Team ID:314
Autonomous Weed Detection and Removal

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1 Project Introduction

According to data published by World Bank 28.141% people depend on agriculture for employment all over the world [12]. In India, the agriculture sector employs around 50% of the population and accounts for 17% of India's GDP [9]. But still, crop yields in India are generally lower than the global average [8]. One of the major reasons behind such yield loss is the presence of weeds on the farm. According to the ICAR's (Indian Council for Agricultural Research) report yield loss due to weeds is as high as 33% [10]. India loses 11 Billion dollars every year because of this [8]. At present weeding is performed manually, either labourers pluck out the weeds from the land or herbicides are sprayed over them. Manual weeding is a time consuming and inefficient method as a lot of chemical herbicide is wasted, also the cost of labours has increased over the years. A farmer has to spend about Rs.70000 to 90000 per acre for weeding for a single cropping season(kharif and rabi). Hence our objective is to implement a robotic system that will automate this process. Here the first step will be to distinguish the weed from crops with the help of Convolutional Neural Network(CNN) and machine vision. After identification of the weed, it will be removed either by applying mechanical force or precise spraying of herbicide directly on the weed itself.

2 Project Literatue Survey

Research on autonomous weed removal system has been going on for many years. Most of the approaches used can be classified into two major parts. First is the traditional image processing approach [5] [6] and second is the deep learning approach [4] [7] [3]. [5] uses image processing but his method heavily relies on the weed crop classification on the basis of area of leaves. Hence this cannot be used in the case of all the crops and during all the stages of the growth cycle. Paper [1] mainly proposes to solve the problem of weed identification using a combination of pixel-wise segmentation and CNN. Important steps involved here are segmentation, blob extraction, and classification with the help of pre-trained CNN. [4] uses a combination of several pre-trained models which enhances the performance of weed detection. In [2] much emphasis is given towards the control system aspect of the robot here a visual servoing camera is used along with a primary camera the feedback loop created here, makes the placement of manipulator more accurate. Non-overlapping multiple camera system is used in [3] to compensate for delay induced due to CNN.

3 Hardware Requirements

1. Intel NUC7 i5DNHE (1)
2. Arduino Mega (1)
3. Lithium ion (2)
4. Lithium Polymer (2)
5. Battery Charger (1)
6. MPU 6050 (1)

7. DC geared Motor (4)
8. DC geared Motor Driver (2)
9. Shock absorber (4)
10.Wheels (4)
11.Stepper motors (5)
12.Stepper motor driver (5)
13.GSM GPRS Module (1)
14.GPS Module (1)
15.Camera 1920x1080p (1)
16.Arduino Nano (2)
17.Arduino UNO (1)
18.CNC shield (1)
19.Body making, delta arm fabrication, materials, miscellaneous, etc.

4 Software Requirements

20.ROS (kinetic)
21.Gazebo 9 for simulation
22.RoboWare Studio
23.Visual Studio Code
24.Autodesk Fusion-360 (V.2.0.6658) for component designing
25. Autodesk EAGLE (9.5.1) for PCB designing
26.OpenCV for image processing
27.Google Colab
28.Arduino IDE
29.MATLAB

5 Implementation

Initially, the farmer will drive the robot with the help of a remote control till, the starting point of the very first row of crops(furrow). Depending on the average height of the crops farmer will adjust the height of the robotic platform with remote control, and will initiate the operation of the bot with a command, this will put the robot in autonomous mode. An on-board camera placed under the platform will be switched on. This camera will be parallel to the ground and will take multiple images of the vegetation underneath as the bot traverses forward. These images will be processed by an on-board processor, which will perform the operation of the identification of weeds and crops using a **CNN** by labelling the weeds and crops accordingly. The coordinates of the weed will be estimated by the processor and enabling signal will be sent to a **delta arm** equipped with a gripper, this gripper will try to pluck the weed out of the ground. If it is found that the complete removal of the weed along with its roots is not possible then it will spray the herbicide directly on the weed. This operation will be continued for the whole row of crops. Once the feed of the camera stops receiving the images of crops, the bot will come to know that it has reached the end of that row and it will turn around by 180 degrees and continue its operation in the next row. A physical marker has to be placed at the end of the very last row so that the bot will **stop its operation** and notify the farmer by sending a message on his/her registered mobile number.

CNN:
CNN is a special case of deep neural networks used specifically for images. CNN will be implemented on a processor. Here Intel NUC i5 will be used as the processor. Images taken from the camera will be pre-processed and then they will be given as an input to CNN. This CNN will be already trained on a dataset containing images of weed and crop. The output of the CNN will be labelled images as weed and crops.

Delta arm:
Delta robot/arm is a type of parallel robot used in industry for high-speed operations

[11]. Its concept is based on a parallelogram which restricts the motion of base/end effector to only translational i.e. only in x, y and z-direction. The delta arm used here consists of three linkages that are connected to base/end effector. The gripper mechanism is attached to the base/end effector for weed removal, also a sprayer is attached to it for spraying herbicide. The end effector will go to the estimated coordinates and pluck the weed using gripper and if it is facing any difficulty in removing weed, the sprayer will spray a precise amount of herbicide directly on weed.

