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Solar powered automatic robovator

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Abstract
Exponential growth of population leads to enormous food demand which creates more stress on agricultural sectors. There are many factors affect agriculture production, one among them is weeds. It will compete with main crop in terms of water, nutrient, sunlight, spacing, energy etc. So weed removal is the biggest task to farmers in present scenario because of lack of labour availability. To overcome this difficulty for farmer, in this study Automatic Solar powered Robotic weeder for Cassava crop is proposed because it has more than 10 type of weed during growing stage. In each stage, removal of weed is not possible by manually and to make machinery application robotic mechanism with solar power is proposed in this study. It can be done by assembling the components like battery, cameras, sensors, gear unit and developer kit etc. After that, performance evaluation of newly fabricated Robovator prototype will be carried out.

Keywords: Solar power, automatic, weeding, robovator, weed detection mechanism, spraying

Introduction
Agriculture with Federal sectors is undoubtedly the largest source of income provider in India particularly in rural areas. High degree multiple agriculture farming systems are assail with different types of weed problems. Weed growth causes 100% crop yield loss which leads to heavy loss of agricultural production to the farmers. So Weed control plays an vital role in economic growth of individual and to the country. If weeds are supervised correctly, it will prevent damaging of crops and will also increase the fertility of the land. On the other hand, if not supervised properly it may cause everlasting damage to the land fertility. A better way of weed control can be done by automatic mechanization. In this research an attempt made to develop prototype of Solar powered automatic robovator. By keeping range of vision, solar as a base as it reduces cost and gives better removal of weeds which in turn increase net profit in agriculture sectors. This machine will have unique ability to distinguish slightest difference between the crops and weeds. The main objective of our paper is to select the crop by analyzing various weeds, cameras and sensors along with encryption of weed detection mechanism using analyzed factors and at the end fabricate and field testing of Solar Powered Automatic Robovator is done.

Materials and Methods
Selection of study crop
Selection of crop among various major crops around the world is done by comparing its characteristics such as duration, major weeds present in them, possibility of weed heights and type of crop (enclosed in appendix table 1). At last Selected Cassava Crop for weed removal. Cassava crop is selected by comparing among the major crop producer in the world. *Cassava* (*Manihot esculenta*), also called manioc or tapioca root, is cultivated as an annual crop in tropical and subtropical regions for its edible starchy in nature. Cassava is 4th most important energy source for human consumption. Plant with underground root (tuber) and it is characterized as highly effective producer and produce more carbohydrate per acre of land than any other plant and becomes 4th largest producer in the world. Cassava is a nutty-flavored, starchy root vegetable or tuber. Native to South America, it's a major source of calories and carbs for people in many countries. Nigeria, Thailand, and Indonesia are the top cassava-producing countries in the world. Because of its ability to withstand difficult growing conditions It is grown in tropical regions around the world. In fact, It is also known as most drought-tolerant crops.

Fig 1: Observation of Cassava

The most commonly consumed part of the cassava plant is the root, which is incredibly versatile. We can consume it whole, grated, or ground into flour to use it in bread and crackers.

Factors Analyzation Weeds

In cassava farms Weeds are classified into three main groups namely grasses, sedges and broadleaf weeds. sometimes; Cassava is also desecrated by certain parasitic plants. Numerous kinds of weeds occur in particular places; The following weeds are the selection of the most widespread species. The following are the various types of weeds that are present in cassava crops which is explained clearly in following paragraph

Sedges-Sedges looks like grasses but are reliable. Sedges are usually erect and have solid and triangular shaped stems. Common sedges which cause problems in cassava farms are *Mariscus alternifolius* and purple nutsedge, *Cyperus rotundus*.

Broadleaf Weeds-Broadleaf weeds stem are solid and irregular in shape. They are herbs and shrubs. Leaves of broadleaf weeds are broad, expanded and single. Leaves are subdivided into leaflets to form compound leaves in cassava farms include Siam Weed, *Chromolaena odorata*, Wild Poinsetia, *Euphorbia Heterophylla*, Giant Sensitive Weed, *Mimosa invisa* Tridax, *Tridax procumbens*, goat weed, Waterleaf, Talinum Triangulare and Tropical spiderwort.

