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A Detection Method of Weed in Wheat Field on Machine Vision

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Abstract

A method of weed detection based on position and edge feature was studied. Firstly, the plant pixels are separated from soil background using the color difference of green plant and soil. Secondly, according to drilling crops are arranged in rows, this paper use pixel histogram method to select centerline of crop rows and set the centerline as starting point and crop rows edge as ending point, then fill crop area and eliminate crop pixels. Finally, weed detection is completed via the feature that weeds tend to grow in small associations and distribute closely. Experiments show that the algorithm obtains good weed recognition rate.

Keywords: Image process, precision agriculture, weed detection, position feature, edge detection;

1. Introduction

In recent years, as the world population growth, existing land and natural resources decreased, the precision agriculture is increasingly capturing more attention of the researchers [1]. The application of image processing technology can accurately identify field weed. The operation of herbicides with fixed point and quantitative spraying are becoming the major research direction of precision agriculture of weeding technology [2].

The growth of most farmland crops is according to the row regularity, but the growth of weeds do not exist regularity. They can optional growth and the cluster naturally. That is, they may growth in the field between crop rows or in crop rows. In terms of drilling crops, the distribution of weeds is erratic between

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crop rows and amount of weeds is small. Therefore, according to the position feature between weeds and crop, we can effectively identify the inter-row weeds. Through determining the center line of crop rows, Olsen H J can identify inter-row weeds thus control the weeds [3]. Through Hough Transform, Geé and Tellaech can completely pinpoint the crop rows [4] [5] and mark the remained plant pixels as weeds in order to identify inter-row weeds. The disadvantage of this method is that Hough Transform needs lots of complicated calculation. When processing a large number of farmland images, the time-consuming algorithm is difficult to meet the real-time demand.

This paper sets the farmland scene of drilling crops as the research object and proposes weeds detection method based on position and edge feature. The weeds target can rapidly and accurately separated from the background. This method can solve technical problems for the future application of precise pesticide and farmland vehicle automated navigation.

2. Weeds detection method based on position and edge feature

Usually the weeds image contains three elements of soil, crops and weeds. Therefore, the weed detection method this paper proposed is divided in three steps, that is soil background segmentation, crop elimination and weeds extraction.

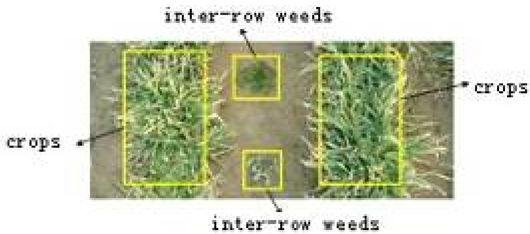


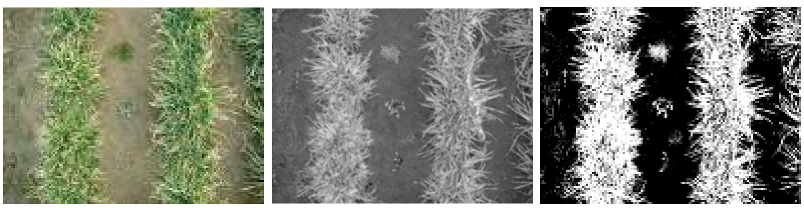
Fig. 1. Schematic diagram of inter-row weeds

2.1. Soil background segmentation

There are obvious differences in color between soil background and plant in crop weed images. Three components (RGB) of the image according to certain combination (2*G-R-B) to make original image changing gray, then the gray intensity of the green crops is increased and soil background be restrained. Oh the other hand, the difference of gray intensity is expanded. Then we choose suitable threshold to segment gray image thus separate soil background and ground. RGB 3-component combination method the paper used is shown as follows:

$$f(i,j)=\begin{cases}0 & 2G(i,j)<R(i,j)+B(i,j)\\ 255 & 2.5G(i,j)-R(i,j)-B(i,j)>255\\ 2.5G(i,j)-R(i,j)-B(i,j) & \text{other}\end{cases} \tag{1}$$

In the formula, $R(i,j)$, $G(i,j)$, $B(i,j)$ are distinguished represent the value of RGB 3-component of point (i,j). $f(i,j)$ is the gray value after image changing gray.



(a) (b) (c)

Fig.2. Segmentation results of soil background. (a) Original weeds image; (b) Gray image;(c) Binary image without soil

2.2. Crop pixels elimination

After green plant is separated from soil background, the next step is to extract inter-row weeds from plant pixels. Due to the green color both the crops and weeds represent, it is difficult to separate them through color feature. There are leaf folded and occluded situation between crops and inter-row weeds, so it also have certain difficulties to indentify inter-row weeds using shape or texture feature. According to the position feature that drilling crops are arranged in rows and row ledge is basically fixed, an effective approach to identify inter-row weeds of drilling crops is provided.

