An Edge Detection Method for UAV Image Based on the Enhancing ABC

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Abstract

In this paper, we propose a novel ABC method called as EABC to improve the efficiency and quality for color UAV image edge detection based on quaternion. We propose a RGB image pixel as a pure quaternion form and applying the principle of rotation quaternion to determine the edge points of the color UAV image. For the artificial bee colony algorithm, two new search equations are presented to generate candidate solutions in the employed bee phase and the onlookers phase, respectively. Then an enhancing artificial bee colony algorithm (EABC) is proposed. Further, a more reasonable ABC parameters is proposed to improve the performance of ABC. Finally, we combine the advantages of quaternion-based color UAV image and enhancing artificial bee colony algorithm to develop color UAV image edge detection. By comparing the performance and computing time processing different images, the proposed method has superior performance which not only provides the best color UAV image edge detection results but also yields better color UAV image quality com-pared to other widely used algorithm.

Keywords: *Color UAV image, quaternion, quaternion vector rotation, artificial bee colony algorithm, edge detection*

I. Introduction

With the development of UAV Technology, Unmanned aerial vehicle (UAV) is characterized by its flexibility, efficiency, economy and high spatial resolution and temporal resolution. It makes up the shortcomings of the traditional remote sensing satellite, such as long operating cycle, high cost, and great influence by weather and other external factors. This provides a new way for low cost, high precision and high efficiency ground object recognition. As a result, it plays a more and more important role in military monitoring, water and soil resources investigation, vegetation monitoring, disaster emergency, land mapping and so on. But the UAV, especially the civil UAV remote sensing imaging platform, mostly adopts digital cameras, SLR cameras, digital video cameras and other conventional cameras to shoot, and color images generated by UAV, the amount of image data is very large, and the UAV carries on the ground object recognition, first of all, the target object must be segmented from UAV image data, otherwise, it will seriously affect the accuracy and speed of target recognition in such a large amount of unmanned aerial vehicle image data for erroneous or inaccurate separation. Therefore, how to accurately and efficiently segment a large number of color images of unmanned aerial vehicle (UAV) is crucial for target recognition.

Edge detection [1-3] is an important method for color UAV image segmentation. Traditional gray scale image [4] is sampled, then discretized into a digital image expressed a two-dimensional matrix. For color UAV images, in the visible band, color spaces such as RGB, HSI, CMY, XYZ can be used to represent them, but the RGB color space because of his natural advantage is usually considered. When the RGB color model is used to represent the color UAV image, a pixel structure includes a red sub-pixel, a green sub-pixel, a blue sub-pixel, so a color UAV image are represented by three matrices, but when use the corresponding image processing methods, that clearly separates red, green and blue color channels of a color pixel. Thus these methods develop image edge detection, the effect is quite poor. Later the vector method [5] use a color image pixel as a three-dimensional vector of three-dimensional space. To a certain extent, consider the relationship between the three color channels of a color pixel, the effect is

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better than the traditional methods, but the vector method does not look the three colors of a pixel as a whole in the conversion, calculation and processing for an image, likely to cause disharmony and partial destruction of the edge details.

Quaternion is discovered by the Irish mathematician Hamilton in 1843 [6], but until the 1990s, with the continuous development and improvement of the theory of quaternions, people try to use all kinds of color models mapping the color images in the quaternion space. The most widely used method is using a quaternion three imaginary parts to represent the three colors of a color pixel. Three imaginary parts of a pure quaternion represent the red, green, and blue of a color pixel respectively, throughout the processing of an image, process the three colors of a color pixel as a whole, so theories and methods of quaternions began to be applied to color image processing. Such as the color image coding and transform [7,8], color image segmentation [9,10], color image correlation measurements [11,12], color image enhancement or denoising [13,14], the color image decompression [15-17] and so on. Although the color image edge detection based on quaternion is considerably less research in this area, made some progress [18,19], but in the color UAV image edge detection, for color UAV images, only quaternions are used to represent the pixels in a visible light band to detect the edges of UAV images. Because the UAV remote sensing imaging system is affected by relative motion, vibration, lens defocus and mechanical and electronic effects in the imaging equipment, as well as, the image data is sent back to the ground for compression and affected by various external factors, the results show that the conventional quaternion method of UAV edge detection is not satisfactory.

Artificial bee colony algorithm [20] is a intelligent algorithms of cluster developed in recent years, which is proposed by imitating the behavior of honey, the algorithm is relatively simple, rapid convergence, better results, less complex parameters, and has more superior performance than heuristic algorithms in a non-limiting numerical optimization problem. Now artificial bee colony algorithm have made progress in many ways. The good performance of the ABC has been demonstrated in solving for complex problems, such as transit network design [21], the digital filter design problem [22], the leaf-constrained minimum spanning tree problem [23] and the vehicle routing problem [24].

