The Study of Identification Algorithm Weeds based on the Order Morphology

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Abstract. In the precise agriculture field, how to identify the weed rapidly and accurately has been a hot topic. Extraction of effective feature is the key point in weed identification based on shape. However, the overlapping of plant leaves is a severe problem in extracting feature. The order morphology theory is an effective mathematic tool to process image. This paper studies the order morphology theory deeply, and puts emphasis on the order morphology transformation of digital image. Based on these, this paper puts forward the segmentation method of overlapping leaves based on order morphology, and also collects some weed images to make the simulation. Simultaneously, it analyses the differences between weed and crop about shape. The simulation results show that the method can segment the overlapping leaves effectively. Moreover, this method is also significant in weed identification.

Keywords: weed identification; order morphology; segmentation; overlapping leaves.

1 Introduction

In modern agriculture, the identify weeds accurately is important in the crop filed management. Spraying pesticides towards weed precisely and quantitatively, it does not only guarantee to kill weeds, but also try to reduce the environmental pollution [1]. At present, weed identification technology based on machine vision has become a main direction in weed identification field.

The shape feature is a significant characteristic to distinguish weed and crop [2]. The gray value difference of each pixel is the basis of color feature to identify the weed [3]. While the shape feature focus on the number of a certain pixel involved by plant, their size and relative position in the real condition [4]. In nature, the shape of plant leaves is diverse, thus it can be the important factor of weed identification.

Previous researches which using shape feature recognizes field weed mainly focus on the selection and evaluation of shape features. Only a few researchers carry out researches under the conditions that plant shape changes in time and space, and overlap (or block) phenomenon of plant leaves. In this paper, on the basis of the in-depth research of order morphology, leaf overlap problem is studied by using order morphology method. Results show that order morphology can solve the leaves...
overlapping problem at seedling stage of maize. Moreover, in this paper, the problem about selection of shape feature factors also researched.

2 Order morphology theory

In order to study the image processing based on order morphology transformation, this paper firstly introduces the definition and properties of order morphology transformation.

Definition 1
i) Let $A$ be the discrete set. ii) Let $B$ is the structure element. iii) Let $\mu$ be the count of $B$, where its range is $0 \leq \mu(B) < +\infty$.

The order morphological transformation of $A$ with $B$ is defined as:

$$x = A \ominus p = \bigcup_{k} \{ k \in \mathbb{Z} : k \leq p \}$$

Where: $p$ is the percentile of order morphological transformation. Discrete order morphological transformation includes two basic morphological transformations, morphological sum and morphological difference.

$$A \ominus B = \{ x : \mu(A \cap B) = (k-1)p+1 \}$$

(1)

(2)

(3)

$A \ominus B$ is the set of $x$ which is the point of $B$ containing the $(k-1)p+1$ point of $A$. That is the geometrical meaning of discrete order morphological transformation.

Definition 2
i) Let $0 \leq p$ and $q \leq 1$ ii) Let $A(p,q)B = A \ominus p B \ominus q B$

$A(p,q)B$ is called complex order morphology transformation. Then:

$$A(0,1)B = A \ominus B$$

(4)

$$A(1,0)B = A \bullet B$$

(5)

$$A(0,1)B \subset A \subset A(1,0)B$$

(6)

$$A^c(p,q)B = [A(1-p,1-q)B]^c$$

(7)
3 Identification algorithm weeds based on the order morphology

3.1 The segmentation method based on order morphology

Extraction of effective feature is the key point in weed identification based on shape. However, the overlapping of plant leaves is a severe problem in extracting feature. So, efficient method should be studied to segment the overlapping leaves.

Before, there have the Curvature function method based on Fourier and Mellin transform, the method based on watershed and the method based on morphology [5]. The accuracy of Curvature decrease with increasing of overlap and the Curvature function is not fit to the identification of saw-teeth-shape leave. So, the arithmetic cannot resolve the problem of overlap completely [6]. The watershed segmentation algorithm is sensitive to noise. So it produces the excessive over-segmentation whether the original image is filtered or not. Then the watershed algorithm must be improved to segment the image [7].

In morphology, the operator of dilate and erode can separate or connect the contact area. Based on this, it can segment the overlapping leaves. However, this method is suitable for the condition that the overlapping surface is small [8].

In the corn field of northeast region in China, the main weeds are crabgrass, barnyard grass, green bristlegrass, nightshade, copperleaf herb, xanthium sibiricum etc. However, in seedling stage of corn, the corn leaf is large, and the weed leaf is relatively small. Therefore, segmentation method based on order morphology is suitable for the corn field.

