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Real-Time Specific Weed Recognition System Using Histogram Analysis

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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 Analysis 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

INCREASING farm sustainability and protecting water quality are two major goals of current agricultural research. United States farmers applied about 1.2 billion pounds of pesticides in 1995, representing a significant portion of the variable costs of agricultural production. Many of these chemicals are soil-applied (pre-emergence) herbicides, which are more prone to movement into ground water and surface water supplies. Soil-applied herbicides such as atrazine and alachlor are potential threats to the safety of drinking water supplies. At numerous sites, concentrations of these herbicides in the ground and surface water supplies have exceeded federal health levels (Marks and Ward, 1993). Public concerns about health risks associated with herbicide residues have increased as more cases of herbicide contaminated water supplies have been reported.

Though most herbicides are applied uniformly in fields, there is strong evidence that weeds are not distributed uniformly within crop fields. Weeds tend to occur in clumps or patches (Wilson and Brain, 1991; Thornton et al., 1990; Mortensen, et al., 1995; Johnson, et al., 1995). For example, Marshall (1988) investigated the effect of sampling intensity on the estimation of grass weed populations. Three species of grasses were observed. From 27% to 79% of the areas sampled had no weeds, depending on the species. In these situations, spatial information management systems and precision application systems hold great potential for allowing growers to fine-tune the locations, timings, and rates of herbicide application. The precision herbicide application technologies that we developed and evaluated will use camera to capture the weed spatial distribution patterns. The realization of these technologies could significantly increase farm sustainability and reduce herbicide threats to the environment.

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 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%.

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 leave weed and narrow leave weed (grass), the objective is to develop an algorithm that can

- Recognize the presence of weeds

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- 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 of a 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 el 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:

$$OEG = 128 + (G - B) + (G - R)$$

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 Analysis

The histogram of a digital image as in [1] with gray levels in the range $[0, L - 1]$ is a discrete function $h(r_k)$ such that

$$h(r_k) = n_k,$$

where r_k is the kth gray level and n_k is the number of pixels in the image having gray level r_k

Width of the Histogram (W) is calculated with the restriction that

$$T1 < W < T2$$

where T1 and T2 are the two threshold values.

After calculating W, Number of Peaks (NP) is calculated with the following restrictions

$$T1 < NP < T2 \text{ and } NP > T3$$

Where T1, T2 and T3 are the threshold values [4], [8].

The calculated values of W and NP 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 analysis. 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.

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 is used in this paper to classify the weeds.

VII. 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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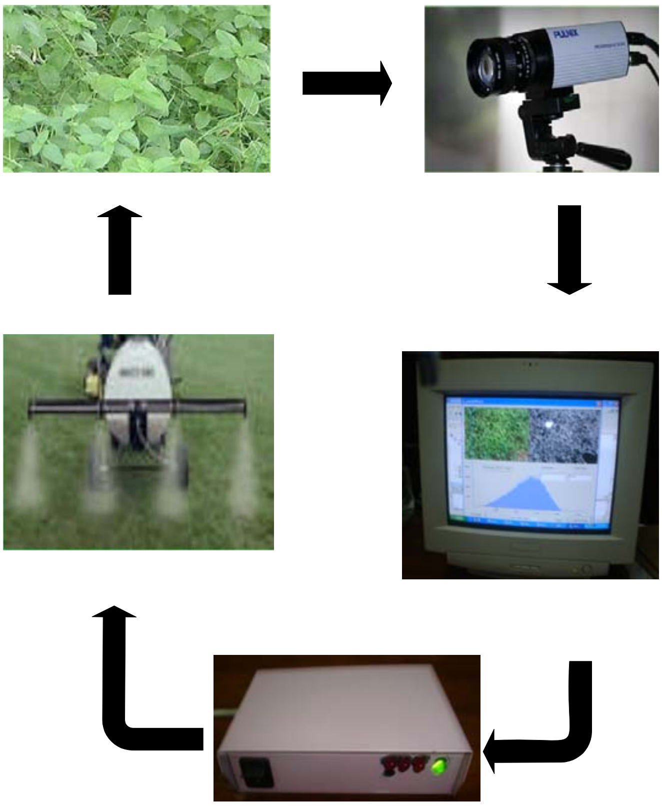

