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Seeking Smart Manufacturing Talents

The 5th Delta Advanced Automation Contest

Project Proposal

Team Number:

<table>
<tr><td>Proposal Name</td><td colspan="4">AARobot (Autonomous Agricultural Robot)</td></tr>
<tr><td>Team Name</td><td colspan="2">Dirac Delta</td><td>University/ Affiliation</td><td>Veermata Jijabai Technological Institute, Mumbai, India</td></tr>
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</table>

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Team Building:

1. Mr. Omkar Shivaji Sargar (Age 19)
Bachelor of Technology Electronics Engineering, Veermata Jijabai Technological Institute (VJTI)
https://github.com/OSSome01

- **Bachelor of Technology Electronics Engineering, 7.4 CGPA as on III semester (08/2018 to present)**
- **Maharashtra State Board Higher Secondary Certificate (Science), 78.45% (08/2016 to 05/2018)**
- **All India Secondary Certificate Examination (10th Standard), 10/10 CGPA (04/2015 to 04/2016)**

Role: Computer Vision, Machine Learning and Programming.

Skills and Specialization:

- **Hardware:** NodeMCU, ESP-32, Rasberry Pi, Azure Sphere.
- **Software Program:** Eagle PCB, Multisim, ESP-IDF, Arduino IDE.
- **Programming Languages:** C, C++, Python, Robot Operating System (ROS), Ladder Logic Programming, Data Structures and Algorithms.
- **Key Technical Skills:** Robotics, Simultaneous Localization And Mapping (SLAM), Machine Learning, Computer Vision, Image Processing, Programming.

Specialization: Robotics and Automation.

Achievements:

- **First prize:** Labyrinth 2019 (Autonomous maze solving robot), VJTI.
- **Third Prize:** Autobot Challenge 2018, VJTI.

Projects:

- **Smart Light:** An IoT based project developed using ESP32, which optimizes the brightness of an LED according to the ambient lighting conditions.
- **Maze Solver:** A robot designed to map any random maze in dry run and solve the maze in the final run by following the shortest route possible.
- **Object Detection:** Software that uses a Kinect 360 to recognize a particular object in a surrounding with the help of several digital image processing algorithms and provide the user with information like its distance from the camera, its dimensions and surface area.
- **Self Balancing Robot based on PID controller:** An Autonomous Robot that follows a line and balances itself on only two wheels using PID control system and Embedded Electronics.

- **3-DOF Robotic Manipulator:** A manipulator with 3 Degree of Freedom (DOF), interfaced with Robot Operating System (ROS) & implemented using ESP32.
- **Simultaneous Localization And Mapping (SLAM):** Simultaneous Automation and Mapping using Intel Real Sense D435.

2. **Mr. Omkar Ananda Bhilare (Age 19)**
Bachelor of Technology Electronics Engineering, VeermataJijabai Technological Institute (VJTI)
https://www.linkedin.com/in/omkar-bhilare-985aa2180/

- **Bachelor of Technology Electronics Engineering, 9.73 CGPA as on III semester (08/2018 to present)**
- **All India Secondary Certificate Examination(Diploma in Electronics), 97.15 % (08/2016 to 05/2018)**
- **All India Secondary Certificate Examination (10th Standard), 95.2 % (04/2015 to 04/2016)**

Role: Electronics and Electrical system design and programming.

Skills:
- **Hardware:** NodeMCU, Esp32, Atmel AVR(16,32,328P), Rasberry Pi.
- **Software Program:** MATLAB, Eagle PCB, Altium, Keil MDK, Multisim and proteus
- **Programming Languages:** Embedded C, Python, C.

Specialization: Embedded System and Automation.

Achievements:
- **State Rank 1** in electronics in diploma.
- Participated in various project presentation competition.
- **Third Prize:** Technical Paper Presentation, VJTI

Projects:
- Universal Integrated Circuit: The digital trainer kit which can clone multiple IC's
- Automated Seed Sower: Customizable robot which can sow seeds according to user's need
- Line following robot.
- Home automation using NodeMCU
- Air quality monitoring system

3. Lukesh Narsingh Ankamwar (Age 20)

Bachelor of Technology Electronics Engineering, Veermata Jijabai Technological Institute (VJTI)

LinkedIn:-https://www.linkedin.com/in/lukesh-ankamwar-212566173/

- **Bachelor of Technology Electronics Engineering, 8.13 CGPA as on III semester (08/2018 to present)**
- **Maharashtra State Board ,(12thStandard),83.33 %**
- **All India Secondary Certificate Examination (10th Standard), 90.4 %**

Role: Mechanical system design and programming.

