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# An Improved Algorithm for Laser Point Detection Based on Otsu Thresholding Method

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**Abstract.** Welding manipulators are important machines in industrial production. It is very important to use the manipulator to weld to the correct spot. However, there are lots of light with surface due to welding process. Nevertheless, we have to find the exact welding point in order to perform accurate welding. Elimination of variable illumination is a bottleneck in laser point detection. It is vitally important to adopt an effective method to solve the problem. In this paper, we propose a thresholding method for laser point detection. The proposed algorithm uses Otsu algorithm and S information in HSV color space for real-time calculation. The experimental results show that the proposed algorithm effectively eliminates the illumination in the image.

**Keywords:** Otsu thresholding, laser point detection, image processing

## 1 Introduction

The weld manipulator performs precisely laser welding at one point on the surface of the object. It is very important to calculate the welding range in order to perform accurate welding. The welding range is very important for the efficiency of the work. However, it is very difficult to identify the exact welded part because of the large amount of light around the welded point. In this paper, we propose an efficient method to detect the range of accurate welding point.

Binary image segmentation method is used to detect an object in the background. Gray levels of the image are used to obtain the thresholding. Otsu thresholding method [1] is useful to extract a binarized threshold value and separate the object having a similar brightness value based on the histogram of the image. Otsu thresholding method in an optical coherence imaging it is difficult to remove the object by binarizing, does not consider the spatial information of the surrounding pixelization. Hence, in this paper we propose the method to remove the light around laser point using Otsu thresholding of S region after separating from HSV channel.

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## 2 Background and Definition

### 2.1 Otsu Thresholding

The Otsu Thresholding algorithm [4][5][6] is a technique for extracting optimal threshold values by separating objects with similar brightness values based on the histogram [7] of the input image. It is often used to divide the background and foreground. It divides the background and the foreground based on a specific value. The specific value here is called the threshold value. The advantages such as simple, fast implementation is the reason for using this algorithm for determining a threshold. The basic idea[2] to determine the threshold is as follows:

Suppose N is a whole number of pixels, the gray scale range is [0, L-1], $n_i$ is the number of pixels with I gray-level. Then the probability is calculated by (1)

$$p_i = \frac{n_i}{N} \quad \textbf{(1)}$$

The whole probabilities satisfy (2).

$$\sum_{i=o}^{L-1} P_i = 1 \quad \textbf{(2)}$$

The threshold T divides the pixels into two class $C_0$ and $C_1$, $C_0$ is made up of pixels whose gray-level is between [O,T], and $C_1$ is made up of pixels whose gray-level is between [T+1, L-1]. The whole image's mean value is $\bar{u}_T \sum_{i=o}^{i-1} ip_i$ **(3)**

Accordingly, the mean value of $C_0$ and $C_1$ respectively is

$$\bar{u}_0 = \sum_{i=0}^{T} \frac{ip_i}{w_1},\ \bar{u}_1 = \sum_{i=T+1}^{L-1} \frac{ip_i}{w_1} \quad \textbf{(4)}$$

Here, we $\mathrm{w}_0 = \sum_{i=0}^{T} P_i$ , $w_1 = \sum_{i=T+1}^{L-1} P_i = 1 - w_0$ **(5)**

The variance between these two classes is calculated by the

$$\sigma_B^2 = w_0(\overline{u}_0 - \overline{u}_T)^2 + w_1(\overline{u}_1 - \overline{u}_T)^2 \quad \textbf{(6)}$$

We can let T value from 0 to L-1, the best threshold is the T that make the variance between the two classes maximum. Using the Otsu algorithm, we can separate the image into two obvious sections thus prepare for segmentation.

### 2.2 HSV Color Value Extraction

In this paper, we improve the visibility of the image by compensating the saturation (S) value by changing the RGB value to the HSV color space value [3]. Also, we applied the Otsu algorithm to configure the algorithm so that the detection performance of the welding point does not change due to the light interference.

