Improved 3D Reconstruction Algorithm based on Monocular Vision

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Abstract
Aiming at the problem of robustness of 3D reconstruction method based on monocular vision in the case of noise pollution, this paper presents a new method for 3D reconstruction based on SURF. Firstly, the edge detection algorithm based on filtering is used before image matching, then set up three-dimensional space coordinates, finally, the pixel coordinates are stored in the spatial database; reduction of 3D coordinates to realize three-dimensional image reconstruction. Simulation experiments show that this paper puts forward the improved 3D reconstruction algorithm based on monocular vision, while increasing the processing speed, the simulation has been improved by 34%, the 3D reconstruction effect is remarkable.

Key words: Monocular Vision; SURF algorithm; spatial database; 3D reconstruction

1. INTRODUCTION

In the field of VR, robot vision navigation and other fields, three dimensional reconstruction has important applications, which is an important research field of machine vision. The visual measurement is based on 3D reconstruction, accuracy and real time of vision measurement, it affects the accuracy and real-time of 3D reconstruction. Currently, vision measurement includes binocular vision, monocular vision and monocular vision with distance sensors. Binocular vision and monocular vision with distance sensor have the advantages of accurate, but the composition is more complex, the measurement process has the calibration, registration procedure and low real-time. The process of monocular vision measurement is simple, the sensing device only needs a single camera, so the real-time performance is high, but there is a problem that the measurement accuracy is low. In order to fully combined with the real-time measurement accuracy of binocular vision and monocular vision, improving the robustness of monocular vision, so as to improve the accuracy and real-time, there has been a lot of research on the technology of 3D reconstruction based on monocular vision. The 3D reconstruction based on monocular vision using single camera capture images, on the picture for calibration, the realization of 3D data acquisition by monocular vision, three-dimensional coordinate data to establish all the sights within the horizon, get the data through pixel spatial database, to realize the reconstruction of monocular vision based on the 3D coordinates of points.

At present, the technology of 3D reconstruction is achieved in two ways: the first is the technique of 3D reconstruction based on rotation, it uses a single camera to capture images at different angles, the 3D information of the object can be recovered by several sets of image information taken at different time or different angles, the 3D reconstruction based on translation and rotation is easy to analyze the influence of various parameters on the reconstruction results, low cost of rotating stereo vision, easy to acquire image sequences. Because of the 3D reconstruction of the rotation based on the calibration of the axis, the principle of the method is set to solve the rotation by only one point on the circular space, the precision is not high, lack of reliability in 3D reconstruction based on monocular vision; The second is the method of hierarchical reconstruction, projective reconstruction based on the pixels corresponding to the image, the projection matrix of monocular camera is calculated, radiation transformation for each pixel in the image, the known parameters into the absolute two curve equation, calculate the internal parameters of camera, then the 3D geometric structure of the image is restored according to the Euclidean reconstruction. The matching of feature points is not accurate in the presence of noise, the results of 3D reconstruction accuracy is low.

The establishment of 3D spatial database based on pixel coordinates is the core of 3D Reconstruction Technology. Since 1983, Martin and Aggrawal first proposed the method of reconstruction model based on object contour, since then, the image and image based on 3D reconstruction technology has gradually become one of the hot topics in the field of computer vision. In 1987, Potsmesil et al. proposed to construct 3D objects in the real world perspective projection view selected by arbitrary image shape. The information is based on object contour to achieve the transformation from 2D image to 3D real world, although some data information of 2D image always contains three-dimensional coordinates, the experiment can not be fully realized to extract 3D pixel information from 2D images reasonably, to realized 3D image reconstruction in the real world. In 2001 Ravi proposed a mapping model based on the amplitude of effective lighting environment, which is used as the
amplitude mapping model with Legendre polynomials moral principle, the principle of using human visual light to sense the light sensitivity of cells, by the principle of different frequency of light, to be arranged processing of different light for different order spherical model, in order to realize the estimation of illumination in different light conditions on the different order of light with different light intensity be arranged. Realization of 3D surface reconstruction of object surface texture based on consistency in natural light condition. In 2004, David Lowe made a further development and improvement of the SIFT operator which describes the local features, because the SIFT operator own good robustness, keep the image information at the same time in the maximum degree, the rotation and translation of image transformation can be achieved, have strong ability in image processing.