In this paper, use quaternions to represent color UAV image pixels, and the Artificial bee colony algorithm is enhanced, according to the quaternion polar coordinate rotation principle, use the enhancing artificial bee colony algorithm for the color UAV image edge detection, then get all the suboptimal solutions as candidate edge points. Take the candidate edge points as the starting points, according to the algorithm proposed in this paper, search for the closest point in the neighborhood, according to the search results, determine and obtain color image edge points.

The remaining work is arranged as follows. In Section 2, we briefly review quaternion representation of color UAV image edge. Section 3 states enhancing artificial bee colony algorithm based on quaternion for color UAV image edge detection. In Section 4, the experimental results and performance comparisons between the proposed method and other color UAV image edge detection techniques are reported. Finally, conclusions are drawn in Section 5.

II. Quaternion Representation of Color UAV Image Edge

Quaternions originated in finding plural three-dimensional counterpart, Non-commutative extension of plural nature. If quaternion set is treated as real numbers set of four-dimensional space, quaternions correspond to the four-dimensional space, if the real part is set to 0, that is the three-dimensional space.

2.1 Definition and properties of the quaternion

A quaternion q consists of four components, that is a real part and three imaginary parts. If the real part is 0, then that is a pure quaternion. Quaternion is different from the real and complex numbers. It does not satisfy the commutative law of multiplication.

The quaternion q can be expressed as follows:

$$q = a + bi + cj + dk \tag{1}$$

Where a, b, c, d are real numbers. And I, j and k are imaginary units. Then for quaternion q, mold and conjugate are defined as follows:

$$|q| = \sqrt{a^2 + b^2 + c^2 + d^2} \tag{2}$$

$$\bar{q} = a - bi - cj - dk \tag{3}$$

Two quaternions $q_1=a_1+b_1i+c_1j+d_1k$ and $q_2=a_2+b_2i+c_2j+d_2k$, their addition and subtraction are addition and subtraction of their respective parts, their multiplication is not commutative, the quaternion multiplication can be expressed as follows:

$$\begin{aligned} q_1 q_2 = {} & (a_1 a_2 - b_1 b_2 - c_1 c_2 - d_1 d_2) + (a_1 b_2 + b_1 a_2 + c_1 d_2 - d_1 c_2) i + \\ & (a_1 c_2 - b_1 d_2 + c_1 a_2 + d_1 b_2) j + (a_1 d_2 + b_1 c_2 - c_1 b_2 + d_1 a_2) k \end{aligned} \tag{4}$$

2.2 Polar coordinates for quaternions

Eigen axis and eigen angle of quaternion q are defined as follows:

$$\begin{aligned} \mu &= \frac{1}{\sqrt{b^2 + c^2 + d^2}} (bi + cj + dk) \\ \theta &= \begin{cases} \tan^{-1}(\sqrt{b^2 + c^2 + d^2} / a), a \neq 0 \\ \pi / 2 \cdots\cdots\cdots\cdots\cdots\cdots\cdots, a = 0 \end{cases} \end{aligned} \tag{5}$$

Where $q = a + bi + cj + dk$, where $q = |q|(\cos\theta + \mu \sin\theta) = |q| e^{\mu\theta}$, μ denote a purely imaginary quaternion (its mode is equal to 1, μ denote the eigenaxis, and θ denote the eigenangle.

2.3 Quaternion rotation representation of color UAV image edge points

For color UAV images, edge detection is to detect the state of each pixel and its neighboring points, if two points on the boundary of the color UAV image, the color change is certainly hopping, that is, two points in the color (chromaticity, brightness and saturation) are not continuous. According to the three-dimensional representation of quaternions, if a color UAV pixel include red, green, and blue colors, let the real part of a quaternion is 0, the remaining three parts of the quaternion represent red, green and blue of the pixel. Color UAV image edge is color discontinuous jump. If a quaternion vector represents a color pixel, a quaternion vector rotate 360 °around a fixed axis, that should coincide with the original vector, after subtraction for the two vectors, the difference is 0, the color corresponding to the difference vector should be black, if the two vectors are similar color, then a color vector rotate 360 °around a fixed axis, then subtract another one color vector, the result should be close to 0, that should be close to the black, if the two pixel vectors for different color, a pixel vector rotated 360 °around a fixed axis, this vector does not coincide with another pixel vector or the two vectors is the same mold but different directions, thus after subtracting ,the result is not 0, the color for the result vector is color.

