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AUTONOMOUS NAVIGATION OF MOBILE ROBOT FOR AUTOMATIC WEED DETECTION AND HERBICIDE SPRAYING IN AGRICULTURE

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ABSTRACT

A new advanced technology is used in agriculture operation due to labor shortage, increase in labor cost etc., In this paper new weed detection method is used and it is achieved by using autonomous navigation mobile robot. Initially plants are classified into crops and weed by using machine vision algorithm. Image is captured from field, where pixels are segmented from background with an adaptive method which is strong against robust lighting conditions. After that, crop and weed is classified by feature extracted using discrete wavelet analysis and it is done in MATLAB. To achieve autonomous navigation of robot is designed by using PIC Microcontroller interface between microcontroller and PC is achieved by using Zigbee technology. The overall classification accuracy is achieved using this method is 95.89% and it is suitable for all kinds of species.

KEYWORDS: adaptive method, MATLAB, PIC microcontroller, Zigbee.

INTRODUCTION

A new advanced technology is used in the agriculture operation due to labor shortage increase in labor cost etc. Agriculture operation needs automation in this one is weed control which demands for automation. In the conventional weed control system, herbicide is sprayed uniformly over the field which may damage crop condition. Apart from that, there is negative impact on the plant, soil large amount of herbicides is wasted and it is sprayed only in some part of the weed in field.

To prevent from these consequences, there is a need for the smart weed control system must develop. It must locate the weed part correctly in the field and resulting in spraying the herbicide in the desired spot of the field. In this, crop is supposed to grow in rows, when any kind of plant grow within row is considered as weed. In order to differentiate between the weed and crop, hence a classification algorithm is required.

There are many classification algorithm is used and different attribute are defined in earlier paper to distinguish between the crop and weed in the field. Some of them are discussed as follows. A.Piron and V. Leemans [3] made a study on to select the best combination of for detecting various weed species located with the carrot row based on quadratic discriminant analysis and the classification accuracy achieved is 72% only. They suggest that better result will be achieved only in advanced growth stage. A.T Nieuwenhuizen [1] proposed the two color-based machine vision algorithm for in field volunteer potato plant detection in sugar beet field. The two algorithms namely Adaptive Neural Network and K-means clustering but the different result is achieved using these two methods. A.J Sachez [5] proposed to construct 3D world map to distinguish between crop and weed and finally to locate it using variable treatment. Motion technique is used for recovering a 3D-map and local map is fused with world map. In this classification of crop and weed is based on the height of the plant. Sogaard proposed a new method to classify the weed based on the active shape. But this method is suitable for real-time application. A.Piron [4] presents a new method to identify the weed in the plant by using the height of the plant. The overall classification accuracy achieved is 83%. S.D Noble [2] made a study on new spectral technique is used for weed detection. The equipment includes data acquisition and use of high and low spectral resolution

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data. The spectral properties are used for image segmentation and species discrimination. This technique is suitable for real-world condition.

RELATED WORKS

System Model

The proposed system for autonomous navigation of mobile robot is designed using PIC microcontroller for weed detection and herbicide spraying.

The wireless camera is fixed on the robot, the image from field is captured is transmit to PC using wireless technology Zigbee further is processed in MATLAB for weed detection.

The processing involves the image de-nosing by median filter and discriminating between the green plants weed according to their gray level. The path planning software receives the matrices of the position for building the environment and defining the optimum path. The computer receives the current position that will be saved in the position system. Then gets commands position received by the position control. The action model involved the mobile robot motor, the robotic gripper and pump of this unit.

The captured image is processed in MATLAB for weed detection. The two methodologies are used for detection. The first method is green segmentation in which new segmentation method is fuzzy c- means clustering. This method extracts the hue plane of the image. The second methodology is feature extraction which is used to detect the feature of weed part in the field by using discrete wavelet transform. This method is used to know the frequency contents and also location of the image.

Robot design and connecting interface

To design the robot, PIC16F788A microcontroller is used. It contains 40 pins with 4 Port Register which performs the input / output function of the microcontroller. The power is provided to the board through VDD & VSS pins. Pin VDD=5v & VSS= GND. Pins 13 & 14 is OSC1 & OSC2 are for connecting oscillator which will provide the necessary clock for operation of microcontroller. Pin 1 is MCLR is used to reset pin of the microcontroller. DC Motor requires high current and voltage than microcontroller can handle. Interfacing DC motor directly with microcontroller may affect the working of microcontroller due to Back EMF of the DC Motor. So interfacing of DC motor in both clock-wise and anti-clock-wise direction. The L293D can provide bidirectional driver current of up to 600mA at voltage from 4.5V to 36V. In L293D driver are enable in pair, Pin1 & Pin9 are enable pins to drive the motor and need to be high.

To drive two DC motors, one L293D motor driver IC is used. First pair of driver is enabled by connecting EN1 to logic high. Pin 2 & 7 are connected to RD1 & RD2 of PIC microcontroller respectively, which are to provide control signal to the DC motor. Similarly Pin 15 and Pin10 are connected to RD3 & RD4 of PIC microcontroller which are used to provide control signal to the DC motor. DC motor is connected to Pin 3, 6, 14, 11 of the L293D.

