Design and Development of interactive and low cost Autonomous Ergonomic Weed Eliminator

Saurabh Suman\textsuperscript{1}, Vijay Kamate\textsuperscript{2} S Mohan Kumar\textsuperscript{3}, Umakant P Kulkarni\textsuperscript{4}

\textsuperscript{1}Computer Science & Engineering, GEC Munger, Munger-811213, Bihar, India
\textsuperscript{2}Mechanical Engineering, SDMCET, Dharwad- 580 002, Karnataka, India
\textsuperscript{3}Mechanical Engineering, Malnad College of Engineering, Hassan-573201, Karnataka, India
\textsuperscript{4}Computer Science & Engineering, SDMCET, Dharwad- 580 002, Karnataka, India

E-mail: \textsuperscript{1}saurabhsuman2406@gmail.com,\textsuperscript{2}vijay.kamate@gmail.com,\textsuperscript{3}dr.s.m.kumar@gmail.com,\textsuperscript{4}upkulkarni@yahoo.com

Abstract. Recently it has been observed that there is a wide gap between agricultural income and non agricultural income. This has compelled huge population to look for job in other sectors where income is high. Thus Indian farmer needs accessible, affordable, user friendly farm automation system which encompasses true cost cutting and improving yield. It is a big challenge to have unified approach to design operator neutral platform, conforming to uniform application standards, localized and easy to use agriculture information system that can eliminate distance, labour and time with low cultivation cost. The aim of this paper is to structure, functionality, ergonomically usage with illustration of user friendly collaborative, interactive and low cost autonomous weed eliminator. The discussed weed eliminator can detect weeds using camera vision and eliminates weed through actuation of cutters using smart phone as a client. Further it has been improvised to accept the Voice Command for its operation. A low cost futuristic autonomous weed eliminator has been designed and developed by the authors. The objective of this weed eliminator equipment is to eliminate weeds from the field ergonomically.

1. Introduction

Any unwanted plant in agricultural fields restricting the growth of the crops and thereby reducing the agricultural yield can be termed as a weed. It reduces the agricultural products value, either by reducing the plant growth or by destroying the agro based plants itself. The yield reduction is mainly due to consuming water, light, soil nutrients and agricultural space by the weed [1].

Impact of Weeds on Crops: Weeds have high growth rates as compared with agro based crops, and if not controlled properly, they may dominate in the cultivating area. Apart from reducing the yield, the weed also host for many plant diseases by providing protection to various deadly worms, insects and microorganisms.

Classification: There are around thirty thousand types of weeds in all around the world, out of which about eighteen thousand species are known to cause serious losses for plants, animals and humans. As per agricultural scenario is concerned, they can be broadly categorized into in-row or intra row weeds (IR weed) and inter row or between row weeds (BR weed).
Economical and Labor Issues Related to Weed Management in Agriculture:
It is estimated by agricultural researchers that around 30% of oil seeds, 50% of food grains and pulses cultivated per annually are lost due to weeds alone, which accounts around 1,05,000 crores of rupees every year [2] forecasted that, if not treated at the proper time, the weeds may result in losses of around 65% of crops. Most of the farmers are still following traditional method of manual weed removal methods like use of (Khurpi), hoe (Salaki), animal driven and simple manual weeder to remove weeds from the fields. Drudgery involved in such operations is more and continuous use of traditional methods may affect the physical and mental well being of the farmers. A weeding process of this kind without considering human capabilities may cause work related injuries to the farmers thereby reducing working efficiency and comfort [3]. In these manual weed elimination stages, most of the farmers follow an unhealthy and awkward working posture which leads to pain in different body parts and further results into work related musculoskeletal disorders (WMSDs).