According to this principle, if a color pixel point is on the edge of the image detected and its next color pixel point is outside the image detected, as the colors between them are a hopping, then the two quaternion pixel vectors subtracting result is certainly not 0, corresponding color is color. Therefore, can detect color image edge points [25,26] according to this principle, and quaternion color image edge detection filter as follows:

$\begin{bmatrix} R & R & 1 \\ R & 0 & 1 \\ 1 & 1 & R \end{bmatrix} [] \begin{bmatrix} \bar{R} & \bar{R} & -1 \\ \bar{R} & 0 & -1 \\ -1 & -1 & \bar{R} \end{bmatrix}$, R is the rotor, $R=e^{\mu\pi}=\cos\pi+\mu\sin\pi$, $u=\frac{1}{\sqrt{3}}(i+j+k)$, μ is a unit of purely imaginary quaternion, that indicates gray line direction. The quaternion rotation edge detection operator can be carried out better for horizontal edges and vertical edges and 45 °direction edge.

III. Enhancing Artificial Bee Colony Algorithm Based on Quaternion for Color UAV Image Edge Detection

Artificial bee colony algorithm is the optimal algorithm, when use artificial bee colony algorithm to search the optimal solution, an optimal solution may be obtained. However, there are more than nectars. That is to say, there are multiple sub-optimal solutions. For the color UAV image edge detection based on quaternion, take advantage of the artificial bee colony algorithm, use a quaternion to represent a pixel of color UAV image, search color UAV image edge points, get a group of local optimal solutions. On the basis of the local optimal solutions, further search to get the edge points, all edge points searched are the color UAV image edge points, in other words, all the suboptimal solutions and optimal solution searched are the image edge points, these edge point set is color UAV image edges.

3.1 Artificial bee colony algorithm

When the artificial bee colony algorithm starts, the number of employed bees or onlooker bees is equal to that of the food source. Each food source location represents a feasible solution, and the fitness value of each location can be calculated through the feasible solution. Each initial solution:

$PX_i = \{PX_{i,1}, PX_{i,2}, \cdots\cdots, PX_{i,D}\}$ is produced randomly in the range of the borders of parameters as follows:

$$PX_{i,j} = PX_{l,j} + \beta(PX_{u,j} - PX_{l,j}) \quad \beta\in[-1,1] \;\; u\neq l \tag{6}$$

Where i =1, 2, …… EB (EB denotes the number of food source positions), j=1,2, …… D and D is the problem dimension; $PX_{u,j}$, $PX_{l,j}$ respectively represent the upper and lower bounds of dimension j.

In the artificial bee colony algorithm, employed bees constantly finds new nectar source and preserve better nectar source, discard the poor quality of nectar source, onlooker bees get information from employed bees, and find new nectar source, scout bees search for new nectar bees near the honeycomb.

In artificial bee colony algorithm, bee finds a new food location from the old food location using the following equation:

$$PV_{i,j} = PX_{i,j} + \rho_{i,j}(PX_{i,j} - PX_{k,j}) \tag{7}$$

Where $k \neq i$ $k\in\{1,2,\ldots\ldots EB\}$ $j\in\{1,2,\ldots\ldots D\}$ k and j are randomly chosen indexes, $\rho_{i,j}$ is a random number and $\rho_{i,j} \in[-1,1]$.

3.2 Two new search equations

In order to improve the performance of artificial bee colony algorithm, the key is to improve the search equation. So far there have been appears several improved search equations [27,28]. The most representative algorithm is the Gbest-guided artificial bee colony algorithm (GABC) [29]. The search equation proposed as follows:

$$PV_{i,j} = PX_{i,j} + \sigma_{i,j}(PX_{best,j} - PX_{i,j}) + \rho_{i,j}(PX_{i,j} - PX_{k,j}) \tag{8}$$

An expression is added to the right of Eq. (7), $PX_{best,j}$ is the jth element of the global best solution, $\sigma_{i,j}$ is a random real number in [0,1.5]. But the experiment results show that improving the performance of this algorithm is not ideal. In this paper, inspired by PSO and combining eq. (7) with eq. (8), a new enhancing ABC algorithm (EABC) is proposed. in the EABC. A new search equation is proposed for employed bees and onlookers, respectively, as follows:

$$PV_{i,j} = PX_{i,j} + \sigma_{i,j}(PX_{best,j} - PX_{r,j}) + \rho_{i,j}(PX_{r,j} - PX_{k,j}) \tag{9}$$

$$PV_{i,j} = PX_{m,j} + \lambda_{i,j}(PX_{best,j} - PX_{m,j} + \delta) \tag{10}$$

Where r, k, i, m, best are not equal to each other, k, $r \in \{1,2,\ldots\ldots EB\}$, $j \in \{1,2,\ldots\ldots D\}$, $\sigma_{i,j}$ is a random number in the range [0,1.5], $\rho_{i,j}$ is a random number and $\rho_{i,j} \in [-1,1]$, $\lambda_{i,j}$ is a random number generated by a normal distribution with mean μ and standard deviation σ. $\delta = \dfrac{b}{PX_{best,j}^{2} + b}$, b=0.04.

