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Alternate of Manual Weeding Tools: A Research into an Automatic Weeding Control Strategies Enabled by Embedded Systems

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Abstract—A key enabling factor for treating individualized weeds in the crops is the Automatic Weeding Control device (AWCd) as it is being capable of finding and distinguishing weeds in the field. The non-herbicide approaches used to manage weeds are a component of the personalized treatment of weed crops. In this study, mechanical weed control techniques are investigated as an alternative. In this study, three specifications—a cutting mechanism, a head-surface tilling (tines), and a foot-surface tilling (arrow hoe)—are taken into account. With different rates of application to herbicide-resistant, these processes were estimated in a controlled field and the efficacy of the implementation is estimated by using the demographic analysis and also, the importance of early interface has also been highlighted. For all the weeds accounted in this research, Automatic weeding control was found to be very effective thus ended up in overall survival probability.

Keywords: Manual Weeding Tools, Embedded Systems, Automatic Weeding Control device etc.

I. INTRODUCTION

Century-long increase in agricultural productivity has been made possible by farm consolidation, which has increased economies of scale and the genetic engineering, bundled breeding, and increasing automation have made this possible. Human protected farms are almost today protected by large-scale machineries and chemical advancements as countries transition to broad-acre farming to boost food yield. Due to the increasing chemical weed control, usage of herbicides in agriculture has also been increased.For low-tillage situations, a mechanical tool application or field ploughing as a substitute to chemical arbitration are inappropriate. This has prompted the adoption of alternative strategies such crop and cultivar selection, intercropping which means growing multiple crops at a time, and alternative patterns for planting.

Fig. 1. AWCdon a fallow field.

One of the possible uses for agricultural robots is to replace this large-scale apparatus that conducts a wide range of chemical or mechanical procedures. Without depending on interventions of broadband and having the ability to take decisions based on the perceptions, Robots can alternate the methodologies for managing the weeds that do not rely on broadcast intervention.

Precision robots used for agriculture makes use of several techniques like head surface tilling, foot surface tilling, and the cutting mechanisms. On herbicide-resistant plants, the efficiency of these tools was assessed. We examined plants at their multiple growth stages along with their treatment timing and effects over the species. In terms of overall performance and overall survival probability, we discovered that head surface tilling has offered the enhanced results when deployed automatically.

II. BACKGROUND/RELATEDWORK

Weeds in agriculture lands are controlled by robots right for all from crops requiring inter-row or intra-row weed management at their growing stages. The most difficult circumstance for weeding is when it occurs within a row of cultivated plants; as a result, many of the earlier instruments are ineffective and risk harming the crops. Crop locations are

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detected and depending upon its visual feedback, implementation is done at the right time by the robotic solutions. Huge number of chemical free robotic weeding methods are classified in to two groups as mechanical and thermal methods. Though the manual methods were using physical instruments for contacting weed or the field, the thermal methods make use of kinetic energy for breaking weedsdown the plant. This will either slow down the growth or may prevent the weeds from future growth.

A tube stamp and the spinning blade are two examples of mechanical approaches to drive weeds into soil being created for automatic systems specifically has variety of results accessible. These mechanical techniques must be distributed by using an actuator in order to be effective and for mechanical robotic weeding, the values of actuators have been taken into consideration.Parallel kinematic manipulators have been used though they are risky to be used at high speeds if they make contact with rough surfaces like soil or rocks. Bowden et al. [7] highlighted that this method can allow robots to stop thereby cutting off the automatic platform efficiency (even for a 2-DOF manipulator). The author also presented a variety of tools that were repeated in a staggered sequence to guarantee complete coverage. It is necessary to do study on the effectiveness of the automatic implements in order to comprehend their advantages and limitations.

A. Research on Weeding Effectiveness

The bulk of the literature does not employ rigorous methodologies to assess the effectiveness of the technology for managing weeds, despite the substantial effort put into developing innovative robotic technologies for weed management. A robotic weed control system does not take into account the various mechanical tools used in previous experiments on various mechanical implements passively pushed by conventional farming tractors in [19]. However, little research has been done to determine if robotic weed management technologies are effective. Individual automated systems' weeding efficiency has been assessed in [12] and [11], where performance was assessed using weed density in both techniques.

