Fruit Picking/Harvesting Robot :-

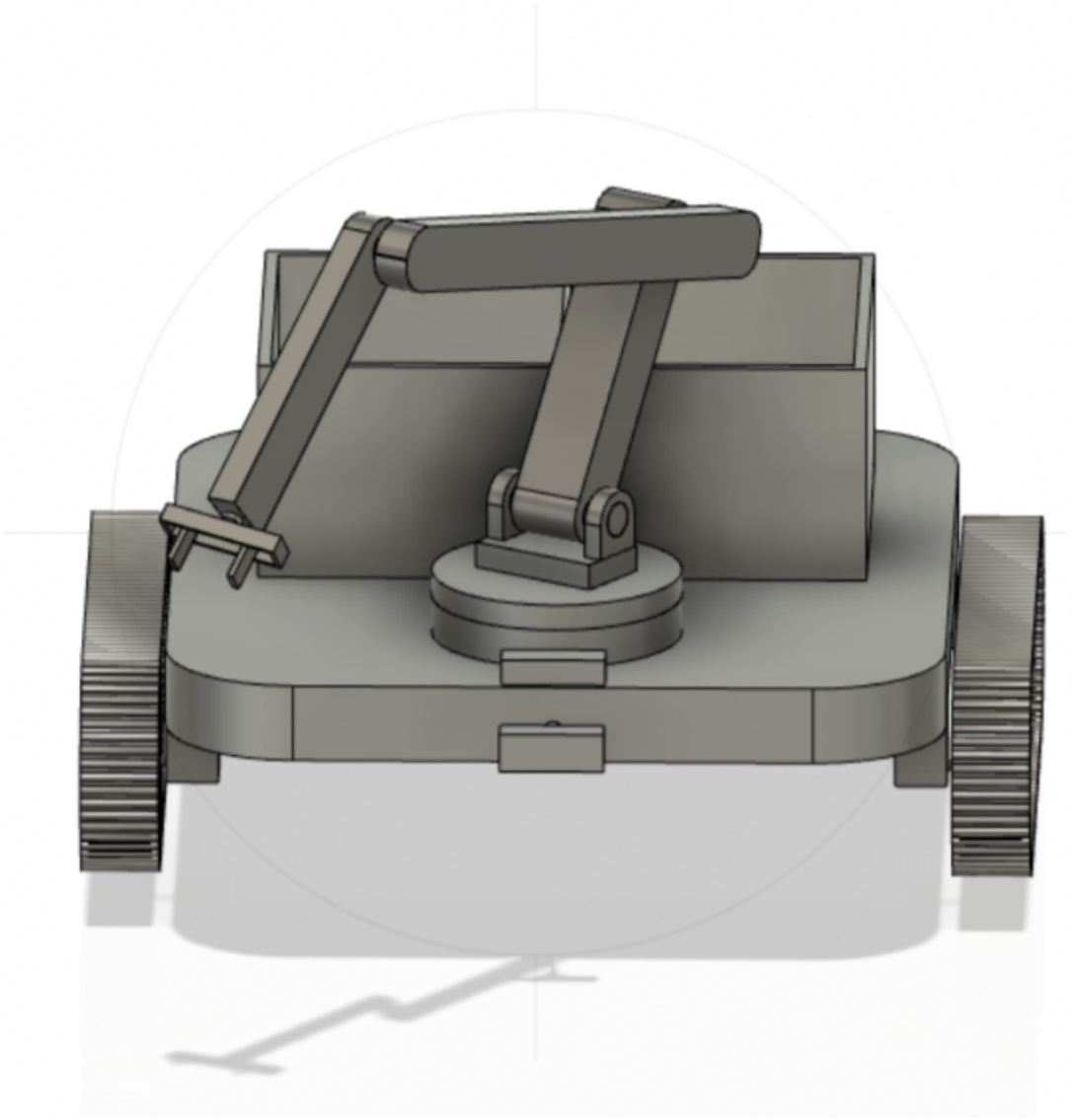
Problem Statement :-

To design a Robot that can pick/harvest fruits on its own.
Tasks that the robot should be able to do on its own to perform this task in an automated manner are :
->Navigate through the Orchard/Garden.
->Detect if the fruit has ripened based on size and colour.
->Safely remove the fruit without harming the plant.
->Storing and segregating the fruits.
The robot does all these tasks in a semi-autonomous way. So not much human interference/assistance would be required for the robot to complete its tasks

Impact of solving the problem :-

Modelling a semi autonomous robot for harvesting fruits would reduce the manpower, maintain uniformity, and can easily pick fruits from trees at any height and slope with ease. Significantly reduces cost of production compared to using labour.

