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INTERNATIONAL PEST CONTROL

Public Health • Agriculture • Horticulture • Forestry • Animal Health

Robotic birds of prey

Urban deer – success or problem?

The knowledge behind rodent bait boxes

Goodnature rodent trap in Tata Steel Zoo

Bird Free – bird deterent gel

Insecticide cockroach paint in Zaragoza

Managing insect resistance for 100 years

Understanding pest movement in Australian crops

Six-row tractor mounted herbicide applicator

Stemming tree cankers with fungicide paint

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A six-row tractor mounted microcoprocessor based herbicide applicator for weed control in row crops

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Chemical measure of weed control includes the use of herbicides (selective or nonselective) at various stages of plant growth. Different methods are adopted to apply these chemicals, spraying being the most common. However, with a large volume of liquid often required and the hazard of environmental pollution, caused by drift of the chemicals, there is a need for an efficient method of controlling weeds without the risk of herbicide drift with minimal impact on non-target plants. If this can be achieved, such practices would result in lower environmental loading and increased profitability in the agricultural production sector.

To guide site-specific herbicide application, a machine vision and image processing system, based on digital camera technology can be used to detect the presence and variability of weeds in the field. Tewari and Mittra (1982) developed and patented a manually pushed herbicide applicator (IITWAM-82) for row crops. He reported that the performance of a sponge roller in Arhar crop was excellent and uniformity of application achieved was 100 percent. The volume of herbicide solution required was 100–120 l/ha. Welker (1985) developed a hand roller herbicide wiper for lawns and gardens. He reported that excellent control of broad leaf weeds was achieved using 2, 4-D, Paraquat and with no evidence of herbicide drift. Gaurav Sharma (2009) developed a microcontroller based manually operated single row roller contact type herbicide applicator for control of the weed population in field crops. A control system was developed to apply the quantity of the herbicide based on quantified weed information. Tewari et.al (2014) also developed a 3- row unit for this device.

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Design Considerations

The tractor is a most versatile machine used on farm for various farm operations and transportation. In India there is a trend of mounting various machines like Combine, VCR and other implements to tractors as most of the operations are seasonal in nature. Therefore, additional tractor mounted herbicide implements could help decrease tractor idle time. The present study was undertaken to develop a tractor mounted contact type, six row, microcontroller based, variable rate, herbicide applicator. A control system was developed to apply the correct quantity of the herbicide based on site specific weed information. It comprises a camera for capturing the images of weeds, MATLAB software for image acquisition and processing, laptop, a serial port communication for communicating between laptop and controller, a proximity sensor to sense the position, a microcontroller for controlling the application of herbicide through relay and solenoid valves for variable rate herbicide application.

Digital Image Processing

An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of any pair of coordinates (x, y) is called the intensity or gray level of the image, at that point. When x, y and the amplitude values of f(x,y) are all finite, discrete quantities, we call the image a digital image. The field of digital image processing refers to processing digital images by means of a digital computer. Pixel is the term most widely used to denote the elements of a digital image (Gonzalez et al., 2009). There are no clear-cut boundaries in the continuum, from image processing at one end, to computer vision at the other. However, one useful paradigm is to consider three types of computerized processes in this continuum: low, mid and high-level processes. Low-level processes involve primitive operations such as image preprocessing to reduce noise, contrast enhancement and image sharpening.

A low-level process is characterized by the fact that both its inputs and outputs are images. Mid-level processing on images involves tasks such as segmentation (partitioning an image into regions or objects), description of those objects to reduce them to a form suitable for computer processing, and classification (recognition) of individual objects.

A mid-level process is characterized by the fact that its inputs generally are images, but its outputs are attributes extracted from those images