The effectiveness was observed to vary from 60% to 80% for one weed species when a revolving blade mechanism was utilised to handle a specific Broad-leaved dock weeding in [16]. A three-week trial of a robotic tool with revolving tines and robotic vision [17] employed a weed pixel reduction statistic to show performance. Although it hasn't been reported, a marijuana experiment was observed [17]. These investigations show that no long-term performance assessment of several mechanical instruments combined with a variety of weed species for a robotic weed management system has been carried out. In contrast to other studies, our analysis of the weeding tool's effectiveness makes use of well-known statistical methods such the Kaplan-Meier [8] estimate of survival function.

III. A ROBOT PLATFORMSET UP

AWCd, a mechanical tool array-equipped autonomous weed management robotis shown (see Fig. 2). The weed detection module of AWCd's weed management system manages the system's deployment. 2 tools were placed in mechanical weed of AWCd array for these researchesenabes us to test the tool in completely autonomous mode. Weed management controlled by weed detection module is described below and the tools that were considered for these experiments are then described.

A. Detection of Weed

A color camera is used for detecting weeds which can detect green flora which was demonstrated in [7]. The method consists of a globe trotter 5 Hz camera facing downwards that are capable of producing Hz using a microcontroller externally and in conjunction, pulsed light module producing 50,000 brightness for 2 milliseconds used in conjunction with this technology. Afterwards, the intensity component is taken out and each colour picture and sent to Luv,Lab, and HSV colour spaces from RGB colour space.

Following that, a Uni-modal multi-variety Gaussian p ($\mathbf{x}$ μ, $\mathbf{\Sigma}$)was used to predict floral colour (green), where $\mathbf{x}$ stands for the element vector and parameters (μ and $\mathbf{\Sigma}$) represents parameters of model studied on set of training mutually annotated photos. A diagonal $\mathbf{\Sigma}$ is assumed generating per-pixel segmentation map, also known as a log-likelihood map. It is shown in Fig. 3. (b) and segmentation map is converted into weed regions, in which every will act as a communication channel with a single plant. We de-noise the segmentation map by expanding and destroying it because it is typically noisy, as shown in Fig. 3(b). For additional information on this system, see [7].

Each endorsing box is examined at the conclusion of the process to identify the specific plant that it corresponds to, as shown in Fig. 3. (d). After weed estimation, AWCD's weeding system will be activated and by changing picture location into global frame, evaluation of weed location will be done by utilizing INS/GPS. Until navigation of lower implement, every weed will be returned back to frame of the robot when a small portion of convex hull is present inside target location.

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Fig. 2. Installing system modules for weeding.

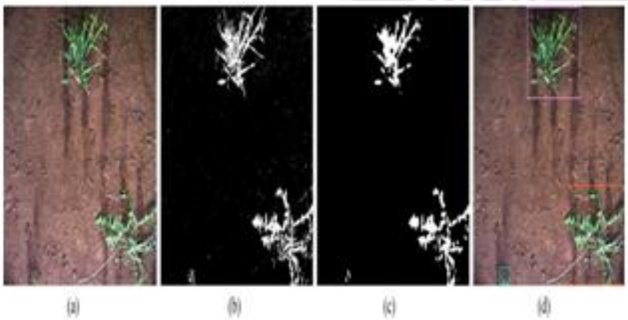

Fig. 3. (a) Depicts the original image. Fig. 3. (b) Illustrates results of per-pixel segmentation post thresholding. Fig. 3. (c) Shows filtered image post dilations and erosions, Fig. 3. (d) Illustrates the detecion regions indiated by bounding boxes. In which each color represents the each sweed species like cotton is indicated by blue color, sow thistle is represented by red color, and the wild oats is indicated by magenta color.

B. MechanicalImplements

Three mechanical tools namely the cutting tool, a tine, and the arrow hoe(whippersnapper) was examined in which first two tools were completely automated cultivation tools that were placed on the mechanical weeding module of the AWCD II (see Fig. 4). The arrow angle was narrow in order to lessen the depth of the illusion, which in turn reduced the amount of tillage and increased the cutting action. To lessen the amount of soil that could become seize in them, the tine and arrow angles were both carefully considered. Since a human fixer applied it rather than a robot, its identification and tool location were both perfectly exact (Refer Fig. 5). Only W/S can be used as a cutting tool as it is having the capacity to permit external power.