Now let's explain with relative detail, how the robot carries out these tasks. We will explain how the robot carries out each of the tasks mentioned above, part-by-part.

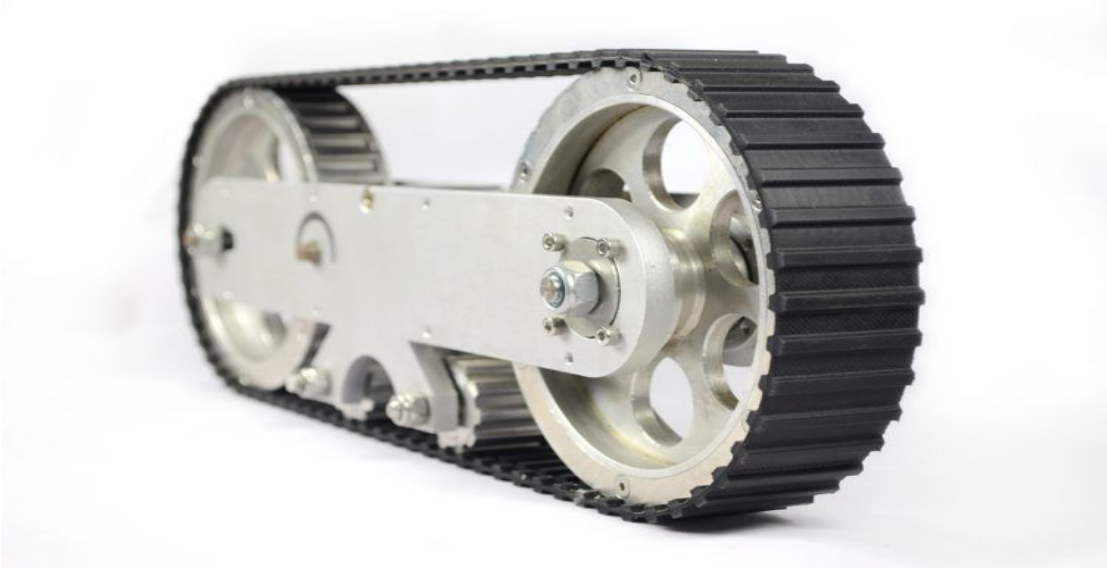


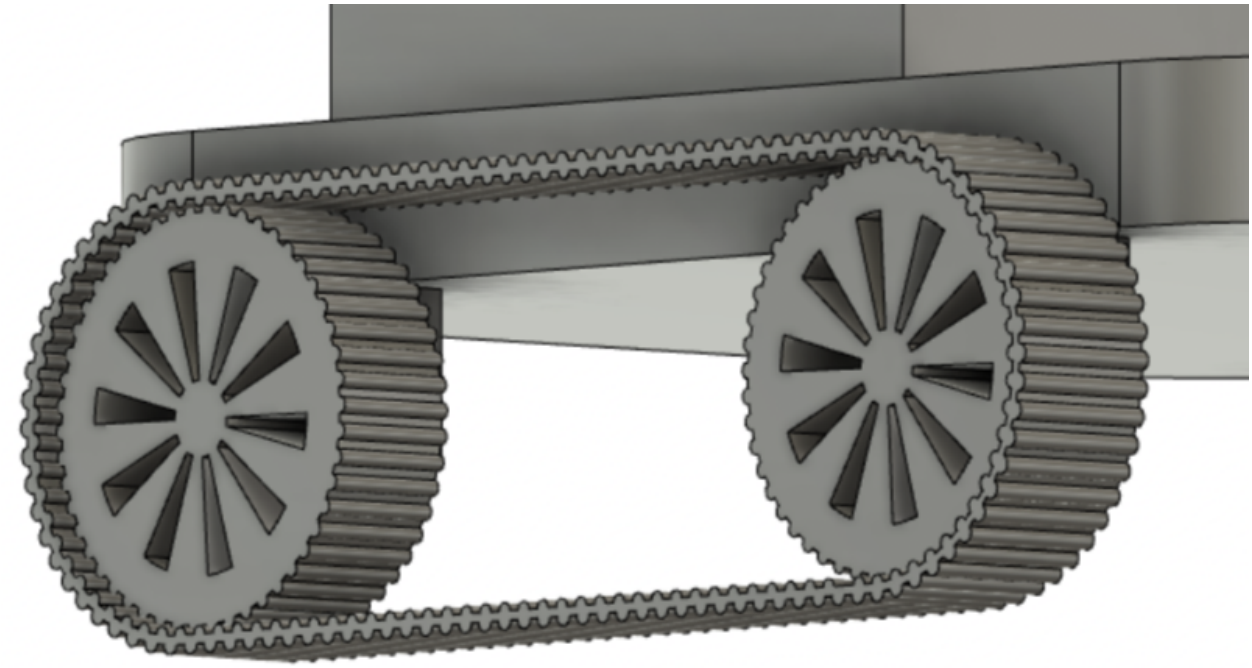
Explaining each tasks that the Robot performs:-