End of Operation:
A GSM module is used for communication between microcontroller and GSM network, it allows wireless communication with other devices such as a mobile phone. When the bot reaches the end of the last row and stops its operation, the onboard processor will send a command to the GSM module through microcontroller. A predefined message will be sent to the farmer's mobile number in English as well as in their native languages so that they come to know the weed removal operation is over. Then controls will be switched from autonomous to manual mode again and the farmer will drive the bot from that location to the shed.

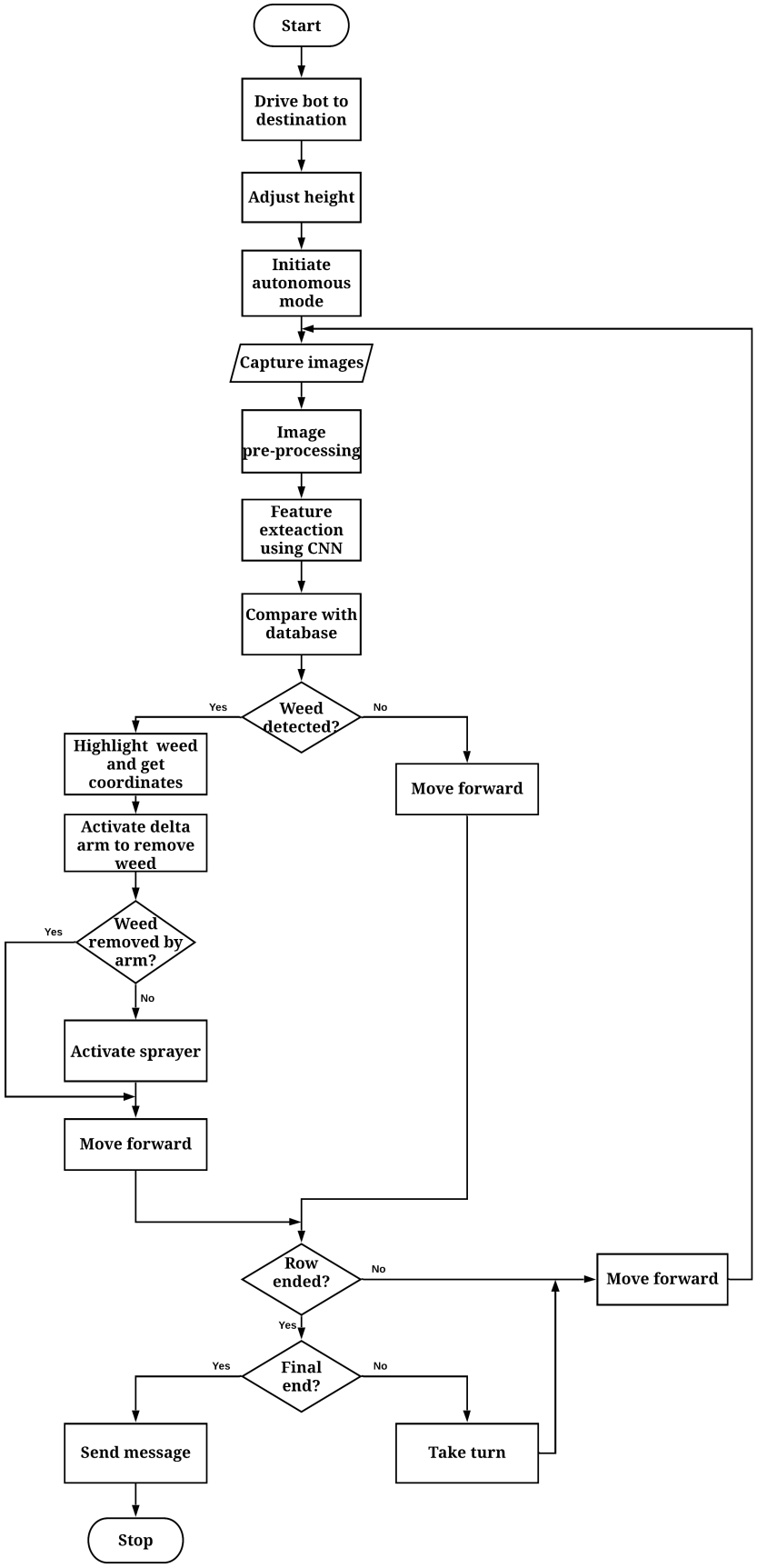

Figure 1: Flowchart

6 Feasibility

There are two methods for removing weeds; one is using manual labour and the other is using chemical herbicides. The traditional manual weed removal method requires lots of labourers and due to lack of availability of labourers, their daily wages are costly. Also, the use of chemical herbicides can cause side effects to the environment as well as human health. The idea of an autonomous weed removal robot uses a rover that distinguishes between plants and weeds and removes the weed by using mechanical force or spray a precise quantity of herbicide on weeds. This will reduce the cost of manual labour and the requirement of chemical herbicides as well as result in increased yield and productivity. The time required for weed removal will greatly reduce as the bot can work 24/7 and this time can be utilized by the farmer to perform other activities. The weeding bot uses an adjustable height mechanism and hence can be used in most of the fields. In India, less research has been done in this area and hence to acquire/create a robust database is itself a challenging task.

7 References

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