

Weed Classification using Histogram Maxima with Threshold for Selective Herbicide Applications

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Abstract—Information on weed distribution within the field is necessary to implement spatially variable herbicide application. Since hand labor is costly, an automated weed control system could be feasible. This paper deals with the development of an algorithm for real time specific weed recognition system based on Histogram Maxima with threshold of an image that is used for the weed classification. This algorithm is specifically developed to classify images into broad and narrow class for real-time selective herbicide application. The developed system has been tested on weeds in the lab, which have shown that the system to be very effectiveness in weed identification. Further the results show a very reliable performance on images of weeds taken under varying field conditions. The analysis of the results shows over 95 percent classification accuracy over 140 sample images (broad and narrow) with 70 samples from each category of weeds.

Keywords—Image processing, real-time recognition, weed detection.

I. INTRODUCTION

A. Background

WEEDS are “any plant growing in the wrong place at the wrong time and doing more harm than good”. Weeds compete with the crop for water, light, nutrients and space, and therefore reduce crop yields and also affect the efficient use of machinery. A lot of methods are used for weed control. Among them, mechanical cultivation is commonly practiced in many vegetable crops to remove weeds, aerate soil, and improve irrigation efficiency, but this technique cannot selectively remove weeds from the field. The most widely used method for weed control is to use agricultural chemicals (herbicides and fertilizer products). In fact, the success of agriculture is attributable to the effective use of chemicals.

Agricultural production experienced a revolution in mechanization over the past century. However, due to the working environment, plant characteristics, or costs, or there

are still tasks that have remained largely untouched by the revolution. Hand laborers in 1990’s still may have to perform tedious field operations that have not changed for centuries. Identification of individual weeds in the field and location their exact position is one of the most important tasks needed to further automate farming. Only with the technology to locate individual plants, can “smart” field machinery be developed to automatically and precisely perform treatments.

Herbicides are applied with a blanket treatment to a whole field without regard to the spatial variability of the weeds in the field. This practice results in some areas where no or few weeds exist receiving just as much chemicals as those areas with high densities of weeds. Obviously, if a more sophisticated chemical delivery system is developed which apply chemicals where weeds exists and abstains where there are no weeds, chemical usage would be reduced and chemicals would be more effectively placed. These practices would result in lower environmental loading and increased profitability in the agricultural production sector. Selectively spraying, spot spraying, or intermittent spraying are different names which are attached to this herbicide application method.

Thus, farmers need alternatives for weed control due to the desire to reduce chemical use and production costs as well as provide safety to under ground water resources and the ecosystem (Marks and Ward, 1993). United States farmers applied about 8.2 billion dollars of pesticides in 2002, in which 2.2 billion dollars of pesticides were used in damaging water resources and the ecosystem. For some weed/crop situations there are no selective herbicides. Since hand weeding is costly, an automated system could be feasible. A real-time weed control system can reduce or eliminate the need for chemicals between broad and narrow weeds.

The purpose of this paper is to investigate a machine vision system to distinguish individual weeds in to broad and narrow weeds.

B. Related Work

Much research has investigated strategies to control weeds with less herbicide to reduce production costs and to protect the environment. Simple methods have proposed such as banding herbicide spray on crop rows and cultivating between the rows (Stout, 1992).

A few real-time field systems have been developed. The photo sensor-based plant detection systems (Shearer and

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Jones, 1991; Hanks, 1996) can detect all the green plants and spray only the plants. A machine-vision guided precision band sprayer for small-plant foliar spraying (Giles and Slaughter, 1997) demonstrated a target deposition efficiency of 2.6 to 3.6 times that of a conventional sprayer, and the non-target deposition was reduced by 72% to 99% Islam et al (2005).

A system that could make use of the spatial distribution information in real-time and apply only the necessary amounts of herbicide to the weed-infested area would be much more efficient and minimize environmental damage. Therefore, a high spatial resolution, real-time weed infestation detection system seems to be the solution for site-specific weed management.

