, the contour of the curve is judged by the introduced straightness parameters, so that distinguish between building outlines and non-building outlines. The algorithm is more
automated than the traditional level set, eliminating the need to manually interpret the segmentation results of the level set, and the result is ideal. At the same time, the algorithm has lower requirements on experimental data and higher practicality.

Building detection of remote sensing images is only part of the automatic interpretation of remote sensing. How to complete the interpretation of all types of remote sensing images is a very difficult challenge. The next work is mainly to study how to make remote sensing image segmentation more accurate and faster, and to integrate and apply these results.

References


