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Mow-Bot

Nagarjun B M
Department of Electronics and Communication Engineering
Dr. Ambedkar Institute of Technology
Bengaluru, India
nagarjunbm711@gmail.com

Mohnish S
Department of Electronics and Communication Engineering
Dr. Ambedkar Institute of Technology
Bengaluru, India
mohnishshivanand@gmail.com

Keerthana N
Department of Electronics and Communication Engineering
Dr. Ambedkar Institute of Technology
Bengaluru, India
nkeerthana365@gmail.com

Ramya B S
Department of Electronics and Communication Engineering
Dr. Ambedkar Institute of Technology
Bengaluru, India
ramya.b.s.289@gmail.com

Harsha R
Assistant Professor, Department of Electronics and Communication Engineering
Dr. Ambedkar Institute of Technology
Bengaluru, India
harsh4no1.ec@drait.edu.in

***Abstract*—While the world becomes more globalized, so will the need for faster and effective agriculture increases. It is essential to use modern agricultural approaches that are less time consuming, harmless to both crops and agricultural fields, and also save energy and manpower in order to improve crop production. To enhance productivity, one way could be to identify and remove weeds in the field. Weeds compete with harvests for resources such as water, nutrients, and light, affecting crop yields. As a result, it is necessary to decrease weed spread in farms. Quack grass is the most widespread weed, but it might be observed in almost every agricultural field. The primary purpose of this project is to develop an autonomous solar-powered Mow-Bot that can detect and cut/mow weeds in farmlands. Apart from weed removal, the Mow-Bot also functions as a pesticide sprayer, allowing farmers to avoid inhaling the harmful chemicals sprayed during the process. To prevent wild animals and other humans from entering the field, the Mow-Bot is equipped with a security alert. Because the Mow-Bot is automated, it saves time and money while also being ecologically friendly because it runs on solar power.**

***Keywords*—*Agriculture, weed cutter, grass cutter, TensorFlow, Raspberry Pi, Ultrasonic sensors, Arduino, Security alarm, Solar energy, weed detection, grass detection, object detection*

I. Introduction

Weeds are any plants that aren't part of the main product in the field. Weeds grow in agricultural fields, lawns, gardens, and potholes in roads and sidewalks, among some other areas, where there is humidity, a suitable temperature, and wetness. Although not every weed has an impact on the crop, there are a few that does. Harmful in the sense that they have the potential to reduce agricultural productivity or possibly destroy the entire crop. The latter is dangerous because weeds grow at a faster pace than the primary crop, eventually decreasing its growth. This can be avoided by taking precautions at the beginning. The mechanical approach, which involves hand pulling, hand plucking, burning, and ploughing, to control weed production, is the four primary methods for weed control. There are a few plants that cause allergies, and other weeds have very deep roots. These practices are time-consuming and tiresome. Continuous cropping over the duration of one year is the other technique. The biological approach of weed control, which includes animal grazing, parasitic plants, nematodes, and other plants, is the third way of weed control. Animals should be avoided from eating some weeds, because a few of them may be harmful. The fourth way of weed management is the chemical method, which includes herbicides. Herbicides contain chemicals that kill weeds but are harmful to the crop raised. To avoid all of the problems identified, an automated system must be designed that efficiently handles all of the work. We present a Mow-Bot in this study, which is meant to complete the functions. The Mow-Bot is equipped with a Raspberry Pi camera that allows the system to see the field. TensorFlow is used to detect grass, and if grass is recognized, the system will demand that it must be trimmed. Neither chemicals nor humans are used in this method of removing the grass. The entire system is powered by solar energy, which eliminates the need for periodic recharging. By using a security alarm that produces loud noises that prevent other animals or wild animals from entering the land at night. Ultrasonic sensors are used to guide the Mow-Bot.