II. OBJECTIVE

Since in practice there are only two types of herbicides used: for broad leaf weed and narrow leaf weed (grass), the objective is to develop an algorithm that can

- Recognize the presence of weeds
- Differentiate the presence of broad leaves weeds and narrow leaves weeds.

III. MATERIALS AND METHODS

A. Hardware Design

The concept of the automated sprayer system is shown in Fig. 1, which includes camera, Central Processing Unit (CPU), and a Decision Box controlling two dc pumps for spraying. The images were taken at an angle of 45 degree with the ground. Using this method, the long narrow area in front of the sprayer could be captured with high resolution without increasing the image size. Agriculture fields are selected for this type of study.

The images are given to Central Processing Unit. The Decision Box is connected to the Central Processing Unit through a parallel port which ON or OFF the corresponding dc pump, based on the type of image processed by the Central Processing Unit.

B. Software Development

The software is developed in Microsoft Visual C++ 6.0. A Graphical User Interface (GUI) is developed that shows the Original image, processed image and the Histogram of that image. The image resolution was 240 pixel rows by 320 pixel columns.

IV. METHOD

Fig. 2 shows the Flow Chart of a Real-Time Specific Weed Recognition System which were developed to accomplish the broad and narrow weed classification [6]. The algorithm was based on a Histogram Maxima with threshold of a gray scale image taken from the green channel of an image to detect the target area in the fields [7].

A. Image Pre-processing

Weeds are general green color, a highly irregular leaf shape, and an open plant structure which contributes to its being a challenging weed to identify in the field. To identify weeds and classified them into one of two classes (broad and narrow) feature extraction are developed [3]. The first stage of feature extraction algorithms is pre-processing operation to segment all weeds from the background [2].

To distinguish weeds from background objects in a color image, a color segmentation image-processing step is conducted where objects are classified into one of two classes (weeds and background) by their color difference in red, green and blue color space. Meyer et al. (1998) indicated that weeds in field images must be carefully segmented; otherwise the feature extraction will yield unreliable results from analyzing soil and weeds [9]. Thus, adequate image segmentation quality is necessary. One simple technique for separating pixels into weed or background class is to calculate an offset excessive green (OEG) value from the RGB image. Each pixel in the RGB image is replaced with the following calculated value:

$$\text{OEG} = 128 + (G - B) + (G - R)$$

Where R, G, B are red, green, and blue intensities of a pixel respectively.

After the OEG image was generated, a threshold value is selected to separate the weeds from the background.

B. Classification of Images using Histogram Maxima with Threshold

The obtained image is converted to Gray Scale image. The gray scale image has 256 different intensities (0 - to - 255).

The histogram of a Gray Scale image as in [1] with L total possible gray levels in the range [0, G] is defined as a discrete function

$$h(rk) = nk,$$

Where rk is the kth intensity level in the interval [0, G] and nk is the number of pixels in the image whose intensity level is rk. The value of G is 255.

After calculating the histogram of an image, the next step is to calculate the intensity level which has a maximum number of pixels.

Maximum number of pixels (Max) is calculated at kth position as:

$$\text{Max} = \text{Maximum}(nk)$$

$$\text{Where } k = 0 \dots L - 1$$

The kth position at which the Maximum is found is equal to the Intensity (I) as:

$$I = k$$

I is compared with the Threshold value (T) [4], [8].

The calculated value will classify the weeds (narrow and broad), [5].

V. RESULTS AND DISCUSSION

Fig. 3 show the classification images of broad and narrow weeds, which are taken in the field. These images are processed by Histogram Maxima with threshold. The algorithms gave 100% accuracy to detect the presence or absence of weed cover. For areas where weeds are detected, results show over 95 percent classification accuracy over 140 sample images with 70 samples from each class as shown in Table I.

Comparing the results data of Tables II and III, it is clear that results of weeds at variable threshold as in Table III are more encouraging than the results as in Table II, which is a clear indication of the fact that individual thresholds show more encouraging results than the results with a constant threshold. Thus varying distance becomes immaterial if the distance from the camera is set with appropriately chosen threshold values.