IV. METHODOLOGY & EXPERIMENTAL ANALYSIS

Cleveland, Australia's Queensland Department of Agriculture and Fisheries Research Station, has shown set of controlled tests using AECD during the period from April to June 2016. This has ended up in demanding the plant growth in the respective field thereby measuring its numbers and biomass.

A. Experimental Setup

Over an eight-week period, 4 herbicide-resistant plants were generated, utilised, & reported. The four species that were planted included sow thistle (Sonchusoleraceus), cotton (genus Gossypium), and two grasses, feather top Rhodes grass (Chlorisvirgata) and wild oats (Avenafatua). Six lanes were drawn through the space, and each lane had 68 separate plots. Depending upon app times, lanes are categorized as shown in Fig. 6.To cut off impact of structural changes dominating the results and species are distributed across plots that are subjected to various three types of treatments with three individual application rates. For each species, a group of control plants were also grown higher. Only one sort of treatment (implement) was used on a plot. Treatment began either at week 4, week 6, or both weeks, depending on the rate of administration.

Figure 4 shows one of the two mechanical tools that were utilized on AWCdin which arrow hoe is on the left side and tine is on right side.

During the weeks 4, 6, and 8, biomass is measured and plant number are counted but, measurements at 4th week are done before the treatment at the 4th week which was ended in estimating the plant count. Similarly, measurements at 6th week are done before the treatment at the 6th week. Then, the plants present at 6th week and its success rate of the treatment are analyzed. We were able to determine how many plants were still alive following treatments at 6th week provided by the measurements taken at 8th week. When compared with plants' natural attrition rates, counts were taken at each of the treatment-undergoing locations and similar measures were taken at the untreated control group.

Fig. 5. On all weeds present, the W/S cutting tool was tested and manually applied.

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Fig. 6. Illustrates the design of the field. The red sections included the control plants, while the blue and yellow parts were treated during weeks four through six4 to 6 (Cntl). The view on the right shows one of the areas and the several plots (P1, P2,..., P16) that are present in each area.

B. Methods of Experimental Analysis

We assessed the probability of survival depending oncategory of therapy (implementation), total time of application, and combinations using a framework for survival analysis. We employ Kaplan-Meier estimates in this research as the plants operate at the event of interest moment [8]. Given that the plant was operating immediately before t_i and that $d_i$representsnumberofdeath satt_i, we use $1 - \underline{d_i}$as conditional probability that plant lives at times. Survival function may then be approximated after observing the Kaplan-Meir estimates by week 4 and 6.

Importance of preserving earlier is denoted by the first two treatments whereas the capability of multiple traverses for enhancing the success rate of the treatments is identified by the third treatment rate.

This was done for a number of models requiring representing important germination & death events happening throughout the time. This was made possible by accounting for the germination week, the week of death, the start and stop periods for each individual plant.

The subsequent data was then incorporated into our models such as SurvivabilityTreatment, Survivability Treatment + Time of Treatment, &Survivability Time ofTreatment and interpreted as "dependsupon".For "Treatment", "Time", and "Treatment + Time", three models created in which each of the one is for each species. By stabilizing entire functional groupings, a set of models was also created. A different model was created by combining all of the grasses. Short populations were used in the experiment during the latter weeks, and as a result, models with mixed variables, Treatment + Time, shows high analytical variance that is related to the small sample numbers.

Thus, bigger population subsets were examined using models (1) and (2), but it was assumed that the other repressor was not subject to fluctuation in the self-conservation. The little number of samples we had at our disposal forced us to make this assumption. ANOVAs was executed once after the evaluation of survival probabilities was done across he combo of application times and treatments. Following the evaluation of the survival probability for each time period, ANOVAs were carried out between various combinations of treatments and application timings. As determined by the ANOVAs' hypothesis tests, this demonstrated whether or not the likelihood for survival was noticeably different across the sub groups.

V. RESULTS OF THE EXPERIMENT

Results of three out of four herbicide-unaffected plant weed species sown are shown as a result of changes in making the germination process successful. Due to low germination rates, 1 wide leaf plant (cotton), 2 grass species wild oats (WO) &feather top Rhodes (FT), & 2 broad leaf plant (sow thistle) cannot be added. Implementation results of treatments and application time are shown below.We contrast the self-reservation charts with the control plots when doing the analysis. Bright red denotes poor chances of survival, and the hue of the bar charts, which ranges from bright red to grey, reflects this.

