Design and Implementation of a Weed Removal Agriculture Robot

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Abstract. Agriculture process is time consuming as well as labour depending, however a demanding sector. Nowadays traditional methods in agriculture fields are leading to huge losses for farmers both in productivity and financially. This chapter is focused on the development of a novel Automated Agriculture Robot. A robot can execute operations like digging the soil, planting seeds, watering, identifying the weed sand removing them with more accuracy and precision with the help of robotics and automation. This will be a solution to the time constraints and labour issues, and it helps to achieve a higher rate of production. Weed control and removing the weeds from the crop fields is an essential part and will make a huge impact in increasing the productivity and quality of the yields. The effective weed management system should be strong and adaptable. A weed robot has been designed and fabricated using image processing technique here.

Keywords: Agriculture · Automated Robot · Identity weeds and insects · Higher rate of production

1 Introduction

Weed is some kind of unwanted plant that grows in the cultivation lands and the place where the crops grow. (Shanmugam et al. 2020) Weeds are the absolute reason why the agriculture crops is not produced in huge amounts and of a good quality (Shanmugam et al. 2020). The advancement that occurred in the agriculture field particularly managing weeds and control made a huge impact in increasing the quality and productivity of the yields (Eldert van Henten and Gert Kootstra 2020). Achieving the needs of foods and products for the rapid rise of inhabitants of the country is an important one in which weed control will play a massive role.

Agriculture is the vital department that has a vital part in a country's development (Fenninore et al. 2017) . So it is important to improve agriculture fields in a digital manner that is why robots can play a important role in agriculture fields (Slaughter et al. 2017). The number of people in our country increases it is also a major reason to increase the production and quantity of products in agriculture fields (Badkhal et al. 2019). An

Agrobot is an autonomous robot used in farming to help improve efficiency and reduce manual labour and time.

In most of the farm fields robotic mechanisms like tractors are used to sow the fields. But this Agrobot is used to identify weeds and manage to remove them from the field. Robots operating at low speed can detect weeds using Image sensing and remove them by using a robotic arm (Kesavan et al. 2018). A robotic arm is used to pickup the unwanted plant which identified by the agriobots. Agriculture Robots are not widely used in rural areas and in small scale farming areas. Basically, the usual agriculture works are being done by the farmers or the heavy machines (Kesavan et al. 2018). More traditional methods are used for sowing like using cattle and using labour for identifying weeds and insects and using harmful pesticides. This results in the production of inferior agricultural products. And using heavy machinery results in noise pollution and causes unhealthy conditions to the farmers (McAllister et al. 2019).

Agriculture is not only cultivating the plants but also it is necessary to protect the cultivated plants from insects and weeds. If a farmer wants good quality and quantity of agricultural products he/she needs to identify the weeds that occur near the plants and they need to remove them (Steward et al. 2019). Most plant-based weeds are tough to identify on naked eyes so Automated Agriculture Robots can be used to identify the weeds and remove them. There are some effective methods to control and manage the weeds in the agriculture fields (Steward et al. 2019). Those methods should be adaptable and strong. Strong weed management methods are methods in which the weeds in the fields should be managed by any certain circumstances that happen in the agriculture fields (Kujawa et al. 2020). The adaptable weed management methods are methods that manage and control the weeds in conditions like generic, climatic conditions and so on.

The main goal is to control the weeds from the fields is to develop the productivity and quality of the agriculture products (Kujawa et al. 2020). However there are some more methods like chemical weed controller and weed controlled by using mechanical methods to control the weeds (Wo et al. 2020). Mechanical methods use larger mechanisms like large machine sprayers which are used to remove them from fields on a large scale and they are quite incompatible with their size in small fields (Wo et al. 2020).

This review is depicted on Robots which are used in agriculture fields for various activities like harvesting, sowing and identifying weeds and insects. Agriculture is the major field in any country. To increase the crop productivity, robots can be used in agriculture. The utilization of robots reduces the labour's field work and lead time of agriculture. The main reason to increase productivity in the agriculture field is the increase in population in our country. Due to increase in population the need for food and its raw material from agricultural fields also increase. Traditional agriculture methods were used in the past and those methods are like ploughing with the use of cows and sowing seeds manually. But nowadays tractors are used to plough the fields. But these traditional methods are used in some village side agriculture fields but they produce small amounts of products. But we are in need of more productivity and food production, so the necessity of development in agriculture fields in artificial ways to improve the quality, quantity and efficiency of agriculture in both rural and developed agriculture.