The results obtained for different distance under a constant threshold value favor a selected height for more promising results. It is evident that from Table II with individual threshold value of 500 shows good results at the selected height of four meters. Thus an optimum height becomes a requirement for data extraction under a constant threshold value.

VI. CONCLUSION

A real-time weed control system is developed and tested in the lab for selective spraying of weeds using vision recognition system. In this paper, feature extraction based system for weed classification and recognition is developed. The system shows an effective and reliable classification of images captured by a video camera. The system composes of four main stages: image capturing, image pre-processing, feature extractions and classification. Histogram Maxima with Threshold is used in this paper to classify the weeds.

VI. FUTURE WORK

In this paper weed image, which has one dominant weed species can be classified reasonably accurate. But the case of more than one weed classes cannot be accurately classified. Further research is needed to classify mixed weeds. One way is to break the image into smaller region. With smaller region, there will be less possibility to find more than one weed classes in this small region.

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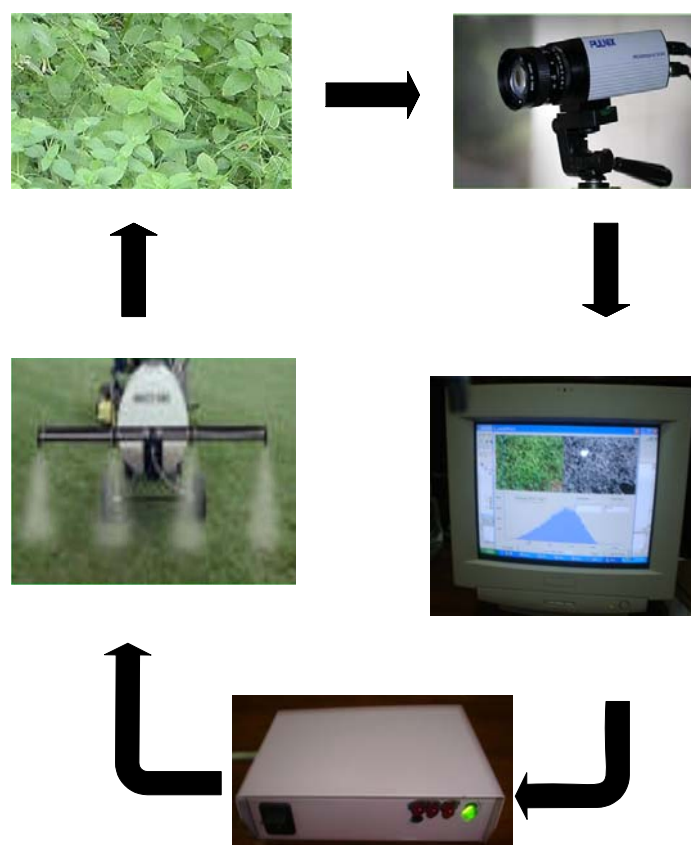


Fig. 1 The concept of a Real-Time Specific Weed Sprayer System

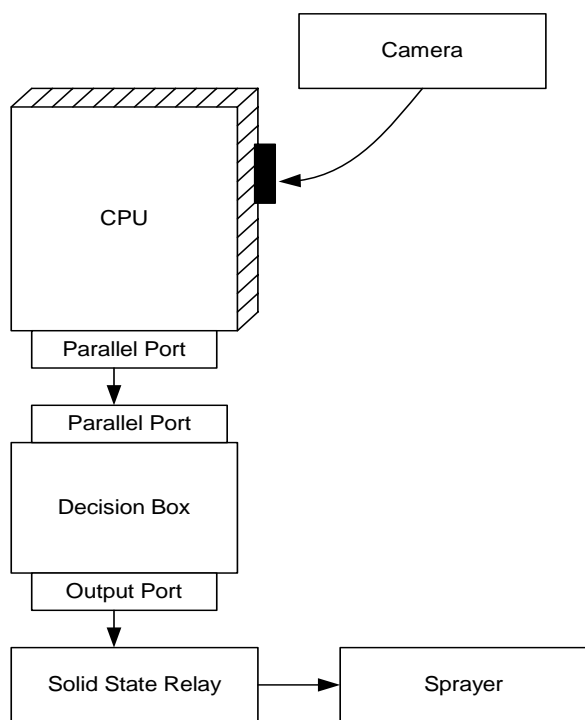


Fig. 2 Flow Chart of Sprayer System

TABLE I
 RESULTS OF THE WEEDS IN FIG. 3 USING HISTOGRAM MAXIMA WITH THRESHOLD

Weeds Type	Results found correct %
Broad Weeds	95%
Narrow Weeds	95%
No or Little Weeds	100%