The main difference between GABC and EABC is that GABC has a search equation eq. (8), and EABC has two different search equations eqs. (9) and (10). Note that eq. (9) has some similarity with eq. (8), but the second term and the third term are different in eqs. (8) and (9). In eq. (9), $PX_{r,j}$ is a solution of random selection, due to its randomness, the possibility of a better optimal solution is greatly increased comparing eq.(9) with eq.(8).

Eq. (10) is proposed for onlookers, the first term and the second term have changed in eq. (10) compared to eq. (8), there is no the third term in eq. (10). The subscript of the first term i and m are different in eqs. (8) and (10), $PX_{m,j}$ instead of $PX_{i,j}$ can improve the exploration capability. For the second term in eqs. (8) and (10), experimental results show $\lambda_{i,j}$ instead of $\sigma_{i,j}$ can improve the quality of the solution, $PX_{m,j}$ instead of $PX_{i,j}$ and add term δ which not only enhances the exploitation but also improves search efficiency. That is to say, eq. (9) focuses on the exploration, and eq. (10) emphasizes the exploitation. The emphases of Eq. (9) is consistent with the employed bees stage, eq. (10) is consistent with the onlookers stage.

3.3 Fitness function

For the color UAV image space based on quaternion, a pixel vector rotate 360 °around a fixed axis, then subtract neighboring quaternion vector. If the two vectors are equal, difference vector will be zero, and difference vector color will be black, if the difference vector is not zero, the two vectors are not equal. So difference vector is closer to 0, the color is closer to black. On the contrary, if the difference vector is color, it is more likely to be an edge point [19]. For how much difference vector is, be able to determine the original vector is an edge point, use a strong correlation function of edge information point as a fitness function, to determine whether a pixel is an edge point, its function value is bigger, corresponding points are more likely to be marginal point, which specifically refer to the literature [30].

3.4 Parameter settings

For color UAV image edge detection based on bee colony algorithm, how to set reasonable parameters that have a significant impact on the image edge detection, specific parameters include bees overall size (the total number of bees) S, employed bees Se, onlooker bees S_0, scout bees Ss, S is generally $500 \le S \le 1200$, employed bees Se is generally $0.4S \le Se \le 0.6S$, S and Se are not too large, if the values are too large for image edge detection , then the effect is not significantly improved but a waste of time and produce false edges. If the value is too small for the image edge detection, there will be a significant loss of image edge. Onlooker bees So is generally $0.45S \le Se \le 0.65S$, onlooker bees can not exceed the number of employed beess, otherwise, the edge detection time is too long, detected edge is too wide. Scout bees Sc generally can not be too small, if the number is too small, will increase the difficulty of the bees out of the local minimum value, increase search time of algorithm, $0.05S \le Sc \le 0.15S$ is more reasonable.

3.5 The proposed algorithm

The proposed algorithm is a the improvement based on basic bee colony algorithm model, first of all, set predetermined value of colony algorithm such as the number of cycles, after reaching a predetermined result, got a group of suboptimal solutions, the sub-optimal solutions are some scattered points of the color UAV image. These scattered points are also possible edge points, then the points are sorted by efficiency value, the first N bees corresponding to N larger value as employed bees, then employed bees recruit some onlooker bees to continue searching in the neighborhood of the nectar, if get a new nectar, the nectar is corresponding to point on the edge of the image, if onlooker bees found new nectar, onlooker bees were upgraded to employed bees, continue search, cycle, eventually search out all the edge points, its collection is the image edge. The algorithm is as follows:

(1) Initialize the the colony, all bees (total number is S) go out, this is a random search of nectar;

(2) When the set conditions are met, assess the all fitness values found nectar, and sorted by fitness values;

(3) Select the previous S_{n1}values, and these bees corresponding to the values are employed bees;

(4) recruit other onlooker bees, go S_{n1} nectar proximity area selected along with the employed bees, and search for new nectar sources that fitness value is equal or close to current nectar source;

(5) If find a new source of nectar, the current onlooker bees are upgraded to employed bees, Otherwise, the employed bees are downgraded to scout bees, continue the search;

(6) eventually find a collection of all the marked point, that is the image edge points;

(7) end.

IV. Experiments and Results

We have done a lot of experiments on the basis of the color UAV image for illustrating the method proposed in this article. we selected a portion of the color UAV image edge detection results. The experiment is divided into two sub-experiments. The first sub-experiment is a test to detect the impact of the colony number changes in color image edge detection. The second sub-experiment is a comparative experiment including quaternion EABC algorithm, GABC algorithm, ABC algorithm and non-quaternion ABC algorithm. The second sub-experiment consists of subjective and objective part.

