Research on Image Denoising Adaptive Algorithm for UAV Based on Visual Landing

Pengrui Qiu[12]
[1]Faulty of Land Resource Engineering,Kunming University of Science and Technology,Kunming Yunnan,China
[2]Training Department, Kunming Metallurgy CollegeKunming Yunnan,China
E-Mail:80420631@qq.com

Shu Gan
Faulty of Land Resource Engineering
Kunming University of Science and Technology
Kunming Yunnan,China
E-mail:ganshu@qq.com

Xiping Yuan
Faulty of Land Resource Enagineering
Kunming University of Science and TechnoloAgyKunming Yunnan,China
E-Mail:yxpkm@163.com

Yu Lin
Department of Computer Science
Kunming Metallurgy College
Kunming Yunnan, China
E-Mail:15087048891@qq.com

Abstract*—UAV autonomous landing refers to the UAV lands on only depending on airborne navigation equipment and flight control system, and ultimately achieves a safe landing. To achieve self-landing, UAV must have the ability to self-navigation and positioning, so that the high-precision visual navigation positioning technology is the key to achieve UAV self-landing technology.This paper concentrating on the noise effects on the pictures obtained during visual landing process of UAV, it has introduced the gravity of classical physics to image pixel, come up with a mathematical expression for the strength of gravity between pixels, then conformed the adaptive window by the gravity between pixels and performed corresponding filtering processing. It is shown by the experimental results that this algorithm has a great improvement on image denoising and detail preserving when compared with the traditional median filterin*g and switching median filtering algorithms.

Keywords-UAV; visual landing; median filter; image;gravity between pixels; adaptive window

I. INTRODUCTION

In recent years, with the rapid development of information technology, UAV (Unmanned Aerial Vehicle, UAV) technology is also developing rapidly. How to achieve the UAV's autonomous flight, especially the UAV's autonomous landing is the most urgent challenge that the current UAV industry need to solve. UAV autonomous landing refers to the UAV lands on only depending on airborne navigation equipment and flight control system, and ultimately achieves a safe landing. To achieve self-landing, UAV must have the ability to self-navigation and positioning, so that the high-precision visual navigation positioning technology is the key to achieve UAV self-landing technology[1][2]. In the acquisition of UAV landing images, it is vulnerable to be affected by random noise. The existence of noise will not only reduce the quality of the image, but also destroy the important information carried by the image, how to effectively eliminate such noise, accurately calculatethe UAV landing parameters, is an important issue in image processing field[3].

Median filtering is a non-linear processing technique based on the ranking theorythat can effectively eliminatenoise[4][5]. The median filter provides good denoising capability for some types of random noise, and better in protecting the edge of the imagethan the same size of linear smoothing filter. Although the traditional median filter has been widely used in denoising, there are many obvious problems. In order to overcome the shortcomings of the traditional median filter, many improved median filters such as the extreme value median filter [6], the switching median filter, the weighted median filter, the adaptive switching weights A mean filter, an improved median filter based on large and minimum values, and many others were produced[7]. These improved filters use some criteria to determine whether the current pixel is noise or not before filtering the image. If it is noise, executes the corresponding median filter processing; otherwise, no special treatment for the current pixel. In terms of denoising, the traditional median filter has been greatly improved. Based on these theories, this paper proposed an improved adaptive median filter algorithm, which not only has a stronger noise removal capability, but also can retain more details of the image information[8].

II. GRAVITATIONAL FORCE BETWEEN IMAGEPIXELS

Gravitational law points out that there is a gravitational interaction between any object, and the gravitational force between the two particles is proportional to the product of the two, inversely proportional to the square of the distance. The mathematical expression is shown in equation (1).

$$\Phi = -\frac{GMmr}{r^3} \quad (1)$$

Where: M is understood as the mass of the central body; G is the gravitational constant; formula(1) describes the gravitational force of the mass of m; r is the displacement vector of m relative to the elbow; r is the distance size of the two. The gravitational pull between image pixels is based on this theory, but it should be noted that the basic concepts and methods of introducing the law of gravitation are only considered in the mathematical sense, regardless of their physical constraints.

A. *Distance of pixel*

A, B is the two pixels of the image, the coordinates in the image are (x_1, y_1) and (x_2, y_2), D (A, B) is the distance between pixels A and B[9] [10].

1) Euclidean distance

$$\Delta(A,B) = [(x_1 - x_2)^2 + (y_1 - y_2)^2]^{1/2} \quad (2)$$

2) Distance of the city block

$$\Delta(A,B) = |x_1 - x_2| + |y_1 - y_2| \quad (3)$$

Distance of board

$$\Delta(A,B) = \max|x_1 - x_2| + |y_1 - y_2| \quad (4)$$

Where: The eight neighborhood of A is the pixel with D (A, B) = 1.