![Fig. 1. Segmentation of overlapping area based on order morphology](image-url)
Based on a great deal of static collection of corn field image segmentation experiments, the results show that the processing effect of segmentation based on order morphology is related with the structure element, percentile p and the operate times. Take the Fig. 1 (a) as an example to illustrate. Original image is collected in test plots in Jilin Agricultural University about maize leaf and large crabgrass leaf overlapping images. This paper uses order morphology operator to segment the image, with different structural elements, different percentile p and different times of operations, the results are shown in Figure 1.

### 3.2 Extract shape feature

Shape is a very intuitive and important feature to describe the image content. Shape is often associated with the target, so shape feature can be seen as a higher level feature than color and texture features. Here are a few basic description methods of image area.

**Area(A):** The area is used to describe the size of area and has RT (Rotation and Translation) inflexibility. The area A of the image region R can be represent by using the number of pixels in R. Assuming image is binary image (target for 1, background for 0), then:

\[
A = \sum_{(i,j) \in R} f(i,j) \quad f(i,j)=1
\]  

**Perimeter(P):** Perimeter P is represented by the sum of the distance between adjacent edge points in leaf area. Using different distance formula, will have different perimeter values. If using 8 neighborhood distance calculate perimeter, the perimeter, in fact, is equal to the number of pixels in edge point; If using Euclidean distance, the distance between pixels is 1 which are horizontally or vertically adjacent, while which are diagonally adjacent is:

\[
d = \sqrt{(i-m)^2 + (j-n)^2} = \sqrt{2}
\]  

**length(L):** refers to the length of the vane external rectangle, namely, the maximum distance of two points on outline.

**width(W):** refers to the width of the vane external rectangle, namely, the maximum distance between straight line chich perpendicular to lengths of wire and the intersection of outline.

The diameter of the inscribed circle (D): inscribed circle refers to the circumference of a circle on the contour, a circle that all pixels within the circle in the leaf area.

Obviously, area, perimeter, inscribed circle diameter are all with RT (Rotation and Translation) invariance, except scale invariance. Width and length are only with translation invariance. Through combining the basic shape characteristic parameter appropriately, some simple dimensionless area parameters can be extracted. Among these, compactness app.addword:scattering has the RST invariance; roundness, elongation, location are with scale invariance. Dimensionless shape parameter has nothing to do with the size and direction of the target which will be recognized.
Perform a statistical analysis on three dimensionless area parameters includes dispersion, roundness, length of large crabgrass and copper leaf herb’s single leaf which are common weeds in corn field, the results are shown in table 1

Table 1. The statistics analysis results of the weed leaf shape

<table>
<thead>
<tr>
<th>plant</th>
<th>Area</th>
<th>perimeter</th>
<th>length</th>
<th>width</th>
<th>Compactness</th>
<th>Roundness</th>
<th>Elongation</th>
</tr>
</thead>
<tbody>
<tr>
<td>corn</td>
<td>30846</td>
<td>782</td>
<td>269</td>
<td>156</td>
<td>0.63</td>
<td>0.53</td>
<td>0.57</td>
</tr>
<tr>
<td>crab</td>
<td>2052</td>
<td>161</td>
<td>59</td>
<td>31</td>
<td>0.99</td>
<td>0.73</td>
<td>0.52</td>
</tr>
<tr>
<td>herb</td>
<td>7938</td>
<td>371</td>
<td>90</td>
<td>89</td>
<td>0.72</td>
<td>1.23</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Seen from the above statistics results, four kinds of geometric characteristics of corn including area (A), perimeter (P), length (L), width (W) are significantly bigger than other two kinds of weeds. In addition, you can see that, only using a single dimensionless parameter and regional torque characteristics is unable to identify corn and weeds effectively, so we can consider corn area as the first identify characteristic, then combined the shape feature in order to form a set of features for identification.

The experiments show that only in the situations that crab grass presence and leaf overlap is not very serious condition, weed recognition rate can reach more than 90%. For a variety of weeds and overlap serious condition, further study should be done.

4 Conclusion

The order morphology theory is an effective mathematic tool to process image, this paper study the theory deeply and put emphasis on the order morphology transformation of digital image. Simultaneously, it analyses the differences between weed and crop about shape. Based on this, the paper applies the theory to segment the overlapping leaves. The method can segment the overlapping effectively, and it is significant in weed identification.

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