The sudden growth and development of the internet and the online world make it easier for proceed the agriculture process in automated and robotic system for artificial

agriculture. Intelligence technologies using machine learning and image processing has evolve not only for sowing, and harvesting, yet for removing or controlling the unwanted plants, whereas weed plant detection still being a difficult challenge (Firthous Begum and Vignesh 2015). Machine learning technologies have been promising technology in processing image and providing the image in perfect condition and that the image is being processed (Ashok Kumar and Tamizharasi 2015). In spite of using Image processing technology, the detection of disease is challenging for microorganism control and it paves a way for the development of mechatronics and robotics solution.

Introducing autonomous robot in agriculture may result in many benefits like producing more amount of products, lesser consumption of energy sources, man labour can be decreased and time taken in field will be lesser than manual activities (Caggiano et al. 2019). The increase in outcome of agriculture fields is mainly based on the prevention of the disease and the insects that cause the disease in the plants (Pandey et al. 2020). So, by using pesticides and other harmful products the agriculture products can result in toxic conditions and it is also very difficult to identify these kind of weeds in naked eyes so it is necessary to use the autonomous robots to identify and control these kinds of unwanted plants (Kesavan et al. 2018).

2 Related Works

In this particular section, the components and the previous works based on weed control robots like Robotic weed control and weed controlled by chemicals are discussed in support of our topic.

2.1 Weeding Robot

Nowadays weeds are basically controlled by automated methods and basically, they work under cameras, GPS systems, Sonar methods and lasers (Wo et al. 2019). These kinds of methods give upto 80% of positive results. The method is based on image processing in which the camera is programmed with some inputs and the perception of unwanted plants grown and field plants is easily done by the camera while the robotic arm is used after the weed is identified and then the arm picks up the weed from the crop fields (Wo et al. 2019). There is another method in which the lasers are used to control weeds from crop fields. The main and most important is to identify which is the crop plant and the weed. Therefore Image processing is used to identify the difference. By using laser technology it results in up to 93% of better positive results.

The most vital feature in using a laser is it removes the growth of weeds from its root and doesn't allow the plant to grow further in any position. (Wo et al. 2019). Figure 1 and Fig. 2 shows the model of the weed robot.

2.2 Weed Controlled by Chemicals

In the traditional way of agriculture the weeds are controlled by using pesticides and herbicides which are manually sprayed by the farmers. In these kinds of methods, the weeds cannot be removed from the crops completely because it is difficult for farmers to

Fig. 1. Model weed robot

Fig. 2. These kinds of robots is used for killing the weed by using a sensor which is placed at the green position where it identifies weed and crop plan

identify weeds and crop plants. These methods work based on spot spraying techniques in which the chemicals are directly sprayed in the roots of weeds and control the growth of weeds. These ways are less efficient than the modern ways. Weed tracking in a crop plant is very difficult when they are in an uncertain position so the cameras which are placed in the robots must identify the weeds despite the conditions and the soil colour. The images are processed and then the robotic arm with the chemicals like herbicides sprays at the root of the weeds directly. Then the weeds are gradually controlled by the further process. The Fig. 3 shows design of proposed weed robot.

2.3   Challenges in Robotic Weed Control

There can be many challenges while controlling the growth of weeds but there are some main challenges and concerns while controlling weeds using mechanical methods. The first and most main concern is the ability to notice whether it is a crop plant or weed and unwanted plant. The second one is the control mechanism of weeds.

2.3.1   Ability to Notice

After many years of research some information about the particular plants in the sensors. These can be carried by the vehicle platforms which can perform with the sensors.
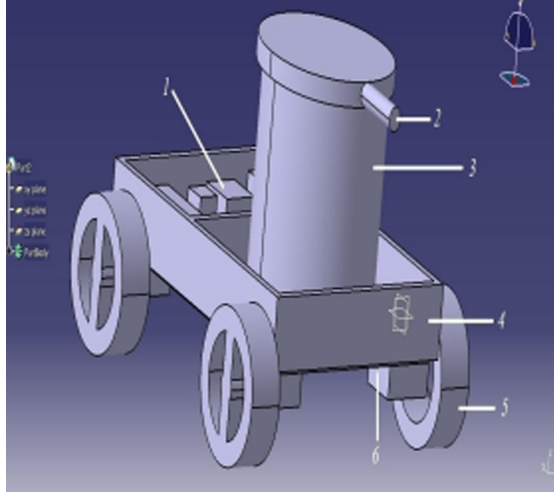
Fig. 3. Design of weed robot

