Three-Dimensional Pose Parameters Measurement of Air Target

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Abstract. In view of the present in aerospace measurement and control range, air vehicle in the field of Three-dimensional pose measurement problem, this system on the basis of inheriting the existing successful experience, using the theory of digital photogrammetry closely and the forefront of the computer vision result, proposed by sequence images of photoelectric theodolite film determines the attitude of the spacecraft three dimensional space plan, will change ever flight target as a particle processing, unable to get the current situation of the flight target Three-dimensional pose parameters, make full use of the measuring position and shape of image information, through the establishment of theodolite camera imaging simulation system, to predict the position of aircraft targets.

1. Introduction
At present, the frontier of computer vision and photogrammetry is using the sequence images to measure the motion position of flying objects with high accuracy. If the image of the target is captured, the three dimensional trajectory and the three-dimensional attitude of the target can be obtained by the principle of photogrammetry and image processing. But in aerospace measurement and control range, many optical instrument has the advantages of real-time, intuitive and precise, the precision is an order of magnitude higher than the radio tracking device, therefore it has an irreplaceable position in the measurement and control system. With the increasing demand of military application of modern range control, it is possible to measure the 3D attitude parameters of aircraft by using optical image. In this system, the sequence image is introduced into the 3D attitude measurement of the flying target, and through the establishment of the theodolite camera imaging system, the attitude of the aircraft is predicted.

2. Image Preprocessing, Edge Detection and Target Recognition of the Target
In order to highlight the characteristics of the aircraft structure under the sky background, the system of vehicle image enhancement filter and image preprocessing method, using the effective edge extraction vehicle detection method of gray system theory based on the edge, on the basis of gray reconstruction theory to identify the target\cite{1}, and then detect the vehicle centroid and feature point using corner detection method, and then prepare for the next step of aircraft attitude simulation.

2.1. Aircraft Target Image Preprocessing
In order to improve the vehicle's ability to identify, extract feature information to enhance the accuracy of aircraft, before the realization of image edge and corner extraction, to filter the aircraft image, while
maintaining the target structure at the same time, noise removal, image enhancement processing feature information.

2.1.1 Aircraft target filtering
The system uses the median filter and the SUSAN filter algorithm to filter the rocket under the sky background, and compares the results of the median filter algorithm and the SUSAN filter algorithm in the experimental process.

Through the experiment, it can be seen from Figure 1, the SUSAN filtering algorithm in image noise filtering preserves fine features image structure, and can improve the quality of image sharpening and vehicle feature structure, while the structural characteristics of the image after median filtering is not clear, small structural features are little vague[2], so that the effect of SUSAN filtering algorithm is better than the median filtering algorithm. so the system uses SUSAN filtering algorithm.

2.1.2 Enhancement of aircraft target
In order to better identify the target area, the system uses the gray window transform to enhance the aircraft target. The target and the background are well separated by the gray window transformation, and the cloud layer is suppressed at the same time, but the plane target and background is not completely separated under sky background, further to do edge extraction.

2.2. Aircraft Target Edge Extraction
The edge detection of the aircraft is very important for the subsequent image processing and attitude analysis, effective extraction of the aircraft's edge can distinguish the target from the background. The image edge detection algorithm based on gray system theory is adopted. This algorithm not only can detect the useful edge information more accurately, but also can improve the anti noise ability of the system, moreover, the edge information can be controlled by adjusting the threshold.

Figure 2 shows the results of using the gray system theory to extract the plane, the missile and the missile edge in the sky background.

![Figure 1. Results of the rocket image filtering](image1)

(a) arrow body image  (b) median filtering  (c) SUSAN filtering

![Figure 2. Edge extraction results of gray system theory](image2)

(a) the arrow body image after SUSAN filter  (b) edge extraction of gray system theory

The system uses the gray system theory to extract the edge information of the aircraft effectively, and prepares for the next step by using the mathematical morphology method to realize the target recognition.
2.3. Aircraft Target Recognition Based on Gray Level Reconstruction Algorithm

In order to better identify the aircraft, the system inhibit the sky background to the image edge after extraction, the effective area of the aircraft is reconstructed by using the gray reconstruction algorithm and the conditional expansion[3], identify the aircraft targets effectively at the same time, the edge of the cloud can be effectively suppressed, the target area is preserved.

Through the experiment, Figure3 shows the recognition results of the arrow in the sky background. Identification of the aircraft target for the next step of the centroid and the angle of the aircraft extraction is ready.