In-row weed removal is one of the crucial farm operations in crop production and protection system. This kind of weed developed between the crops is a main problem for both dry and wet land farming process, causing a significant loss of agricultural yield. Weed elimination from the crop rows is most tedious and difficult, which needs to be accomplished without damaging the main crops. Farmer in traditional in-row weeding approach removes the weed either by hand plucking or using simple tool like sickle. Thus, a farmer engaged in in-row weed removal process occupies squatting or forward bend postures for long period, which is harmful and further leads to work related musculoskeletal disorders (WMSDs) like lower back pain, knee pain, shoulder and neck pain. For in-row weeding many sophisticated weeders are available but these are not affordable by the marginal farmers [4]. The main objective of this work is to design and develop next generation collaborative, interactive and low cost autonomous ergonomic weeder to reduce the risk of musculoskeletal disorders (WMSDs)[5][6].

2. Improvised In-Row Weed Eliminator based on Ergonomics
The initial version of In-row weed Eliminator designed and developed by the authors is shown in figures from Figure 1 to Figure 3. In this equipment camera high resolution camera fixed towards the crop side and display unit is fixed nearer to the farmer end. While moving inside the row, the camera captures the images of both crop and weed. The image thus captured is displayed on the display screen. The farmer after looking into the screen identifies or differentiates between crop and weed in a comfortable standing posture. A cutting tool and its actuation lever are attached to the main chassis to perform the weed removal task. A DC motor is fixed for the operation/rotation of cutting tool using a simple switch. After identifying the weed and its exact location in the display screen, the farmer triggers the cutter with the help of a switch and removes the weed by simply moving the actuating lever comfortably.

The initial version of In-Row weed eliminator has been designed based on the ergonomic guidelines to address these issues of discomfort. The equipment helps in achieving the weeding operation in comfortable working posture with reduced drudgery and work related musculoskeletal disorders. In this approach of in-row weed removal method though achieved its intended goal but still cutter has to be actuated manually by the user. In-Row weed eliminator has been further refined and made much sophisticated to handle by adopting a touch screen based mobile application interface to actuate the cutter by simply touching the weeds on the display screen or giving voice command. This allows the cutter to go to the weed location automatically and destroys it. This equipment can further sense real time farm data for further analytics and visualization for scheduling of other agricultural process. Different profiles of cutting tools and their actuating mechanisms can be designed as an add-on to the existing system to suit the different weed types. The conceptual model of the improvised In-row weed eliminator is shown in Figure 4.
Based on the crop spacing data available from different sources, the chassis length and width is taken as the average value of 600 mm. The chassis height is made adjustable to suit the crop growth at various phases of its existence. The height from the camera lens to the ground was set to 1m in order to allow the solution to target in-fallow weed regrowth for a variety of weed species. The ground clearance underneath the robotic vehicle is fair to adopt Indian farm land. No external shading or lighting has been used for the optical system not to limit vehicle’s maneuverability. A high-end image capturing camera captures the images of the cultivated crop and weeds. The operator accordingly then positions the equipment at an appropriate location to remove the weed using the direction control buttons provided in user interface of the mobile client application. The cutter is actuated both in clockwise and anticlockwise by using the buttons provided in user interface of the mobile client application. After successful removal of weed, the operator moves the equipment to next location where weed is present through mobile application.

The cutter profile is prepared based on the soil interaction while operating the in-row weed removal process. To a cylindrical drum, various sharp nails are welded all along its surface for better weed removal. Based on the torque generated by the motor, the cutter is tested in the field to ensure its intended performance of removing weeds and loosening of soil for better aeration.
and moisture absorbing capability. The CAD image of cutter profile and the fabricated cutter are shown in the following Figure 6. In order to actuate the mechanical systems of the current equipment an interface with electronic system is necessary. The user operates the equipment and the cutter using mobile application. When a button is pressed, a signal is sent to the Raspberry Pi board. The Raspberry Pi receives the unique input signal from the mobile application and sends high or low voltage pulse i.e., Pulse Width Modulation (PWM) signal to the dual DC motor driver. Power bank is used to supply power to the Raspberry Pi board. The motor driver supplies power to the motor from the 12V power supply i.e., battery based on the PWM signal from Raspberry Pi board and sends data signal to the DC motor which then starts operating accordingly.