B. *The Pixels Between the Gravitational Force*

Assumption there is a digital image I (m, n), (m, n) ∈I (m, n) represents the gray value at the position (m, n). According to the law of gravity, I (m, n) can be described as the quality of the pixel at the position (m, n). A, B is random two pixels of the digital image, where the positions in the image are (m1,n1) and (m2,n2),and the corresponding gray values are I (m1,n1) and I (m2,n2). So we can get the formula of resulting pixel gravitational.

$$\Phi(m_1, n_1, m_2, n_2) = \kappa \frac{I(m_1,n_1) * I(m_2,n_2)}{r^2} \quad (5)$$

Including:k is the gravitational constant value of pixels, this paper use k = 1 ,r is the distance between the two pixels.

III. THE CONTENT OF THIS ARTICLE

A. *Median Filter and Adaptive Window*

This paper use the noise criterionis in the digital image I, if the gray value of the current pixel in the neighborhood window is the maximum value or the minimum value, the pixel is judged to be noise; otherwise, the pixel is a signal. The mathematical expression is shown in equation (6).

$$\Sigma = \begin{cases} 0 = I(m,n) = \min(W) \text{ or } I(m,n) = \max(W) \\ 1 \quad \text{others} \end{cases} \quad (6)$$

Including:I(m,n) is the gray value at the position (m, n); W is the neighborhood window which centered on I (m, n), It is a pixel gray value matrix which can be shown in equation (7). Here, the signal judgment S = 0 indicates that I (m, n) is noise and S = 1 is expressed as a signal.

$$\Omega = \begin{bmatrix} I(m-1,n-1) & I(m-1,n) & I(m-1,n+1 \\ I(m,n-1) & I(m,n) & I(m,n+1) \\ I(m+1,n-1) & I(m+1,n) & I(m+1,n+1) \end{bmatrix} \quad (7)$$

Select the 3 × 3 size of the adaptive window, the initial condition $AW = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ If the I= (m, n) value is not updated and the value of S at the position is 1, the 3 × 3 window data is skipped to the next position; if S = 0, I (m, n) is updated, calculate the maximum and minimum values of the 3 × 3 window W data firstly, and then calculate the gravitational force of I (m, n) of the pixels in its eight neighborhoods. The adaptive window AW is updated by Eq. (8).

$$A\Omega(\iota,\varphi) = \begin{cases} 1 \; I(m,n) = W_{min} \& \; t_2 < F(m,n,m+i,n+j) < t_1 \\ 1 \; I(m,n) = W_{max} \& \; t_4 < F(m,n,m+i,n+j) < t_3 \\ 0 \quad \text{others} \end{cases} \quad (8)$$

Including:i ∈ {-1,0,1}, j ∈ {-1,0,1}, and I, j can not be 0 at the same time.

After determining the matrix AW, update the window W which centered on I (m, n), and the expression between W and AW is shown in equation (9). Sort the window W non-zero elements, and then replace the original gray value with the original (m, n) position, the expression is shown in equation (10).

$$\Omega(\iota,\varphi) = \begin{cases} I(m+i,n+j) & AW(i,j) = 1 \\ 0 & AW(i,j) = 0 \end{cases} \quad (9)$$

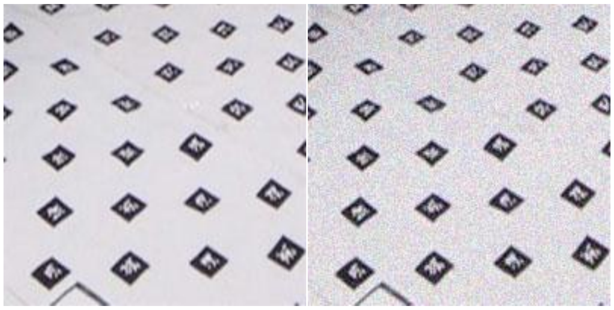
$$I(\mu,\nu) = \underset{\substack{(i,j)\in|-1,0,1| \\ \text{and } W(i,j)\neq 0}}{\text{median}} \{W(i,j)\} \quad (10)$$