4.1 Number changes of three different types of bees and their impact on the color UAV image edge detection

In this experiment, selected from Se = 0.52S, so = 0.41S, Sc = 0.07S, the color UAV image is obtained from the laboratory, and its size is 700 × 460. All color UAV images are based on quaternion representation. When the colony initialize, cycle is 150 times, select S = 500, S = 600, S = 800, S = 1000, the experimental result is shown in Figure 1. If S is small, such as S = 500 even when S = 600, edge detection results show there are some obvious undetected points. In Figure 1, the tiny textures of some vegetations were not detected, and there were more discontinuities on the edges of houses and roads. Some false edges appeared on the edges of some vegetation. With the gradual increase in the value of S, the detected edge is gradually clear, when S = 800, tiny vegetation textures become clearer. In particular, the outline of the houses and roads is the more complete, some vegetation edges can be detected more fully. when S = 1000, the details are clearer for the outlines of the houses and roads even vegetations. But when the value of S continues to increase, the effect is not obvious, and if the time is longer, there will be widened edges.

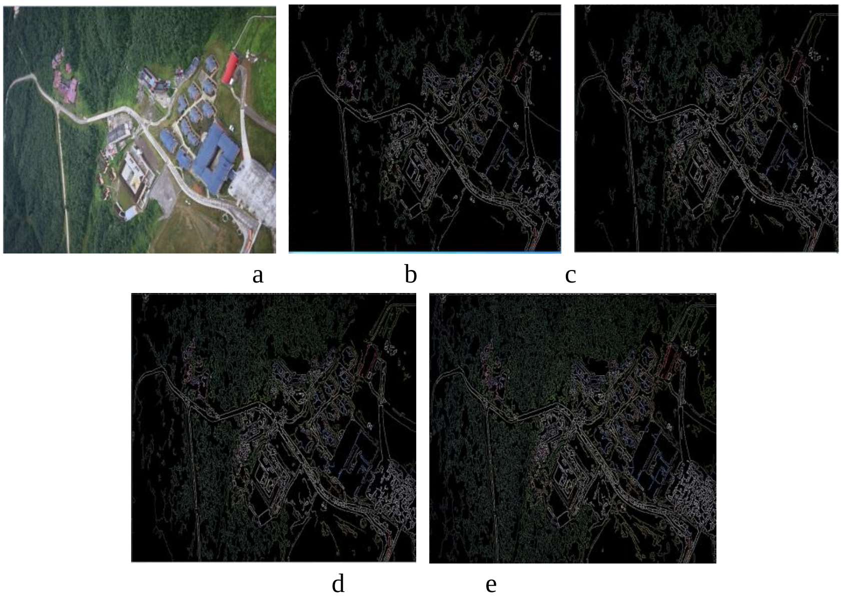

Fig 1: Performance evaluation: (a) "vegetation image" original image (b) " vegetation image " edge detection result with 500 bees (c) "vegetation image " edge detection result with 600 bees (d) " vegetation image " edge detection result with 800 bees (e) " vegetation image " edge detection result with 1000 bees

4.2 Color UAV image edge detection experiments for enhancing bee colony algorithm

In this experiment, use EABC algorithm, GABC algorithm and ABC algorithm to do edge detection for seaside landscape UAV image and Beijing Bird's Nest UAV image based on quaternion representation. Where the size of the seaside landscape image is 418 × 454, Beijing Bird's Nest image size is 728 × 705. The first part of this experiment is a subjective experimental part. The second part of this experiment is objective study from the edge detection of speed and quality, respectively.

In the subjective part of the experiment, three algorithms were conducted on the two images. Experiment for the seaside landscape image is shown in Figure 2, experiment for the Beijing Bird's Nest image is shown in Figure 3. It can be seen on the seaside landscape image, ABC algorithm for the color UAV image based on non-quaternion representation is the worst effect. On the left side of the image, there are many undetected and error detection points on coconut leaves. A portion of the edge for some swim rings is not detected. The edge of the conical roof has many breakpoints, the contour of a man carrying a backpack is obviously not continuous. Some people playing in the slightly distant seaside whose edges are quite vague. But ABC algorithm based on the color UAV image quaternion representation are significantly better results than ABC algorithm for the color UAV image based on non-quaternion representation, the main reason is using a quaternion vector to represent a color UAV image pixel vector. The three colors of each color pixel is involved throughout the experiment as a whole. Detected palm leaf edges are clearer than the ABC algorithm based on non-quaternion color UAV images, trunk contour is relatively intact, and increase the number of the detected swim rings, the edges of detected swim rings are also more, the breakpoints of the edges for each swim ring are less. Conical roof and people have a clear outline in the figure, when GABC algorithm is used in color UAV image edge detection based on quaternion, the effect is slightly better, but in general the progress is not obvious. The effect for the EABC algorithm used in quaternion-based color UAV image is the best, details of palm leaves are clearer, undetected points and error points are least, and all of the swim rings are detected, the edges of each swimming ring are relatively intact, the contour of the visitors and conical roof are the most clear.