While observing in our field we observed weeds which come under Grasses

Grasses- Shape of stems of grasses can be Oval or Cylindrical. The leaves of grasses are much longer than they are broad and are never subdivided into little leaves(leaflets).The most commonly used grass weed is called as spear grass also known as Heteropogon contortus which most commonly found in tropical and subtropical regions. It has wide range of medicinal uses (figure 2), Bermuda grass also known as crab grass and has excellent wear, drought and salt tolerance (figure 3), Guinea grass also known as Green Panic Grass for making silage and Hay (figure 4) Panicum maximum; and the feathery *pennisetum*, *pennisetum polystachion*.

Fig 2: Spear Grass

Fig 3: Bermuda Grass

Fig 4: Guinea Grasses

Selection of suitable sensors and camera

Selection of suitable sensors and camera is done by comparing with previous weeding robots proposed with year scope, methods of weed control, sensors and camera which are used for previous proposed robovators (enclosed with table NO. 2). By analyzing various factors for our study we are going to use USB Camera as major camera and sensor for weed detection mechanism

USB Camera
USB Webcam is camera or multimedia application that connects to a computer usually through plugging it in to a USB port on the machine. The specification limits the length of a cable between USB 2.0 devices (full speed or Hi-speed) to 5 meters (or about 16 feet and 5 inches).

Robovator
Robovator is a robot which is well equipped with a special plant detection camera which is present above the each row of Crop.It has a mechanical tool (much like a hoe) which is operated by a hydraulic power.

Features
- High Efficiency of Mechanical Components.
- Automatic Alignment.
- Very easy to operate even for the unskilled operator.
- Low Power Requirement of only 5KW.

Basic components of Robovator
Jetson Nano – 4 GB RAM- Run multiple Sensual networks in equidistant for many applications like image classification, object detection, and segmentation. All is an accessible platform that runs in as little as 5 watts.

USB Camera- Camera that is connected to a computer, by plugging to a USB port on the prototype and also Supports Jetson Nano and takes photo.
Arduino UNO-Programmable Open-source micro controller board which is developed by Arduino and also development board.
Drive unit- It converts electrical power into mechanical motion and term is shortened to drive
Battery – It gives extremity power to a load when input power source is failed.
Gear box -To meet the Technical requirements of an application and power which is coming from the gearbox which amplifies and goes for the drive.
Alert unit-Receives a signal and sends power to the siren and strobe. Robot body -Generates arm movements and senses the visuals and instant feedback.

Herbicide usage for Cassava Weeds in India Grasses and Sedges
When weeds like broadleaf and sedges are predominant, use 2,4 D Sodium salt (Fernoxone 80% WP) +1.25Kg/ha which is liquefied in 625 litres of water with a high amount of volume sprayer, 3 weeks after leaf stage.

Fig 5: Herbicide for Grass and Sedges Weed

Encryption –Image Processing Coding
This portion tells about the code for our project. Codes for the purpose of weed classification because accurate identification of weeds is most important step for a weed Management. The weed detector software has different color to differentiate which is a plant, and which is a weed coding programmes.

Robovator Mechanism
The weed detection mechanism is given across the robovator to operate. The mechanical and chemical action takes places are the major steps in robovator are is given Figure 3.10.It includes various components such as solar power, battery, camera, Jetson Nano, Herbicide spraying, Arduino, drive unit which has motor controller, drive motor which has speed of 60 rpm, machine movement and rotary action. Flowchart for robovator mechanism is given in appendix page

Results and Discussions
Technical Data functions
Normally cassava is grown in 4 feet spacing row to row width because for irrigating purpose and to increase crop growth. During 6 to 8 months bunding is done by manually or mechanically through the row to increase yield so machine dimensions (2.75 m* 1.45 m* 1.55 m) are designed accordingly. The size of the vehicle was determined by the standard track width used in agriculture. The precision was set at 2cm to cover only the weed and not the surroundings. Speed is set at 0.4 m/s for better performance of the weeding which helps in better analysis and removal of weeds. Batteries are selected based on the total mechanism involved in the weeding practice and for better area coverage. It also facilitates all the functions of the machine by providing the energy required for the function. Four Rotary blades are provided to cover 2 feet distance on both sides of the crop. The design is made such that it makes the process seamless and gives a better output. The two spraying nozzles mounted in robotic arms uses a small dose of herbicide on detected weeds, based on a non crop detector that was centered on inter rows only. Intra-row weeding will be performed by mechanical actuator.