Although the former results have very strong image matching processing ability, can quickly realize the operation of the image, when the 3D spatial database is set up for different resolution images, the reconstruction algorithm exists the problem of poor simulation degree. In order to solve the 3D reconstruction problem of low degree simulation, in this paper, the processing flow of 3D reconstruction algorithm based on single purpose is redesigned, the RSURF algorithm is used to improve the accuracy of the data reconstruction algorithm based on single purpose 3D reconstruction, the simulation degree based on single purpose 3D reconstruction is improved.

2. IMPROVEMENT OF 3D RECONSTRUCTION ALGORITHM BASED ON MONOCULAR VISION

The core process of 3D reconstruction technology is divided into three steps: first, a single image is obtained by a monocular camera, calibrate the camera’s internal and external parameters, calculate the distance and pixel coordinates of the target object projection distance of monocular camera; then use ray casting algorithm for single image reverse processing process, then the 3D pixel spatial database is established; Finally, the fusion of spatial pixel data is processed, while improving the level of simulation, realization of 3D object reconstruction based on monocular visual. During the whole process, the establishment of 3D pixel spatial database and 3D reconstruction after the simulation degree of object is the core. The method of 3D reconstruction method mainly includes the typical stereo vision method and hierarchical 3D reconstruction. Therefore, the method of 3D space pixel database will directly affect the quality and speed of 3D reconstruction, Improved RSURF algorithm based on SURF, can improve the quality and speed of 3D reconstruction, to achieve the maximum simulation based on monocular vision in 3D reconstruction, the algorithm of 3D reconstruction is improved, in order to improve the effect of 3D reconstruction.

2.1 The original 3D reconstruction principle of SURF operator

Speeded Up Robust Feature algorithm use of Hession matrix proposed by Bay H et al as its core, in the SURF algorithm, the pixel coordinates of the image are used instead of the function values of the mathematical functions, we use the two order standard Gauss function as image filter, the two order partial derivative is calculated by a certain convolution function, the three matrix elements in matrix function can be calculated by convolution integral function. The image is stored in a computer in a digital form of a two-dimensional array, each pixel in the matrix represents the gray value of the current image, the value of each pixel in the image coordinate system is determined by the unique coordinates (x, y) in the image coordinate system.

![Figure 1. Image coordinate system](image)

The Hessian matrix is a matrix composed of two partial derivatives of a multivariate function, used to describe the local curvature of a function, is the core of SURF algorithm, a real valued function consisting of two order partial derivatives of vector, the key points in the image can be extracted, the specific formula as shown in (1):
\[ H(f(x,y)) = \begin{pmatrix} \frac{\partial^2 f}{\partial x^2} & \frac{\partial^2 f}{\partial x \partial y} \\ \frac{\partial^2 f}{\partial x \partial y} & \frac{\partial^2 f}{\partial y^2} \end{pmatrix} \quad (1) \]

In order to improve the speed of feature points detection, reduce time complexity, the SURF operator is used for 3D reconstruction using Gauss filter function, after filtering the Hessian matrix as shown in formula (2):

\[ H(x,\delta) = \begin{pmatrix} L_{xx}(x,\delta) & L_{xy}(x,\delta) \\ L_{xy}(x,\delta) & L_{yy}(x,\delta) \end{pmatrix} \quad (2) \]

Among them \( \delta \) as the space scale factor.

According to the image of the Pyramid structure, each layer in the image is detected by extreme value, by using the integral calculation of the feature points in the image, you can get the formula \( a_{k+1}^j \), the formula is shown in (3):

\[ a_{k+1}^j = \frac{\sum_{i\geq 2}^m (x_i^j / T_i)^T x_i^j R_{x_i^j}}{\sum_{i\geq 2}^m \|x_i^j / T_i\|}, \quad j = 1, 2, \ldots, n \quad (3) \]

For the regularization of \( a_{k+1}^j \), calculate the X coordinates of every point of the image, using similar methods can calculate the coordinates of each image corresponding to Y, Z.

In general, the 3D reconstruction based on SURF algorithm is an efficient algorithm for 3D reconstruction, the advantage of this algorithm is mainly in:

1) SURF has good robustness with position invariance and scale invariance well under certain illumination conditions, can search for the key point of potential.

2) The search of the key points, we can realize the orientation invariance and ensure the invariance of the similarity transformation.