II. Background

A. Rationality behind choosing the project

The backbone of India's economy is agriculture. There is either a profit or a loss with every yield obtained. One of the major consequences of agribusiness is the control of weeds that develop among the estate crops. A prominent method for weed control is the harvest manor, which involves sprinkling herbicides throughout the estate. To counter these impacts, a multipurpose Mow-Bot is developed to trim weeds and spray plant pesticides while simultaneously serving as a security alarm at night. All of this is accomplished through the use of solar energy, which is both environmentally friendly and cost-effective. Agriculture is the primary source of livelihood for approximately 58 percent of India's population. Furthermore, they must deal with several problems. The spread of weeds is one of them. Weed may grow in any moist habitat, including farmland, lawns, and gardens. They lower the yield of the crop. Only a few farmers use herbicides, and most farms spend the majority of their time plucking them. Herbicides are highly toxic to humans and animals, and they also degrade soil fertility. Another major problem that farmers confront is that they must keep a watch on their fields at night since there is a high risk of wild animals entering the field and damaging their crops. As a result of this, many lives were lost. Spraying pesticide sprayers for the plant is another major problem that farmers face. Herbicides and insecticides are examples of pesticides. These pesticides contain highly hazardous chemicals such as endrin, aldrin, chlordane, DDT, and others. Food crops are essential for anyone's survival. As a result, it's necessary to develop modern methods to solve the challenges that farmers face.

III. LITERATURE SURVEY

A. *Guo-Shing Huang, Hsiung-Cheng Lin, Keng-Chih Lin, Shih-Hung Kao[1]*

The abovementioned authors conducted study on the topic of "Robotic Lawn Mower." The DMA-2450 platform for the ARM9 system was used to construct this auto-saving energy robotic lawn mower, which uses the posture sensor TCM2 and some ultrasonic sensors to solve navigation guidance approaches. The key to compass accuracy, navigation, and control is to use the compass to provide for the position of interfering with a modest magnetic field. This is an ultrasound-based microcomputer processor that can change direction automatically when it encounters barriers, allowing it to avoid obstructions. The energy-saving programme and the light circuit breaker will conserve energy and calculate to avoid a power outage.

B. *Muhammad Wasif [2]*

"Design and Implementation of Autonomous Lawnmower Robot Controller" was the subject of Muhammad Wasif's research. The controller here employs a sense-act strategy to operate in a dynamic, unstructured, and uncertain environment without relying on external data. The controller is built using the Motor Schema architecture, which employs continuous response encoding and a cooperative behavior coordinating mechanism. To accomplish the mowing tasks, a series of continuously running behaviors is defined. To identify and avoid obstacles, sonar ranging is employed. For local positioning, a combination of shaft and visual odometry is used, while the Global Positioning System (GPS) is used.

C. *Taj Mohammad Baloch and Timothy Thien[3]*

These researchers worked on a project called "Design and Modeling a Prototype of a Robotic Lawn Mower." This robot was designed to cover a particular amount of flat land while avoiding any obstacles. It was also thought to be quite inexpensive and simple to install using a PIC microcontroller or PLC controller. Rather than requiring tiny details to be stated, the task in this project was completed by examining the important design elements such that the installed system could autonomously complete its job in a manner that met its objectives. The sensors, microcontroller, and output drives interacted perfectly as expected, and they were able to complete the task.

D. *Sarmad Hameed Imran Amin[4]*

Hameed, Sarmad Imran Amin conducted research on "Detection of Weed and Wheat Using Image Processing" in order to detect weed in wheat crops and reduce weed development so that wheat growth can be increased. Using an unmanned aerial vehicle (UAV). Other than the edges, the area is barren ground, while the edges indicate the presence of crops in that area. Future Convolution Neural Network (CNN) research can be used to improve results, and better cameras can be used with other sensors.

E. *Muhammad Hameed Siddiqi, Irshad Ahmad, Suziah Bt Sulaiman[5]*

These researchers studied "Edge Link Detector Based Weed Classifier." To develop a real-time machine vision weed control system that can detect weed locations, classify images into broad and narrow classes for real-time selective herbicide application, develop a vision algorithm that can recognize the absence of weed and differentiate the presence of broadleaf weed and narrow leaf weed, and to develop a real-time sensor that can recognize the presence and type of weed.

F. *Jerosheja B R, Dr. Mythili C[6]*

They looked into a "Solar-Powered Automated Multi-Tasking Agricultural Robot." Design a multitasking vehicle for agriculture that can run automatically, increasing the speed and accuracy of work, controlling insect and weed attacks in the field, ensuring the use of environmentally acceptable energy sources, and avoiding frequent vehicle recharge. Four DC gear motors (12V) can be used to control the robot, which is controlled by a Raspberry Pi 3 Model B. An application is being built to control and monitor all of the actions involved in seeing the field's status, sensor data, and displaying live video from the field.

