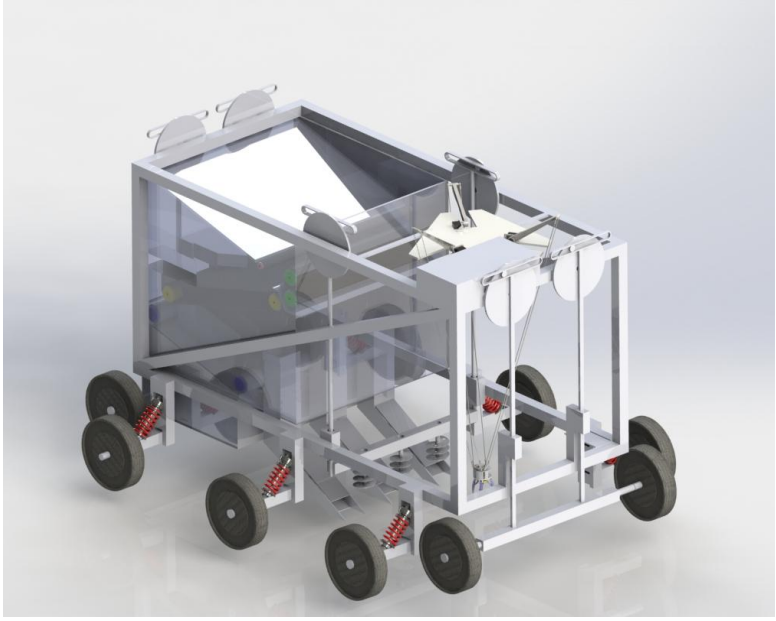
INTER IIT TECH MEET 9.0 - AgroBot Design Innovation Challenge



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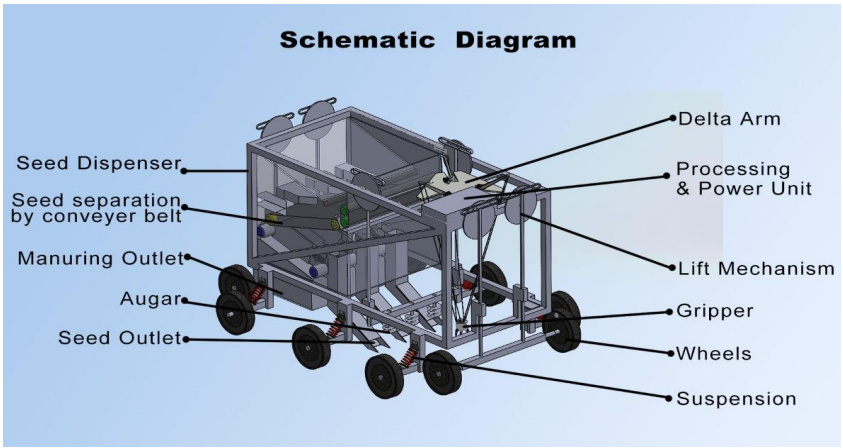
- ## Problems faced during farming in hilly terrains

  Hill agriculture has some inherent constraints of remoteness and inaccessibility, marginality in moisture stress, poor soil conditions, and a short farming season. These are socio-economic constraints such as poor productivity, labor shortages, smallholdings, and shoddy production management. The harsh weather conditions also cause a lot of problems. Farmers only get a concise economic window of opportunity when the crops can be planted and harvested. Due to the uncontrollable weather, the yield isn't high enough to make profits on a particular crop many-a-times. Due to the rugged terrain of the hilly areas, traditional equipment is used, which results in decreased efficiency. They have to use slower means of transportation to reach the main markets.

  To overcome the above-stated problems, we propose to build an autonomous farming robot suitable to work in rough and hilly terrains.

- ## Introducing Agrobot:

  The robot is autonomous, and a safe engineering solution to the problem like farming on hilly terrain, containing rough surfaces, slopes, and steep edges. The robot has a well-defined locomotion system for hilly terrain comprising various mechanisms, joints, and suspension systems for the robot to move in a straight line. The robot contains a well-crafted seeding system for a rhizome seed like ginger, turmeric, etc., with the use of a conveyer belt and deflecting mechanisms. The robot consists of a delta arm gripper, which helps remove weed from the ground after it is differentiated from other plants with the help of image processing. An augur system is attached to the bot to make holes in the soil to seep and transplant saplings. **The robot also provides manuring to the plants and seeds on the farm**. Hence, the robot is very effective, efficient, and with a very low chance of manual interference.