3) The 3D reconstruction process, the algorithm is stable, low redundancy.

At the same time, although the local SURF using Hessian matrix images obtained maximum effect is stable, the process of solving the main direction is dependent on the pixel gradient of the local region, there are some deviations in the search for the main direction, small number of pixel spatial information, the spatial orientation is not accurate, influence the effect of 3D reconstruction, the algorithm runs slowly, unable to meet the requirements of real-time 3D reconstruction.

2.2 improvement of 3D reconstruction algorithm based on SURF

According to the need to get the camera matrix in the 3D reconstruction repeatedly, the external parameters of the 3D reconstruction based on high coupling degree, the repeated computation reduces the efficiency of the algorithm, the following three improvements are made for the SURF 3D reconstruction algorithm.

2.2.1 Improved camera external parameters matrix calculation

This paper presents a DLT algorithm based on normalized transformation, after the experiment, it proved that the algorithm has some advantages, this paper draws on the advantages of its improvement, on this basis, the algorithm is further modified and studied. The normalized DLT algorithm is carried out by the following steps.

1) In order to make the pixel coordinate point at the origin, translate the pixel coordinates in the image.

2) Before the image is scaled to denoise, remove redundant salt and pepper noise and other factors, scale the image so that they meet the distance to \( \sqrt{n} \), in the 2D image point coordinate \( n=2 \), in the 3D image point coordinate \( n=3 \).

3) The pixel coordinates of the 2D image and the pixel coordinates of the 3D image are processed independently, this transformation is based on the formula (4):
On the basis of a solution obtained by linear DLT algorithm $P$, to meet the $\| P \| = 1$.

Set $P = T^T P U$, $R_t = A / P$. $A$ is the intrinsic matrix, $R$ is a subset of the rotation matrix $R_t$, the use of SVD matrix to get $R = WDV^T$, $R$ satisfies the orthogonality constraint.

The above method can be used to solve the external parameters of the camera. However, there is a large linear error in the linear solution, the DLT algorithm shows some limitations. Therefore, in order to prevent the local minimum value has been improved, using a nonlinear method -- genetic algorithm, genetic algorithm can effectively avoid the phenomenon of local minima, the general form of nonlinear equations for real functions can be expressed as shown in formula (5):

$$
\begin{align*}
    f_1(x_1, x_2, \ldots, x_n) &= 0 \\
    f_2(x_1, x_2, \ldots, x_n) &= 0 \\
    \cdots \\
    f_m(x_1, x_2, \ldots, x_n) &= 0
\end{align*}
$$

A formula with $n$ variables $X = [x_1, x_2, x_3, \ldots, x_n]$ and $M$ equation, which satisfies the equation is solvable. In the process of solving the equation can be equivalent to the equation (5) to obtain the minimum value of the process, the equivalent conversion equation for the minimum value is shown in equation (6):

$$
\begin{align*}
    \text{find} & : X = [x_1, x_2, \ldots, x_n] \\
    \text{min} & : f(X) = \sum_{i=1}^{n} f_i^2(x)
\end{align*}
$$

Because the genetic algorithm has its unique attribute standard, in this paper, a dynamic adaptive function is used to limit the fitness of Goldberg genetic algorithm, the function satisfies the numerical value and the probability function of each individual unit is positively related to the next generation, the adaptive degree function (7) is as follows:

$$
\begin{align*}
    f(X_j) &= \sum_{i=1}^{m} |f_i(X_j)| \\
    E(X_j) &= \exp \{-f(X_j)\}
\end{align*}
$$

In the upper form, $X_j$ representing the $j$ individual in the population, $E(X_j)$ indicates the fitness of the corresponding $j$ individual.

In this paper, an improved genetic algorithm based on dynamic adaptive function with good robustness, can be achieved on the camera external parameters matrix solution, through the solution of the camera parameter matrix, it can improve the accuracy of monocular vision 3D reconstruction to the greatest extent.