**Figure 6.** In-row weed cutter profile

**Figure 7.** Pinout configuration for Raspberry Pi B3 to motor control driver

### 2.2. Motor control using Python Programming

Python code has been developed for controlling the vehicle movement by controlling the DC motors using the Raspberry Pi. The code contains of four modules:

- **Pin configuration specification:** It is necessary to specify the pins used in the Raspberry Pi to be connected to the motor driver so as to send signal from the board to the particular pin of the motor driver.
- **Camera feed:** The camera connected to the Raspberry Pi board is programmed to send the feed directly to the mobile application through wireless transmission in real-time situations.
- **Signal receiving and transmitting:** Each button in the mobile application when operated sends a unique signal in the form of alphabets to the Raspberry Pi board which is programmed accordingly to receive, decode and instruct the driver to operate the required motor.
- **Voice Control:** It is used for providing voice based command Like Move Forward, Move Backward, Turn Left, Turn Right, Turn Soft Left, Turn Soft Right, Stop and equipment speed control command.

### 3. Results and Discussion

The Improvised In-Row Weed Eliminator was physically built and tested for its intended purpose. The salient features of the physical prototype are mentioned below:

- The body/chassis of the equipment was built with mild steel angle bars and plates.
Three varieties of cutters were fabricated for different weed variants commonly observed in agricultural fields.

Sufficient clearance was ensured between the crop and chassis structure so as to move the equipment in the agricultural fields without damaging the main crops.

Electronic components, power source, battery and its related items were mounted on the top of the equipment.

DC motors are assembled with wheels and cutter shafts, which further receives signals from the operator to function according to the instructions given.

High definition camera was mounted on to the chassis frame at an appropriate location so as to capture the cutter and its positional area clearly. This live video is noticeable on the mobile screen in real time.

A separate camera is mounted to capture images of different weeds to collect the image data set of weeds. The prepared image data set of weeds can be used to train the system.

The CAD model and the fabricated functional working prototype of the mobile app controlled agricultural weeding equipment are shown in the following figures from Figures 8 to Figure 15.

4. Conclusion
Field test of the developed weed eliminator prototype has been conducted and the found that the equipment is comfortable in its operation. A comfortable working condition for farmer is
achieved as there was no need for physical presence in the field during weed removal. Mobile application program can be easily installed to any android operating mobile smart phone and was user friendly in controlling the equipment movement and cutter actuation. Different cutters can be installed to ensure proper weed removal for variety of weeds and in different soil conditions. This method of weed elimination technique avoided traditional way of harmful weeding positions like squatting postures, forward bend postures thus reducing work related injuries in farming community. This In-row weed eliminator can be further improved by implementing deep learning for more accuracy in identification of weed and actuation.

References

[1] Slaughter, D., Giles D., and Downey D. (2008), “Autonomous robotic weed control systems: A review, Computers and Electronics in Agriculture, 61 (1), 63-78.

[2] Yaduraju NT., Prasad Babu MBB. and Poonam Chandla. (2006), “Herbi-cide Use. In: Agriculture and Environment”, Swaminathan, M.S.and Chadha, K.L. (Eds.) Malhotra Publishing House, New Delhi, India, 192-210.

[3] Villarejo D. & Baron S.L. (1999), “The occupational health status of hired farm workers”. Occupational Medicine: State of the Art Reviews, 114(3), 613-635.

[4] Kumar Satish, Kumar Ashok and Kumar Sanoj (2017), “Performance Evaluation of Developed Manually Operated Rotary Weeder for Vegetable Crops”, Performance Evaluation of Developed Manually Operated Rotary Weeder for Vegetable Crops, 6(11), 4012-4019.

[5] Lynn McAtamney and E Nigel Corlett (1993), “RULA: a survey method for the investigation of work-related upper limb disorders”. Applied Ergonomics, 24(2), 91-99.

[6] Mohan Kumar S and Vijay Kamate (2019) Anthropometric Data of Farm Workers of North-Karnataka Region of India and its Practice for Better Design of Agricultural Tools and Implements J Robot Mech Eng Resr 3(2): 8-21,doi: https://doi.org/10.24218/jrmer.2019.31. Copyright: © 2019 Mohan Kumar.