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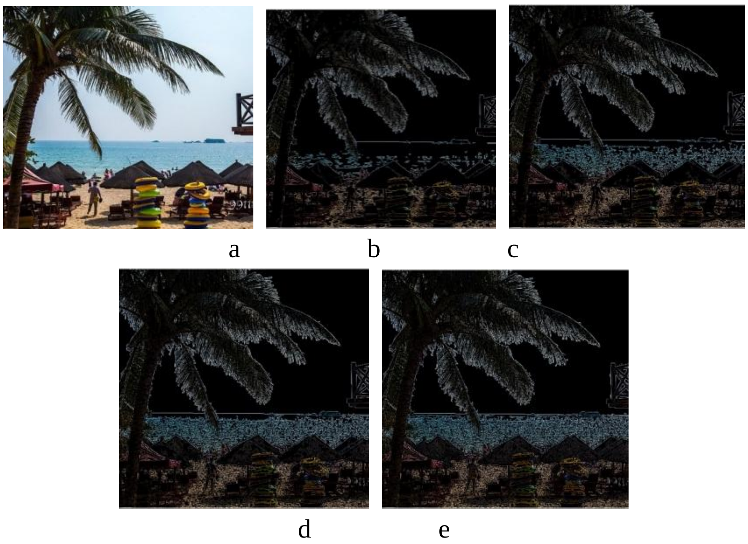

Fig 2: "Seaside" original image and the three algorithms results: (a) "seaside" original image (b) ABC of non-quaternion representation result image (c) ABC of quaternion representation result image (d) GABC of quaternion representation result image (e) EABC of quaternion representation result image

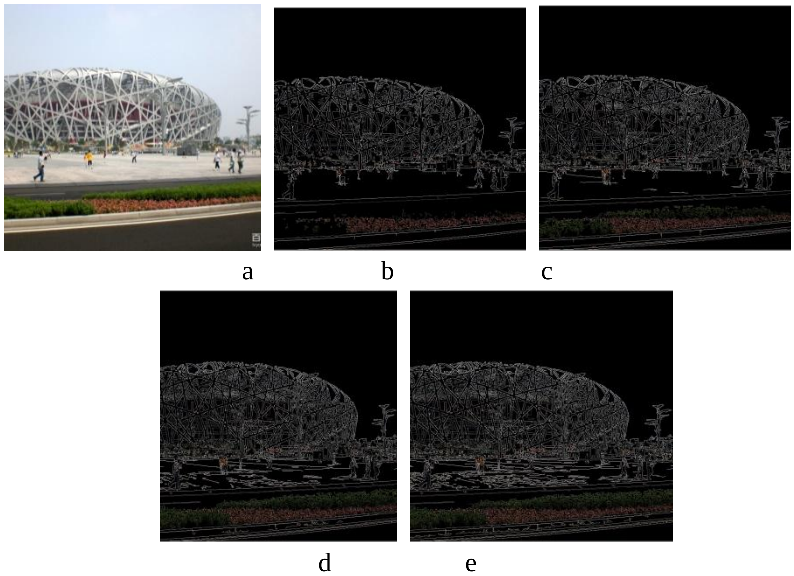

Fig 3: "The Bird's Nest" original image and the three algorithms results: (a) "the Bird's Nest" original image (b) ABC of non-quaternion representation result image (c) ABC of quaternion representation result image (d) GABC of quaternion representation result image (e) EABC of quaternion representation result image

The same can be seen in Figure 3, the worst effects is the ABC algorithm for color UAV images based on non-quaternion representation, edges of the flowers are discontinuous, there are clear break phenomenons in the edge of Beijing Bird's Nest image, and there are many breakpoints in the edges of visitors and lamppost on the square, and also there are some false edges, the pillar edges of Beijing Bird's Nest image have many discontinuous points. In particular, the edge of Sports Center inside the Beijing Bird's Nest can barely be detected. But ABC algorithm for the color UAV images based on quaternion representation is carried out on edge detection, the edges of flowers are relatively intact, breakpoints of edges of the square and tourists are relatively few, lamppost outline is relatively intact. Edges of the nest pillar basically be detected, and the missed points in nest edge lines are less, the outline of sports center inside the nest is basically can be seen, GABC algorithm for edge detection in color UAV images based on quaternion is slightly better results, but the effect is not obvious, but the effect for the proposed EABC algorithm based on quaternion color UAV image edge detection is best, the edges of the flowers are detected

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almost completely. The outlines of the visitors in the square, the square edges and contours of the lamppost are the clearest. Huge pillar edges and the edges of the nest are also completely detected, even edges of sports center inside the nest are also more clearly presented.