Dimensions: 2.75 m* 1.45 m* 1.55 m (L*W*H)
Weight: 300Kg
Crop spacing: 4 feet-121 cm
Speed: 0.4 m/s
Robotic arms exerts: 4000 movements/hour approximately
Precision: <2 cm
Traction: 4 Driving Wheels
Motor: 500 W Motor with speed of 2000 rpm.
Gearbox to reduce speed and increasing torque
Energy: 2 Photovoltaic panels, lithium batteries
Rotary Blade Type: Rotary hoes (N0-4)
Sprayer Type: customized Sprayer
Work Rate: up to 10 acres/day

Dataset Collection

Dataset Collection involves the process of collecting cassava crop dataset from Kaggle as shown in Figure 6. It will be fed for training with the deep learning algorithm. Increasing amount of dataset increases the accuracy. Performance of dataset which is collected is explored at large scale by Google with 300 million images.

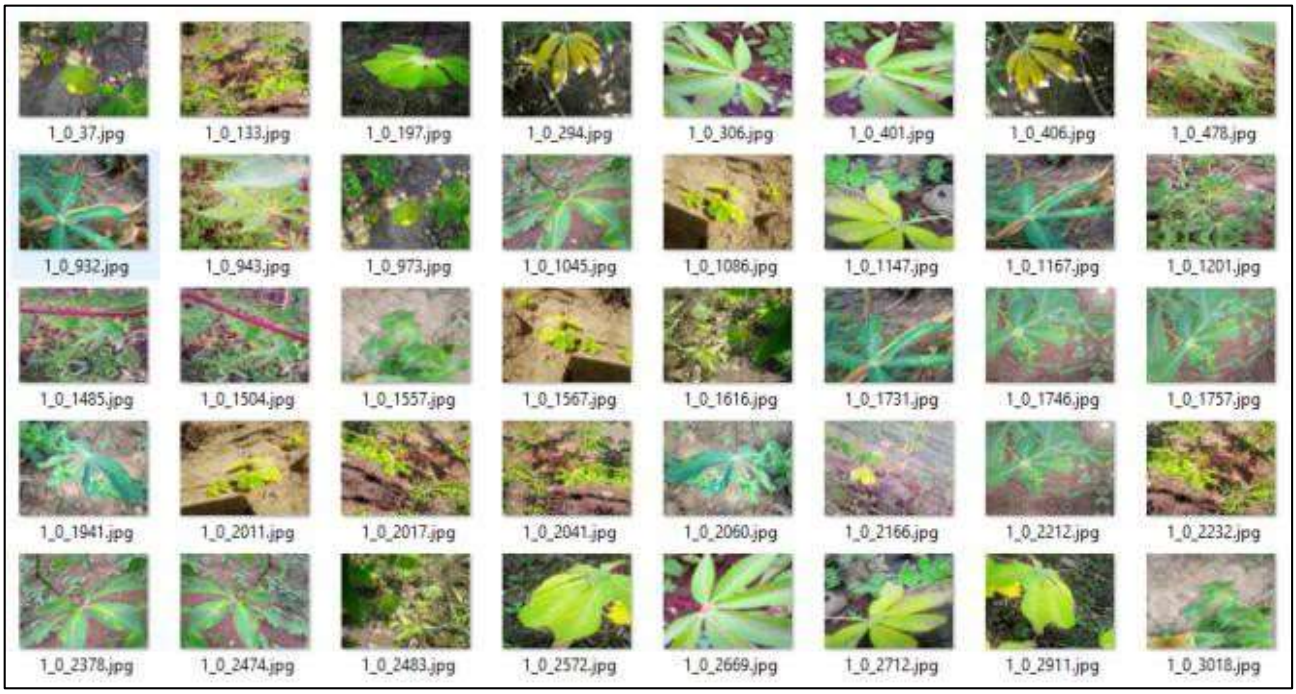

Fig 6: Dataset Collection

Dataset Augmentation

Then datasets are then augmented, as shown in Figure 7, to increase dataset size.

