# Laser Line Profile Recognition Using Canny Edge Detector with Haralicks Facet Model

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**ABSTRACT:** Weld seam recognition is critical for providing information for automated welding process control. Most of the methods used for laser line recognition are sensitive to noise & position change, and cannot identify a curved laser stripe such as square-groove, which affects the welding quality. To identify curved laser stripe such as square-groove and extract the central line of the laser stripe of square-groove, Canny edge detection with Haralicks Facet Model is developed to extract the central line of the laser stripe of square-groove. After conducting a series of detection experiments on square-type butt grooves, the proposed method was effectively able to extract the laser line profile. After that, the proposed method was compared with Laplacian of Gaussian (LOG). The obtained detection results show that the proposed method can easily and effectively extract the central line of the laser stripe of square-groove.

**Keywords:** *Weld seam detection, Canny edge detector, square-type butt groove.*

## 1. INTRODUCTION

The process of the laser line profile recognition are two: Firstly is the image pre-processing, and secondly is laser line extraction [**1**]. Laser stripe extraction is the second step in the weld recognition process. There are a number of methods for extracting the laser line of the weld groove, such as using the edge detection process[2-3], centre-of-gravity method [4], and Hough transform[5-6]. Another approach scans each image row or column and uses the Laplacian of Gaussian filter to measure the result[7-8]. Moreover, luminance histogram and threshold segmentation method[9], and gray centroid method[10] were used for laser line recognition. Also, there are many methods for extracting the laser's centre line by searching for the highest pixel in each row or column and extracting the centre line since the laser stripe region has the highest pixel intensity in the picture [11-12]. Despite the fact that these methods can extract the laser line profile, they have certain drawbacks, such as the inability to identify a curved laser stripe, sensitivity to noise, and time-consuming. Where the Laplacian of Gaussian filter is sensitive to noise, and Hough transform cannot identify a curved laser stripe. Therefore, the Canny edge recognition technique with[14-15] Haralicks Facet Model [13] will be used to extract the laser line profile effectively. Canny edge recognition technique with Haralicks Facet Model is able to identify a curved laser stripe such as square-groove and is not sensitive to noise.

## 2. Research Methodology

### 2.1 *Feature Extraction*

#### *2.1.1 The extraction of the laser line profile*

To extract the laser line profile, Image pre-processing will be applied first to remove the noise and select the region of interest. Therefore, median filter will be used. Canny edge detection algorithm for laser line extraction will be proposed[15]. This method is robust and efficient for extracting the laser line profile[15]. The profile of the laser line will be extracted using the canny edge detection. Noise reduction, gradient estimation, non-maximum suppression, double threshold, and edge tracking by Hysteresis are the five steps in the Canny edge detection algorithm [15]. Firstly, until detecting the edge, the image was first filtered to remove noise. For this task, a Gaussian filter is used as shown in equation 1:

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}} \qquad (1)$$

The formula is used to approximate the magnitude of the gradient.

$$SG \Big| = \sqrt{Gx^2 + Gy^2} \approx \Big| Gx| + |Gy_n^{\circ} \qquad (2)$$

After this, use the gradient in the x and y directions to determine the edge direction as shown:

$$\theta = \tan^{-1}\left(\frac{Gy}{Gx}\right)^0 \qquad (3)$$

Once you've figured out the edge path, you'll need to figure out what degree it belongs to. In horizontal, positive, vertical, and negative diagonal, resolve the edge direction. To get the middle line of the laser line, Haralicks Facet Model will be used [14]. The idea behind this method is to use a first order polynomial to suit local sections of the image surface, the model is given by:

$$g(r,c) = \alpha r + \beta c + \tau + n(r,c) \qquad (4)$$

## 3.0 Result

An experimental test platform was established to verify the effectiveness of this method and the rationality of the structured design of the visual sensor. Halcon software was used for the image processing. Capturing images from a CCD camera, setting up the region of interest (ROI), and filter selection and image subtraction were the three stages of image pre-processing. Then, for laser line recognition, Canny edge detection will be combined with Haralicks Facet Model. As shown in

Fig.1, Canny edge detection with use of Haralicks Facet Model was able to identify a curved laser stripe such as square-groove and was able to effectively remove all the noise and extract the central line which demonstrates the effectiveness of this method as shown in Fig 1.

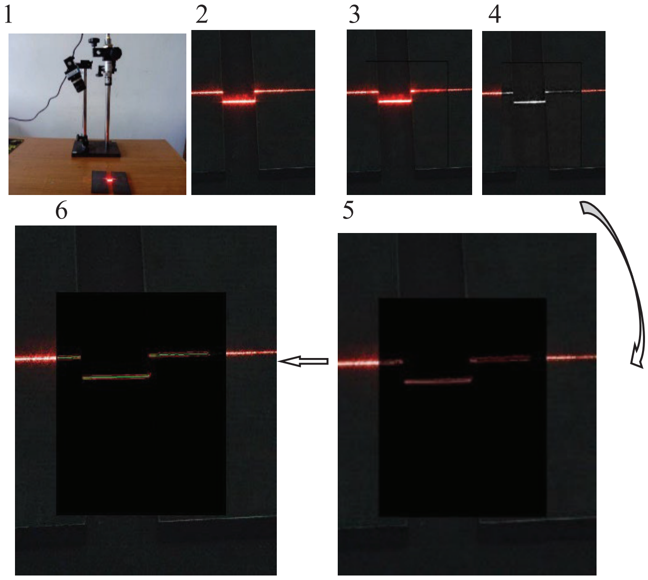


Fig. 1: laser line recognition of square-groove (1) Laser vision system;(2) The captured image; (3) Median filter; (4) Skeletonization result; (5) Edge detection by Canny; (6) Middle line extraction.

Fig 2. shows the comparative result between the proposed method and Laplacian of Gaussian(LOG). As shown in Fig 2, LOG is sensitive to noise and position change compared to the Canny edge detection that was able to remove the noise and extract the laser line profile effectively.

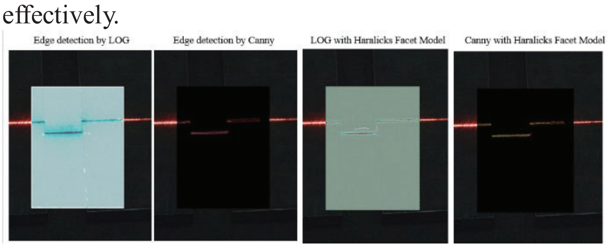


Fig.2: Comparative result of the Canny edge detection with LOG

## 4.0 Conclusion

In this paper, the method of Canny edge detector with Haralicks Facet Model was developed to recognize the central line of the laser stripe of square-groove. After conducting a series of detection tests on the square-type butt grooves and compared the proposed method to the LOG method, the obtained detection results of the proposed method show that the proposed method was able to identify a curved laser stripe such as square-groove and was able to effectively remove all the noise and extract the central line of the laser line profile which demonstrates the effectiveness of the proposed method.



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