Satellites, aerial and ground based machines can be used widely to detect the plants where they can be operated in the fields and based machines which can carry sensors can be used for detecting the plants in the fields. However ground can work based on the crop size and able to be accurately related to the distance that is covered by those weeds in crop fields. There can be two categories in which the ground machine works are Spectral Reflectance and the Biological morphology of the plants.

The biological morphology of the plants includes the size and colour and its characteristic of plants that are related to the crop fields. Whereas spectral reflectance is the process in which the rays are introduced there are two types: field/soil reflectance and crop reflectance. The soil reflectance are the one which is very minute and varies which the rays get deflected by the soils and the fields and the other one crop reflectance is the one in which the rays get deflected by the particular plants that need to be grown in the field. There are definitely amounts of reflection for the definite plants that are grown in fields.

3   Hardware and Software

In this chapter, it is a agriculture robot which control weed in agriculture which is controlled by micro controller. The weed control is based on row type crops cultivation. The main part of the robot is colour sensor which senses and colour and DC motor which run the wheel of the robots and a servo motor which helps in cutting the weeds from the cultivated crops. An IR sensor is used to detect the location of the stem and root of the weed plants and these sensors are also used to track the obstacles present in front of the robots and allows the robots to proceed further after finishing the first row of the column in the crops. An vision system like image sensing and machine vision is used to detect the position of the crop plant and weed plant in agriculture field.

4   Methodology

While there are many methods and ways of controlling the weed grown in the agriculture fields there are some ways which can be accurate and beneficial. These ways are employed in either mechanical ways or chemical ways. Mechanical ways are where the weeds are removed by using the machines and while in chemical ways the solutions are used such that they are sprayed in the unwanted plants and then the growth of those plants stops and it results in controlling them from crop plants.

4.1   Perception and Detection

The identification of the center position of crop plant and cannabis plants and position of stem and root of the weed plants is an important process in robotic weeding system. To remove the weeds from crops physically it requires accurate information and location of the weed plants where it is quite difficult tasks. The main areas to be targeted while weeding systems are interring row, intra row and close to crop areas. The inter row cultivation crops is commonly based on row production crops. The weeding system for row and close to crop areas is different. These inter row crops are highly effective in corn and soybean where the herbicides are directly applied over the crop rows. The intra row crops are based on where the weeds are grown in between the crop plants. If the weed is present in the row crops the colour sensor in the camera gets trigger and it gets information and passes it to microcontroller and if there is no weed present in the crops then the sensor fetch and information to the microcontroller and the weeding controller to proceed further. The weed control is placed vertically to the ground where the image sensor sends the signals to the microcontroller. Fig. 4 shows Weed are detected by using image processing technique where the marked indicates the location of weeds. Fig. 5 shows Image taken under digital camera and processed under machine vision to detect the weed.
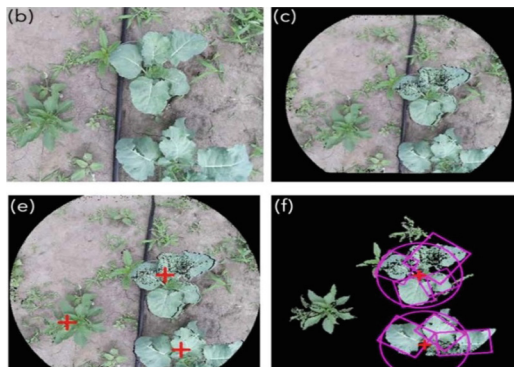

Fig. 4. Weeds are detected by using image processing technique where the marked indicates the location of weeds
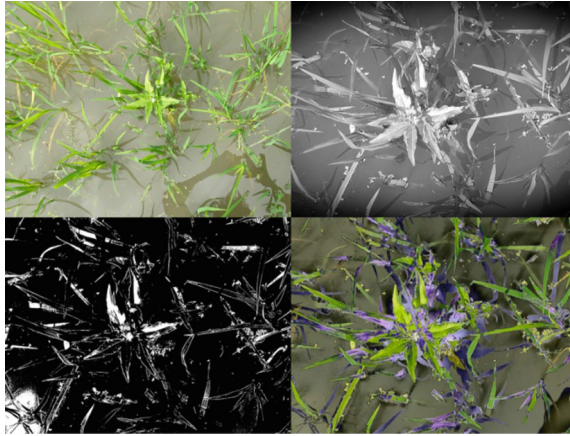
Fig. 5. Images taken under digital camera and processed under machine vision to detect the weeds.