Traversal :-

Here instead of regular wheels, for our design we have decided to use 2 rubber tracks connected to a gear Mechanism on either side of the Robot. A motor is connected to each of the tracks which helps in independent motion of each of the tracks and increases the degrees of freedom. Since the Robots are not moving through perfectly plane concrete floors hence we are using these tracks instead of regular wheels as they allow for better grip and prevents slipping. This also allows for a slow and steady motion which makes sure that the Robot does not leave any fruit behind.Since the fruits are stored and segregated in these baskets We also had to consider the stability parameter which works very well for these kinds of wheels.Having two motors for each wheel allows us to turn easily by lowering the speed for the motor in the direction we want to turn.
Here the only disadvantage of using this mechanism is that it is subjected to more friction so that more battery power is required than in a normal wheel mechanism.

Other Advantages of Track & Gear mechanism are that it is simple to use and the repairs can also be done by a normal mechanic. The parts are also easily available, and with this kind of a setup we can also add hydraulic suspensions for load fluctuations (if we consider this bot for a large scale use).
The wheels are connected to the side of the Chassis of the robot through a constrained rotational joint. This setup gives stability to the main upper body while moving along the Orchard. The joint also provides more Degrees of freedom(that allows for easier movement along slopes) which in turn increases flexibility for single track which gives stability to the robot.
Here also note that the wheels on the same side of the robot are also connected internally such that they are powered through the same motor.



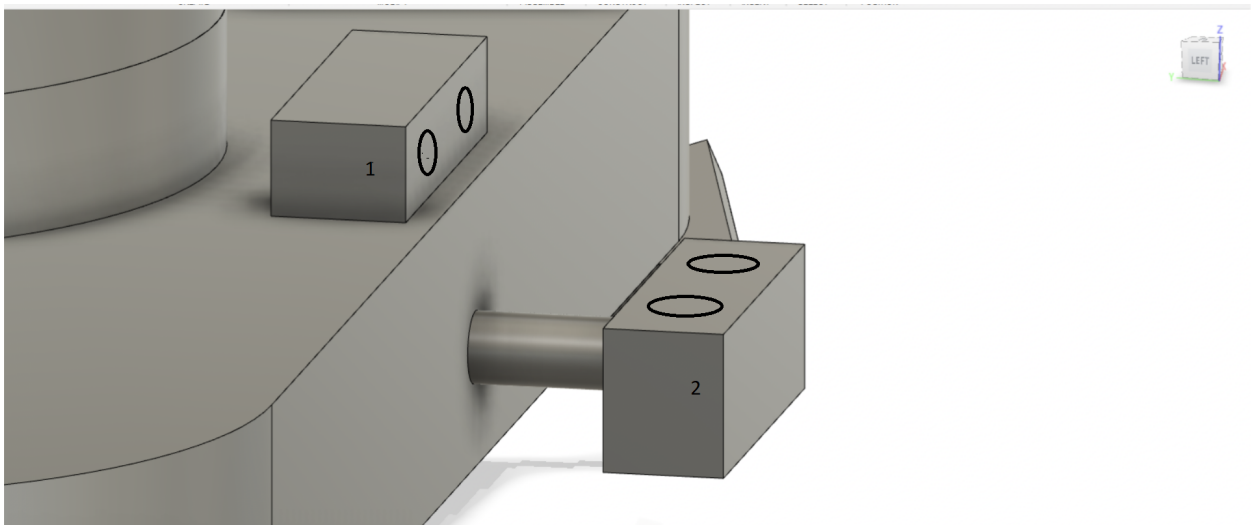


Navigation :-

A mobile robot requires a representation of the environment for autonomous navigation in the form of a map. Based on the environment characteristics and the type of the map, it is possible to build robot maps using existing maps by other means. But in most cases, the robot needs to build a map of the environment as it moves for better efficiency.