B. *The Main Steps of the Algorithm*

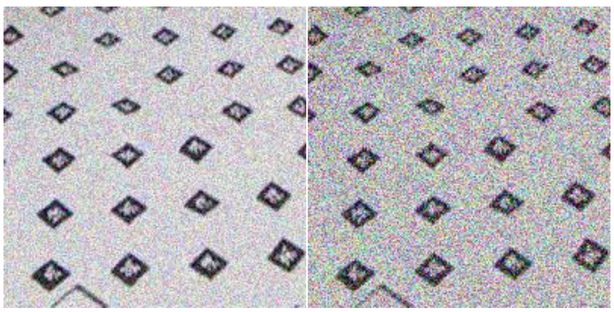
- Determine whether I (m, n) is noise according to the window W which the image is centered at a certain pixel I (m, n).
- If I (m, n) is a signal, I (m, n) is not updated and window W slides to the next position.
- If I (m, n) is noise, the adaptive window AW is calculated according to Eq. (8).
- When the adaptive window AW is not 0 either, the pixel I (m, n) is updated according to Eq. (9) (10).
- When the adaptive window AW all is 0, record the data that has been updated and the number equal to I (m, n). If the number is less than the threshold count, update I, otherwise I is not updated. The default count is 2; if the original image has a large area of gray value is 255 or a large area of gray value, count is 1.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

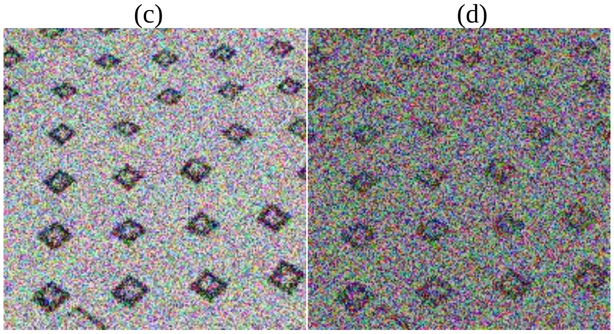
Select the UAV image size as 200×200 pixels.Picture1 is the UAV original image and the UAV image which after add the noise density of 0.1,0.2,0.3,0.4 and 0.5 . Picture 2(a)is the process effect of the SM (switch median) filter, Picture2(b)is the processing effects of he TM (traditional rate) filter t.Picture2(c)is the processing effect of the algorithm.



(a) (b)

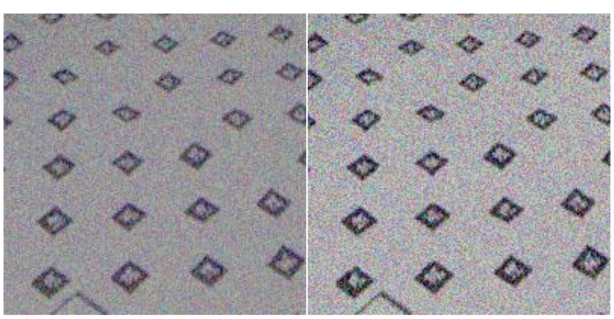


(c) (d)

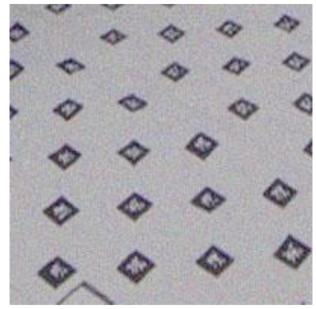


(e) (f)

Figure 1. UAV original image and the UAV image which after add the noise density of 0.1(b),0.2(c),0.3(d),0.4(e) and 0.5(f)



(a) (b)



(c)

Figure 2. Picture 2(a)is the process effect of the SM (switch median) filter, Picture2(b)is the processing effects of he TM (traditional rate) filter t.Picture2(c)is the processing effect of the algorithm.

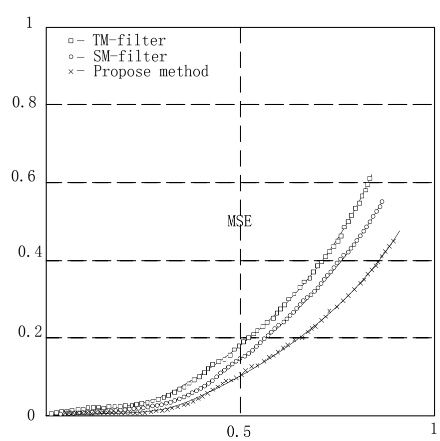
In the point view of the visual , it can be seen fromPicture2.This paper proposed the algorithm which has been greatly improved in removing salt and pepper noise and preserving the details of the image, especially under the interference of large noise, the effect of denoising is more obvious The meanings of the algorithm are quantitatively described by mean absolute elror (MAE) and mean square error (MSE) respectively. The definitions of MAE and MSE are given in Eqs. (11) and (12).