The objective part of the experiment, we test the three algorithms on the seaside landscape image and Beijing Bird's Nest Sports Center image. Use the time and quality of the image edge detection to evaluate the proposed algorithm.

In terms of time, the experiment image includes quaternion representation color UAV image and non-quaternion representation color UAV image, then test on the seaside landscape image and Beijing Bird's Nest Sports Center image by three algorithms, respectively. Each algorithm was run 30 times, respectively, the results are as follows:

Table 1 Comparison of time of the three algorithms for the seaside landscape image

Times	Quaternion representation			Non-quaternion representation
	EABC	GABC	ABC	ABC
1	56.49	73.96	75.12	140.35
2	53.23	71.40	73.24	138.98
3	52.94	71.90	74.40	141.09
4	54.85	70.35	76.29	142.75
5	55.27	73.36	73.45	138.76
6	54.45	72.06	74.41	140.29
7	55.26	71.12	73.29	139.87
8	54.16	72.45	74.16	142.43
9	54.26	71.12	73.15	139.97
10	53.78	72.50	71.26	140.26
11	54.87	72.51	75.38	139.26
12	52.26	71.24	74.45	140.88
13	55.98	72.30	73.42	139.26
14	53.03	73.12	74.91	141.35
15	53.56	72.30	73.29	142.35
16	54.55	71.13	73.90	140.23
17	55.98	72.30	74.43	139.25
18	54.24	73.13	76.88	138.92
19	55.98	72.43	74.38	135.39
20	53.25	73.40	74.45	135.05
21	55.60	72.12	73.34	136.28
22	57.01	73.30	74.12	135.18
23	56.97	72.12	74.30	133.20
24	55.48	71.45	75.21	139.27
25	55.44	72.02	74.18	141.28
26	54.01	73.33	75.50	136.28
27	55.20	74.23	74.12	140.29
28	56.03	73.25	75.12	139.76
29	55.35	70.92	74.55	140.23
30	55.79	71.95	76.04	137.29
mean	54.84	72.29	74.36	139.19

Table 2 Comparison of time of the three algorithms for Beijing Bird's Nest image

Times	Quaternion representation			Non-quaternion representation
	EABC	GABC	ABC	ABC
1	131.25	168.23	172.60	315.79
2	129.45	165.22	169.23	312.21
3	130.38	166.38	167.38	302.19
4	131.25	165.29	176.24	318.04
5	129.12	169.30	179.23	318.45
6	132.04	173.24	181.20	313.14
7	131.26	179.01	178.23	309.67
8	132.29	173.24	178.90	328.9
9	133.80	169.34	169.19	310.45
10	138.30	172.09	167.18	333.23
11	132.89	168.20	174.20	345.23
12	138.90	172.10	175.46	319.75
13	130.03	169.23	174.20	326.43
14	131.12	169.24	172.20	313.89
15	133.94	168.13	173.23	317.25
16	130.26	165.43	169.24	354.12
17	131.29	169.14	171.29	323.19
18	133.75	168.97	169.12	313.24
19	134.07	170.43	173.24	319.03
20	133.98	170.24	171.23	314.94
21	131.92	165.23	173.26	309.13
22	130.58	167.79	167.23	318.98
23	134.49	173.45	177.49	324.23
24	134.54	172.12	175.12	308.17
25	133.78	173.45	176.34	320.17
26	132.09	168.01	169.30	308.03
27	131.25	169.50	171.26	313.28
28	134.90	171.89	173.56	330.34
29	132.06	170.26	173.35	326.88
30	131.57	169.49	171.67	323.47
mean	132.55	169.79	173.05	319.73

From Table 1 and Table 2, it can be seen, for the image edge detection, the time of EABC algorithm based on quaternion color UAV image edge detection is the shortest, in other words, EABC algorithm is the fastest, when ABC Algorithms for non-quaternion color UAV image edge detection is performed whose time is the longest. From Table 1, the time of EABC algorithm based on quaternion color UAV image edge detection is 39.4% of ABC algorithm based on non-quaternion color UAV image edge detection, the time of GABC algorithm based on quaternion color UAV image edge detection is 52.3% of ABC algorithm based on non-quaternion color UAV image edge detection, the time of ABC algorithm based on quaternion color UAV image edge detection is 53.4% of ABC algorithm based on the non-quaternion color UAV image edge detection. Also be seen from Table 1, compared with the ABC algorithm, GABC algorithm is not significantly reduced time, from Table 2,the time of EABC algorithm based on quaternion color UAV image edge detection is 41.5% of ABC algorithm based on non-quaternion color UAV image edge detection. The time of GABC algorithm based on quaternion color UAV image edge detection is 53.1% of ABC algorithm based on the non-quaternion color UAV image edge detection. The time of ABC algorithm based on quaternion color UAV image edge detection is 54.1% of ABC algorithm based on the non-quaternion color UAV image edge detection. From comprehensive results in Table 1 and Table 2, the time for EABC algorithm based on quaternion color UAV image edge detection is probably about 40% of ABC algorithm based on the non-quaternion color UAV image edge detection.