TABLE II
 CLASSIFICATION ACCURACIES USING VARIABLE CAMERA DISTANCE & FIXED THRESHOLD FOR HISTOGRAM MAXIMA WITH THRESHOLD

Camera Distance	Threshold	Presence Or Absence	Broad Weeds	Narrow Weeds
3 meter	500	100%	85%	84%
4 meter	500	100%	95%	95%
5 meter	500	100%	76%	81%

TABLE III
 CLASSIFICATION ACCURACIES USING VARIABLE CAMERA DISTANCE & VARIABLE THRESHOLD FOR HISTOGRAM MAXIMA WITH THRESHOLD

Camera Distance	Threshold	Presence Or Absence	Broad Weeds	Narrow Weeds
3 meter	450	100%	85%	84%
4 meter	500	100%	95%	95%
5 meter	550	100%	90%	86%

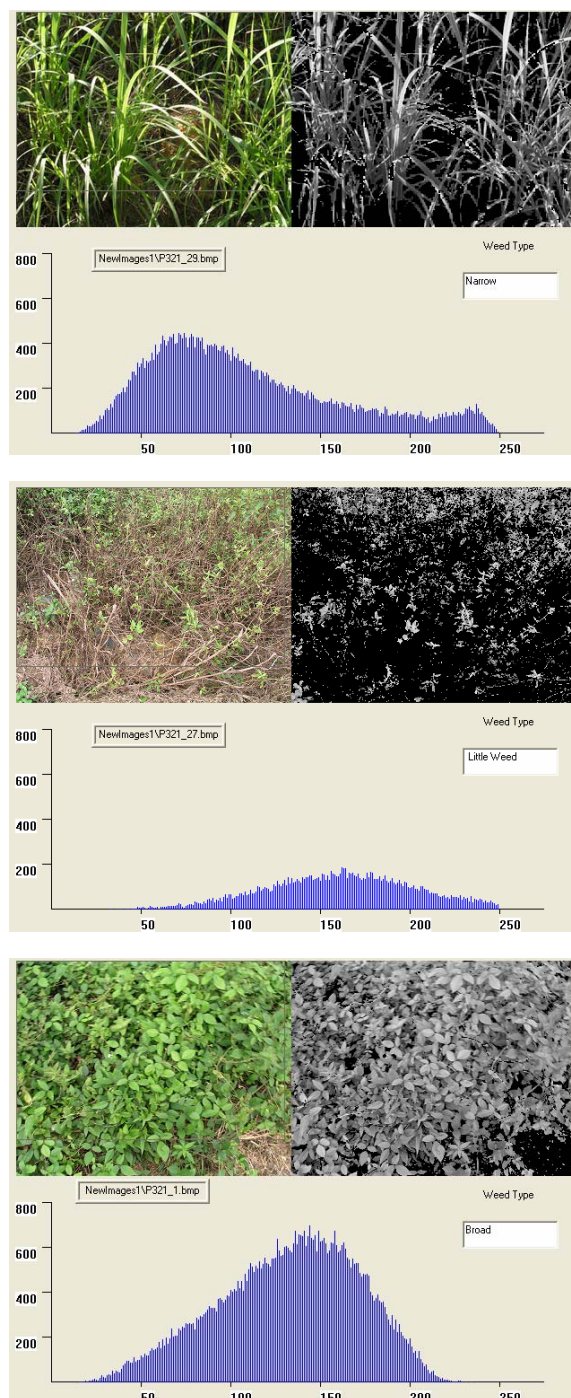


Fig. 3 Results of Different Type of Weeds