Fig 7: Dataset Augmentation

Simple preprocessing

Then these datasets are preprocessed which is shown in Figure 8 from convert the random size images into required size format of 224*224 so that it can be made ready for training with the model. Then these images are annotated.

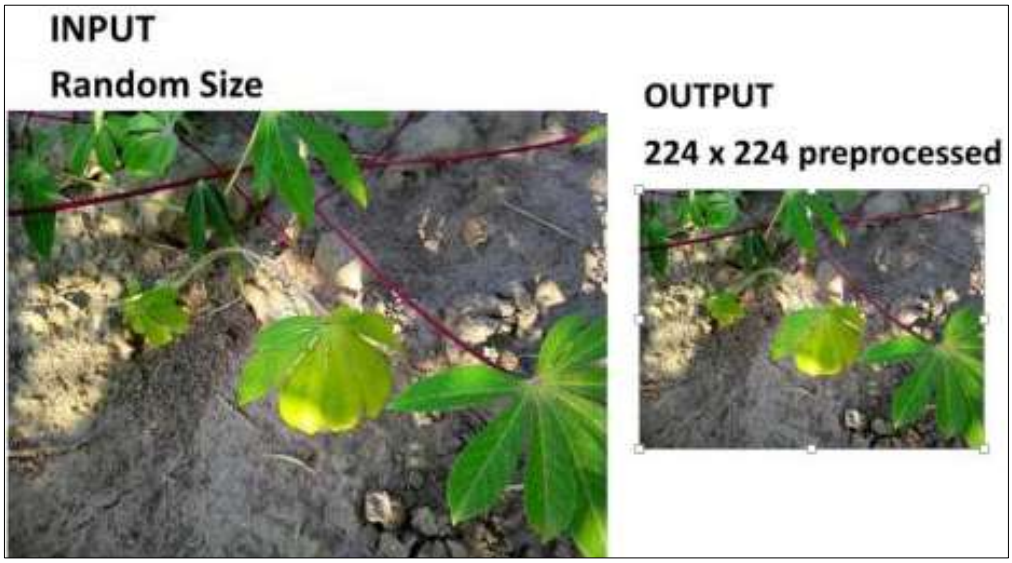

Fig 8: Simple Pre-Processing

Then these images are annotated using roboflow. The below figure shows that creating project in rob flow.

Fig 9: Creating Project in roboflow

The below figure shows, uploading images in roboflow after creating project.