4.2   Robotic Weed Controller

The robotic system consists color sensors, two DC motors and two servo motors and where all of them are controlled by the microcontroller placed at middle of the robot. The DC works under simple electromagnetic process and energy are given to the wheels. Depending upon the energy the DC motor controls the wheel of the robots and servo motor controller will be worked for cutting the weeds. When the DC motor start working which controls the wheels and move particular crop rows. The color sensors are place at the front and side of the robot. The sensor placed in front of the robots sense the colour of weeds and send information to the microcontroller whereas the sensor at the side helps in movement of the robot. If there no signal from the sensor then the controller indicates that the process is completed. In that particular position the robots tries to rotate at 270°. And then moves to the another row and follows the above process. If any obstacles present before robot the infra red sensor indicates the information to microcontroller and it stops the robot and change its direction. After detecting the weeds the servo controller comes and uses shaft to control the weed by cutting the weeds from the crop plants.

Step 1: If weeds present in the crops then the IR sensor present in the front of the robots gets trigger and fetches information from the camera and send the information to the microcontroller and the microcontroller gets the information. If there is no weed then the sensor sends the information to the microcontroller and then the robot moves further by using the DC motor attached along with the wheels of the robot.
Step 2: If there is no weed present in the particular row of crops then the information is passed to the microcontroller and then the robot turns at angle of 270 and then repeat the process in another row of crops.
Step 3: If there is any obstacle before the robot which affects the motion of the robot then the obstacle is detected by the sensors placed at the side of the robots and passes the information to the microcontroller and then the robot stops and the obstacle needed to be removed by the farmers.

Figure 4 shows the proposed weed removal robot (Fig. 6).

Fig. 6. The Weed removal robot

5   Result

In this chapter we have used weed management with the automated robotic technology. It is resulted in 83% success rate while detecting the weed and removing them from crops. The speed of the robot depends on the surface level of soil. The DC motor controls the movement and the speed of the wheels and servo motor use to pick up the weeds from the crops. The future scope on the weed management using automated robot will have high efficiency and result at high successive rate.

6   Conclusion

Agrobot is made to ease the work of poor and uneducated farmers by detecting the weeds that are grown in between plants. By detecting the weeds the production for the farmers can be increased and the quality of the products can be very good. By controlling the weeds in fields the requirements that a plant need can be intake only by plants can grow healthier and the quality and productivity will be higher. This is mainly focused on decreasing the usage of energy sourced and man power which can beneficial to the farmers. The robots are used for a variety purpose like sowing, weeding, harvesting and other agriculture purposes. Robots can be created as per the requirements that are made by the farmers in which in return they will get a huge profit and production in agriculture fields. The usage of the internet can take part in a vital impact on usage and improvisation of these kind of robots. These kinds of robots should be practiced and knowledgeable to the rural area farmers and small scale farmers. So that they can use these kinds of robots manually.