Skills:

- **Hardware:** NodeMCU, Esp32, Atmel AVR (16,32,328P), Rasberry Pi.
- **Software Program:** Solidworks, Crio, Ansys, MATLAB, Eagle PCB, Altium, Keil MDK, Multisim and proteus
- **Programming Languages:** Python, C and C++.

Specialization: Mechanical Design and Analysis.

Achievements:

- **First prize:** Labyrinth 2019 (Autonomous maze solving robot), VJTI.
- **Third Prize:** Autobot Challenge 2018, VJTI.

Projects:

- **Maze Solver:** A robot designed to map any random maze in dry run and solve the maze in the final run by following the shortest route possible.
- **Object Detection:** Software that uses a Kinect 360 to recognize a particular object in a surrounding with the help of several digital image processing algorithms and provide the user with information like its distance from the camera, its dimensions and surface area.
- **Self Balancing Robot based on PID controller:** An Autonomous Robot that follows a line and balances itself on only two wheels using PID control system and Embedded Electronics.
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Introduction:

Problem Insight:

Employment in the agricultural industry fell by 9 million from 2011 to 2018, contrasting to the 93 million increase in population in the same period. The newer generations are not interested in agriculture and hence the ratio of demand to supply is very high. Thus introducing automation and robotics in agriculture is a better method to improve overall agricultural produce and reduce labor requirements. There are very limited automatic agricultural robotic systems available in India but they are not feasible and are usually oriented towards harvesting, cleaning and packaging agricultural produce. The damage to agricultural crops due to pests account for 13.6% annual loss globally (which accounts for around 18 billion dollars). Similarly weeds amount to 8.8% annual loss globally. Additionally a loss of 861.8 million is incurred due to over usage of fertilizers in India. It would be a huge boon for the Indian Agricultural Industry if these losses can be minimized with the help of Automatic Agricultural Robots.

Project Idea:

After analysis the current situation of Automation in Agriculture we have come up with a innovative idea to design a solar powered agricultural robot which can do various tasks like: pest removal, weed removal, spraying fertilizer, helping in cattle farming, and generating electricity to power basic appliances in the farm. The robot will have two operating modes: automatic and semi-automatic. The robot will help to reduce the wastage of time and other resources needed in the above mentioned tasks. AARobot will also help to analyze the crops by sending data to a cloud server where analysis will be done on the data and the feedback will be provided to the farmers.
Using the concepts of Machine Learning, Computer Vision, Mobile Robotics we aim to build AARobot. Traditionally the main area of application of Automatic Agriculture Robots is at the harvesting stage. These robots are usually designed to do only a specific set of tasks, which makes them even more impractical for Indian farmers. We are aiming to maximize the produce by dealing with the losses incurred due to pests, weeds and overuse of fertilizers. Also we are designing a robot which can do varied tasks like helping in cattle farming, generating electricity for basic farm needs, and thus increasing its value for money.

Objectives:

1. Crop Detection
2. Pest detection and removal
3. Weed detection and removal
4. Optimizing the process of spraying fertilizer
5. Analysis of data provided by AARobot. Sending all the data collected (Number of

crops, number of crops infected by pests, number of weeds detected, area of farm where maximum number of pests and weeds were detected, etc.) to a cloud and perform analysis on this data and give appropriate feedback to the farmer.

6. Designing a simple but effective system on the AARobot to help with cattle farming.
7. Charging a battery which can then be used for basic powering electrical appliances.

Applications:

Crop Detection: We are using Machine Learning and Computer Vision algorithms to detect crops in the field. In our case we are detecting cabbage a common vegetable grown and consumed in India. After a plant is detected the robot will perform all the tests and the details of the plant will be uploaded on the cloud.