Fig 10: Uploading Images

The below figure shows the annotation of images

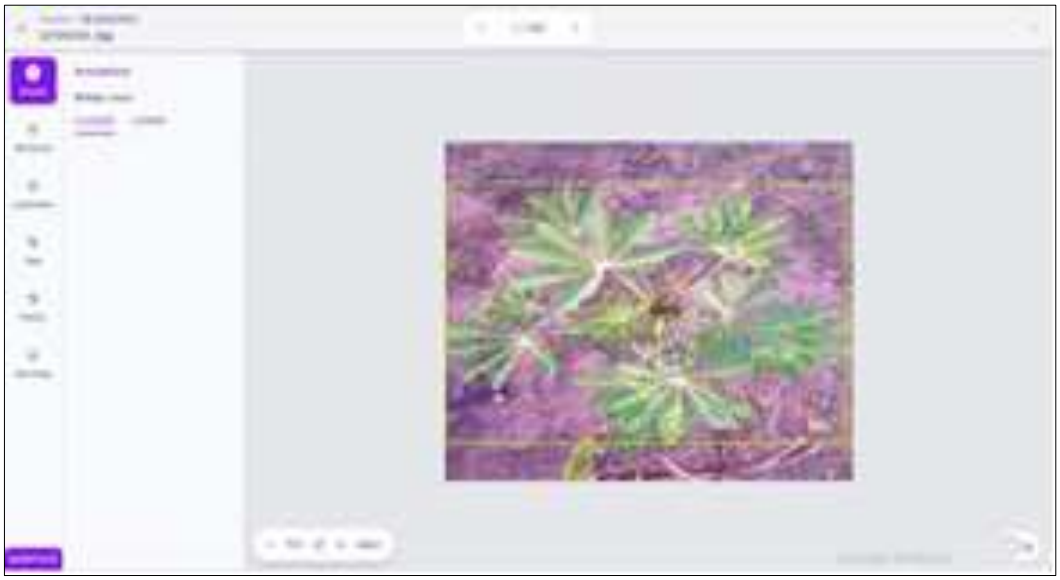

Fig 11: Annotating Images

The below figure shows the class names assigning in roboflow

Fig 12: Assigning Class Names

The below figure shows, saving images with train test split.