References

1. Fawakherji, M., Youssef, A., Bloisi, D., Pretto, A., Nardi, D.: Crop and weeds classification for precision agriculture using context- independent pixel-wise segmentation (2019)
2. Shanmugam, S., Assunção, E., Mesquita, R., Veiros, A., Gaspa, P.D.: Automated weed detection systems: a review (2020)
3. Fenninore, S.A., Slaughter, D., Simmens, M., Lenon, R., Saber, M.: Technology for automation of weed control in specialty crops (2017)
4. Fountas, S., Mylonas, N., Pekkeriet, E.: Agricultural robotics for field operations (2020)
5. Slaughter, D., Glies, D.K., Downey, D.: Autonomous robotic weed control systems: a review (2010)
6. Johnson, F.T., Aker, J.: Artificial Intelligence for weed detection (2020)
7. Ruigrok, T., van Henten, E., Kootstra, G.: Application-specific evaluation of a weed-detection algorithm for plant-specific spraying (2020)
8. Badkhal, T., Sharma, R., Sonu, I., Patil, S., Maapri, R.: Automatic Weed Killing Robot for Agriculture Purpose and Insect Killing (2019)
9. Firthous Begum, N., Vignesh, P.: Design, and implementation of pick and place robot with wireless charging application. Int. J. Sci. Res. (2015)
10. Kulkarni, V.A., Deshmukh, A.G.: Advanced agriculture robotic weed control system (2014)
11. Pandey, P., Dakshinamurthy, H.N., Young, S.: A Literature Review of Non- Herbicide, Robotic Weeding (2020)
12. Ashok Kumar, K., Tamizharasi, K.: Gesture controlled robot using MEMS accelerometer for eradication of weeds. Indian J. Sci. Technol. (2015)
13. Bawden, O., et al.: Robot for weed species plant-specific management (2017)
14. Roy, K.C.: High Tech Agriculture in Bangladesh. The Daily Star. N.p., 2012. Web. 3 March 2017
15. Aravind, K.R., Raja, P., Pérez-Ruiz, M.: Task-based agricultural mobile robots in agricultural farming: a review. Research (2017)
16. Kesavan, K., Monish, R., Murali, S.: Automatic weed removal system (2018)
17. McAllister, W., Osipychev, D., Chowdary, G., Davis, A.: Agbots: weeding a field with a team of autonomous robots (2018)
18. Wo, X., Lottes, P., Pradalier, C.: Robotic weed control using automated weed and crop classification (2020)
19. Koteswara Karthik, P., Ravi Chandra, P.: Overview of Agricultural Robots Posted by Yuva Engineers on 25 January 2014
20. Wu, X., Aravecchia, S., Lottes, P., Stachniss, C., Pradalier, C.: Robotic weed control using automated weed and crop classification
21. Kujawa, S., Niedbała, G., Zaborowicz, M.: Plant and weed identifier robot as an agroecological tool using artificial neural networks for image identification (2020)
22. Rajawat, A.S., et. al.: Robotic process automation with increasing productivity and improving product quality using artificial intelligence and machine learning. In: Artificial Intelligence for Future Generation Robotics, pp. 1–13 (2021). https://doi.org/10.1016/B978-0-323-85498-6.00007-1
23. Sindhu, B., Asha, K.: Department of IS & EGM Institute of Technology Davanagere, INDIA "Automation in Agriculture using AGROBOT". Int. J. Eng. Res. Technol. (IJERT) (2021)
24. Chandan, S., et. al.: Inverse kinematics analysis of 7-degree of freedom welding and drilling robot using artificial intelligence techniques. In: Artificial Intelligence for Future Generation Robotics, pp. 15–23 (2021). https://doi.org/10.1016/B978-0-323-85498-6.00004-6
25. Rajawat, A.S., et. al.: Depression detection for elderly people using AI robotic systems leveraging the Nelder–Mead method. In: Artificial Intelligence for Future Generation Robotics, pp. 55–70 (2021). https://doi.org/10.1016/B978-0-323-85498-6.00006-X

26. Fountas, S., Mylonas, N., Malounas, I., Rodias, E., Santos, C.H., Pekkeriet, E.: Agricultural robotics for field operations (2020)
27. Mahmud, M.S.A., Abidin, M.S.Z., Emmanuel, A.A., Hasan, H.S.: Robotics and automation in agriculture: present and future applications (2020)
28. Das, S., et. al.: Advance machine learning and artificial intelligence applications in service robot. In: Artificial Intelligence for Future Generation Robotics, pp. 83–91 (2021). https://doi.org/10.1016/B978-0-323-85498-6.00002-2
29. Amritha Ashok, K., Savy, A., Shijoh, V., Shaw, R.N., Ghosh, A.: Hospital assistance robots control strategy and machine learning technology. In: Bianchini, M., Simic, M., Ghosh, A., Shaw, R.N. (eds.) Machine Learning for Robotics Applications Studies in Computational Intelligence. SCI, vol. 960, pp. 35–46, Springer, Singapore (2021). https://doi.org/10.1007/978-981-16-0598-7_3
30. Caggiano, A., Jianjing Zhang, C., Vittorio Alferi, D., Fabrizia Caiazzo, D., Gao, R., Teti, R.: Machine learning based image processing for online defect recognition in additive manufacturing (2019)