So for this we have used a stereo camera which is fixed at the front. This has an image sensor which allows the camera to simulate human binocular vision, and therefore gives it the ability to capture 3 dimensional images.This camera sends

the captured data through an ros program where it is processed. Using the final data we can send the specific commands to the motor drivers. The motor drivers (placed in an Electric Board) are connected to the motor through an Arduino. Here for edge detection, we can place multiple Cameras at the sides of the Robot which could process all the data through an ros program and would be able to detect all the edges and would be able to navigate in a more autonomous manner.



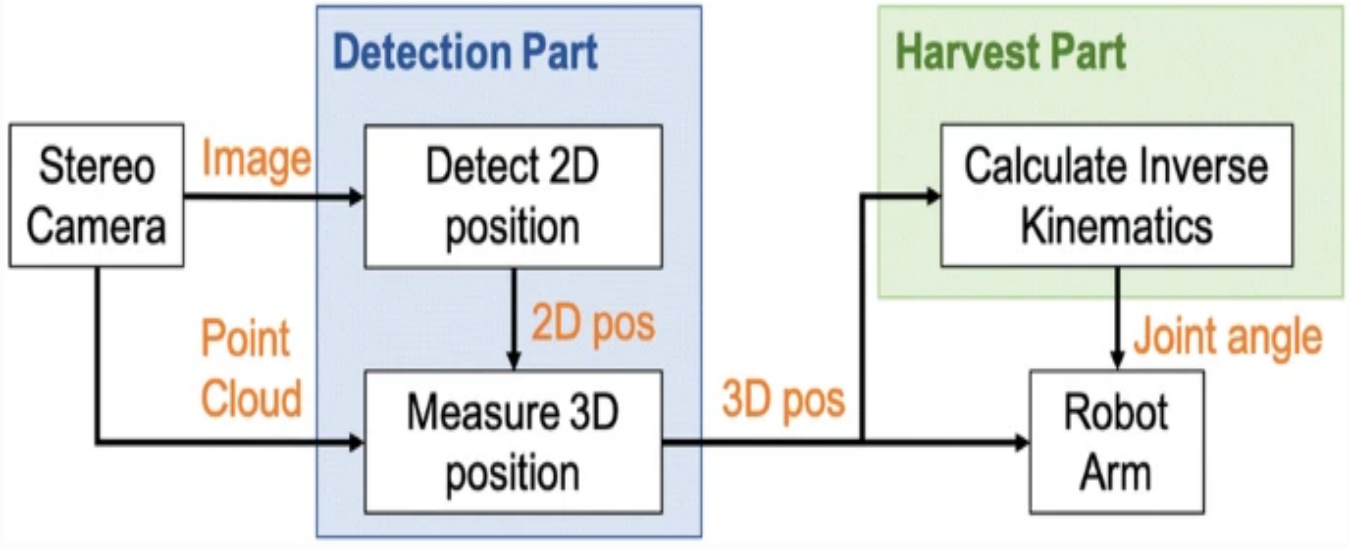
Here the Camera 1 is used for Navigation and the Camera 2 is used for Fruit Detection.

Fruit Detection :-

The robot is equipped with a stereo camera and a robot arm.The algorithm for the fruit detection and harvest involves three steps: detecting the 2d position of the apple, detecting the 3d position of the apple, and calculating the inverse kinematics.

The first step involves capturing the image with our stereo camera and detecting the 2d position of the fruit. For detecting the fruit from this 2d image we are checking based on the colour and the size as we want only the ripened fruits of a certain size. We have surrounded the area where the possibility of fruit was

higher, with a frame(whose colour codes matched with the colour we wanted our fruits to match).This helps the robot to detect the fruits easily.



The next step is to find the 3d position of the fruits using the sensors and our stereo camera. Once the 3d position of the fruit has been mapped, the robot will send commands to the Robotic Arm to move accordingly.