- ## Mechanized farming in hilly terrain

  With this advanced farming robot, we propose to provide different mechanized solutions for each different solution. Therefore making it multitasking in every possible scenario.

1. Maneuvering in the hilly region

A hilly region may contain crust, troughs, steps, rocky surfaces, slopes, and steep edges. The robot is a ten-wheel system, with six wheels attached to the chassis and other four wheels (in sets of 2) attached in the front end and rear end of the robot. The front and rear wheels are attached to a system that moves vertically, helping the robot dodge crust troughs and rocks on the surface to change the height of the bot according to the need.

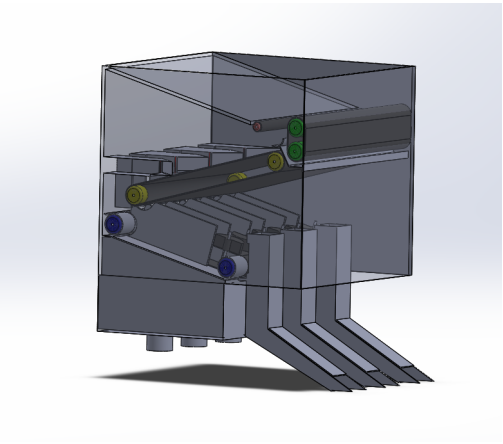
A camera module is attached at the robot's front to make the system robust to irregularities of surface and move in a straight line autonomously. On detecting the trough step, it will change the bot's height and help it cross the step.

The chassis' wheels are hinged at the point of contact and are supported by a proper **suspension (K=60N/mm)** system. Motors attached to these wheels are powered separately so that their rpm would change according to the need, and hence the robot moves in a straight line.
Since the center of the robot's mass is near the center plane, it will not face any significant problem due to gravitation.

Wheels are well gripped and broad in terms of width and are ten in number, thus providing a better grip with the ground.

The front and back axle's vertical motion is vital for locomotion in regions where there are steps.

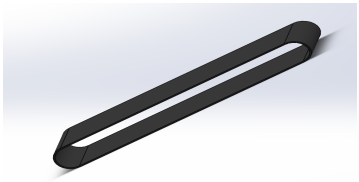
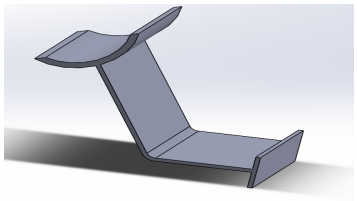
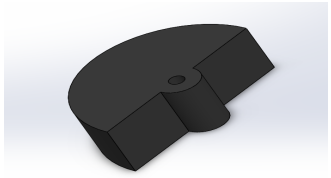
2. Automated seeding and seed metering mechanism

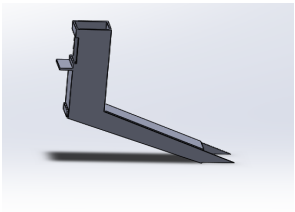
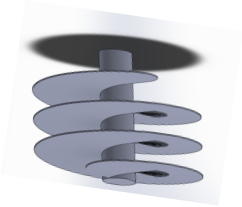


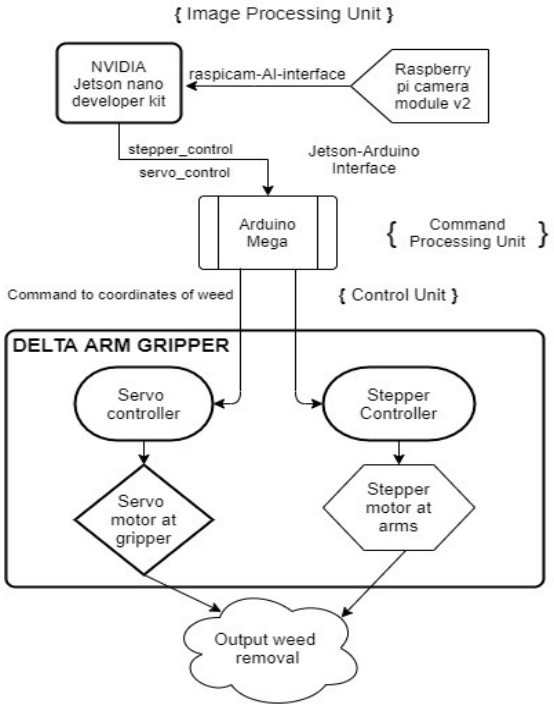
- The automated seeding system comprises conveyor belts and deflectors, rotors, servo-operated gates, and some push rotors.
- The belts are moving at sufficient speed such that seeds do not slip out of the belt.
- Seeding in the holes is done by the following mechanism:

1. Seeds are kept at the top of the slant plate.
2. The seeds slide down to the next conveyor slowly with the help of rotors and conveyors moving in the opposite direction to provide the seeds a force to go down to the next belt. Here, the roots get uniformly distributed in a single layer due to vibration caused and rollers running.
3. Now, the single layer of seed will get deflected into three belts with rollers' help on the sidewalls and go to the 2nd conveyer containing three belts powered by a stepper motor. Now, we can observe that seeds are uniformly distributed in each belt, in a single layer one after another.
4. As soon as the augur makes the hole in the soil, two processes take place:
   a. The roller at the end of the belt rotates 360 deg and pushes the seed in the pipe.
   b. The serve gate opens and pushes the seed down to the pipe.
5. The manure box, attached at the back of the bot body, will provide the manure to the seed hole.
6. As the first seeding is done, the conveyor's motors move 180 deg to bring the next seed in the front of the rotor. Also, the bot's body moves 15 cm to make the next hole by the auger, and the process continues.

- To add on, we can adjust the height of augur according to the seed's need since different sources require different **depths of seeding**.
- **The manuring** box will provide manure to the seed hole.

COMPONENT NAME	COMPONENT IMAGE	USE OF COMPONENT
Conveyor belt		It is used to move the seed/root and give them the required direction.
Transition plate		It deflects the seeds/roots falling on it in the required direction.
Motor-driven rotor (made of foam brick)		It pushes seed a single seed into the pipe

Hollow pipe containing servo mechanism gate		It takes the seed root to the hole made by the augur.
Augur		It makes a hole for transplantation and seeding.
Roller		It gives a swift motion to the seed/ root on the conveyor



3. Autonomous Weed removal

We approached the problem of weeding with the help of Machine Learning and AI. Agro-Bot contains a Raspberry pi camera v2 module, which detects the weeds in the crop plants. With the Jetson Nano interface, we are using OpenCV to differentiate the two. After detecting the weed plant, the camera detects its coordinate or its position given to Arduino through Jetson-Nano, in Jetson-Nano -Arduino mega interface. Arduino Mega, which is connected to the delta arm gripper, controls the controllers of stepper motors connected to arms and the servo motor controller connected to the gripper. These three stepper motors control the arm part, and the servo motor controls the gripper part of the delta arm. Arduino commands the arm for the weed plant's coordinate, and then the gripper, gripping the weed plant, takes it out of the ground and places it in a container attached to the bot. In this way, our bot completes the task of weeding mechanically, without the use of weedicide.

4. Transplantation

To explain the transplantation process through our bot, we take the example of tomato seeds. Early stages of the transplantation process should be done by the farmer, sowing some seeds of tomato in a tray having slots full of rich soil and manure mixture as shown in figure 1. When tomato plants germinate and grow enough, these plants are to be transferred to the biodegradable transplantation cups or a cheaper alternative, for instance, newspaper cups, which serve the purpose. Read this blog on the same:- https://artsycraftsycrunchy.wordpress.com/2010/06/02/how-to-make-newspaper-seedling-cups). Now, here the main work of the bot starts. There is a container where the farmer should place these cups. After placing and giving the command of transplantation to the bot, the bot begins to execute its transplantation task.