Color information plays an important role in interpreting internal information in image analysis or improving visual quality of image. In this paper, color information is extracted by using HSV color model among the various available color models. The Hue part of the color model is represented by an angle with a range of 0 ° ~ 360 ° in a circular shape. Saturation is a radius part with a range of 0 ~ 1 and expressed as 0 when it approaches the center axis. We use only the saturation value to remove illumination part of laser point.

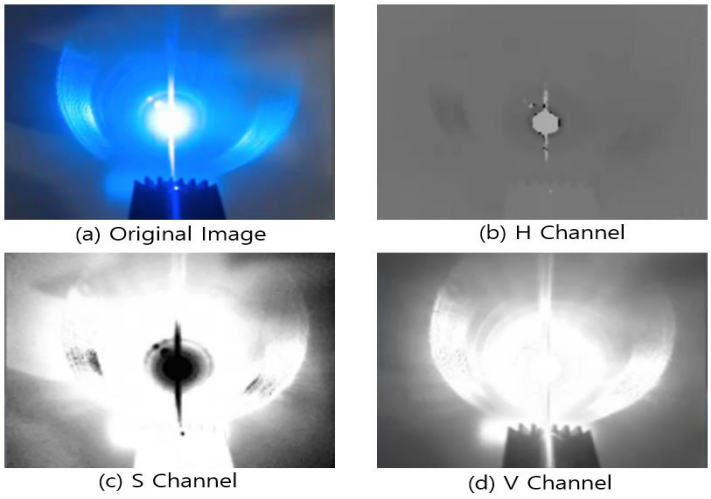


**Fig. 1.** The Separate Result about HSV Channel of Laser Point Image

## 3 An Improved Algorithm

Fig 2. Shows the algorithm for laser point detection method proposed in this paper. In the proposed method, the input image is subjected to a preprocessing process such as histogram smoothing. Then, Otsu segmentation is performed using S channel. The binary image generated by this method has robust characteristics with respect to variable illumination and intensity. It can be seen from the above segmentation results that the segmentation method proposed in this paper provides better segmentation effect compared to the previous segmentation results obtained using HSV channel.

The proposed algorithm using S channel is as follows:

- Convert the laser Point image from RGB to HSV color Space after that extract S components of HSV
- Separate background region according to the analysis of S channel from laser point center. S channel image will be divided into high and low saturation region between laser point and around illumination
- When a rough laser pointer image is obtained from the otsu algorithm, a smoothing image processing operation is performed.

- The binarized image is used to calculate the number of pixels and the blob labeling is performed to detect the correct area.