$$\text{MAE}=\frac{\sum\sum|X(i,j)-Y(i,j)|}{m*n} \tag{11}$$

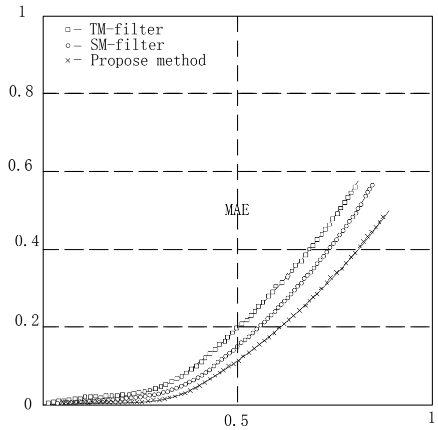
$$\text{M}\Sigma\text{E}=\frac{\sum\sum|X(i,j)-Y(i,j)|^2}{m*n} \tag{12}$$

Including: x (i, j) is the original image; Y (i, j) is the filtered image; m, n is the number of rows and columns of the image.

In Fig .3, each map maps the MSE and MAE curves corresponding to the different algorithms.



(a)



(b)

Figure 3. Picture3(a)is MSE curve, Picture3(b)is MAE curve use TM-filter,SM-filter and Propose method

It can be seen from the curve that the algorithm proposed from this paper is closer to the real data after image denoising, so the algorithm from this paper is better than the other two algorithms. The main reasons are as follows:

Detecting noise of pixels before filtering, onlyprocessing the pixels that are currently noise, and no noise-contaminated pixels are not processed, thus preserving more details of the image and reducing the degree of image blur. The median filter unconditionally treats all the pixels in the image, which may destroyed some unpolluted pixels while processing. When the contaminated pixels in an area of the image are processed, the shape of the adaptive window is controlled by the gravitational force between the pixels, thereby selectively filtering the pixels of the region, removing the interference of other noises, and more precisely gets the gray value of the current pixel. The median filter can not adapt to the local variation of the image when determining the size of the filter window El thus when the noise density is large, the processing effect is drastically deteriorated.

V. CONCLUSION

In this paper, we design an improved median filter, which introduces the concept of gravity in physics. By introducing the law of universal gravitation, this paper leads to the gravitational force of image pixel, and gives the mathematical expression of pixel gravitation. At the noise point, using the size of gravity between the pixels to determine whether the pixels in the neighborhood are noise or not. If the answer is yes, the data will be discarded; otherwise, the data is placed in the median filter data set. From the effect of image processing, graph of MAE and MSE, we can see that the algorithm proposed in this paper has greatly improved the denoising and detail reservation.

REFERENCES

[1] Xiangyu Yu,Lihua Guo.Image Registration by Contour Matching usingTangent Angle Histogram[J].IEEE computer society 2008.

[2] David G.Lowe.Distinctive image features from scale-invariant key-points[J].International Journal of Computer Vision,2004,60(2):90-110.

[3] S. T. Nuske, S. Choudhury , S. Jain, A. D. Chambers, L. Yoder,S. Scherer, L. J. Chamberlain, H. Cover, and S. Singh, “AutonomousExploration and Motion Planning for an Unmanned Aerial VehicleNavigating Rivers,” Journal of Field Robotics, June 2015.

[4] I. Sa and P. Corke, “System Identification, Estimation and Control for aCost Effective Open-Source Quadcopter,” in 2012 IEEE InternationalConference on Robotics and Automation (ICRA), 2012.

[5] G. M. Hoffmann, S. L. Waslander, and C. J. Tomlin, “Quadrotorhelicopter trajectory tracking control,” in AIAA guidance, navigationand control conference and exhibit, pp. 1–14, 2008.

[6] P. Pounds, R. Mahony, and P. Corke, “Modelling and control of alarge quadrotor robot,” Control Engineering Practice, vol. 18, no. 7,pp. 691–699, 2010.

[7] M. Achtelik, S. Weiss, and R. Siegwar, “Onboard IMU and MonocularVision Based Control for MAVs in Unknown In- and OutdoorEnvironments,” in Proceedings of the IEEE International Conferenceon Robotics and Automation (ICRA), May 2011.

[8] C. Zhang and J. M. Kovacs, “The application of small unmanned aerialsystems for precision agriculture: a review,” Precision agriculture,vol. 13, no. 6, pp. 693–712, 2012.

[9] M. Burri, H. Oleynikova, M. W. Achtelik, and R. Siegwart, “Real-timevisual-inertial mapping, re-localization and planning onboard mavs inunknown environments,” in Intelligent Robots and Systems (IROS),2015 IEEE/RSJ International Conference on, pp. 1872–1878, IEEE,2015.

[10] Akkoul S,Ledee R,Leconge R,et al.A new adaptive switching median filter[J].Signal Processing Letters,2010,17(6):587-590.