![Edge extraction results of gray system theory](image1)
![The result of target recognition](image2)

Figure 3. Aircraft target recognition

3. Aircraft Imaging Simulation

The system uses laser triangulation principle to obtain three-dimensional coordinates of space point cloud body, and filtering, smoothing, compression and denoising the point cloud data, the Delaunay triangulation is realized, reconstructed three-dimensional image body by using triangular mesh reconstruction technology. Then, the method of quantitative control of the OpenGL perspective imaging process is analyzed by using the method of photogrammetry, and the attitude of aircraft image sequence is simulated by OpenGL.

3.1. Picking Up 3D Coordinates of Aircraft

Because the aircraft is a rigid body, and is an axis symmetric figure, the point cloud data of the aircraft can be obtained by using the range of triangle technique[4]. In order to obtain the shape information of the object accurately, the measurement point cloud has the characteristics of mass and disorder.

3.2. Data Processing of the Point Cloud

Point cloud data processing mainly includes point cloud data preprocessing, triangulation and 3D reconstruction technology.

The point cloud data processing method is used to segment the point cloud data, and the model of OpenGL is used to deal with the data, then the rocket reconstructed model of the Figure4 is obtained.

![The reconstructed rocket model](image3)

Figure 4. The reconstructed rocket model

3.3. Simulation of Sequence Image Vehicle

In order to improve the image sequence for aircraft attitude accuracy, according to the imaging mechanism of OpenGL, because the imaging process of OpenGL is consistent with the imaging process of digital photogrammetry, using three-dimensional solid rocket which reconstructed by point
cloud data, in VC++ platform, the 3D modeling software is used to build the model of aircraft by using the OpenGL graphical programming technology, and simulation of the vehicle is realized.

4. Experimental Results
A rocket attitude $\phi=45^\circ$, $\omega=30^\circ$, $\kappa=50^\circ$ and fixed, in the 3.5 km and 6 km distance, the deviation between the simulation values and the measured values is obtained, using the generalized point image matching algorithm based on least squares, according to the error correction model to correct the attitude of the rocket, the simulation parameters of photoelectric theodolite are shown in Table 1, obtained by the experiment of rocket attitude simulation values and measured values are shown in Table 2, gesture image is shown in Figure 5.

| Table 1. Parameters of analog photoelectric theodolite |
|--------------------------------------------------------|
| **Focal distance of photoelectric theodolite** | **Principal point of photograph eccentricity** | **The pitch angle, yaw angle and roll angle of the rocket** | **Exterior orientation element** | **Pixel size of imaging element** |
| 1000mm | (0.00mm, 0.00mm) | (45°, 30°, 50°) | (0.00mm, 0.00mm, 0.00mm) | 0.011mm |

| Table 2. Simulation values and measured values of the rocket attitude |
|--------------------------------------------------------|
| **Position(m) measured value** | **Position(m) analog value** | **Position(m) measured value analog value** |
| **distance** | **$Y$** | **$Y$** | **$Z$** | **$\phi$** | **$\omega$** | **$\kappa$** | **$\phi$** | **$\omega$** | **$\kappa$** |
| 3500 | -958.56 | 2698.62 | 681.51 | 29.9109 | 44.1964 | 49.6378 | 0.0891 | 0.8036 | 0.3622 |
| 6000 | 436.58 | -2512.97 | 4413.17 | 30.9253 | 44.7425 | 49.5587 | -0.9253 | 0.2575 | 0.4413 |

(a) The attitude image of the rocket with a distance of 3.5 km 
(b) The attitude image of the rocket with a distance of 6 km

**Figure 5.** Different distance images of pose $\left(45^\circ, 30^\circ, 50^\circ\right)$

5. Conclusion
Based on summarizing and inheriting existing successful experience, lead the sequence image into the measurement of three dimensional attitude of flying target in the system, through the establishment of theodolite camera imaging simulation system, the attitude prediction of aircraft target is realized. The system not only retains the advantages of the existing methods, but also overcomes the shortcomings of traditional methods, which has high practical value and practical significance.
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7. Reference
[1] Zhao qiang, “The analysis of the influence of photoelectric theodolite focusing line difference on the total error of angle measurement”. Opto electronic information. 2011-12
[2] Guo yu, “Attitude angle measurement technology based on monocular vision”. Changsha, National University of defense technology. 2010- p27-28
[3] Shi huiping, Geng Guohua, “Image enhancement based on fuzzy set”. Micro computer information. 2008-24
[4] He xiaoj, “Research on flight conflict detection and resolution algorithm based on dynamic speed regulation”. Chengdu, Sichuan Normal University. 2010-p46-47