A. TypeofImplementation

We investigate the overall efficacy of the tools used in the first set of studies without considering the types of plants. In Fig. 7, it can be observed that all of the implements are efficient with a noticeable difference while comparing to 8th week final observations.

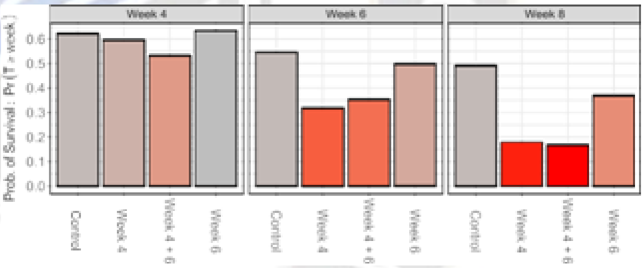

Fig. 8. The cotton's chances of surviving a certain treatment over the course of eight weeks, as determined according to how different each week was from the control.

The survival probability of the control plants, as shown in Table I, is 0.70 0.10, but the survival probabilities of plants are treated with degree, angle, & W/S were 0.28 0.15, 0.37 0.11, and 0.44 0.11, respectively. For a deeper understanding of each application's performance. For the wide category of plant species, we separated the research into broadleaf (cotton) & grass species (feather top Rhodes &wild oats). Because the unique species' growth conditions are so dissimilar, we draw this difference and think that different treatments will be more or less successful on different kinds of plants.

Broad Leaf (Cotton) Efficiency:

The most efficient way to utilize cotton is using a cutting tool, as shown in Fig. 8. The tiny number of plants that

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survived is what led to the significant variance for W/S. When utilizing the W/S (cutting tool), the estimated survival rates are 0.06 0.68, as shown in Table I. Tine application came as second best, with a survival expectancy of 0.24 to 0.29. The survival probability of control is 0.77 0.15 whereas the survival probability of arrow hoe is 0.45 0.18. Depending upon the type of application, ANOVA analysis will be executed and the following survey is made (see Table II).For cotton with 0.11 p-value, no differences will be found between applications using the controls and the applications using the arrow hooker. But for cotton with p-values of 9.4 $10^{-4}$and 7.1 10^{-6}, p-value the W/S and Tine are different than the controls. Efficiency of W/S is assumed on both the sides and initially, it was 100% range to begin with. We give each side of the W/S equal credit for its effectiveness. When manually administered to each plant, it had a 100% range. According to a robotic principle, this is not possible in reality as there are chances of mistakes to be occurred while deploying tools. since there will be mistakes made when the tool is deployed automatically.

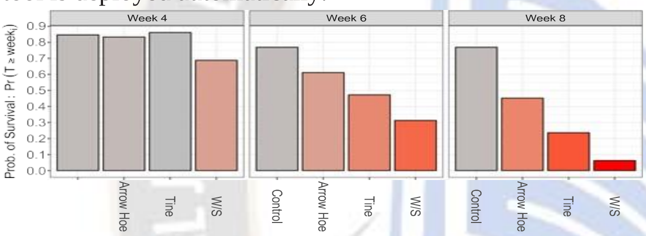

Fig. 9.The degree to which treated grasses deviate from the control each week over the course of eight weeks affects their likelihood of surviving.

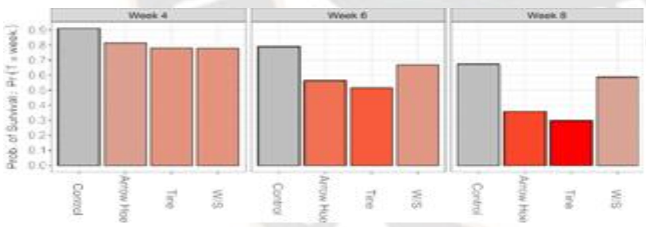

Fig. 10. The differences from the control in each week's survival rates for all species, given a specific treatment, over the course of eight weeks.

Development will be affected when the cotton plant stem is damaged by a spinning tool when the cotton meristems are found at both the lower area of plant and upper area of the plant. With p-value of 0.28, no difference will be found between tine and W/S. But the functioning may be depending upon the performance between tine and arrow hoe as the arrow how works below it whereas tine works above the earth. When compared with arrow hoe having huge and deep contact area, tine is having only a smaller and shallow contact.

