Extraction of centerline of large-format laser stripes against ambient light interference

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Abstract. In order to carry out real-time 3D reconstruction of large components in the outdoor environment, this paper proposes a laser stripe centerline extraction algorithm that is resistant to ambient light interference. The median filter is used to preprocess the laser stripe to be extracted, and the Rosenfeld thinning and least square fitting algorithm are organically combined to extract the centerline of the laser stripe. Experimental results show that this method can effectively avoid strong light interference and accurately obtain the centerline of the laser stripe to be extracted.

1. Introduction

With the emergence and development of laser three-dimensional scanning technology, it has been widely used in many fields by virtue of the rapidity of scanning, the accuracy of detection, and the non-contact measurement method.

The main processing location for the 3D reconstruction of large components is outdoors. Therefore, the extraction of the centerline of the laser stripe is the first step of 3D scanning. The accuracy and speed of the extraction algorithm and the ability to resist ambient light interference have a huge impact on the final reconstruction result. There are many effective methods for extracting the centerline of the laser fringe as shown in Fig.1[1].
Aiming at the real-time 3D reconstruction of large components, the method of combining skeletonization and least square method is used to extract the center line of laser stripes. At the same time, a method of extracting a region of interest that can effectively eliminate ambient light is proposed. This research uses VS C++ and OpenCV programming to improve the accuracy and speed of extraction.

2. Algorithm Description
Comparing the extraction effects of several commonly used laser stripe centerline extraction algorithms, it is found that the least square method based on punctuation can quickly and accurately obtain the laser stripe centerline [2]. However, the process of extracting fitting points in the image is quite time-consuming, so it is necessary to refine the light strip before using the least square method to fit the centerline. In this way, the laser stripe skeleton of single connected pixels is obtained, and the coordinates of the points on the skeleton are obtained through traversal, which greatly reduces the time for the least squares fitting process [3-4].

Therefore, this paper proposes an anti-ambient light interference algorithm to extract the centerline of the laser stripe. The processing process of the extraction algorithm is shown in Fig.2:
3. Image Processing

3.1. Median filter
Compared with other filtering algorithms, median filtering can well protect edges while effectively removing burrs during the skeletonization process [5-6]. Therefore, the median filter algorithm is used for image preprocessing in the research process.

3.2. Morphological thinning
Use fire burning to simulate the process of image refinement, that is, when the edges of the graphics are ignited at the same time, the speed of the fire spreading inward of any edge is set to be consistent, then when the flame of one edge meets the flame from another the flame on the edge, the position where the flame goes out is where the skeleton of the figure is located. The method adopted in this paper is Rosenfeld's algorithm, which is different from other algorithms in that Rosenfeld's algorithm is a parallel refinement algorithm, which greatly reduces the running time [7].

Expressed by the eight-neighborhood method shown in Fig.3, Rosenfeld's algorithm can be understood as the foreground pixel point $p_1$, if $p_2 = 0$, then $p_1$ is called the northern boundary point. Similarly, when $p_6 = 0$, then $p_1$ is called the southern boundary point; $p_4 = 0$, then $p_1$ is called the eastern boundary point; $p_8 = 0$, then $p_1$ is called the western boundary point [8].

![Fig.3 Eight-neighborhood representation](image)

The refinement condition of Rosenfeld's algorithm is described as:

Traverse all the pixels. If the current pixel is the northern boundary point, the southern boundary point, the eastern boundary point, or the western boundary point, except the isolated point and the endpoint, and if the pixel is set to 0, the connectivity of the surrounding 8 pixels will not be changed, then the pixel will be deleted.

After performing the above steps, an iteration is completed, and the iteration process is repeated until there is no point in the image that can be deleted, and the iteration loop is exited. Finally, all the light bar skeletons in the image are obtained.

3.3. Extract ROI
The obtained skeleton image is traversed to find the pixel coordinates of the first white point in the image, and then the two-way traversal method is used to extend from this point to find the existing light strip curve. Use the random color operator to randomly paint the found light strip curve, and then the laser stripe can be obtained by color selection with a certain threshold, which can accurately extract the region of interest and eliminate the interference of ambient light on the extraction of the laser stripe centerline.

3.4. Least Squares Method to Fit the Centerline
The laser stripe skeleton obtained by the Rosenfeld algorithm has a large number of burrs due to the influence of the ambient light, and even the curve smoothed by the median filter, there will be some
small ripples [9]. Therefore, this paper proposes to traverse the pixel coordinates of the white point in the region of interest after morphological refinement to obtain the laser stripe skeleton, and then perform the least squares fitting on it, to obtain a smooth laser stripe centerline.

4. Image Processing

Taking the three-dimensional reconstruction of the aircraft door surface as an example, the process of extracting the centerline of the laser fringe image using the method described in the text as shown in Fig.4 is:

(1) Image preprocessing: filtering and denoising, and the image shown in Fig.5 is obtained.

(2) Rosenfeld thinning: get all the light strip skeletons and randomly color them to get the image shown in Fig.6.

(3) Extraction of the region of interest: remove the ambient light interference, and obtain the laser stripe skeleton to be extracted as shown in Fig.7.
5. Conclusions
This paper proposes a laser stripe centerline extraction method for real-time 3D reconstruction of large components, and also proposes a method of selecting regions of interest, which can eliminate the influence of ambient light according to the actual situation. The experimental results show that the use of C++ combined with OpenCV library to achieve Rosenfeld laser fringe refinement and improve the extraction speed. This method can effectively eliminate the interference of ambient light and greatly reduce the environmental constraints of the application of laser 3D reconstruction technology.

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References
[1]  Zeng Chao, Wang Shaojun, Lu Hong, et al. Algorithm for extracting center of line structured light stripe[J].Journal of Image and Graphics, 2019, 24(10):1772-1780.
[2]  Li Yingying, Zhang Zhiyi, Yuan Lin. Summary of center extraction of line structured light strips[J].Progress in Laser and Optoelectronics, 2013, 50(10):9-18.
[3]  LU Yonghua, ZHANG Jia, LI Xiaoyan, et al. A robust method for adaptive center extraction of linear structured light stripe [J]. Transactions of Nanjing University of Aeronautics and Astronautics, 2020,37(4): 586-596.
[4]  Li Zhonghu, Guo Lei, Yan Junhong, et al. Research on center extraction algorithm of line structured light strips[J]. Journal of Inner Mongolia University of Science and Technology, 2019, 38(3): 252-257.
[5]  Niu Min, Wu Zhanjun, Niu Yanxiong, et al. A fast image median filtering method based on ranking statistical theory[J]. Electronic Measurement Technology, 2015(6): 60-63.
[6] Han Jianfeng, Song Lili. Improved character image thinning algorithm[J]. Journal of Computer-Aided Design and Graphics, 2013(01): 62-66.

[7] Shi Yeqing, Mu Pingan, Dai Shuguang. Defect detection of automobile multifunctional panel based on skeleton feature points[J]. Information Technology, 2015(05):192-194.

[8] Zheng Qiqi, Zhao Juan, Sun Qingze, et al. Research on frame oil seal image processing based on machine vision[J]. Machine Design, 2019, 36(S2):99-102.

[9] Raid A M, Khedr W M, El-Dosuky M A, et al. Image Restoration Based on Morphological Operations[J]. International Journal of Computer science Engineering & Informa, 2014, 4(3):9-21.