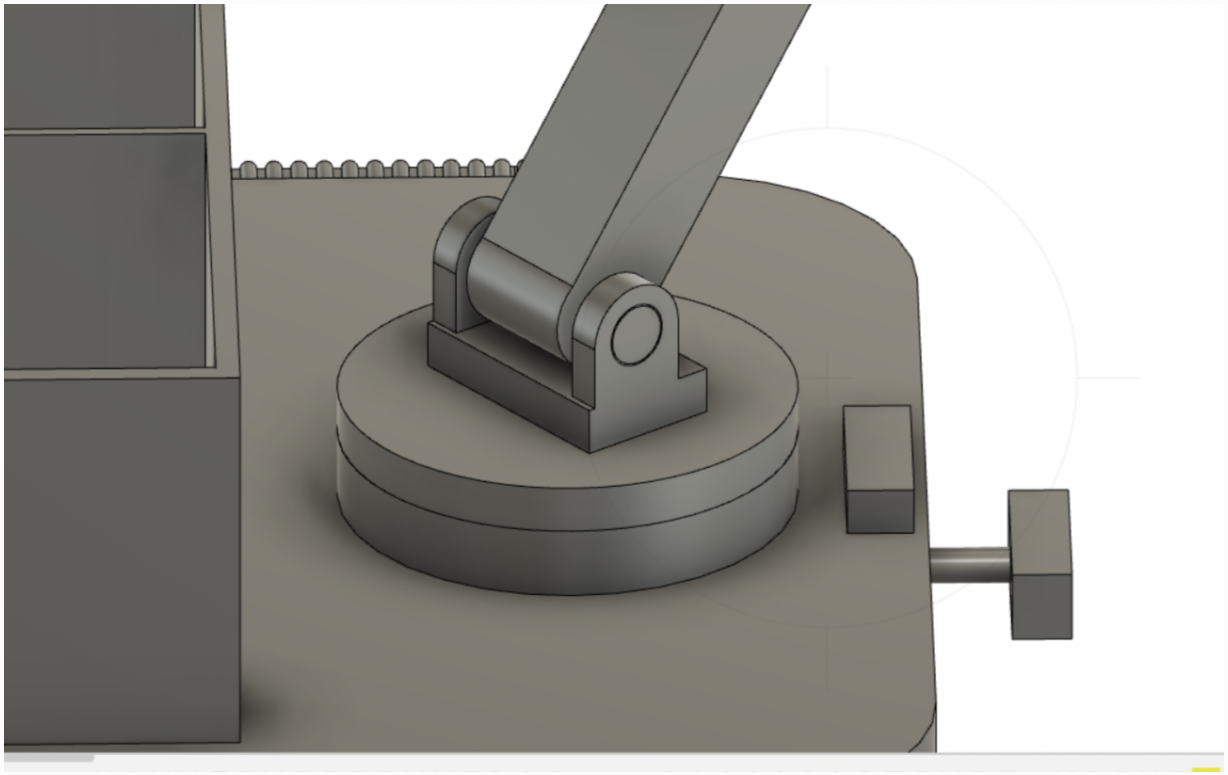
Harvesting the Fruit :-

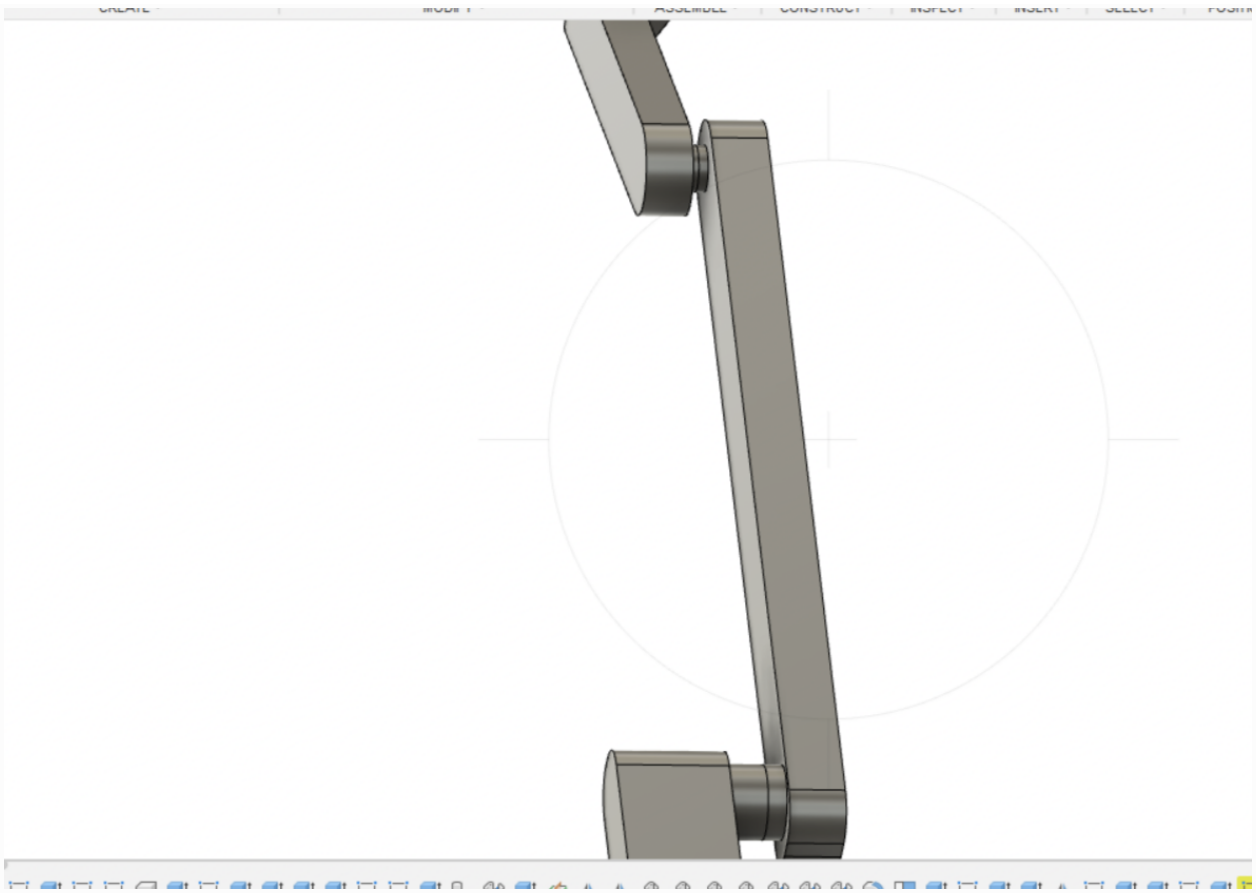
For harvesting the fruit we have the robot's arms which allows for full 3 dimensional motion. Our Robot's arms comprises 3 parts each connected by a revolute joint and the last one connected to the Chassis using a revolute joint(here the base can rotate) for more movement.The Gripper is connected to the Arm using a slider joint. Here one thing we can add is a ball joint between the End effector and the arm to make the twisting process easier.