Case 1:
The damage caused to agricultural produce due to pests is very high. Traditional methods like using bright sticky pads are quite effective to counter flying pests; however there are no good solutions to counter bugs and ground pests. The only solution for bugs is the use of pesticides, but it leads to pollution and may also damage the crops if not used in proper quantities.
Solution:
Pest Detection and Removal: We are using Computer Vision algorithms to detect pests on cabbage plants. We are proposing to use a thermal camera which can be used to detect pests accurately. After a pest is detected a pest removal tool will help to suck off the pest from the plant. The detailed working of the pest removal tool is specified in the upcoming sections.

Case 2:
Traditionally weeds are removed manually by hand picking or by the use of weedicides. The first method impractical as it is very time consuming and is also not feasible as labor costs are very high. The second method leads to pollution and may destroy the crops if not used in proper quantities.
Solution:
Weed Detection and Removal: This will be similar to crop detection where Machine Learning and Computer Vision algorithms will be used. After a weed is detected a weed removal tool will act to remove the weed. The detailed working of the weed removal tool is specified in the upcoming sections.

Case 3:
Traditional methods of spraying fertilizer include manually spraying fertilizer using a pump like device. Manual spraying of fertilizers often lead to improper dosage to plants which

may destroy the crops. It also leads to wastage of fertilizers. Manual spraying of fertilizers is also harmful for humans if proper precautions and safety measures are not followed.

Solution:

Spraying Fertilizer: When a crop is detected the robot will calculate the midpoint of the crop and a spraying tool will spray the fertilizer at the exact location calculated, thus reducing the amount of fertilizer used and hence optimizing the process.

Case 4:

Usually in cattle farming when the cattle are to be taken out for grazing humans are needed to keep them in check and guide them to the grazing grounds.

Solution:

System for Cattle Farming: This is a simple add-on feature wherein a speaker can be mounted on the robot which will play the cattle owner's voice in a loop to attract the cattle towards it. Thus it can be used to direct the cattle towards grazing grounds. It will help reduce the involvement of humans as the robot can be controlled remotely.

Case 5:

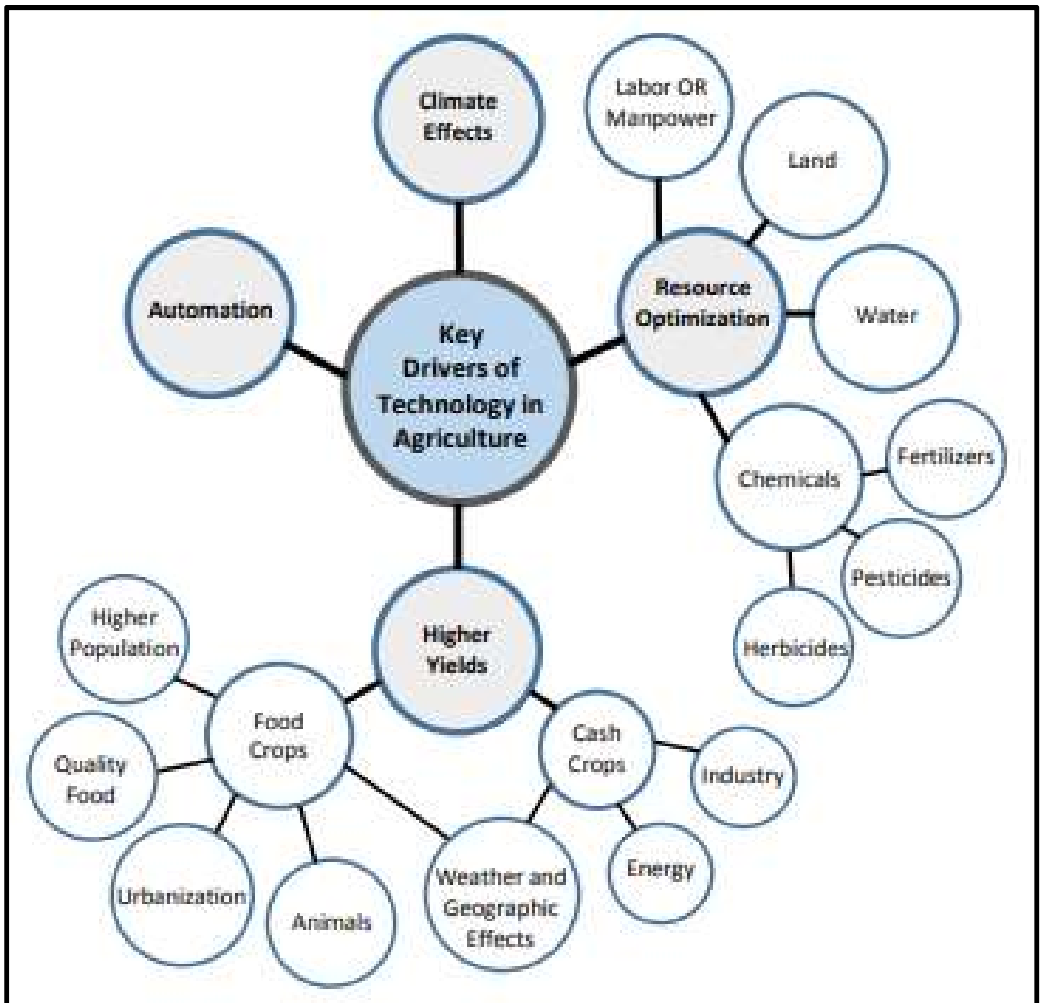
In India it is a common practice that in every farm there is a small room or house which is made to keep all the necessary tools and equipment (this room is equipped with basic electrical appliances like tube-light, fan, etc.). Also there are bore wells which are used as a primary water source for agriculture in many parts of India. Many regions in India don't have electricity supply which makes it difficult for the farmers to use bore wells.