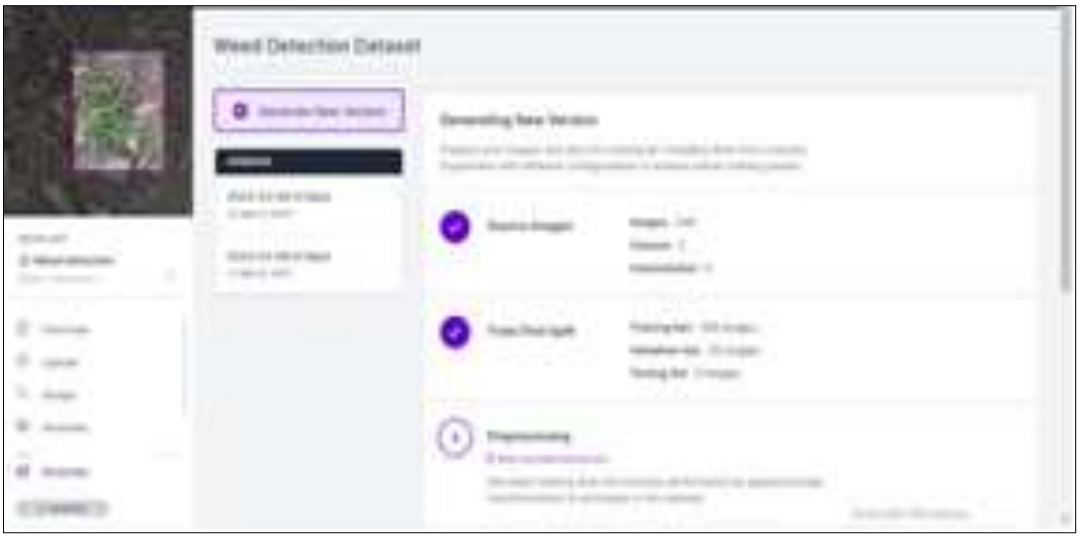

Fig 12: Saving Images with train test split

The below figure shows, saving annotated file in PyTorch format

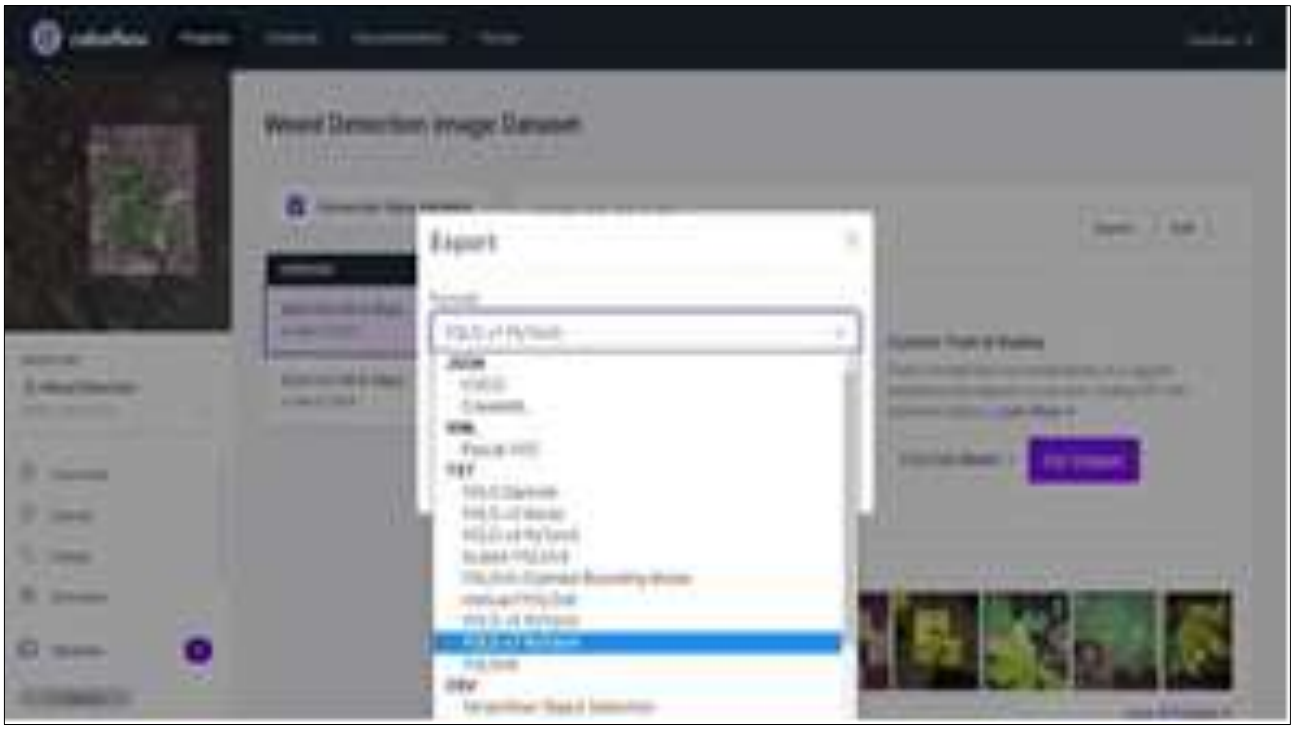

Fig 13: Selecting Py Torch format

After annotating images, training is performed using Yolov7-tiny algorithm

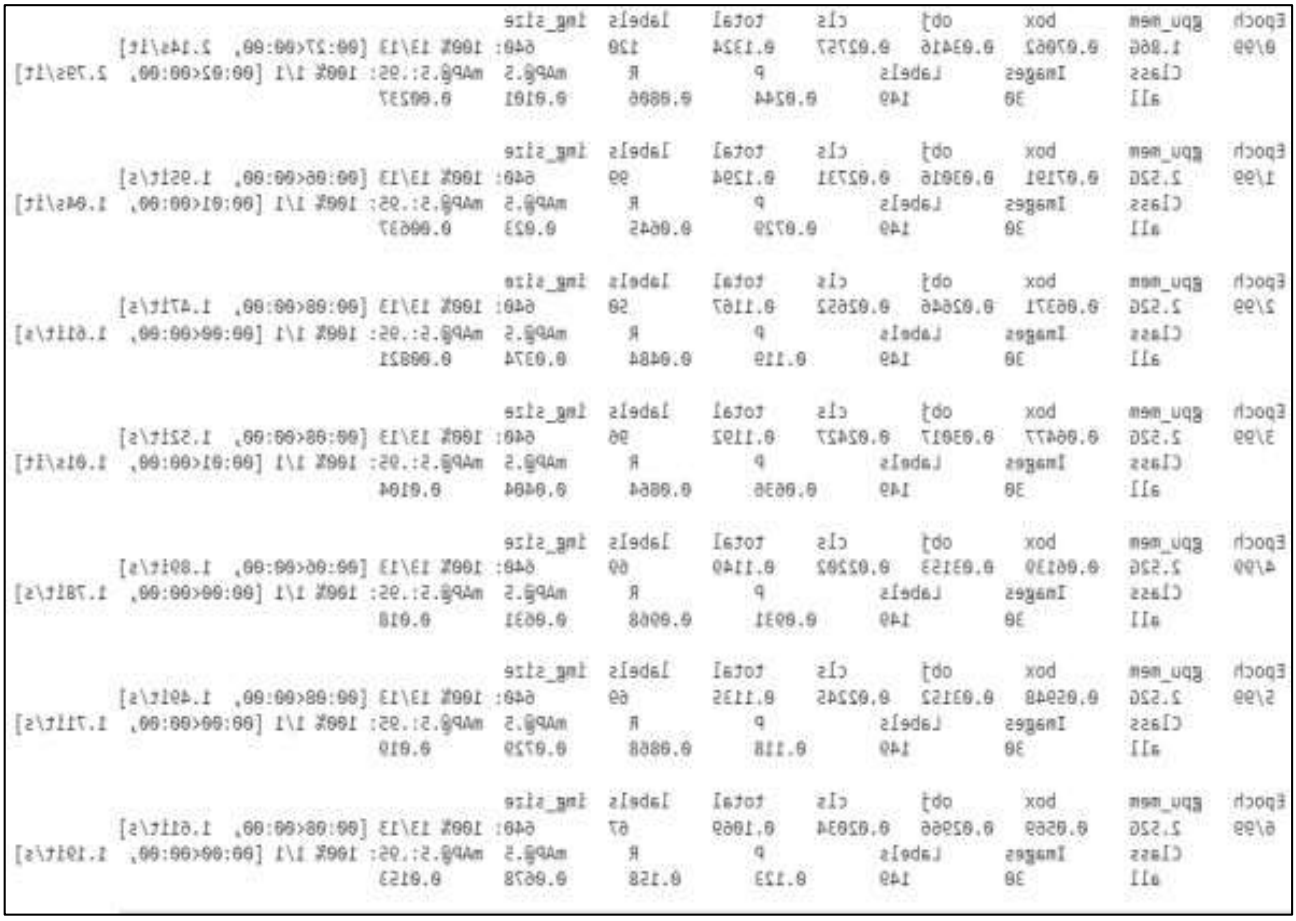

Fig 14: Training