**2.2.2 Improvement of image pixel coordinate extraction operator**

In order to improve the accuracy of 3D reconstruction, in this experiment, the single camera images are pretreated to extract pixel information. First, Sobel operator is used to suppress the image noise, the magnitude of Sobel operator for image edge processing in different directions, through the calculation of the weighted average, at the same time to improve the detection accuracy, be able to get a clearer edge profile, improving the stability and reliability of image pixel information acquisition, through the experimental comparison of the improved image processing effect, as shown in Figure 2 and figure 3.
2.2.3 The establishment of 3D spatial database based on point cloud

Using the RSURF operator in this paper to extract the feature points of two dimensional image, through the 2D feature information into 3D space points, the 2D pixel coordinates are transformed into the spatial pixel information in the 3D coordinate system, the conversion of 3D coordinates of points stored in the 3D space coordinate system, so that you can establish a correspondence between the spatial pixel coordinates of pixels in 2D images and 3D spatial coordinates. Three dimensional spatial pixel information is stored in the space coordinate system in the form of data coordinates, furthermore, the process of establishing the spatial database is realized.

2.3 The reconstruction of image

The improvement algorithm based on SURF, after the image feature points extraction, feature points matching, solution of camera parameter matrix to realize the reconstruction of 2D objects to 3D coordinates finally. After the simulation experiment, we use the following method to realize the reconstruction of 3D pixel coordinates from 3D space.

2.3.1. 3D image preprocessing

In order to realize the reconstruction of 3D objects using 3D spatial database, in the spatial pixel coordinate system, a three-dimensional space in the pixel coordinates of points corresponding to only one of the feature points in the 2D image, based on the correspondence between the pixel coordinates, the feature points and the camera matrix, as shown in formula (8):

\[ X^{(k)} \leftrightarrow (x_1, x_2, ..., x_m) \leftrightarrow (P_1, P_2, ..., P_m) \]  

(8)

The feature points in each image can be obtained by two coordinate equations in the 3D coordinate system, the matrix equation A can be obtained by formula (8), the matrix equation as shown in formula (9):

\[
\begin{pmatrix}
P_{11}u_1 - P_{11} \\
P_{11}v_1 - P_{11} \\
P_{21}u_1 - P_{21} \\
P_{21}v_1 - P_{21} \\
\vdots \\
P_{mm}u_1 - P_{mm} \\
P_{mm}v_1 - P_{mm}
\end{pmatrix} \begin{pmatrix}
x_1 \\
x_2 \\
\vdots \\
x_m
\end{pmatrix} = 0
\]

(9)

In order to get the optimal solution, using the singular value decomposition in linear transformation to solve the matrix equation. In the process of solving the three-dimensional coordinates, the formula (10) is used to optimize the adjustment, to ensure the accuracy of the reconstruction results. The representation of the formula (10) is as follows:

\[ \sum_{i,j} \text{dis}(x'_i, P'X_j) \]  

(10)
2.3.2 3D image matching

After the RSURF algorithm in this paper to remove the points that do not meet the requirements, get the key points in the image, the basis matrix F is calculated according to the threshold, for any two points in a 2D space in the real plane coordinates of the pixel coordinates (x, y) and (x', y'), the polar line in the image plane can be solved.

Set the pixel coordinates (U, V) in any imaging plane, P=(U, V, 1) is the homogeneous coordinates of the spatial points in the physical imaging plane, inverse (K) *p=u, u=(x/z, y/z, 1) is the homogeneous coordinates in normalized image plane, according to the coordinates of u and P, the projection matrix of each normalized image plane in the image, constructing linear equations: \( \lambda \cdot u = px \) and \( \lambda \cdot u = px' \), X=(x, y, z) is obtained by solving the equations. The coordinates of the three vectors are saved to the corresponding point cloud coordinate system, the pixel coordinates (X, Y, Z) are stored in the three-dimensional coordinate system to draw the pixel coordinates in the three-dimensional coordinate system.

2.4 Algorithm description

The algorithm flow is described as follows:

Begin

Initialize the algorithm variables in the calculation, self calibration of camera parameters, the realization of the image sample collection, gray-scale image binarization processing to get image;

In this experiment, we use the corresponding algorithm to preprocess the image, to better meet the experimental requirements;

In this paper, the RSURF algorithm is used to process the image, get the image pixel coordinates (x, y) and the corresponding numerical pixel information;

The conversion formula of 2D coordinates to 3D space coordinates, The realization of 2d image coordinates to 3D mapping, the 3D coordinates of points stored in the pixel database;

Three dimensional pixel space data based on point cloud, extraction of the pixel values in the 3D coordinate system, in the corresponding 3D coordinate system to achieve data graphics;