Solution:

Battery Charging: A additional feature which can be added is that AARobot can be used to charge a Battery which can then be used to power basic electrical appliances in the farm.

Use of IIoT:

- The contribution of agriculture plays an important role in the economic growth of India. In India, **more than 60%** of peoples depend upon agriculture. This 60 % of people produce food for the country. Recently, the number of farmers in India decreasing day by day. The agriculture results depend up on the various controlled and uncontrolled factors like sudden change in climatic conditions; high and low rain fall and also the timing of the rain, storms and heat waves, and effects of cold, etc. For these conditions, traditional farming techniques are not appropriate.
- **To minimize these effects and increase the productivity of agriculture, automation and IoT techniques are required.**

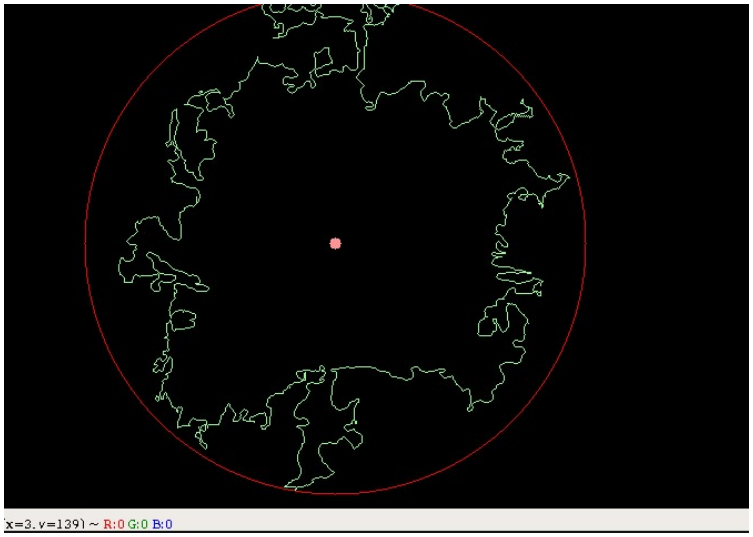


- In this project we have integrated internet of things such that the overall efficiency and usability Increases exponentially. We are focusing on **automation of weed and pest removal** and also, on **resource optimization** like chemicals, pesticides etc.