The below Figure 15 shows, Confusion Matrix of Yolov7-tiny model to find out the performance of crop, weed, background with crop, predicted weed

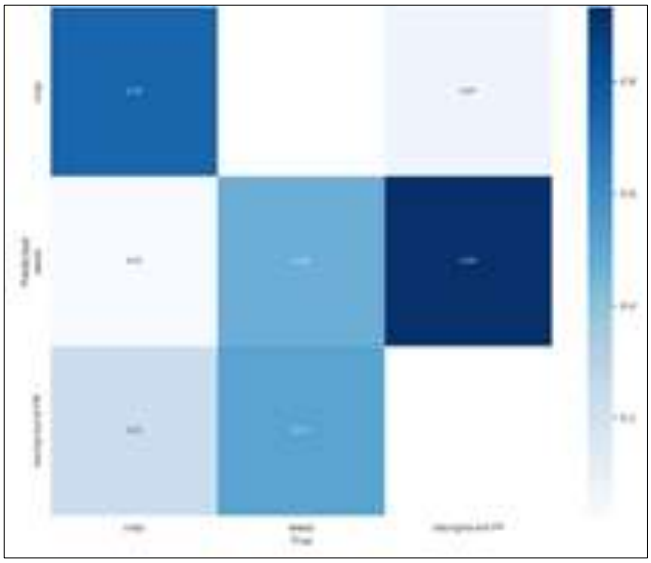

Fig 15: Confusion Matrix

The below figure 16, 17 & 18 shows the detection of crop, weed and crop and weed

Fig 16: Detection of Crop

Fig 17: Detection of Weed

Fig 18: Detection of Crop and Weed

The below figure shows robot with jetson nano module.