G. *Kumawat Mukesh M, Dipak Wadavane, Naik Ankit[7]*

These researchers created a "solar-powered sprayer for agricultural use." Sprayers are mechanical devices that are meant to quickly and easily spray liquids. They come in a variety of shapes and sizes. One of the better variations of the petrol engine pesticide sprayer pump is the solar-powered pesticide sprayer pump. Solar panel, motor pump, pesticide, nozzle, battery, and relay were among the components used. However, the battery management is not up to par; no use for a short period of time may harm the cells, and the extra energy collected should be used for other purposes rather than being stored in the battery.

H. *Zhu Haishui, Wang Dahu, Zhang Tong, Huang Keming[8]*

They created a "Design on a DC motor speed control." Designing and manufacturing a low-cost, high-efficiency DC motor controller for use with a powered golf bag. The controller accepts human input to control the motor's speed and drives it at that speed independent of load. Battery & Power Regulation, User Input, Controller, Buck Converter, DC Motor & Encoder are some of the components used. The switching components chosen were rated for the 50A demand that had been anticipated. The MOSFETs were driven at the bottom of their load range because they couldn't work in this region, thus they weren't as efficient as they could have been.

I. M. Jain, M. Sehgal, Y. Kalra, P. Jain, N. Aggarwal[9]

Object Detection and Gesture Control of a Four-Wheel Mobile Robot was created by the aforementioned writers. The creation of a four-wheel mobile robot with a gesture-controlled robot arm manipulator system is described in this work. The human hand is employed to manipulate the motion of its arm using an accelerometer and a Wi-Fi-based gesture control model. Arduino, Relay Motor Drivers, Camera, Wheels, PCB Casting, and Ultrasonic Sensors are among the components used. Even yet, the model has a technique for completely differentiating between objects. There should always be someone to supervise or guide (Lacks Autonomous control).

J. Bandi Narasimha Rao and Reddy Sudheer[10]

They created a "Surveillance Camera with IoT and Raspberry Pi." Using Raspberry Pi and IoT, this research proposed a security camera. The pi-cam camera will be used to capture the photographs. Because it only records video and captures photos when motion is detected in the monitored area, the suggested surveillance system uses less storage space. A PIR sensor can be used to detect movement. The suggested surveillance camera's implementation is straightforward, with the acquired data encrypted at the transmitter and decoded at the receiver. As a result, the suggested system allows for safe data transmission. It can be extended to determine the person's exact location. Because the suggested system only records video and captures photos when motion is detected, it saves a large amount of memory. It's solely used for live streaming, not recording. The video is not continuously recorded; instead, it is only recorded when the PIR Sensors are triggered.

IV. OBJECTIVES

- To defoliate the weed-grown weeds utilizing the Raspberry Pi microprocessor's image processing approach.
- To create a Pesti-Spray that includes a pesticide sprayer tank as well as a nozzle for spraying pesticide on plants.
- To detect animals using a Raspberry Pi camera and the TensorFlow object detection algorithm, and to ensure that if any animal is detected, an alarm sound is emitted.
- To save energy and create an environmentally friendly atmosphere by utilizing solar energy.

V. METHODOLOGY

A. Block diagram

The block diagram of Mow-Bot is as shown in Fig. 1. The block diagram consists of the following:

1) Microcontroller and Microprocessor: Microcontrollers and microprocessors are used to manage and control the flow of all processes in a problem-free manner.