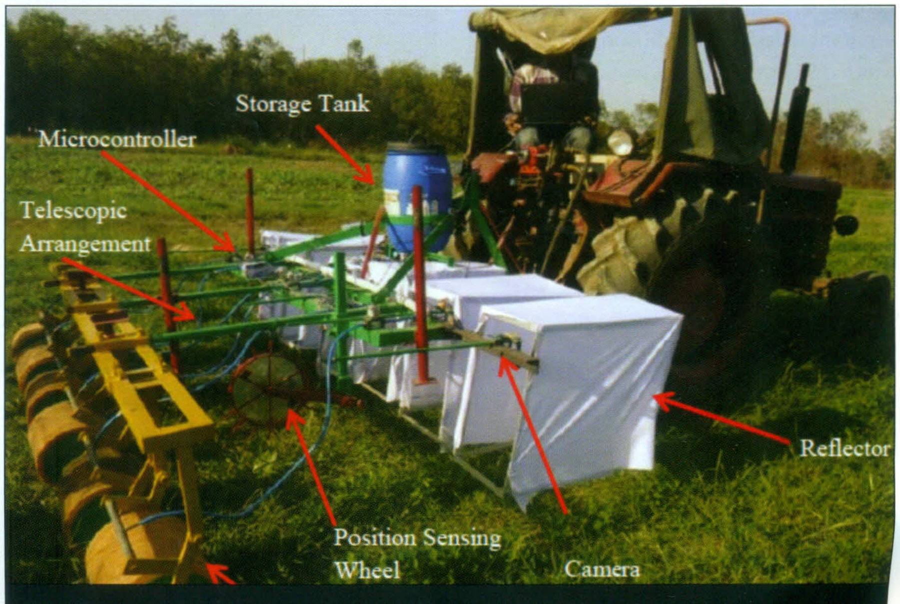
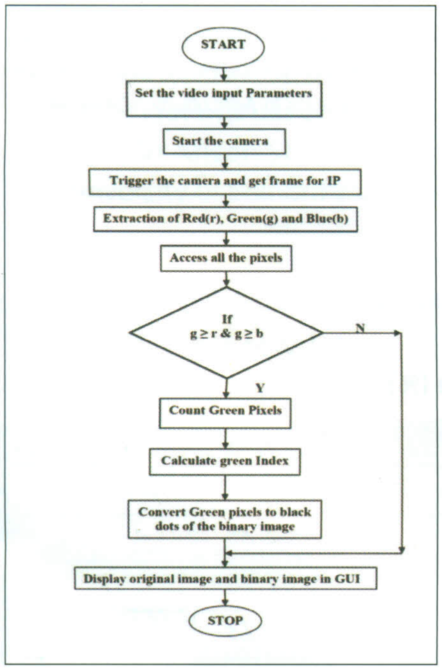


Fig4. Tractor mounted six- row contact roller type herbicide applicator

Fig 2. Original weed image, Fig 3. Processed weed image (Green index = 0.1593)

(e.g., edges, contours and the identity of individual objects). Finally, higher-level processing involves 'making sense' of an ensemble of recognized objects, as in image analysis and, at the far end of the continuum, performing the cognitive functions normally associated with vision. The common steps involved in digital image processing are shown in Fig1.

Fig 1.Flow chart of digital image processing system



Discrimination of weeds from soil background

A graphical user interface was developed with MATLAB software for digital image processing. For discrimination of weeds from the background of field images, the RGB comparison method was used in this experiment. The camera captures an image of ground cover underneath the camera and sends it to the laptop, where the application software processes the captured image, on the basis of comparison of intensities of Red (R), Green (G) and Blue (B) components of each pixel (the smallest single component of a digital image) of image. When G colour intensity is greater than R as well as B colour intensity, than the pixel is assumed to be green (weeds) and its value is set to 0 (i.e. black colour). When G colour intensity is less than R, as well as B colour intensity, then the pixel is assumed to be background and its value is set to 1 (i.e. white colour). A typical weed RGB image is shown in Fig.2 and its binary image showing all pixels having green intensity as red colour and blue intensity as black dots, has been shown in Fig.3.

The percentage of weeds present in between crop rows was calculated in terms of Green Index. The Green Index is defined as the ratio of the number of green pixels in a given image to the total number of pixels in the same image. A proximity switch was installed with a ground wheel to sense the distance travelled by the rollers. As the rollers cover a distance of 600 mm, the proximity switch sends the signal to the camera through microcontroller to capture an image. The Frame Grabe Interval property in MATLAB specifies how often the video input object acquires a frame from the video stream. The system acquires an image frame after every 600 mm distance and the extra frames acquired in that period are deleted.

Herbicide applicator

Based on all design considerations, a six-row herbicide applicator was designed with individual weed sensing and contact type herbicide application unit for individual row (Fig 4). The main frame was provided with telescopic arrangements so that the horizontal spacing between the cameras and rollers can be adjusted to match the speed of operation. The height of the cameras can be adjusted by lifting and lowering the unit with the help of tractor three point linkage hitch. A circuit diagram of the microcontroller with different components for controlling the operation of the solenoid valve for applicator is shown in Fig 5.

Field evaluation of applicator

The cameras are calibrated for the height along with the size of the image boundary (length×width).Fig 6 shows the calibration curve between the height of the camera from the ground and the size of the weed image on the ground. The machine was field tested in groundnut crop and brief typical results are given in table 1.