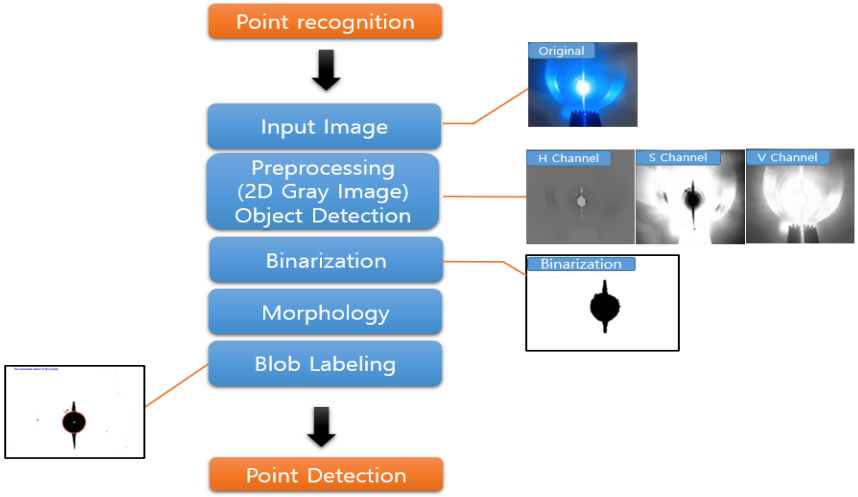


**Fig. 2.** The Flow Chart

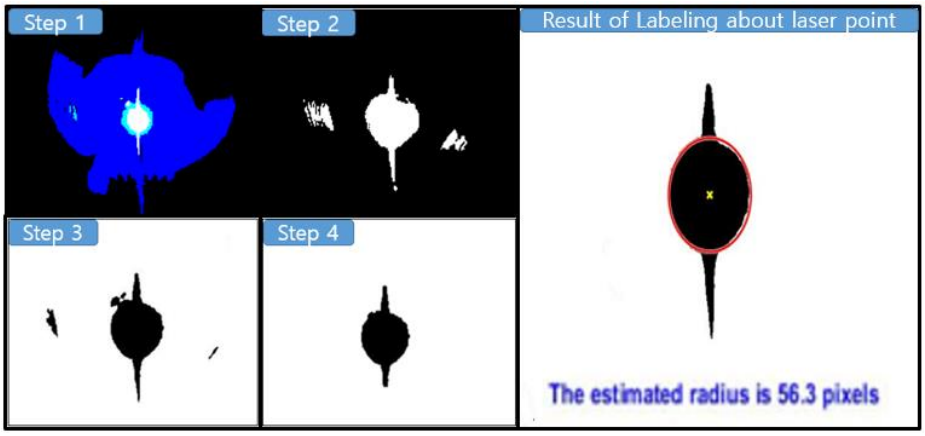


**Fig. 3.** Smoothing Binarization Step and Labeling

## 4 Experiment and Analysis

In this part, some experiments were done to verify the effectiveness of Otsu Thresholding method based on S channel of HSV color space. Using Visual studio 2013 Integrated Development Environment and C++, the experimental environment and results are shown in Fig. 4.5.:

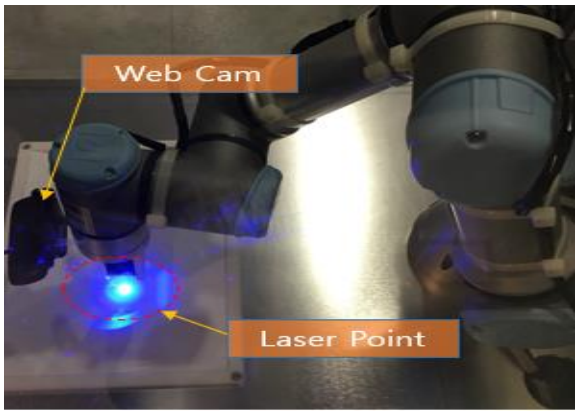


**Fig. 4.** The Experimental Environment

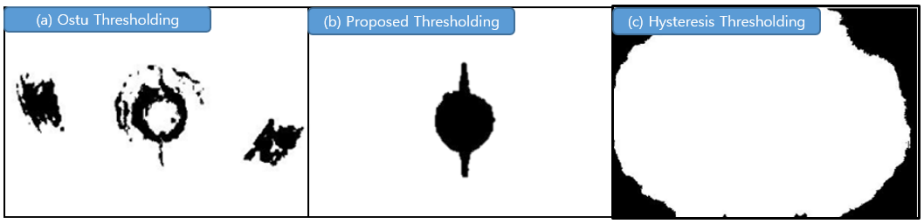


**Fig. 5.** Comparison of segmentation result by different method on laser point image

Fig. 5 (a) give the results of single threshold Otsu in gray space. (b) is in threshold Otsu in S channel of HSV color space. (c) is in Hysteresis Thresholding method which is the dependence of a system not only on its current environment but also on its past environment. It is can't distinguish the differences between laser point and background. But (a) can find laser point however it has some part of noises. (b) is effectiveness of segmentation algorithm has been greatly improved.

## 4 Conclusion

In this paper, we propose a point detection technique using the Otsu thresholding method to separate the S channel of the HSV color model to remove ambient light during laser point detection. The experimental results shown that, the proposed algorithm showed robust performance against the laser ambient light. This algorithm helps in detecting accurate laser point using image processing. These results clearly show that the accuracy the efficiency can be improved in real-time laser welding.

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