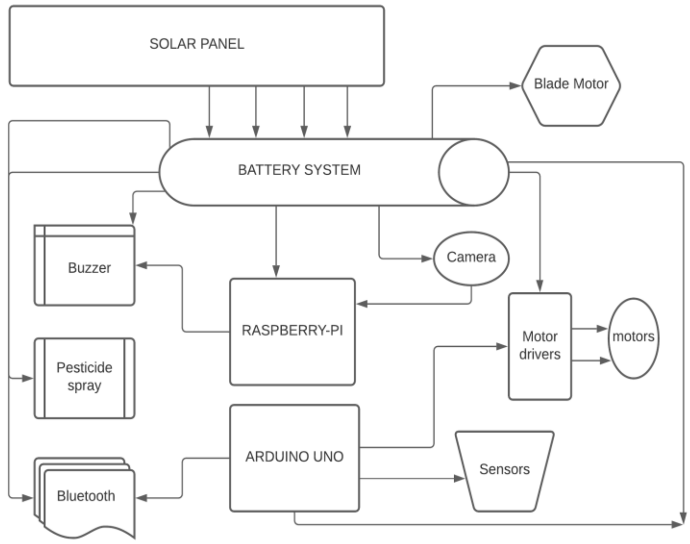

Fig. 1. Block Diagram

The Arduino Uno R3 is the microcontroller used in Mow-Bot. The main reason for using Arduino UNO is that it provides a simple communication line with a solid SPI interface for Raspberry Pi. Arduino is also a low-power device. There are a total of 20 pins to setup, with both digital and analogue connections for communication. Mow-Bot requires Arduino above other controllers since it can communicate with motor drivers and other components without the use of the internet. It works with a simple code to control the pump and trimmer motors. It gets information about Object Detected from the Raspberry Pi. It also has great Bluetooth data transmission and reception It can easily start the Mow-Bot using a Bluetooth terminal and a simple command. Arduino may be used to control basic motion because the Atmel AVR family relies on RISC commands.

The Raspberry Pi microprocessor is utilized in Mow-Bot. The Raspberry Pi is required in Mow-Bot in order to provide a camera interface for object identification, noise generator, and Arduino control. The Raspberry Pi uses less power and can be operated remotely via VNC viewer using an IP address, eliminating the requirement for a display interface. With only 20 pins, it's possible to drive as many sensors and devices as you like using a breadboard or direct connection. This is the brain of Mow-Bot, an SBC (single-board computer) that governs all functions and controls the Arduino for Mow-motion Bot's and safety. The following are some of the Raspberry Pi's distinguishing characteristics. The Master in - Slave out serial communications, as well as MOSI. The 40-pin processor with a plethora of low-cost connections. Power usage is low. An attractive user interface and an operating system that supports a wide range of programming environments. The Raspberry Pi is used for Object Detection, mostly to detect quack grass/weed so that useful crops may be distinguished from unproductive weeds. It also helps with many communications between the user and the Mow-Bot by controlling and guiding Arduino for correct Mow-Bot movement. Mow-Bot is implemented in

Python and relies on Tensor Flow for detection and serial communication with the camera.

2) Camera Modules: The Mow-Bot employs two camera[11] modules, one for object detection and the other for security via the live display. The Quantum QHM495LM 6 Light Webcam and the ESP32 CAM are the two. Raspberry Pi uses the Quantum QHM495LM 6 Light Webcam for object detection. For efficient recognition, the camera interpolates images up to 25 megapixels, providing a good depiction of all boundaries and pixels. The ESP32 CAM module is used to broadcast live video collected with the help of a mobile hotspot to an IP address preset. The ESP Cam is a low-cost IP address video telecasting Wifi enabled module that is very similar to Arduino coded in the Arduino IDE and may be quickly implemented.

3) Power Supply: The Mow-Bot is powered by an adaptor or even a battery. The solar panel provides constant power to the battery[12]. The battery in Mow-Bot is roughly 12 Volts, which is enough to run it for up to 18-20 minutes at most. The solar panel utilised is a 15-watt panel that can charge the battery in bright sunlight. The Mow-Bot power load divider accepts an adapter or battery as input and divides the supply into 12 V, 5V, 3V, and even ground. When using a battery, the positive terminal of the battery is linked to the supply terminal's 12 V. Except for the motor driver and the relay, which use 12V, all of the modules run on 5V.

4) Sensor Modules: In Mow-Bot, two sensors are used. Ultrasonic Sensor (HCSR-04) and Temperature and Humidity Sensor are the two sensors (DHT11). The ultrasonic sensor is mounted on Mow-front, Bot's facing forward. It is in charge of identifying any obstacles, such as large plants, animals, rocks, or anything else that could injure Mow-Bot and directing it away. The ultrasonic sensor operates similarly to a radar system. It sends a trigger signal to the sensor, which emits an acoustic wave that bounces back if it hits an obstruction. Meanwhile, the ultrasonic sensor runs a clock cycle to determine the time it takes for the wave to reflect and be sensed by the echo pin. The DHT11 sensor is used in Mow-Bot to monitor the temperature and humidity of the lawn/field[13], which is then relayed through Bluetooth to the user's phone. The humidity sensing component, which consists of two electrodes separated by a moisture-holding substrate, is used to measure humidity. When a result, the conductivity of the substrate or the resistance between these electrodes changes as the humidity changes. The IC measures and processes the change in resistance, preparing it for reading by a microcontroller. These sensors, on the other hand, use an NTC temperature sensor or a thermistor to measure temperature.