Table 1.Control Signal and Motor Status

RD1/IN1	RD2/IN2	Motor Status
L	L	Stop
L	H	Anti-clockwise
H	L	Clockwise
H	L	Stop

To display the notification whether weed detected (or) not is shown by using LCD Module JHD162A. JHD162A is 16 pin configurations. The power supply of 5V is supplied to Pin2 (VCC) is connected to the negative rail. To get a stable +5V power supply. Pin3 is the contrast seeing pin and it is connected to potentiometer to control the contrast. In order to get greater contrast lower resistance is used namely 1.5K-2K. And also set voltage to around 1-1.5K for optimum contrast. Pin7 to Pin14 are Data pins of the LCD. Pin7 is LSB and Pin 14 is MSB of the data inputs. These pins are also used for giving certain commands to the display. Upon giving the correct signal to the 3 control pins the character code (or) commands given to the Data pins will be written to the display (or) executed by the LCD. In this project execution of the LCD is done by interfacing with PIC16f788A microcontroller. And the Data Pins of the LCD is connected to microcontroller in RB0 to RB7. Pin 3 Control pins have 3 parts: R/S, R/W, E. RS full form is Register Select. Here instruction mode should be set high and character mode should be set low. Enable: data at the data pins will be executed on its falling edge. RW: In this, setting the LCD to read (or) write and set is low permanently. Pin 15 & 16 is Backlight within LCD which makes us seeing the character on the screen and it is optional.

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To interface GSM SIM 300 with PIC16f788 microcontroller used to send and receive the SMS commands to control the robot. To connect this, MAX232 IC is used. In PICf16788A, RD4 is Receiver pin is connected to Pin 9 R2OUT. RC7 is Transmitter pin is connected to Pin 10 T3IN. And in turn Pin 8 R2IN is connected to DB9 connector of Pin2. And Pin 7 T1OUT is connected to Pin3 of the GSM Module. In MAX232, they are 3 capacitor is used in Pin 1& 3, Pin 2&16, Pin 4&5 of 1µf. Pin 15 is Ground.

Zigbee is standard that defines a set of communication protocol for low data rate, short range of wireless networking. In this project, Zigbee Pro which has receiver and transmitter is used in both ends of PC and microcontroller to transmit and receive the information. UART interface is used to serial data transfer between Zigbee and microcontroller. The connecting interface between the Zigbee and microcontroller is achieved by using MAX232 IC. Some procedure is followed as that of GSM Module. Power supply to the Zigbee Module is 5V.

Wireless camera is fixed on the microcontroller to capture the image of field and then transmit to PC for further processing.

MPLAB is free software that is needed to burn hex file into PIC16f788A program memory. Connect PICStartPlus programmer using RS232 cable with your PC. Follow the instruction to burn the hex file into PIC16F788A chip. Once complete, remove PIC16F788A from PICStartPlus and insert it into the development board. Turn On the power supply. PICStartPlus is hardware programmer that is used to burn the hex file into PIC16F788A. It consists of power supply socket, RS232 cable that is connected to PC and 40 pin ZIF socket. PIC16F788A chip is placed ZIF socket.

Weed detection process in MATLAB

The captured image from the wireless camera is transmitted to the PC using Zigbee. They are 2 methodologies is followed in MATLAB.

i. Green Segmentation
ii. Feature Extraction

I. Green Segmentation:

The image is captured by using wireless camera to classify the pixels into two categories: a plant pixel which includes crops as well as weed and soil. In this, first of all extract the hue plane of the image. Then fuzzy c-means clustering method is applied to the image which is followed by some morphological operation. The output image is clear under different lighting conditions.

II. Feature Extraction:

To extract the features sharply, so that weed parts within row could be distinguished from the crop in the field, feature extraction is done. To do this, Discrete Wavelet Transform (DWT) method which provides both the spatial and frequency content of the image has been implemented.

Algorithm for DWT in Haar Waveform

1: Start
2: Input image (I) captured from the field
3: Calculate DWT2 for feature extraction
[CA, CH, CV, CB]=dwt2 (x,'wname')
CA- computation of the approximation coefficient matrix.
CH- detail of coefficient Matrix.
CV, CB- coefficient of vertical and diagonal.
4: DWT maps the image using the mathematical equation.
X=B.Y
Y-wavelet Coefficient
B- wavelet basis
X-input image (pixels)
5: Normalized coefficient wavelet
C= $\tilde{W}$ I
which gives least-square approximation of the image.
6: Compute the wavelet
i. Compute $\tilde{W}$ I
ii Sort of coefficient in order to decreasing absolute value.
C= $\tilde{W}$ I
C- normalized wavelet coefficient.
$\tilde{W}$- wavelet transform
I - image
7: Compute the 1D transform for each column and vector $\tilde{W}$ I in an image I
8: Compute the 1D transform of each row of I.
9: Output: $K.2^a$ coefficient.

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CONCLUSION

The project presents the design of mobile robot for autonomous navigation in field for herbicide spraying in agriculture and weed detection in the field. The robot is designed by using PIC microcontroller. The robot is controlled by mobile in agriculture field for weed control and detection. Preventing damages and consequences of chemical herbicides as well as saving money is most recent trend. In this proposed image processing algorithm, 95.89% classification accuracy can be achieved in MATLAB. Then the connection between the robot and PC can be achieved by using Zigbee technology.

Limitation of the algorithm is classification is achieved by using MATLAB and in future any software could be used to achieve the classification.

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