Fig. 1 The concept of a Real-Time Specific Weed Sprayer System

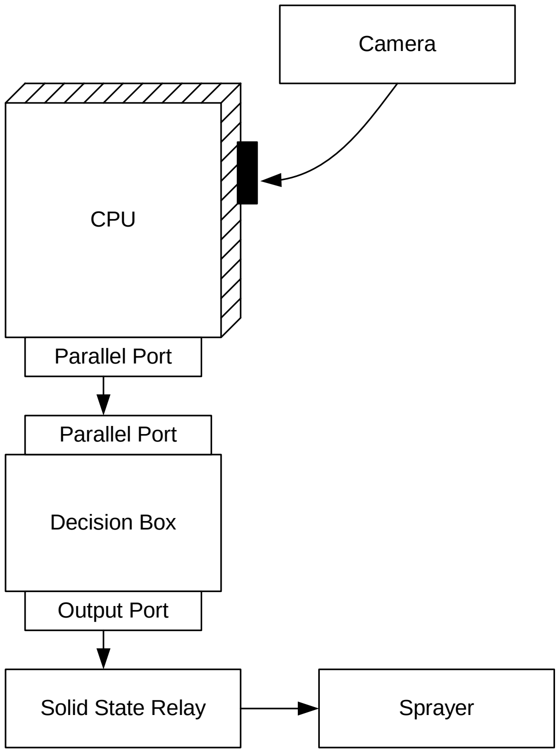

Fig. 2 Flow Chart of Sprayer System

TABLE I
RESULTS OF THE WEEDS IN FIG. 3 USING HISTOGRAM ANALYSIS

Weeds Type	Results found correct %
Broad Weeds	99%
Narrow Weeds	99%
No or Little Weeds	100%

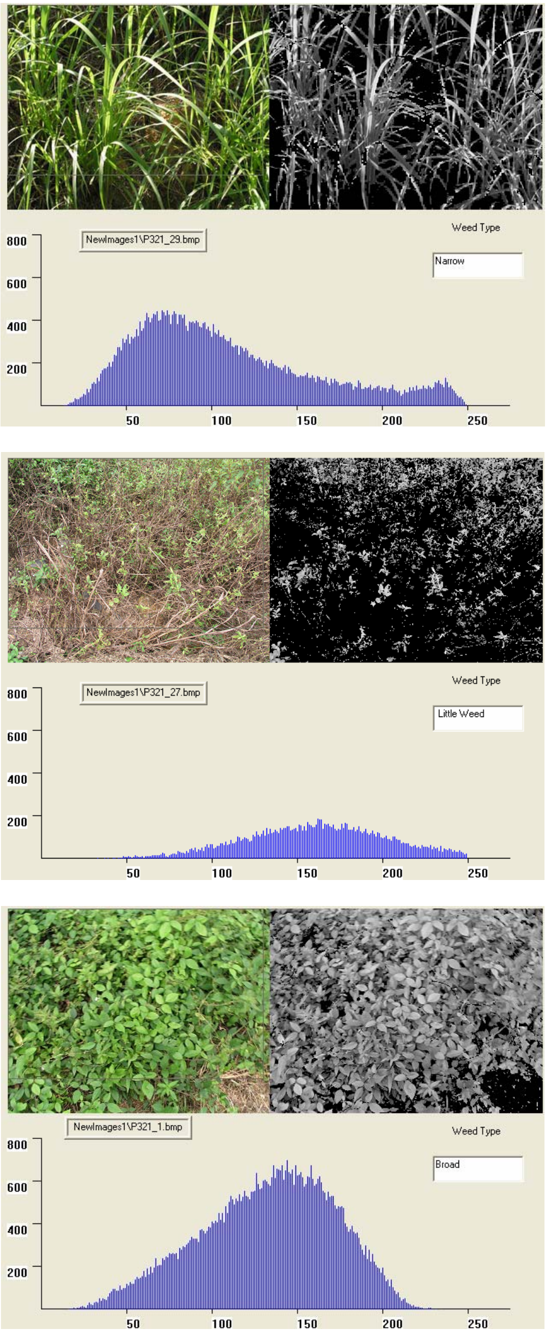

Fig. 3 Results of Different Type of Weeds