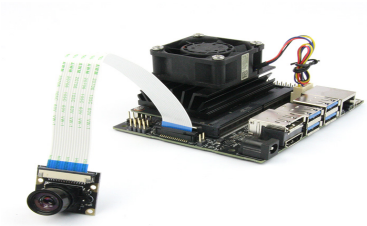
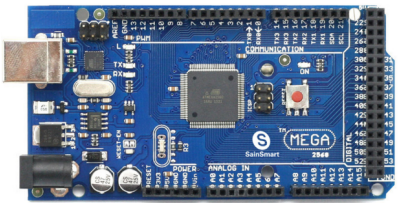
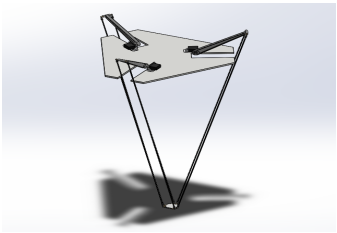
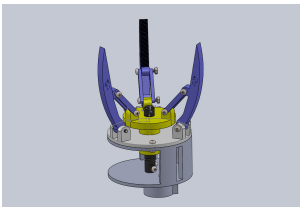
- First, the augur attached to the bot will drill the hole as the size of the cup.
- Next, the camera module detects the holes and cups in the container and sends coordinates or positions of the spots and cups through Jetson-Nano.

- Then Arduino, as controller, plans the gripper's entire movement and commands it to work in the required way.
- The gripper holds the cup and will place it into the hole, as shown in Figure 3.
- A manuring system in the bot provides a manure mixture to the plant at a placed hole through a sort of pipe, covering the hole completely.

figure1

figure2

figure3

Component Name	Component Image	Use Of Component
Jetson Nano Development Kit With Raspi Camera v2 Module		Detection and removal of Weed amidst the crop and this, for transplantation of saplings, using the image and video processing.
Arduino Mega Board		For commanding and controlling the delta arm gripper
Delta Arm Robot		For moving the gripper to various coordinates and lifting objects
Gripper		For gripping and placing objects

Future Developments

1. We will be using image processing in the irrigation and monitoring of plants. The camera module will compare the current picture of the plant to a picture of healthy plants, will measure the moisture of soil, and hence will provide the right amount of water, manure and if pests attack the plant, the right amount of pesticide will be sprayed on the plant on the defined target.

2. With a very stable mechanical system and a heavy locomotion system (in terms of power), we can attach several tools like plowing tools, tilling tools, cutters for harvesting crops, etc., at the back of the robot.

Features

1. The robot will provide manuring to the field at the point of seeding and transplantation, which will provide maximum nourishment to the plant.
2. The robot's height elongation system will help the robot body get damaged and damage standing crops of field.
3. With the help of a camera module, we can continuously monitor plants' health on the field.

Maintenance and replacement

1. The wheel may wear out after 3-4 years and needs to be replaced.
2. The nylon conveyor belt needs to be replaced after 6-7 years.
3. Checking of distilled water level for lead-acid battery after a few months.

Bill of materials

Component Name	Amount	Cost per Piece (in Rs.)	Total
Planetary Geared DC Motor	4	2400	9600
jetson nano 2GB	1	6000	6000
Exide Lead acid battery 64Ah	1	4330	4330
motor driver	3	250	750
Aurdino Mega 2560	2	700	700
jhonson geared DC motor grade B	15	384	5760
6300 ball bearing	10	100	1000
Raspberry Pi camera module	2	1149	2298
Raspberry Pi 4B	1	6749	6749
High torque DC servo motor	1	4200	4200
stepper motor	4	1565	6260
Stepper motor driver	3	900	2700
Conveyer Bilt nylon	1	500	500
servo motor	3	549	1674
rubber cork	1	999	999
aluminium hollow pipes	1	2000	2000
fibre sheet	1	9900	9900
Misc. (welding, shock absorber,etc.)	1	10000	10000
		Total	**75420**

Why is the proposed model considerable for scalability and realization?

- Our compact robot helps to reduce the number of man-hours in fields.
- With Multiple tools attached to the same robot it can perform a wide variety of tasks.
- Differential drive with terrain recognition provides maneuvering of the robot even in highly rough terrains.
- A modern farming approach with an AI-based robot.
- Advanced frame designed with a balanced center of mass and stable design with deflection of 0.3 mm under self load.

Youtube link of simulation video: https://youtu.be/ue7ZCo6AQ7Y