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Table 3 Experimental data table for ABC algorithm based on non-quaternion representation

Image	Edge points (a)	4-connected number (b)	8-connected number (c)	C/a	C/b
Bird's Nest	133927	3817	2616	0.019533	0.685055
seaside	27879	798	526	0.018867	0.659148

Table 4 Experimental data table for ABC algorithm based on quaternion representation

Image	Edge points (a)	4-connected number (b)	8-connected number (c)	C/a	C/b
Bird's Nest	148346	4198	2703	0.018221	0.643878
seaside	29103	855	532	0.018280	0.622222

Table 5 Experimental data table for GABC algorithm based on quaternion representation

Image	Edge points (a)	4-connected number (b)	8-connected number (c)	C/a	C/b
Bird's Nest	154821	4457	2819	0.018208	0.632488
seaside	28645	849	527	0.018398	0.620730

Table 6 Experimental data table for EABC algorithm based on quaternion representation

Image	Edge points (a)	4-connected number (b)	8-connected number (c)	C/a	C/b
Bird's Nest	179746	4817	3015	0.016774	0.625252
seaside	34237	918	567	0.016561	0.617647

Quantitative analysis of the three algorithms in image edge detection are presented in Tables 3-6. According to the literature [31], A represents edge points detected by the three algorithms in the color UAV image, B indicates the number of four-connected pixels in the color UAV image, C indicates the number of eight-connected pixels in the color UAV image, and C / A, C / B indicate the degree of edge line connection detected in the color UAV image. If the edge line connection is better, indicates the effect of edge detection is better in the color UAV image, and wrong and missed the points are the fewer. Of course, if the detected edge line is incomplete, it means there is many wrong and missed points in the image edge detection, and may produce false edges. From the numerical point of view, if the C / A, C / B are smaller, then the edge line connection detected is better. For the C / A, C / B of the two numbers, C / B has a greater influence, C / B is smaller, indicates the edge line connection detected is better. As can be seen from Table 3 to Table 6, for the Bird’s Nest image, value of the C / A was reduced from 0.019533 to 0.016774, and value of the C / B is reduced from 0.685055 to 0.625252. That show regardless of the size of C / A or C / B in the three algorithms, EABC algorithm based on quaternion color UAV image edge detection is the best effect, ABC algorithm based on non-quaternion color UAV image edge detection is the worst effect. For the color UAV image edge detection based on quaternion representation, ABC algorithm is the worst effect, EABC algorithm is the best effect. From the numerical point of view, GABC algorithm is a little better than the ABC algorithm. For the seaside image, value of ABC algorithm based on non-quaternion color UAV image edge detection is highest in all C / A values, its value is 0.018867, the seaside image is different from the Bird’s Nest image, the value of C / A for ABC algorithm based on quaternion color UAV image edge detection is smaller than that for GABC algorithm. But that does not mean that ABC algorithm is better than GABC algorithm, for the C / A, C / B of these two numbers, C / B have a greater impact on the image edge detection results. As can be seen in Tables 3-6, C / B is maximum value in the color UAV image edge detection based on non-quaternion. For the color UAV image edge detection based on quaternion representation, corresponding C/B value for ABC algorithm is greater than GABC algorithm corresponding C/B value, GABC algorithm corresponding C/B value is greater than the corresponding C/B value of EABC algorithm, thus in the color UAV image edge detection based on quaternion representation, Although for C / A , ABC algorithm corresponding value is smaller than the corresponding value of GABC algorithm, but for C / B, ABC algorithm corresponding value is greater than the corresponding value of GABC algorithm, so from a comprehensive point of view, in color UAV image edge detection based on quaternion representation, GABC algorithm results are slightly better than the ABC algorithm results.

V. Conclusion

In this paper, use a pure quaternion to represent a color UAV image pixel. So that color pixels can be used as a whole to participate in various operations and changes for color UAV image processing. And the search equations of the bee colony algorithm were significant improvements. For employed bees and onlooker bees, in this paper, proposed the corresponding search equation, on this basis, enhancing artificial bee colony algorithm is proposed based on quaternion. In order to test the validity of the enhancing algorithm. For EABC algorithm, GABC algorithm and ABC algorithm, did three color UAV image edge detection experiments based on quaternion representation and one color UAV image edge detection experiment based on non-quaternion representation. Include testing the impact of different types of bees for color UAV image edge detection and subjective effects of the experiments evaluated, then the time were analyzed for each experimental run 30 times, and the color UAV image edge detection results are analyzed quantitatively. Experimental results show that the proposed algorithm has achieved the desired results in both subjective and objective aspect.

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