The approach of weed detection based on position and edge feature is: Firstly, this paper use the pixel histogram method to set centerline of crop rows, through the Roberts edge detection operators the edge of crop row is marked. Then starting from the pixels of crop centerline, the pixels are determined belonging to crops or weeds through analysis according to distinguished rows both right and left, until it reaches the edge of crop row.

It is difficult to determine the edge of the crop due to the fact that the binary image segmentation results are not perfect, crop area is not consisted of uniform and white pixels, black pixels are mixed among them. Thus crop pixels elimination method introduces sliding window and through the calculating of the number of black and white pixels in the window to decide whether it reaches the edge of crop area. The nearby centerline of crops is crop pixels and background pixels are far from the crop centerline. Therefore two distance thresholds d_{min} and d_{max} are introduced. While the distance between the center point of sliding windows and the centerline is less than d_{min}, the pixels in the window are crop pixels, otherwise, the distance between the center point of sliding windows and the centerline is more than d_{max}, the pixels in the window are background pixels. When window moves to a certain pixels mixed in crop area or to the edge of crop area, the target pixels can't well marked by only distance and boundary point. The problem can be resolved through the analysis of the total number of white pixels S_w and black pixels S_b in window. Algorithm process is shown as follows:

(1) Detect edge of the binary image, mark edge pixels

(2) Set a window W(3×3 or 5×5 etc), mark the center pixel of the window as C

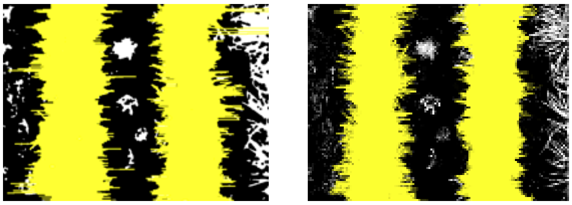
(3) Set distance parameters d_{min}, d_{max}, progressively scan binary image with W. The scan rule is: Starting from the pixels P_c of crop centerline(c=0,1,2,…,H-1， H is the height of binary image), sliding explore both sides with W(Due to the similar process of both sides and to simplify the discussion, the chapter elaborates the left model. The following steps are conducted on the basis of left exploration.)

(4) Calculate the total number S_w of white pixels in sliding window. If S_w larger than threshold M, consider all the pixels in W are belonging to crop pixels then set them as background pixels 0 (namely filling crop area), at the same time, the center pixels of the window C are set as the next center point of the scanning area (left sliding W).

(5) If S_w of W is less than threshold M and the distance between point C and centerline $d_c>d_{min}$, meanwhile C is the boundary point detected in step(1), S_b of W is less than the sum threshold m of black pixels, then we consider all the pixels in window are background pixels. The target pixels of 3 lines the current window accounts are completely marked (If the window is 5×5, the window accounts 5 lines.)

(6) Compare d_c and d_{max}. If $d_c>d_{max}$, stop current line marking, select next 3 lines to continue determination; If $d_c \le d_{max}$, continue the current line determination because it doesn't reach the edge of crop area. Repeat steps (4) and (5) until the cease conditions are met.

Any situation that does not meet above situations is shown as W doesn't reach the boundary of crop area, the determination should be continued. Repeat steps (4) and (5) until the cease conditions are met. The results of crop pixels elimination are shown as figure 3:



(a) (b)

Fig. 3. Crop area filling effect. (a) Size of window 5×5, d_{min}=15, d_{max}=50, M=15, m=10; (b) Size of window 3×3, d_{min}=15, d_{max}=50, M=6, m=6

It is shown that the size of window does not obviously influence the filling results. The algorithm is time-consuming if choose the smaller window. Comprehensively consider the strict requirements of filling effect and application background on time, this paper set the parameter of crop area filling algorithm as: 3×3 window, d_{min} =15, d_{max} =50, M =6, m =6.

2.3. Weed extraction

As the field environment is complex, natural plant is not grown in static and relative positional form, the images collected from the field would be affected by these uncertain factors. For example, crop rows elimination algorithm can't adapt to all situations, i.e. this algorithm can't fill the background pixels by the crop pixels correctly. As shown in Figure 4(a). Therefore, after eliminating crop pixels, we need to do some work to filter out the incorrect white pixels which are residual in the images. Then we can extract weed pixels accurately.

we divide the binary image into several small areas, calculate the total number of white pixels in every small area (similar to the use of sliding windows step used in previous section), then we compare the amount of white pixels and the threshold so as to decide which are weed pixels while others are isolated and meaningless dots.

Before the determination of weed pixels, we firstly give the binary image dilation and corrosion treatment, like the morphological treatment used in testing edges of crop as before. This treatment can not only remove mostly obvious noise, but also enhance the input image slightly. The following is the determination of weed pixels.