All the pixels in the 3D database are all traversed, restore all points in 3D mode, refresh the 3D coordinate system obtained simulation results after reconstruction;

End

For number of spatial points do

Threshold limit on the number of spatial points;

If the space point value satisfies the threshold break;

Else remove the point from the 3D spatial database;

End

Using the pseudo code fragment, can realize the 3D reconstruction based on monocular image, by acquiring the feature points, the corner detection, optimize the original test algorithm, to achieve the largest possible three-dimensional reconstruction of monocular images;

3D reconstruction of spatial data in a well processed 3D point, optimization of 2D image to 3D image reconstruction, to achieve reconstruction in the spatial coordinate system;

End

3. SIMULATION EXPERIMENT AND ANALYSIS

In the course of this experiment, using Windows 7 computer operating system as platform, the verification and simulation of the experiment are carried out on the MATLAB R2015b platform, the main hardware of the experimental computer is configured as Intel i5 CPU Core 2.80GHz, the memory is 8.00GB, hard disk storage capacity of 1TB.

3.1 Improved operator performance experiment of RSURF algorithm

The need for experimental purposes, on the basis of increasing test reliability, all the experiments were carried out with the same monocular camera, as shown in Figure 4, figure 5:
Figure 4. image with noise after camera shooting

The matrix form of the image data information is represented in the form shown in the following Table, the values represent the coordinates of the pixels, the data matrix is shown as follows:

<table>
<thead>
<tr>
<th>pixel value matrix</th>
<th>1.03</th>
<th>0.74</th>
<th>0.02</th>
<th>0.51</th>
<th>1.31</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.23</td>
<td>1.61</td>
<td>0.02</td>
<td>0.88</td>
<td>2.39</td>
</tr>
<tr>
<td></td>
<td>0.09</td>
<td>0.69</td>
<td>0.12</td>
<td>0.72</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>2.02</td>
<td>1.62</td>
<td>0.35</td>
<td>1.67</td>
<td>2.46</td>
</tr>
</tbody>
</table>

Table 1. test results of data matrix

Obtained by singular value decomposition \( \sigma_1 = 6.04, \sigma_2 = 0.22 \), after comparison, \( \sigma_1 \) is much larger than of \( \sigma_2 \), the data contained noise, remove the dependence and redundant information of data, retain the main data.

Figure 5. contrast image before and after noise reduction

Comparison of image noise reduction based on image processing, as shown in Figure 6:

Figure 6. contrast image before and after noise reduction

After preprocessing of image information, to preserve the most valuable information in the image, remove the redundant information, the amount of data has been reduced, at a certain extent, it has some significance for the subsequent processing of the image, the following table shows the improved RSURF operator, the original and not improved SURF corner detection algorithm to feature point map.

<table>
<thead>
<tr>
<th>Table 2 the effect of different operators in the image detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>operator</td>
</tr>
<tr>
<td>accurate point</td>
</tr>
</tbody>
</table>
Matrix table for the use of SURF operator, to eliminate redundant points of the original image data and the establishment of coordinate system of coordinate, figure 6 corresponds to the class of calibration plate image, the latter is the use of RSURF operator in this paper, the coordinate system is set up to eliminate redundant coordinates and redundant data, in Figure 5, it can be found that the coordinate matrix after the RSURF operator can be fitted to a straight line, meet the expected test expectations.

From table 2 can be obtained that, the improved RSURF operator is much higher than the previous SURF in the same experimental conditions, meanwhile, because of useless points in the image, to eliminate redundant points in advance, the running time can be shortened to a great extent, on the premise of preserving the essential information of image, processing of noise, by the simulation experiment in the laboratory, the improved RSURF algorithm is used to preprocess the image, it can lay a good foundation for subsequent 3D reconstruction.