Conclusions

1. The special features of the device include gravity feed, no drift loss, no effect on non-target plant and easy to operate and maintain.
2. The variable rate technology increases its ability to reduce the chemical application to the field. Thus a variable rate herbicide applicator using site specific weed information is a promising solution for reduction in herbicide usage, cost savings and reducing the environmental hazards.
3. The average herbicide application rate by variable rate contact type method and constant rate contact method was 386.67 l/ha and 524.44 l/ha respectively. The average reduction in herbicide application was 26.27 % with weeding efficiency of 78 %.

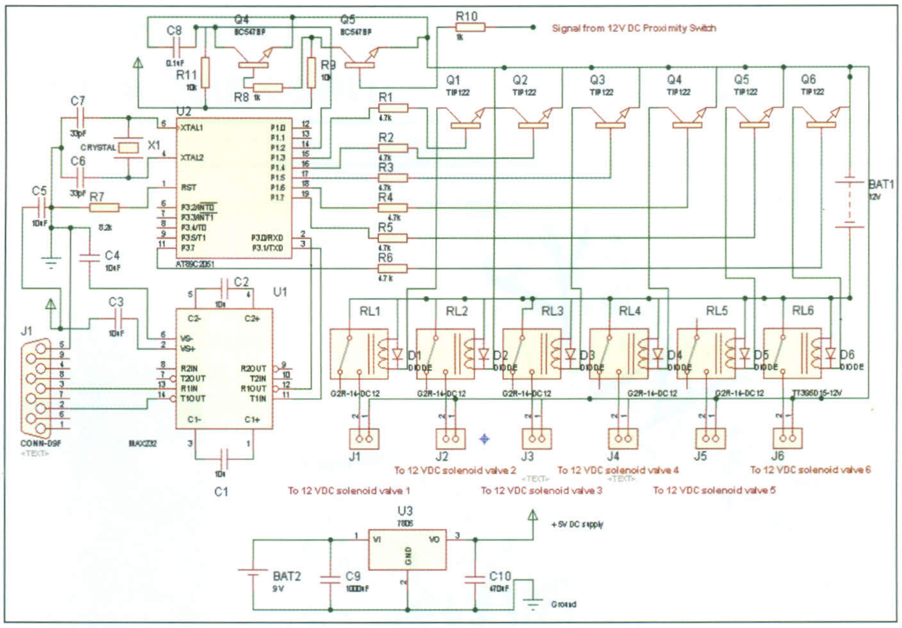


Fig 5.Circuit diagram of microcontroller assembly with various components.

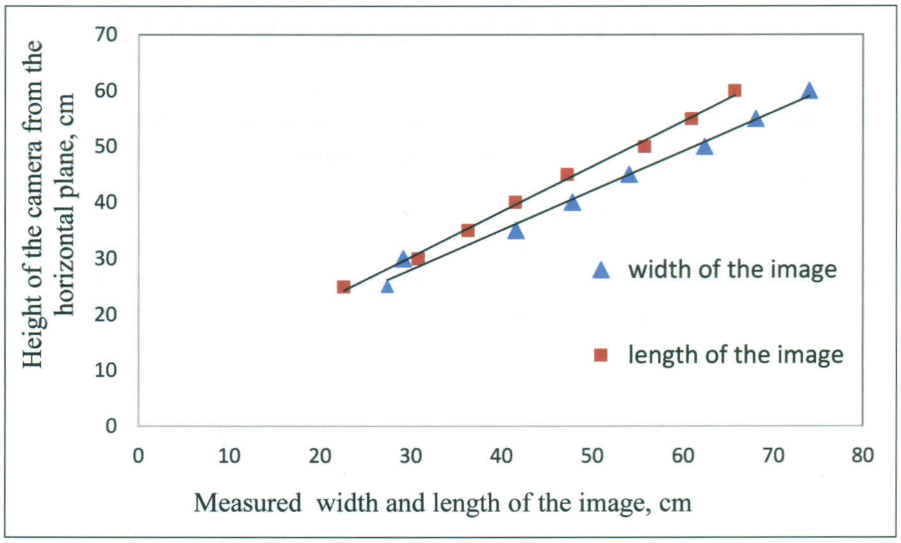


Fig 6. Calibration of camera and image size

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Table 1: Herbicide use and weeding efficiency

Plot No.	Application rate (l/ha)		Reduction in herbicide use (%)	Weeding efficiency (%)
	Variable rate application	Constant rate application		
1	362.96	525.92	30.98	84.35
2	370.37	518.51	28.57	88.03
3	407.40	518.51	21.42	62.26
4	385.18	525.92	26.76	67.78
5	407.40	533.33	23.61	74.23