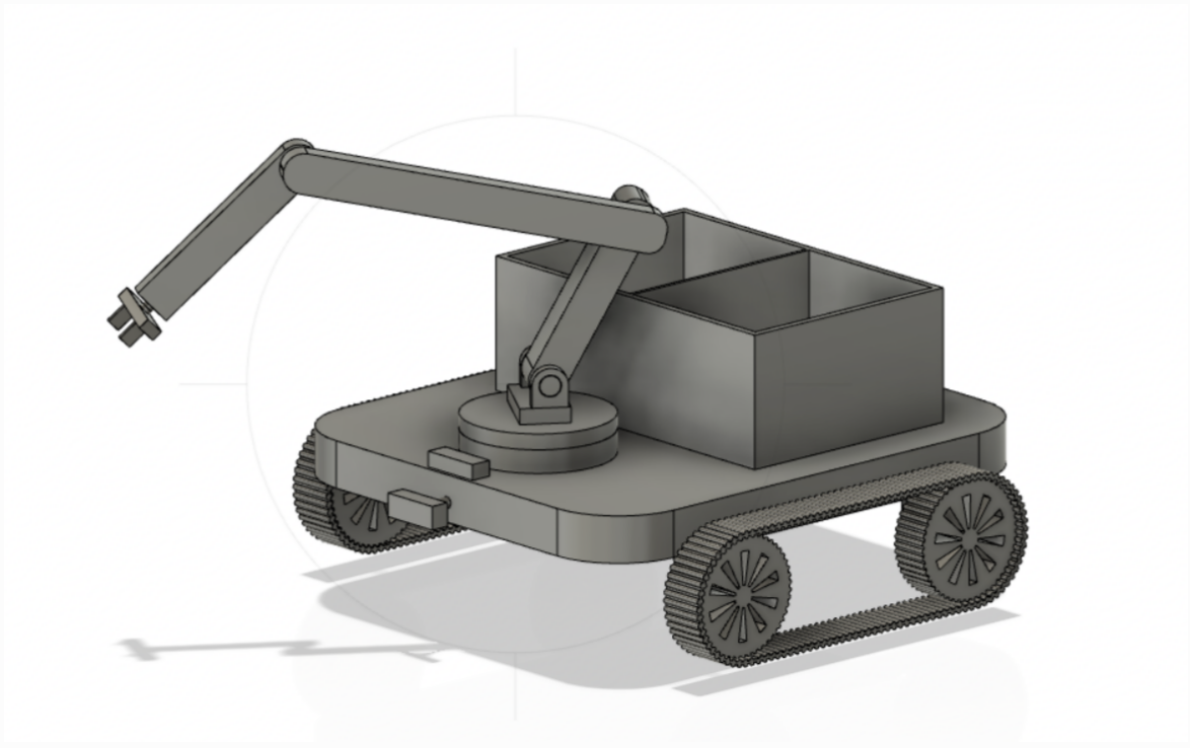
Now the harvesting part, first to insert the robot hand from the underside for fruit harvesting, the robot is to be moved directly below the target fruit. The arm then rises below the fruit. The robot hand then grasps the fruit and harvests it by twisting from the peduncle by rotating 1 or 2 times (depending on the sturdiness of the peduncle) and pulls it to harvest the fruit without damaging the plant.

