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An Autonomous Pest Detection and Pesticide spraying system Using Image Processing and Embedded Processor

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ABSTRACT

Pests in plants cause major production losses in agricultural industry worldwide. A proper measure has to be taken to control pest of crops with minimum use of pesticides. The techniques of embedded system and machine vision are extensively applied to agricultural science, and it has great perspective especially in the plant protection field, which ultimately leads to crops management. Existing autonomous spraying system do not have accurate pest detection and also it causes pollution to the environment. This paper addresses the problem with the objective of image processing algorithms with embedded processor that can detect pests in agricultural field. Our aim is to demonstrate automatic sprayer, which can spray pesticides selectively with respect to the characteristics of the pests. We experimentally evaluated an automatic spraying machine with ARM9 processor. We have taken 4 different sample images from agricultural field and were analyzed using Moving object Extraction method. It shown the pests images with high accuracy of 96%.Hence we applied the pesticides in pests identified location selectively to improve the productivity of the crop. Our proposed machine is cost effective; it uses lesser amount of pesticides and avoids environment pollution.

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INTRODUCTION

Agriculture in India accounts for nearly 54% of the country's employment, 22% of the total GPD and nearly 12% of total export earnings. Agriculture is not only the back bone of Indian economy and food security but also a way of life, a tradition and anchor of overall livelihood opportunity. Though the country is self sufficient in food production, there is a serious concern about the slow rate of growth in agriculture has to come largely because of shrinking natural resources. Hence technology is the main driving force for further agricultural growth. Green revolution has no doubt led to increased world food supplies, but at the same time it has caused several ecological, environmental and socioeconomic problems. Food plants of the world are damaged by more than 10,000 species of insects, 30,000 species of weeds, 100,000 diseases and 1000 species of generally considered as major pests. In terms of monetary value, the Indian agriculture currently suffers an annual loss of about Rs 8, 63,884 million due to insect pests. This loss could be reduced greatly by adopting our proposed method. This method provides maximized farmers profitability and avoids environmental pollution. In nearly 20 years since 1990s, hardware and software for machine vision have been highly improved, and various techniques have been highly feasible and reliable practices in agriculture harvesting or fruit picking system, vision based localization for green house robot, pesticide spraying, inspection and grading of agricultural, de-leading, weed control and other works have been carrying out. The detected pest is greenhouse whitefly (Trialeurodes vaporariorum), is a major pest of many fruit, vegetable and ornamental crops, frequently being found in greenhouses. The greenhouse whitefly is controlled by autonomous spray of pesticides using embedded processor with image processing. Plants like sugarcane, tomato, beans, chillies, soybeans, potato etc are affected by whiteflies. Nowadays production rate are decreased due to pests. Our aim is to increase the production rate by pest detection and controlled spray of pesticides and also reduces the human effort. In literature review of methods for targeted crop

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protection systems in agriculture was given by VAN DE ZANDE *et al*. (2008).It was shown that solutions for targeted spraying of pesticides in orchards are still in prototype phase, however, there are already commercially available sprayers for weed control and plant fertilizing in the arable land. Recently, the Hough-transform-based vision algorithm for crop row detection of an automated agricultural vehicle was reported to be the most promising method in orchard management (KISE *et al*. 2005; ROVIRA-MÁS *et al*. 2005).The purpose of our research was to develop an automated sprayer consisting of a spraying arm with nozzles controlled by an RGB image processing system. Results on comparisons of spray coverage characteristics as well as the savings of pesticides between two working modes (with and without automated guidance) .Our approach can be achieved with the aid of RGB image acquisition and analysis.

II. Overall Scheme Of A System:

2.1 CMOS camera:

The camera is based on CMOS technology which has an advantage of low noise output, high speed operation, and low power consumption. It has a built-in USB transceiver pins to perform USB data transfer. It provides image acquisition process and converts the image to digital frames of different colours and it transfers the images through USB bus lines which connect directly to processor USB HOST interface through USB drivers.