  The use of IIOT in this project explained in following steps:

  1. **Detection of plant and its center:**

     - Before proceeding further for pest and weed removal we needed to detect plants, we have detected plant using **OpenCV** (computer vision). The example of detection of plant given below:



- **By using OpenCV we were able detect the center of the plant by using which we can fertilize the plant, and if we provide the data set of same plant with infection.**
- **Then we can also detect Infection in plant.**
- **And by using same technique we can also detect pest in plants and further remove it using vacuum**

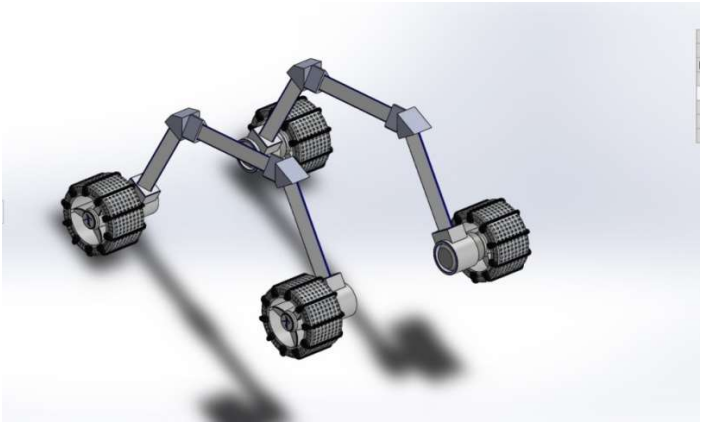
2. Availability of data on cloud:

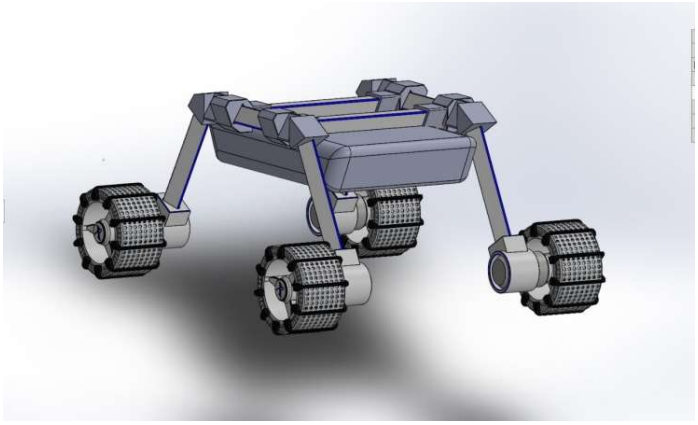
- **After obtaining data from OpenCV program it is send to cloud for further analyzing of obtained data**

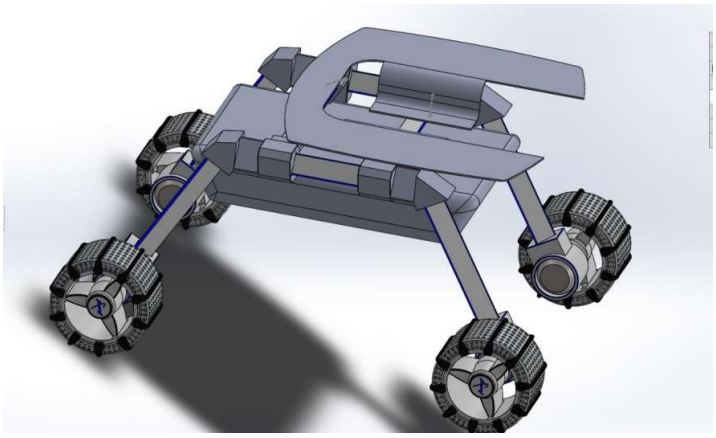
- We can monitor data on cloud and graphs like above can be made.
- In specific by plotting graph of pests captured w.r.t to its position in the field we can monitor the specific area where density of pests is more so one can take appropriate steps to reduce its adverse effects.

Thus, by using internet of things we can increase the productivity of agriculture and overall profit will also be increased because of IOT.