Efficacy with Grasses (Wild Oats and Feather Top):

As shown in Fig. 9, the cutting tools were not successful for grasses and thus, the time and arrow hoe are found to be effective ending in survival rates of 0.30 0.18 & 0.36 0.14 after 8 weeks which is then balanced to 0.67 0.12 for the controls. As illustrated in Table III, ANOVA analysis for grasses was managed for the application tools. Hence, no difference will be there between using W/S (cutting tool) for grasses and the controls having p-value 0.86.but, there will be a difference between control and applications of grasses with p-values like 2.3 $10^{-2}$and 2.1 10^{-3}apart.

As illustrated in Fig. 9, time and arrow hoe are found to be useful with resulting survival rates 0.30 0.18 and 0.36 0.14 while cutting instruments were unsuccessful for grasses after the balancing at 8 weeks to 0.67 0.12. As shown in Table III, the ANOVA analysis for grasses was managed for the application tools; thus, the application utilizingcutting tool W/S for the grasses, and the controls with p-value 0.86 did not show any difference. However, there is a difference between the controls and the applications with P-values of 2.3 $10^{-2}$and 2.1 10^{-3} apart that utilizes either tine or arrow how.

Both the FT (quill top Rhodes) and WO(Wild oats) have a strong probability of survival when using the W/S, which we attribute to the positioning of their benefits. The cells grow and begin to expand in meristems of grass places at plant's lower section. As can be shown in Fig. 9, damage to the grass's case and leaves will not materially alter the grass' chances of surviving.

B. Application Time

When it comes to weed control or robotic or automatic weed control, timing of application is very important as plants are hard to grow. Ans also, it is hard to regulate with increased energy reserves. During appropriate time intervals, efficiency is calculated for Week 4 + 6, Week 6, and Week 4.The significance of applying a tool in the earlier stage of plants growth cycle are tested for probabilities of survival analysis as shown in Fig 10. Probability of survival at week 6 is 0.54 0.0. This is different from applying at week 4 or week 4 + 6 as these have the survival probabilities of 0.24 0.23 and 0.32 0.18 apart. This is then compared with the control having survival probability of 0.70 ± 0.10.

Table with ANOVA results shows the significance of analytical results and with p-value 0.34, there is no significant difference observed when treatment is applied at week 6 when compared to controls. With the p-values 1.2 10^{-6} and 1.2 10^{-5} apart, there is a difference when applied treatment at week 4 or both week 4 and week 6 to the controls. But, with p-value of 0.98, there is no significant difference between the applying treatment at week 4 or applying treatments twice during week 4 + 6. This is because the plants aren'ttreated between weeks four and six are today

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more likely to withstand treatment. The treatment's results from Week 6 are the greatest part of this. As a result, we recommend that future research look at the impact of weed control techniques even sooner on the likelihood of plant survival.

VI. CONCLUSIONS AND FUTURE WORK

In dealing with weeds that are unaffected by herbicides, robotics can be crucial. Applying specialized treatment to each weed type can help achieve this. The non-herbicide techniques used in conjunction with herbicide strategies to manage weeds are vital for weed species treatment. Here three types of mechanical weed-control tools have been overlooked. Three tools are tine, arrow hoe, and cutting mechanism. Tine is for above surface tilling. Arrow hoe for below surface tilling. It was discovered that the W/S (cutting tool) was very good at treating cotton but ineffective at treating grasses. The tine, which was the most effective tool, caused a survival difference overall of 0.28 to 0.15. More study on the date of the application suggests that this was crucial to its success.

It is not useful to treat plants after six weeks of planting. If it is treated after six weeks, it will be same as not treated. The odds of survival increased when therapy began earlier, either at Week 4 or Week 4 + 6, and were 0.24 0.18 and 0.25 0.17, respectively.Undertaking therapy twice at week 4 and repeating it in week 6 is same as like treating it in week 6. Hence, if the weed isn't treated at week 4, there is lesser chances for making it successful at week 6. This is because applying treatment at week 6 will not create such differences than left untreated. Hence, we recommend that future studies must consider the possibility of earlier involvement.

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