2.2 ARM9 Processor:

The processor S3C2440 is based on ARM910T core technology which is Harvard architecture with AMBA (Advanced microcontroller bus architecture) technology. It provides both 16 bit and 32 bit operations and has separate registers for 16bit and 32bit data/instructions. It has two modes of operation THUMB mode (16 bit) and ARM mode (32bit). The processor is capable to operate at 400 MHz and it can be over clocked up to 533 MHz with 100mv positive voltage shift. The processor is enhanced to operate at low power hence it provides better performance in handheld devices at low cost.

2.3 Host interface:

Host interface provides remote communication with the processor unit. It transmits system control codes for movement and camera rotation control. The processor streams the captured images to the host device. It transmits 7 control bits via Serial transfer in RF communication. The seven bits control the motors and its direction.

2.4 I/O Drivers:

The I/O drivers provide interface between processor and output devices via GPIO bus. It consists of ULN2803 IC driver circuitry which is an 8-channel Darlington driver provide 8 channel drivers for output device. The ULN2803 IC transfers the control signals from processor to relays. The relays are responsible for controlling the output motors. The directions of the motors are determined by switching of relay terminals and processing results can be displayed through the LCD or transmitted to the backend server to publish. Framework map of overall scheme of a system is shown in Fig.1.

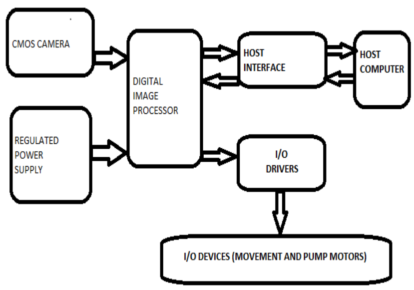

Fig. 1: Sketch map of overall scheme of a system.

III. Design Of Hardware System For Agricultural Pests:

CMOS Camera is defined as an image capturing device manufactured based on CMOS technology. It captures image in frames and transmitted by data lines. The data transmitted consists of frames with specific colours. The use of CMOS camera improves efficiency of capturing images than other device such as CCD cameras. For higher efficiency the dimension of the captured frames must be higher. The captured images are transferred through USB to the processor. The processor directly separates each image to two frames (RBG frame and YC_bC_r frame). The separated frames are stored in separate registers.

The S3C2440 has a CMOS camera interface. It is marked as CAMERA on the schematic. It is a 20 pin 2.0mm connector CAM130 module. It is basically a converter and directly connects to ZT130G2 camera module. The port can communicate directly with the camera to processor for data and control transfer. It can be used as GPIO by setting corresponding registers.

IV. Control Circuit:

The captured image is stored in the memory and transferred to the host machine via wireless transmission based on RF transmission. The little-endian method in codec path is used to store in the frame memory. The pixels are stored from LSB to MSB side. AHB bus carries 32-bit word data. So, CAMIF makes each of the YC_bC_r words in little-endian style. For preview path, two different formats exist. One pixel (Color 1 pixel) is one word for RGB 24-bit format. Otherwise, two pixels are one word for RGB 16-bit format. Frame memories consist of four ping-pong memories for each of P and C paths. C path ping-pong memories have three element memories – luminance Y, chrominance C_b, and chrominance C_r. If AHB-bus traffic is not enough for the DMA operation to complete during one horizontal line period, it may lead to malfunctioning.

4.1 Display, Relay and Motor Unit:

The motors are driven by relays and it's controlled by IC ULN 2803.The control signals are received from the ARM9 processor. It consists of RELAYS driven by IC ULN 2803.The relays are connected to output motors.The display unit consists of 3.5 inch TFT touch screen LCD screen connected to the processor. The processor sends the captured image to the display and touch interface options. It provides control access and input source to the processor The relay and motor unit provide interface between processor and output motor devices. The relay is driven by Darlington driver package IC ULN2803. The relay is capable of switching 12v 7A NONC operations.

