Field Weed Community Identification Algorithm with Euler Number

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Abstract. Precision spraying of herbicides has always been an important development direction of modern agriculture. The weed identification is the foundation of the precision spraying. In order to identify weed communities in the field, a novel algorithm of weed identification is proposed with Euler number. First, the weed images in the field were converted into binary images by image segmentation, and then the Euler number was extracted from the binary images. Finally, the positive and negative Euler number was used to determine whether weed communities in the vegetation needed herbicide spraying. The experiment include 20 images which are 10 field images with herbicide spraying and 10 field images without herbicide spraying. The experimental results showed that the identification rate reached 85%. This indicates that Euler number is a more effective image feature to describe weed vegetation community, which will be helpful for the further study of precise herbicide spraying technology.

Keywords: Euler Number, Weed Community, Identification

1. Introduction

Precision spraying of herbicides is an important development direction of modern agriculture, especially the increasing pressure of agricultural environment makes this need more urgent. In previous studies, image processing technology has been widely used to distinguish whether herbicide spraying is necessary for the collected field images, which is widely regarded as an effective way to solve the problem of precision herbicide spraying. Therefore, the application of image recognition technology for weed community identification has become an important basis for precision herbicide spraying [1][2][3].

In weed image identification, the extraction of image features has always been the focus of research [2][3]. With the continuous development of color feature [4], geometric shape feature [5] and texture feature [6][7], many features in image processing technology are gradually introduced into weed image identification [8][9]. On the other hand, Euler number is often used in image processing to express image integrity [10]. However, the increase of weed number in field images often destroys the spatial integrity of weed vegetation distribution. Therefore, Euler number can be introduced to identify weed communities.
2. Segmentation of the Weed Field Image

The extraction of Euler number is generally aimed at binary images, so first need convert field images into binary images. Under the existing technical conditions, generally adopt field images represented by RGB space. In other words, use red (R), green (G) and blue (B) for each pixel in the image to represent the degree of red, green and blue, thus forming a color image. Four field images are shown in Figure 1. (a)(b) Both images have weeds that require herbicide spraying, (c)(d) neither image requires herbicide spraying. It can be noted that although the four images were collected at the same time and in the same vegetable field, the colors were not uniform due to the influence of light. Therefore, it is difficult to use color characteristics to identify weed communities. However, there is a big difference between the green vegetation and the background soil, so the general image segmentation is to separate the green vegetation and the background soil in the image.

![Figure 1. Weed images (a) with more weed (b) with some weed (c) with less weed (d) without weed](image)

Image segmentation generally adopts ultra-green feature, which in essence is to transform color image into gray scale image. Each pixel is represented by its original three values of color, converted to a single value. The corresponding formula is $EXG(x, y) = 2G(x, y) - R(x, y) - B(x, y)$. Where, $EXG(x, y)$ represents the value of the pixel $(x, y)$ after gray scale, and $R(x, y)$, $G(x, y)$, and $B(x, y)$ represent the value of $R$, $G$, and $B$ of the pixel $(x, y)$ respectively. The gray images of FIG. 1 are shown in FIG. 2.
After obtaining the gray scale image, the image can be segmented, in gray scale images, the green corresponding G value multiplied by 2 is highlighted, which makes pixels in vegetated areas made up of crops and weeds have larger ultra-green eigenvalues, the eigenvalue of the pixel corresponding to the soil background is small. In view of this phenomenon, a pixel whose threshold value is greater than the threshold value is generally set as vegetation, and a pixel whose threshold value is less than the threshold value as the background. This method is the threshold segmentation method. FIG. 2 Segmentation results are shown in FIG. 3.

3. The Calculation of Euler Numbers
Euler number is generally used to represent the integrity of graphics in image processing technology, and its formula is $E=C-H$. In the formula, $E$ represents Euler number, $C$ represents the number of objects in the image, which can be understood as the number of connected regions in the image, and $H$ represents the number of holes, that's the number of black areas surrounded by white pixels.

It can be seen from Figure 3 that compared with the two images (c) and (d), on the one hand, the corresponding areas of weeds in the image (a) and (b) increase the number of holes, and on the other hand, the number of connected areas increases more. In the image of (a) and (b), many holes appear in
the originally regular vegetation area due to the superposition of corresponding areas of weeds, and these appeared holes are nowhere near as abundant as weeds. This phenomenon is more obvious in the slender blade weeds such as foxtail grass and barnyard grass. Therefore, the size of the Euler number can be used to determine whether the image needs to be sprayed with herbicide.

The threshold for determining whether herbicide spraying is needed is generally related to the leaf type of the crop and associated weeds. In the image shown in Figure 1, the crop is leafy vegetables, and the associated weeds are mainly gramineous weeds. Therefore, the threshold value can be set at 0. That is to say, the occurrence of weeds in gramineae dramatically increases the number of connected regions in the image, while the number of holes is insufficient.

4. Experimental Results and Analysis
In the same leafy vegetable field, collect 20 images for the experiment. 10 images required herbicide spraying and 10 images did not require herbicide spraying. Extract Euler numbers from 20 images respectively, as shown in Table 1.

| Table 1. The Euler Number of the Field Weed Image |
|--------------------------------------------------|
|                                | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
| with herbicide spraying         | 462 | 163 | 313 | 169 | 111 | 441 | 582 | 99  | -17 | -28 |
| without herbicide spraying      | -66 | 167 | -133| -87 | -114| -8  | -52 | -132| 41  | -33 |

If use 0 as the decision threshold to determine whether herbicide spraying is needed, the judgment results are shown in Table 2, and the overall recognition rate reaches 85%.

| Table 2. Identification Results |
|----------------------------------|
| Identification results with      | 8   | 2   |
| herbicide spraying               |     |     |
| Field images with herbicide      | 1   | 9   |
| spraying                         |     |     |
| Identification results without   |     |     |
| herbicide spraying               |     |     |

Obviously, according to the results in Table 2, the application of Euler number can better reflect whether the corresponding area of the field image needs herbicide spraying, and Euler number can be used as a good image feature.

5. Conclusion
Aiming at the identification of weed community in the field, according to the feature of weed destroying the geometric integrity of crop image, a novel algorithm is proposed which extract Euler number as the image feature for weed community image identification. The experimental results show that the Euler number is an effective image feature to describe the weed vegetation community, which will be helpful for the further research of the precise spraying herbicide technology.

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