The flow of extracting weed is described as below:

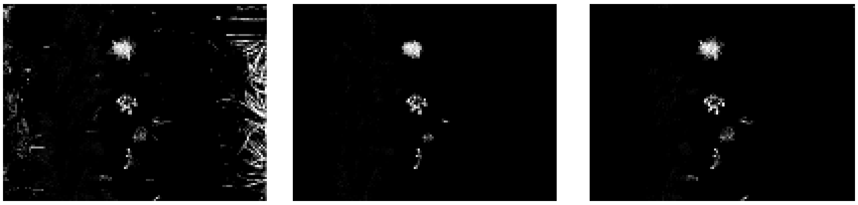
(1) Subdivide input image: divide the input binary image into N 3*3 areas

(2) Set the parameter largest and percent: calculate the amount of white dots that each small area contains, make the maximum as largest and set the value of percent according to experience (between 0.1 and 0.9)

(3) Determine the ownership of the white dots in the small area: compare the amount of white dots in small area to largest*percent. If the value of the former is larger, determine these white dots to weed pixels, then choose a next area to determine; otherwise, determine the white dots to non-weed pixels, set all the values as 0, pad into the background pixels, then select a next area to determine the ownership.

(4) Terminated condition: in order to stop the decision process, set N as the flag of termination, N minus one by itself while determining a small area, estimate the value N before selecting a next small area to determine, if N>0,it indicates that the area is not the last one, so it needs to choose next area to be determined; if N=0,it means that the area which is determining is the last, stop the weed extraction after determining the current small area.

The results of weed extraction are shown in Figure 4(b, c).



(a) (b) (c)

Fig.4. (a) Binary image after filtering out crop pixels; (b) the final outcome of weed extraction, percent=80%; (c) the final outcome of weed extraction, percent=50%

3. Experiment

Correct detection rate of weeds and false detection rate are two common indicators in assessing the performance of the weeds detection algorithm. The experimental method: meshed the original image and weeds image got from recognition by hand, counted manually the number of girds that wheat and weed occupied in the images, then got correct detection rate of weeds and false detection rate based on some specific formulas. In the statistics of the number of grids weeds and other elements occupied, we counted according to the area proportion of each element in the box: took up 1 lattice, the accumulator plus 1, plus 0.5 while 0.5 lattice, plus0.3 when it occupied 1/3 lattice, plus 0.7 when 2/3 lattice. The measures needed to count were:

The correct and false detection rate r_c and r_e of weeds between the wheat lines is given by

$$r_c = \frac{S_{wr}}{S_w} \times 100\% \quad \text{and} \quad r_e = \frac{S_{we}}{S_{nw}} \times 100\% \tag{2}$$

Where S_{wr} is the number of weed pixels identified correctly, S_{we} is the number of weed pixels identified falsely, S_w is the number of weed pixels identified ideally, and S_{nw} is the number of non-weed pixels identified ideally

According to formula (2), we calculated the correct detection rate of weeds and false detection rate, the experimental data was shown in Table 1.

Table 1. Estimative results of weed extraction algorithm

Image number	correct detection rate r_c (%)	false detection rate r_e (%)
1	92.5	4.88
2	95.1	3.32
3	93.9	4.58
4	94.3	4.83
5	95.6	4.21
average	94.28	4.36

As can be seen from the data in the Table 1,the algorithm proposed in this paper has the correct detection rate between 92% and 95% while the false detection rate in the range of 3% to 5%.The main factors affecting the correct detection rate are: affected by the segmentation threshold in the step of background segmentation and weed extraction, distribution of smaller clusters of weed groups were misinterpreted as backgrounds; some parts that weeds overlap with crops were misjudged, weed pixels missed because the algorithm misinterpreted the overlap of blades and edges as crop pixels in the crop rows elimination step. The main factors affecting the false detection rate are: in the edge detection process, due to matte edges, jagged edges were partly missed; not completely eliminated crop pixels resulted in misinterpreting these pixels as weed pixels in the weed extraction step; some background color is closer to plant color, this situation caused the failure of complete separation of these background pixels, what's more, it led to non-weed pixels mistakenly decided to weed pixels in the following extraction steps.

4. Conclusions

The weed detection algorithm proposed in this paper treats grayscale image since image gray step. The system's speed has been greatly improved to ensure requirements of real-time in the spot operations. In the separation of weeds and crops process, the algorithm makes use of the position features of weeds and crops and the crop edges, so the accuracy is increased, comparing to the traditional recognition method depend on the differences of weeds and crops' color. Moreover, for other plants sowed in lines, such as soy, corn, etc., the weed recognition algorithm proposed in this paper also has good adaptability.

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