Robot Design:







Working:

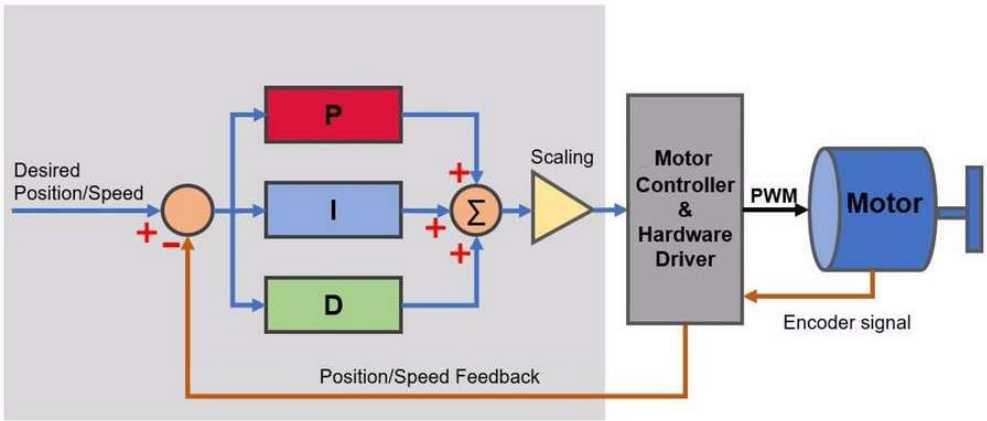
Motion Control:

1. In the base of this project we are going to use two delta servo motor which are gear coupled with the two rear wheels and front two wheels are used as dummy wheels.

(a) narrow track (b) wide track

2. In this project, we are keeping wheel configuration dynamic that is the distance between two side wheels can be customizable according to user input on HMI panel. This will be achieved by using two delta servo motors directly coupled to two lead screw.

3. In our project motion control system is going to have high accuracy, high speed, insignificant or no overshoot and robustness. To achieve this we are going to use a PID controller which will be mathematical model of a motor based on classical root-locus approach.



Tool Control:

In this Project we are using Three Main tools which are stated as below:

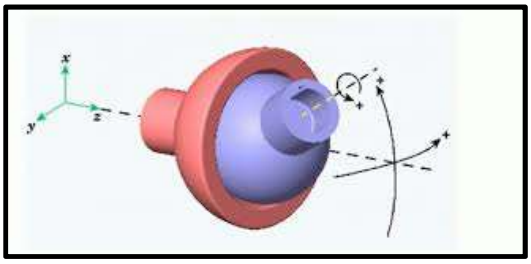
1. Vacuum for pest removal
2. Spray gun to spray fertilizers
3. Weed Removal tool for removing weed

1. Vacuum:

- A vacuum gun will be used to suck pests off the plants.

2. Spray gun:

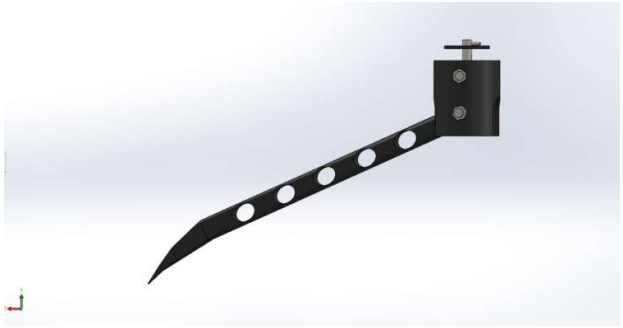
- A pump motor is used to spray fertilizers on the farm land.
- Here we are using universal joint to move spray gun.
- The reason for using universal joint is to access every point in the frame.

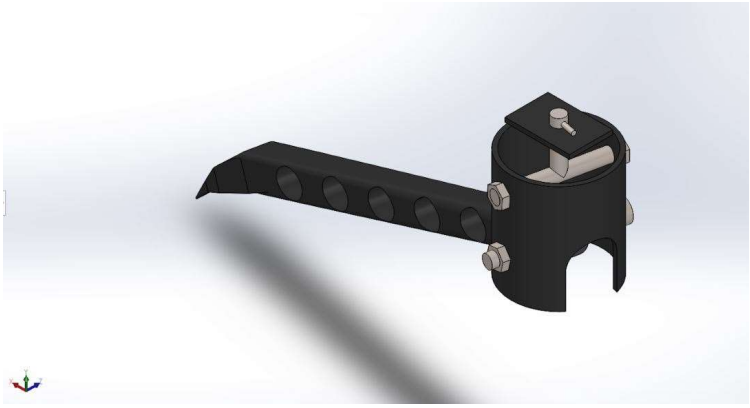


Working Video Link: https://youtu.be/Sef_fJh3OgQ

3. Weed Removal tool:

This robot can be also used to remove weeds from the surface of the field. To remove weed we have designed our own weed removal tool according to our need.