### 3.2 Improved process performance experiment in RSURF algorithm

In order to improve the experimental results, for the improved RSURF operator, with the original SURF operator on the same gray processing to remove the noise after the image corner detection, in the case of maintaining the same image resolution, the experimental results are obtained as follows:

| false point | 374 | 80 |
| exact ratio | 89.53% | 98.89% |
| run time | 165 | 69 |

**Figure 7.** detection of the original experimental corner

**Figure 8.** experimental corner detection

| Table 3 Comparison data between improved RSURF and improved SURF algorithm |
|---|---|---|---|
| operator | SURF algorithm | improved | RSURF algorithm | improved |
| accurate point | 728 | 714 |
| false corner | 94 | 31 |
| precision | 91.526% | 97.731% |
| run time | 1.791 | 0.835 |

Figure 7 and figure 8 are the same picture taken by the same camera, image for the same parameter, based on the detection of the number of corner points in the image contrast can be seen, the original RSURF operator detects as many information points as possible, the detection of key points in the image is accurate. Compared figure 7 and figure 8, although some points in the image have not been detected, the detected points can meet the need of 3D image reconstruction in some extent.

As can be seen from the data in Table 3, although the RSURF operator in the detection of the image to a certain extent of the decline, the final accuracy of the value does not decline, this makes the effective
information in the image are preserved to the maximum extent, it can be known from the ratio of the running time, the running time of the improved algorithm is improved by about 34%; at the same condition, the running time of the algorithm has been improved.

For the two value images contain more obvious noise, under certain circumstances, the camera is easily affected by the external uncertainty, white noise is relatively more, when the original filtering method is used to remove the image noise, can not achieve the desired effect, in some cases the noise may be preserved as an effective information in the image, in the morphology of the image using open operation, etching the image, can effectively remove the image of the white noise, this experiment not only can maintain the original information of the image gray value, it’s possible to maintain the relative stability of the larger bright color regions, suitable for image preprocessing, image corrosion as shown in Figure 9:

![Figure 9. Original image after corrosion](image)

Through theoretical analysis, SURF operator without image preprocessing, the number of image points detected on a stroke, but if the image of each pixel detection time is t, the detection end for all the number of points for nt, for the same image using the improved operator for processing, in the case of reducing the number of detection points, the time used will be significantly reduced, set the detection time is nt, at this time n<m, based on the RSURF operator, while ensuring the subsequent 3D reconstruction of pixel information, can reduce running time, so the running speed is improved, the total running time consumption is reduced.

The use of 3D reconstruction method based on space coordinates by transforming the two-dimensional space to three-dimensional coordinates of pixels in spatial database, finally, the 3D reconstruction of the image is realized by using the coordinates of pixels in the spatial database, through the simulation of image reconstruction simulation experiment, it can be seen from Figure 10, the effect of reconstruction can be in a certain extent with the original image, it can shows some of the basic image features of the original image.

![Figure 10. Three-dimensional reconstruction of the original image renderings](image)

### 3.3 Experimental comparison of different resolution image reconstruction

In order to verify the practical performance of the improved algorithm, different resolution images are selected to reconstruct the 3D image based on the algorithm. In this paper, the time consumed by 3D reconstruction and the matching efficiency under the same reconstruction effect are analyzed, specific results are shown in table 4:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Resolution 1</th>
<th>Resolution 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1024x768 ms</td>
<td>1024x1280 ms</td>
</tr>
<tr>
<td>SURF</td>
<td>82.72 s</td>
<td>91.2 s</td>
</tr>
<tr>
<td>RSURF</td>
<td>56.60 s</td>
<td>95.8 s</td>
</tr>
</tbody>
</table>

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As can be seen from table 4, the image size of 1024 x 768 and 1024 x 1280, this algorithm is used to reconstruct the time compared to the case of minimum; Under the same resolution image, the improved efficiency of the algorithm is also improved, although the number of detection points is reduced, there is no effect on the reconstruction process, within a certain threshold, can achieve relatively ideal reconstruction effect.

Based on the experiments in this paper, it can be seen that this method has some advantages, it also shows that the improvement of this paper has certain practical value and practical significance.

3. CONCLUSIONS

This article starts with the use of SURF operator, introducing the RSURF operator defined by the author to the original SURF algorithm, to achieve the fast image reconstruction, and to improve the 3D effect after reconstruction, to a great extent, the effect of 3D reconstruction is improved. From the combination of theory and practice, the RSURF algorithm overcomes the shortcomings of the SURF algorithm for the slow reconstruction speed and the reconstruction effect is not realistic, compared with the previous 3D reconstruction algorithm based on the original SURF, at the same time improve the reconstruction effect, algorithm running time is relatively reduced, the 3D reconstruction effect can be obtained with high quality, meet the requirements of 3D reconstruction, has a good practical effect.

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