4.2 Power management:

The charger unit consists of SMPS based design of step down of 240v AC line to 12v 2A dc output. The output dc line is coupled to robot by mono jack coupler for charging the battery. The empty battery requires 3.75 hours of charging to attain full charge. A fully charged battery can provide power to robot up to 2.33 hours. The board needs an external 5V power supply. The processing board requires regulated 5v/0.5A power supply. The wheel motors requires 12v/1A power supply. The driver unit requires 12v/0.5A power supply. In total the whole unit requires 12v/2A provided by 12v/7A sealed lead acid battery. The whole unit functions 2.33 hours with fully charged battery.

V. Hardware Implementation:

The camera is based on CMOS technology which has an advantage of low noise output, high speed operation, and low power consumption. It has a built-in USB transceiver pins to perform USB data transfer.

Fig. 2: Autonomous vehicle.

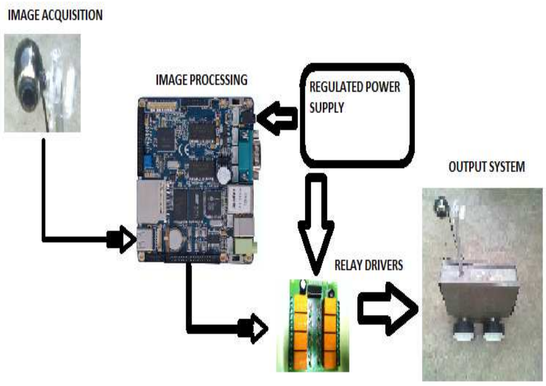

Fig. 3: Hardware implementation for autonomous pest detection.

It provides image acquisition process and converts the image to digital frames of different colour it transfers the images through USB bus lines which connects directly to processor USB HOST interface through USB drivers. The processor S3C2440 is based on ARM910T core technology which is based on Harvard architecture with AMBA (Advanced microcontroller bus architecture) technology. It provides both 16 bit and 32 bit operations and has separate registers for 16bit and 32 bit data/instructions. It has two modes of operation THUMB mode (16 bit) and ARM mode (32bit). The processor is capable to operate at 400 MHz and it can be over clocked up to 533 MHz with 100mv positive voltage shift. The processor is enhanced to operate at low power hence it provides better performance in handheld devices at low cost. Host interface provides remote communication with the processor unit. It transmits system control codes for movement and camera rotation control. The processor streams the captured images to the host device. It transmits 7 control bits via Serial transfer in RF communication. The seven bits control the motors and its direction. The I/O drivers provide interface between processor and output devices via GPIO bus. It consists of ULN2803 IC driver circuitry which is an 8-channel Darlington driver provide 8 channel drivers for output device. The ULN2803 IC transfers the control signals from processor to relays. The relays are responsible for the controlling the output motors.

VI. Extraction Of The Moving Pest:

In the extraction of the pest a rectangular bounding box is plotted with the dimensions of the pest produced in the residual image. Steps for extraction of moving pest is as follows

i. Read the image difference.

ii. For (present position = initial value: final value) of Y resolution

iii. For (present position = initial value: final value) of X resolution. Calculate the sharp change in intensity of image from top to bottom. Store the values in an array.

iv. Height of the bounding box = bottom – top

v. For (present position = initial value: final value) of X resolution

vi. For (present position = initial value: final value) of Y resolution. Calculate the sharp change in intensity of image from top to bottom. Store the values in an array.

vii. Width of the bound box = right value – left value

viii. Using the dimensions, draw boundary to the image Initial value: starting position of the pixel in an image. Final value: the ending position of the pixel in an image

$$Height = \frac{bottom\ value - top\ value}{2}$$

$$Width = \frac{right\ value - left\ value}{2}$$

ix. Add the height value with the top value and store it in the variable like mid top.

x. Assign the max intensity to the pixel at pixel value at (mid top, mid left).