Working Video Link: https://youtu.be/WgTvQdC92Rc
https://youtu.be/4lKjg0JsSTg

Robot's Work Space:

- Robot can move anywhere in the normal farm.
- Robot can move in muddy and rocky surface
- Cannot move on extremely uneven terrain.

Uncertain Error Handling:

- In any uncertain situation the robot will be stop working and battery will be open Circuited so electrical safety is maintained.
- Emergency Alarm will be switched on and emergency light will be displayed
- HMI panel will show the information which will help to debug these uncertain errors.

Innovative Planning and Value:

1. AARobot is a unique robot which will strive to increase the efficiency of tthe agricultural industry. It is one of a kind robot which will help in such aspects of agriculture which are traditionally ignored by the other robots available in the industry.
2. The main idea is to make a multi-purpose automatic robot which can perform multiple tasks and hence provide good value for money.
3. Using concepts like Machine Learning, Computer Vision and Mobile Robotics AARobot will boost the agricultural industry and will help reduce human interference in agriculture.

Cost Analysis, Feasibility and Reasonability:

As we are using all parts according to the industrial standards, we are having very cost-effective structure. AARobot is a multi-purpose robot and hence improves the value for money. If we compare the losses incurred by farmers due to the various issues which AARobot is trying to solve to the cost of the robot then we can say that its cost is well justified.

Component Specification and Bill of Materials:

Sr	Product Name	Delta Product Code	Quantity	Description
1	Wireless Module	DVW-W02W2-E2	2	To connect with internet
2	Servo Drivers	ASDA2ServoDrives	4	To drive all Axes motors
3	Servo Motors with encoders	ASDA20721U	4	To drive all Axes motors
4	Planetary Gearbox	PS Series	2	To change torque based on requirement for Constant speed motor.
5	PLC	DVP28SV11R2	1	Main controller which accept the input through HMI and cloud server and do control according to ladder logic.
6	HMI	DOP-107WV	**1**	To observe the status of the robot on the field and to control it

7	AC-DC Power Module	AB60S2400A	1	For power supply to PLC (24V)
8	Analog I/O Modules	AH04AD-5A	3	
9	Vision Sensor	VIS100 Series	2	For object detection on plants and positioning of robot
OTHER PRODUCTS				
10	Microprocessor	Raspberry Pi	2	For any alien object detection on plant and sensor data acquisition
11	Wheels	Third Party	4	For moving the robot on field
12	BLDC Blower Fan	Third Party	2	For cooling Drives
13	Power Supply(5V)	Third Party	2	For powering microcontrollers and other peripherals
14	Wire	Third Party	Multiple	Wiring
15	Wire Connector	Third Party	Multiple	Wiring

16	Microcontroller	Arduino UNO	1	For sensor data acquisition in BOTs
17	Ethernet Shield for Arduino	Third Party	1	For IoT Application
18	Ball Bearings	Third Party	Multiple	Miscellaneous
19	Linear Bearings	Third Party	Multiple	Miscellaneous
20	Solar Panels	Third Party	2	For charging the battery
21	Nuts and Bots	Third Party	Multiple	Miscellaneous
22	Spacers and Washers	Third Party	Multiple	Miscellaneous
23	Power inverter	Third Party	1	For Solar Panel
24	Kill Switch	Third Party	1	For Stopping all applications
25	Sprinkler	Third Party	2	For sprinkling fertilisers
26	Storage Tank	Third Party	1	For storing seeds/fertiliser
27	Vacuum Pump	Third Party	1	
28	DC Servos	Third Party	5	For use in various tools

Future Scope:

1. It can be further used in Harvest management.
2. It can be also used for Field Mapping.
3. It can be used for Soil Management.
4. It can be an important part of a greener future for mass scale farming.
5. By bringing Artificial Intelligence and around the clock activity, the robots will help optimize the yield of farm far beyond what could humanly be possible.

Summary:

The AARobot is thus a feasible multi-purpose automatic agricultural robot which can help boost the agricultural industry in India.