SUAV Image Mosaic Based on Rectification for Use in Traffic Accident Scene Diagramming

Qiang Chen
School of Automobile and Transportation
Tianjin University of Technology and Education
Tianjin, China
chen@tute.edu.cn

Da Li
School of Automobile and Transportation
Tianjin University of Technology and Education
Tianjin, China
3214120801@qq.com

Bin Huang
School of Automobile and Transportation
Tianjin University of Technology and Education
Tianjin, China

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***Abstract*—After the traffic accident, it is a very important work on how to collect evidence from the scene, draw accident scene map, and clean up the area as soon as possible, without causing further casualties. In this paper, a method of drawing traffic accident scene map using small Unmanned Aerial Vehicles (SUAV) image mosaic based on rectification is proposed. Firstly, the accident scene images collected by SUAV are preprocessed and rectified through plane homograph. Then, two images are stitched into a large view image through feature point matching and image fusion which contains Harris corner detection and SIFT feature matching algorithm. Finally, taken the accident mosaic image as background, the accident scene map is drawn. Using this method, the scene information can be displayed correctly, which is convenient for the traffic accident scene investigators to draw the accident scene map, and ensure the complete panoramic information collection of the whole scene.**

Keywords—Traffic accident, Image mosaic, SUAV, Image Rectification, Accident scene diagramming

I. Introduction

Drawing traffic accident scene map is the core of traffic accident investigation, which can provide data for traffic management and law enforcement. Usually, sketches and field scale maps at the scene can be drawn first using tapes to measure the distance according to Ministry of Public Security's relevant ministerial standard and requirement. It has been causing great trouble to determine responsibility for accident because the defect of long time consuming, on-site information losing, and inability to review the investigation after recovering traffic.

Images taken at the scene contain abundant information on-site, such as vehicle rest positions, brake marks, tire imprint, traces of debris, etc. [1]. Unmanned Aerial Vehicles (UAV) offer an opportunity to collect forensic-quality scene information, speed up investigations and reduce exposure to hazardous roadside conditions. In recent researches, UAV has been used as a mobilized camera to collect data for traffic monitoring and analyzing. For example, a single image from hovering UAV has been used to reconstruct the accident scene through "four-point photogrammetry" method [2, 3]. It is fast and easy to store information, which contains image correction algorithm for rectifying the perspective image to orthographic image. Then, the orthophoto map has been used to permit extraction of geometric elements, which is completely objective when analyzing the causes and motives of the accident [4].

Meanwhile, since the UAV is not easy to carry and it's single image has narrow field of view due to the limitation of focal length, the distance between two objects in different images cannot be measured directly from image coordinates. In order to obtain more information about regional targets, we need to broaden horizons further to achieve the purpose of expanding the field of view [5, 6]. The large view image through stitching two or more images can be used as a reference to construct a global coordinate system for determining the absolute position of objects in different images.

This research hopes to play a certain application research experience, uses rectified image mosaic based on SUAV to draw accident scene map. The paper is organized as follows. First, the system structure is introduced. Next, image mosaic method which contains image preprocessing and rectification, feature point matching and image fusion is established. Then, a simulated traffic accident analyses are performed to demonstrate the feasibility of this method. Finally, discussions are presented and conclusions are drawn.

II. Methodology

A. System structure

Aiming at the problem of image mosaic, the image used in this study is acquired by SUAV, which has four propeller with crisscross structure for taking aerial photographs, as shown in Fig. 1. The advantage of it is flexibly controlling, requiring low takeoff condition and easily hovering in the air. Meanwhile, high-resolution camera has been carried, which is transmitting images to the ground receiving terminal through wireless transmission technology. On this basis, the SUAV image mosaic system based on rectification for investigating the traffic accident scene is proposed, as shown in Fig. 2.

Fig. 1. SUAV.

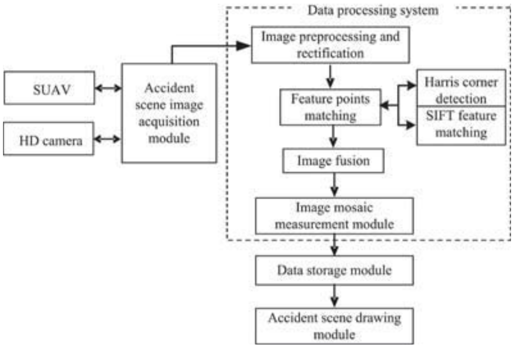


Fig. 2. Sketch of SUAV image mosaic system

B. Image preprocessing and rectification

In order to use images for distance measuring, it is necessary to preprocess and rectify the image.