VII. System Experiment:

In order to detect a movement within a secured area, a surveillance camera is positioned to monitor the area. An Image-processing scheme to detect moving objects in real time is a key technology for the automatic surveillance. The movement detection uses a simple but efficient method of comparing image pixel values in subsequent still frames that are captured every two seconds from the surveillance camera. Two still images are required to detect any movement. The captured image size is 256x256 pixels. The first image, which is called “reference” image, represents the reference pixel values for comparison purpose, and the second image, which is called the “input” image, contains the moving object. The two images are compared and the differences in pixel values are determined. If the input image pixel values are not equal to the reference image pixel values, then the input image pixel values are threshold and saved in a third image, which is called output image, with a black or white background. The choice of the output image background (black or white) is determined by comparing the average pixel value of the “Difference” between the result output image and the reference and input images. If the “difference” average pixel value is Smaller than a certain threshold value, then the output image Background will be white (pixel value is 255); otherwise, the background will be black (pixel value is 0).After tracking the moving object motion, the previous input image will now be used as a reference image, and a third image is captured and is called now the input image. This process is repeated with the images being captured every two seconds, where the same comparison method is applied. If there is a difference between the reference and input images, then an output image is created.

From the above table it is observed that false detection rate is reduced and maximum number of pest is detected using moving object extraction method.

Figure5 shows detection of pest count is improved in Moving object extraction method compared to colour based method.

V. Software Description:

The processes to the processor are coded with *embedded Linux* and debugged in Linux kernel debugger. The whole process is debugged using ARMv4 debugging algorithm. The program is debugged in Linux which is based on C++ language. It provides control of processor directly by configuring the headers based on the processor instruction set and architecture. The coding is debugged based on Linux kernel by the processor library files which is configured as header files. The processor transfers the entire code into image file which is capable to be boot by the system. The inbuilt C++ debugger in Linux consists of library files for i-386 architecture which is capable to boot the computer Intel based architecture.

VIII. Conclusion:

This proposed work will be effective over the existing systems in automatic pest detection and spraying system. The application of pest detection using image processing technique will lead to phenomenal increase in earlier pest detection and it will lesser the manual work involved in the agricultural field. Time consumption is yet another advantage adding to its remarkable success in detecting and controlling pest using autonomous spraying method. About 4 different sample images were analyzed and it was found with an accuracy level of 96%.This proposed methodology will increase production rate of the crop and reduces amount of pesticides used in plants. The implementation of autonomous pest detection using embedded processor shows low power and high performance. The design provides low cost to implement the operation. It can be further implemented by intelligent techniques like neural network for pest recognition. The performance analysis can be measured for image segmentation and recognition.

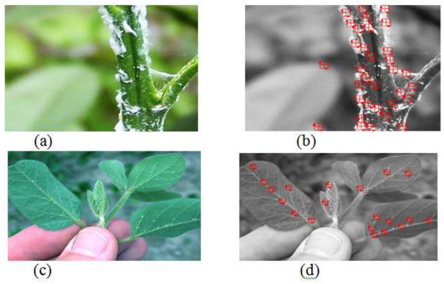

Fig. 4: (a) &(c) input image; (b)&(d) segmented image.

Table 1: Comparison between Proposed method & Colour based matching.

Input Image	No.of pest Present	Colour Based matching			Proposed Method –Moving Object Extraction Method		
		No.of pests Detected	No.of correct pests detected	No.of wrong object detected	No.of pests Detected	No.of correct pests detected	No.of wrong object detected
sample 1	3	1	1	0	4	3	1
sample 2	20	2	2	0	23	20	3
sample 3	10	3	2	1	14	9	5
sample 4	25	45	22	19	27	24	3

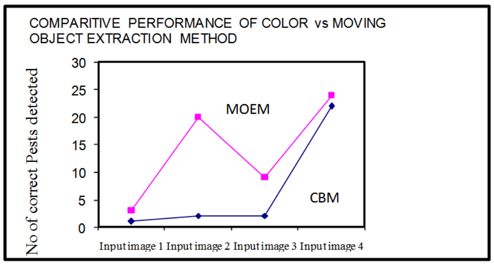

Fig. 5: colour vs. Moving object extraction method.

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