5) Bluetooth Module (HC-05): The The Mow-Bot communicates wirelessly with the help of the HC-05 module, which may be configured as a master or slave. Through serial communication, the Bluetooth both broadcasts and receives orders and data. Bluetooth sends data from dht11 and ultrasonic sensors, and Arduino and the user's phone receive movement commands such as forward, backward, right, and left.

6) Motor System: Motor Drivers and Motors make up the Motor System. The L293D motor driver is utilised in Mow-Bot to interpret the data/signals received from Arduino and Raspberry Pi and rotate the motors and turn the wheels accordingly. The low voltage and power of microprocessors and microcontrollers are insufficient to run motors constantly, necessitating the use of motor drivers. The L293D is a 16-pin IC with eight pins dedicated to operating a motor on each side. Each motor has two INPUT pins, two OUTPUT pins, and one ENABLE pin. The L293D is made up of two H-bridges. The H-bridge is the most basic circuit for controlling a motor with a low current rating. The motors rotate in response to the input to the motor drivers. The motor driver's H-Bridge regulates the direction of the motors and, as a result, the wheels. Mow-Bot is powered by three motors, two of which are 9V and one of which is 5V. Mow-movement Bot's is aided by the two 9V motors. The grass is trimmed with the help of a blade in the middle of the front end, which is powered by a single 5V motor.

7) Hardware: Mow-hardware Bot's consists of a few wheels, an open plate chassis, a wooden board, a few connecting cables, and a plastic fan blade for showing the notion of weed/grass trimming[14]. The Mow-Bot also has a buzzer that sounds when it is turned on. All of the following components, as well as jumper wires from female to male and male to male, are used.

B. Technology used

1) Computer vision: Computer vision is a discipline of computer science or artificial intelligence (AI) capable of reconstructing, interpreting, and even analyzing a 3D scene taken in 2D format. In layman's terms, it's a system that mimics a human's vision and knowledge of the environment, which means creating a system that can perform Image Processing, Pattern Recognition, and Photogrammetry.

2) Open Source Computer Vision Library (OpenCV): This is a cross-platform library that allows developers to build real-time computer vision applications. It focuses mainly on image processing[15], video capture, and analysis, which includes features such as face and object detection. OpenCV is a free software library for computational methods. OpenCV is built to have a centralized database for computer vision tasks and to implement machine perception more efficiently. As OpenCV is a BSD-licensed product, it is simpler for firms to use and improve the technology.

3) You Only Look Once (YOLO):): When compared to the R-CNN family, it is one of the fastest realtime object identification algorithms (45 frames per second) (R-CNN, Fast R-CNN, Faster R-CNN and others). The Yolo algorithm is currently one of the quickest algorithms. It would be really useful in quickly evaluating the images produced by our camera.

4) TensorFlow: TensorFlow is an open-source machine learning software package. It is a tool that must be used in order to detect any type of object. TensorFlow includes models that have been pre-trained as well as models that can be fine-tuned. The ssd_mobilenet_v1_coco model was chosen for the project after a thorough examination of various models, their accuracy, and speed. It has a COCO mAP of 21 and a speed of 30ms. The comparison of these values in different models is shown in TABLE I.

C. Software analysis

The Arduino is programmed in C language to control the Mow-Bot. To begin, initialize all of the libraries and then set a few test conditions to ensure that the various components are functioning properly. Then, after initializing the motor and sensor pins and taking inputs from them, as well as the Bluetooth module for receiving commands and relaying data to Bluetooth, you'll be ready to go. The code then exits the loop after specifying the H-bridge switches for motor rotation and the trimmer delays. The ESP32 CAM is programmed in the Arduino IDE in a similar way, by supplying the mobile hotspot's name and password so that it may get an IP address. When the Raspberry Pi is turned on, it emits a buzzing sound, and the terminal window is utilized for object detection, which first unzips the necessary test and data folders for object detection before allowing the camera interface with the Raspberry Pi. Then, after unzipping the test folders and the 13 COCO data set, executing the algorithm and providing a camera terminal with the object detection.