Now for certain fruits which may have a soft skin, this process might rupture the skin and might damage the fruit so for these fruits we have a different Arm design. This one has a different end effector and an additional stereo camera, here instead of just the gripper we have another finger-like protrusion over it,with a blade attached to cut the branch.Here the stereo camera is to find where to properly cut the stem. Hence the gripper won't have to pull the fruit.

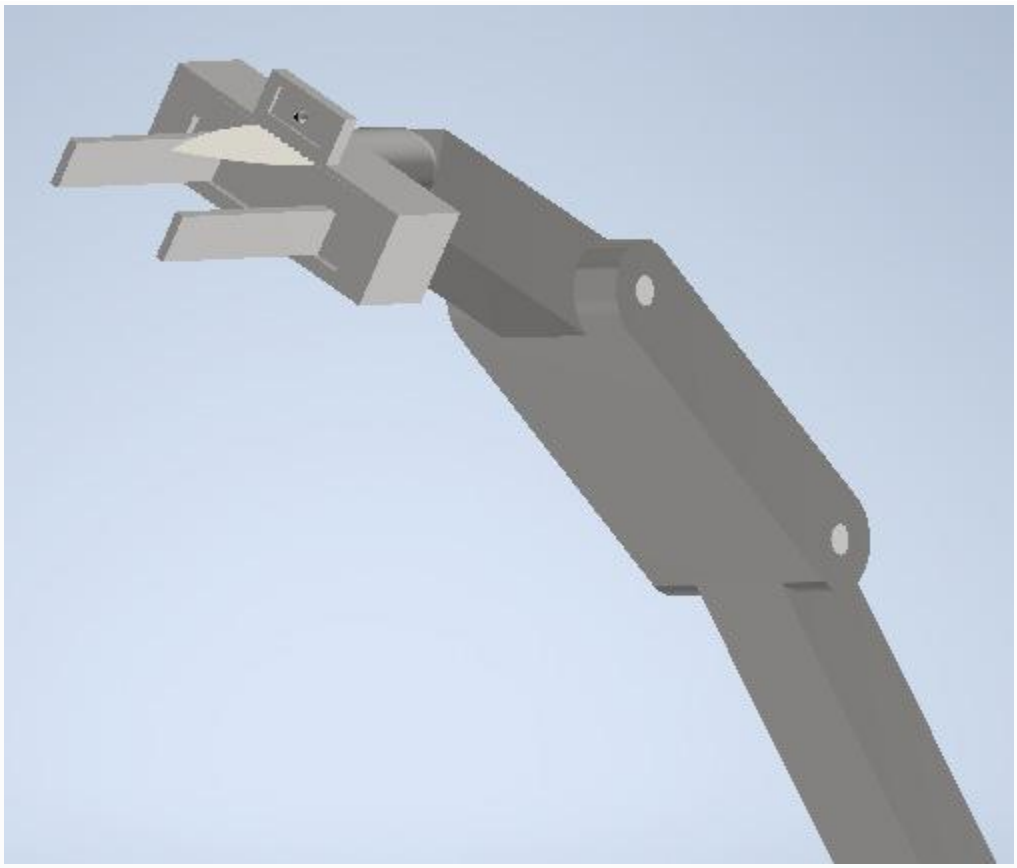
The joints of the Arm :-





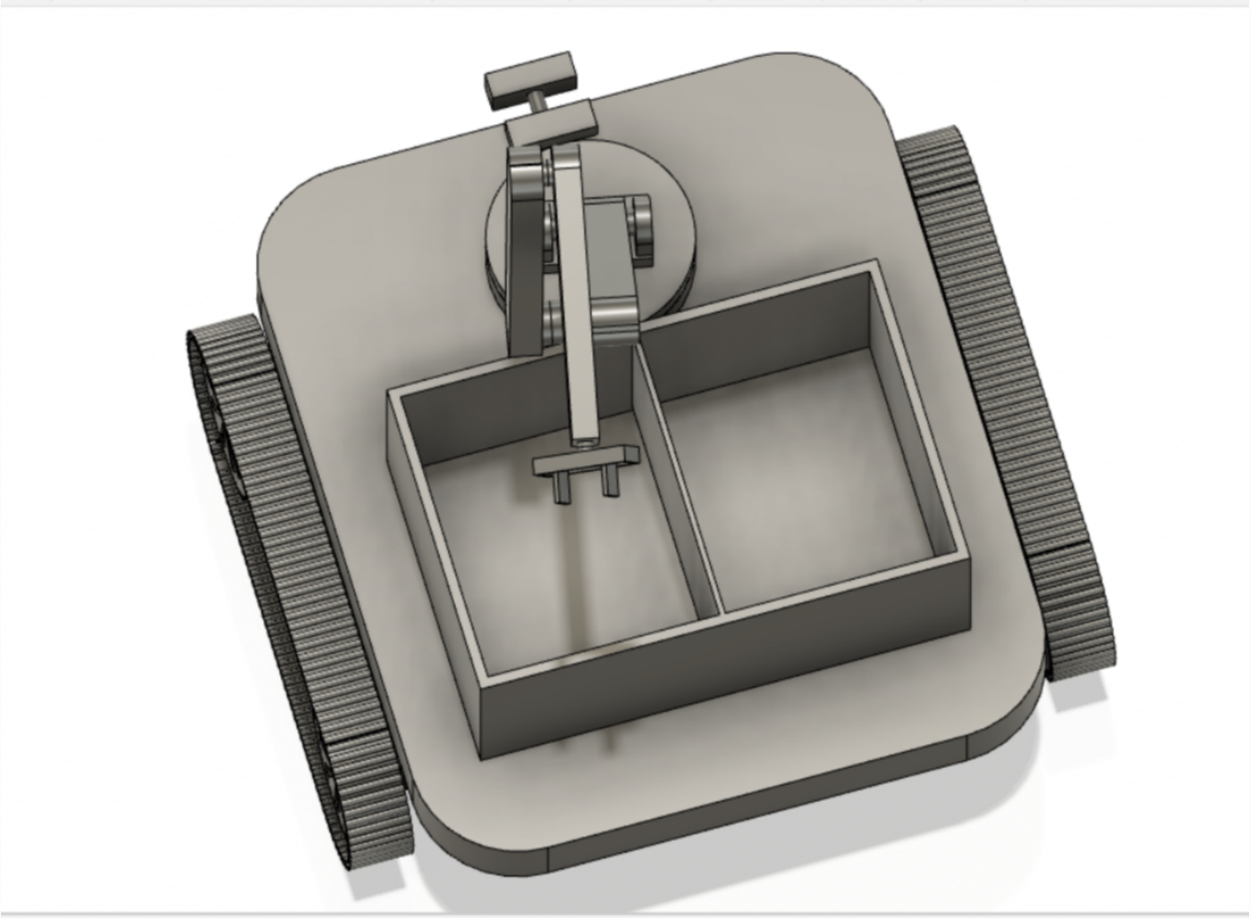


Design 2:-



Storing and Segregation :-

As the Robot harvests a fruit it can store them in its basket that is attached to the robot. This basket has 2 compartments for storing 2 different fruits, but this number can be increased by adding multiple compartments for storing other fruits.Since we are considering Orchards, for our robot at the end of each row we can change the detection criteria and the place to store with our remote control or can be incorporated into our code itself to make it more autonomous.



So, with this, we can say that all of the objectives of the problem statement would be achieved, and we also briefly explained all of the major components we will be using, and some algorithms used by the robot to perform its tasks.

Team Members :-

C R Ashwin Raj

Dhamodaran

R S Harish Krishnan

Praneeth B

THANK YOU