The purpose of image preprocessing, which contains gray level adjustment and image smoothing, is to reduce the difficulty of image registration and improve the quality of mosaic image.

Camera imaging uses pin-hole model, with which all the scenery projected to the image plane through the center of the camera optical axis. However, due to camera lens distortion, the straight line in the photo should be distorted. This phenomenon causes problems in image processing such as distance measurement and object recognition.

Image rectification uses plane homography method to solve the above problems, which contains normalizing approach to reduce ill-conditions of matrix calculation.

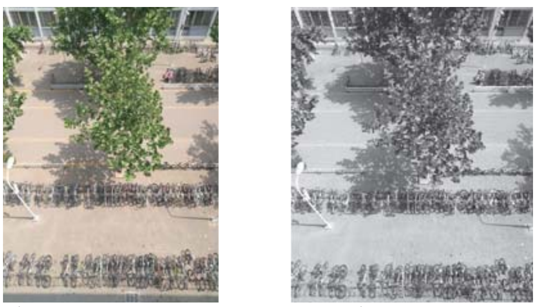
The homogeneous coordinates of corresponding point $P(x, y)$ and $I(u, v)$ are respectively set as follows. For $\forall\ s \neq 0$, define $p = (xs, ys, s)^T$. For $\forall\ t \neq 0$, define $i = (ut, vt, t)^T$.

Projective transformation is a reversible homogeneous linear transformation on the projective plane, which can be described by 3×3 matrix:

$$i = \begin{bmatrix} ut \\ vt \\ t \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{bmatrix} xs \\ ys \\ s \end{bmatrix} = Hp \tag{1}$$

where, H is called the projective transformation matrix.

The coordinates of image point and the corresponding space point in the rectified image can be calculated by homography matrix H. Fig. 3 shows the image comparison before and after preprocessing and rectification.



A) B)

Fig. 3. Image comparison before and after preprocessing and rectification

C. Feature points matching

1) Harris corner detection:

Harris corner detection algorithm is a high-speed and effective feature point extraction algorithm, which is actually an improvement and optimization of Moravec corner detection operator [7]. A sliding widow has been taken to detect the change of pixels in it, which is moving on the image continuously.

This algorithm only uses the first-order gray difference and filtering, which is simple in calculation and reasonable in point feature extraction. It can extract feature points effectively and stably even if the image has twist and gray change. As shown in Fig. 4, the process of algorithm is as follows:

- Calculate I_x and I_y, which are gray gradients in horizontal and vertical directions of a pixel $I(x, y)$ respectively.
- Calculate I_x , I_y , and I_{xy} according to (2).

$$\begin{aligned} I_x^2 &= I_x \cdot I_x \\ I_y^2 &= I_y \cdot I_y \\ I_{xy} &= I_x \cdot I_y \end{aligned} \tag{2}$$

- Constructing M which is the autocorrelation matrix of the pixel $I(x, y)$, and M is shown in the following (3).

$$M = G(s) \otimes \begin{bmatrix} I_x^2 & I_{xy} \\ I_{xy} & I_y^2 \end{bmatrix} \tag{3}$$

- A threshold t is set to analyze the Harris response value R of each pixel, and the response value less than t is equal to zero.

$$R = \{R : detM - \alpha\left(traceM\right)^2 < t\} \tag{4}$$

- The corner points extracted are points with the maximum values of R in the image.

Fig. 4. Harris corner detection

2) SIFT feature matching:

SIFT feature matching algorithm is a method that was proposed by David Lowe [8].

Since the obtained features are unique, this method has the advantage that it is stable to the scaling and rotation changes in the image. SIFT has five steps for the feature detection

- The generation of scale space.

$$L(x,y,\sigma) = G(x,y,\sigma) * I(x,y) \quad (5)$$

where, G is called the Gaussian function with variable scale.

- The detection of extreme points with scale space.

By analyzing each sample point to its eight neighbors in the present picture and nine neighbors in the above and below scale, the extreme points with scale space are discovered.

- Accurate location of extreme points.

After measuring its stability, the extreme points are selected by eliminating the points with low contrast or badly edge position.

- Specify direction parameters for each key point.

To determine the orientation of each key point, the magnitude of gradient and orientation angle should be calculated. At this stage, according to the local characteristics of the image, a fixed orientation is given to each obtained key point.

- Key point descriptor generation.

The key point descriptor shows the eight directions in each histogram orientation with the length of each arrow according to the magnitude of the value from the original histogram.