VI. OUTCOME OF PROPOSED RESEARCH

The finalized Mow-Bot model is shown in Figure 2. The Mow-Bot works well with Raspberry Pi and Arduino, as well as all of the other specs listed above. Through our Mow-Bot Bluetooth application, where it sends data from all the sensors and supplies, the Mow-Bot keeps track of all the activities and reports. The Pesticide spray, on the other hand, is powered by a different source because it consumes the majority of the electricity and may cause the Mow-Bot to short circuit. Mow-Bot can work successfully with an active supply, but it can also work for around 40 minutes on a 12 Volt battery.

TABLE I. COMPARISON OF MODELS

Model name	Speed (ms)	COCO mAP	Outputs
faster_rcnn_nas	1833	43	Boxes
faster_rcnn_resnet50_coco	89	30	Boxes
faster_rcnn_inception_v2_coco	58	28	Boxes
ssd_mobilenet_v2_coco	31	22	Boxes
ssd_mobilenet_v1_coco	30	21	Boxes

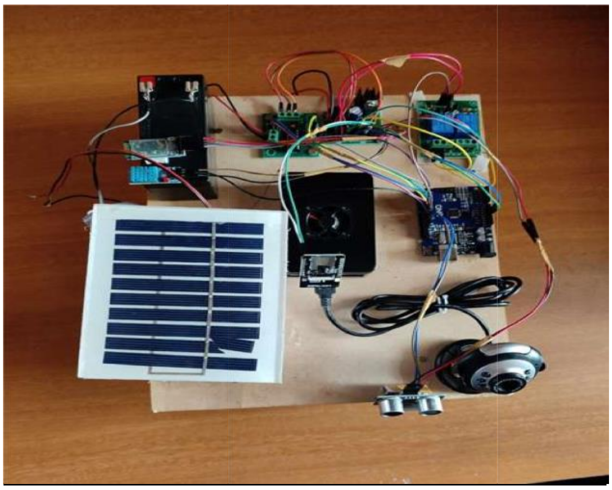

Fig. 2. Mow-Bot Model

As soon as Mow-Bot is turned on, the live display using the ESP-32 CAM continues to monitor the field. The results of grass detection are shown in Figure 3. Grass detection model is used to detect grass and cut or mow it effectively. It uses the farm view as input and detects grass if any is there.

The dataset was derived from the DandelionImages dataset on the Kaggle website, as well as a few photos found on the internet. The total number of photographs in the dataset chosen for this project is 300. Out of them, 240 photographs were chosen as train data (representing 80% of the dataset) and 60 images were chosen as test data (representing 20% of the dataset) (20 percent of the dataset). Because it is faster and lighter, the TensorFlow pre-trained model ssd mobilenet v1 coco is utilized for grass detection. On Google Colab, the model was trained using a graphics processing unit (GPU). The initial step of training resulted in a loss of 10.6280. The model was trained until it had a loss rate of 0.8260.

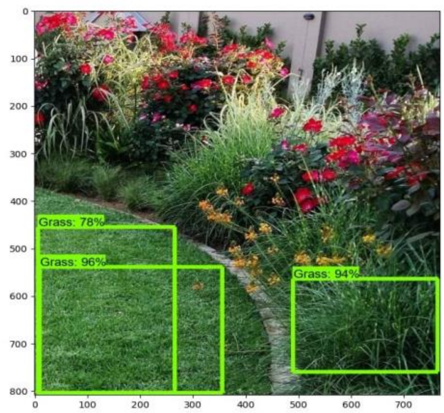

Fig. 3. Results obtained from grass detection model

VII. Drawbacks and Future Scope

In comparison to polycrystalline solar panels, the solar panel utilized here is less efficient and produces less power. In order to run Mow-Bot at full speed, the battery system employed here requires more time to charge fully. Adding several classes to detect different types of grass, as well as using an advanced camera and battery management system, could be used to improve the model.

VIII. Summary

The presentation of our concept culminates in the creation of an autonomous system (Mow-Bot) that can detect and defoliate all unwanted weeds that are threatening the health of the vital plants. The team's goal is to create a system that is low-cost and makes efficient use of open-source resources at no additional cost. When implemented in a large number of farms, the project can limit the growth of weeds and grass, hence enhancing the nation's food crop production. People dying of hunger is one of the world's greatest issues. Only when there is enough food for us can we be free of hunger. And this is only achievable with effective crop growth, which can be achieved indirectly with Mow-Bot.

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