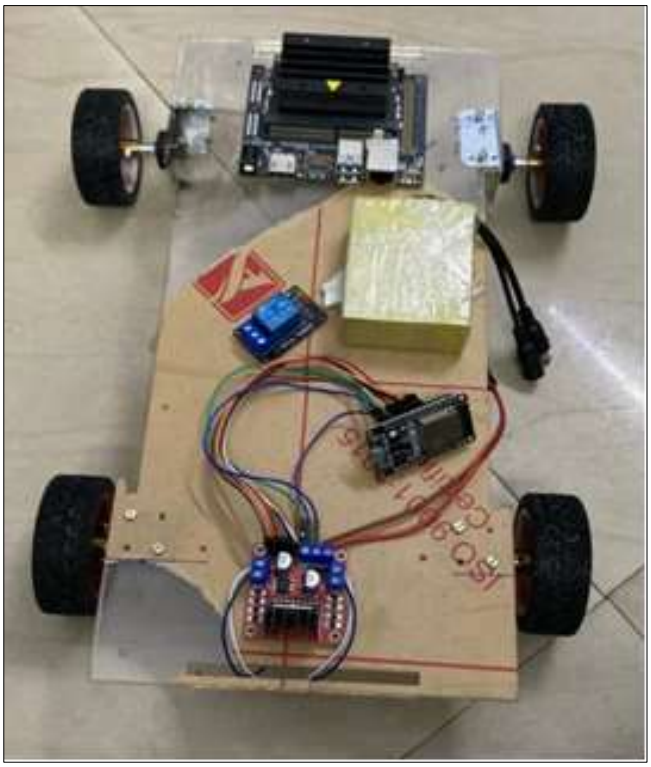

Fig 19: Robot

Whenever the weed is detected, the robot stops and fertilizer is automatically sprayed and a DC motor with blades rotates to cut down the weed plant The below figure shows, robot detecting weed and stops for spraying fertilizers

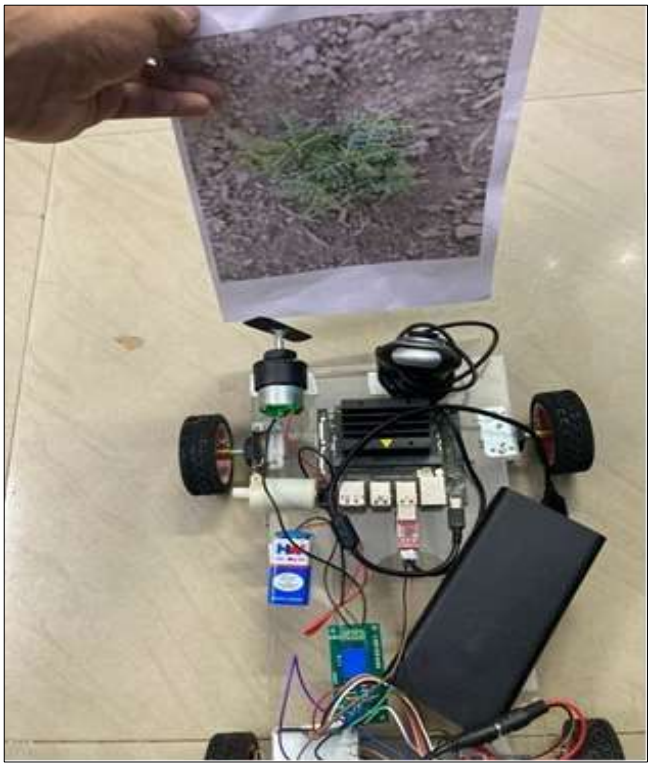

Fig 20: Robot detecting weed and stops

Conclusion

In this study, Weed detection Mechanism linked with Automatic Robovator using solar power. Selected Cassava crop for weed removal by detecting with appropriate camera and sensors. Various factors for the selected cassava crop are analyzed with its own weeds characteristics, cameras for detecting and sensors for sensing. Coding for the accurate identification of weeds is given in the developer kit. Implementation of fully automatic robovator helps and can be better alternative than other conventional weed control methods. Elimination of problem of weed removal by applying herbicide is possible for equipment to accomplish weeding task. Both Rotary and spraying action in a machine will make effective weed control process.

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