After key point and descriptor from the previous process has been acquired, the matching process is carried out by the brute-force matcher with the Euclidean distance, as shown in Fig. 5.

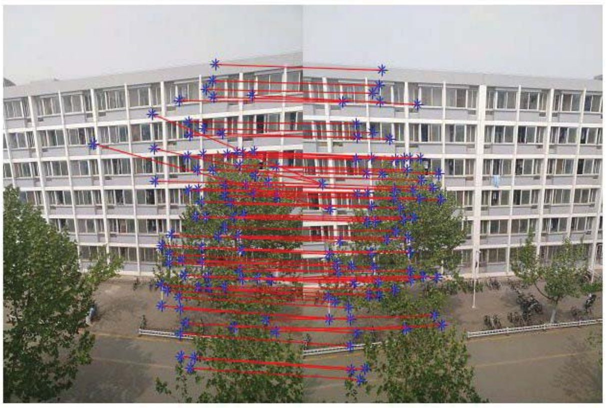


Fig. 5. SIFT feature matching

D. Image fusion

Image fusion algorithm is carried out when good matches are acquired. In this process, warping on one of the images is processed by adjusting the match obtained from the two images, and then the two images are overlapped.

Fig. 6. Image through mosaicking

III. Results and Discussion

In order to verify the effectiveness and practicability of the proposed method, an experiment has been carried out. To achieve the above application, the program ImAR has been written. The hardware used was a laptop device with the specifications of Intel (R) Core (TM) i3-2350M CPU 2.30GHz and 2.00GB RAM. The operating system is Win7 64-bit. HD camera carried by SUAV has the resolution of 1600 pixel × 1200 pixel.

Take a simulated traffic accident as an example. Several images of the accident scene were taken by the SUAV. Fig. 7 shows the corner detection results. Fig. 8 shows the feature matching results of key point. Fig. 9 shows the mosaic image based on rectification. Fig. 10 shows the diagram of traffic accident scene. Within rectified mosaic image at the scene, the length of the brake marks, lane width and distance between the vehicle and roadside are marked. Compared with actual value, the measuring relative error of the proposed method is showing in Table 1.

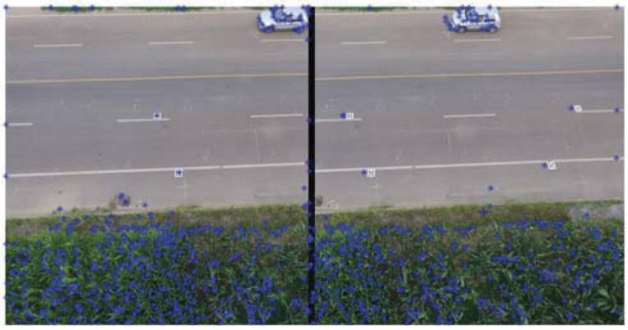


Fig. 7. Diagram of corner detection results

Fig. 8. Diagram of feature matching results of key point

Fig. 9. The mosaic image based on rectification.

Fig. 10. The diagram of traffic accident scene.

TABLE I. MEASUREMENT VALUE AND RELATIVE ERROR OF PROPOSED METHOD

Data description	Actual value (m)	Proposed method (m)	Relative error (%)
AB	2.34	2.38	1.70
CD	4.00	4.06	1.50
DE	6.00	6.02	0.33
EF	4.00	4.04	1.00
DG	3.50	3.51	0.29

From Table I, using the proposed method compared with the actual value, the relative error can be controlled within 2%. This can completely meet the requirements of traffic accident scene investigation. It can be seen that the proposed method using SUAV image mosaic based on rectification can easily draw the accident scene map with the mosaic image as the background.

IV. CONCLUSIONS

When using SUAV for traffic accident scene diagramming, single image has narrow field of view due to the limitation of focal length. This research proposed a system structure to play a certain application experience, which is used rectified image mosaic based on SUAV to draw accident scene map. Images that are preprocessed and rectified through plane homograph are stitched into a large view image. Then, image mosaic is carried out through feature point matching and image fusion which contains Harris corner detection and SIFT feature matching algorithm. Through a traffic accident analyzing, the accident scene map is drawn with the accident mosaic image as background, and the relative error of measured value is less than 2%. In this way, it is convenient for investigators to draw the accident whole scene map and ensure the integrity of information acquisition.

In actual use, SUAV can be easily affected by strong winds, which can lead to poor effect of taking photographs from aerial. The development of special SUAV to road traffic accident scene investigation will be helpful to the application of this method.

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