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WPC-1.0: The Weed Plant Cutter

Jeetkumar Gupta[1], Aman Gurudev[2], Ritik Koul[3], Akash Desai[4], Manisha Bharati[5]
[1,2,3,4]*Student, Dept. of Computer Engineering, Indira College of Engineering and Management, Pune, India*
[5]*Assistant Professor, Dept. of Computer Engg., Indira College of Engineering and Management, Pune, India*

***Abstract*: In agricultural field there are different tasks like sowing, ploughing, weeding, harvesting, etc. Weeding is a tedious and frustrating process so we can make the use of robotics to resolve the issues related to weeding. In this study, we developed a system which can work autonomously using computer generated code and algorithms along with sensors which are integrated in it. The mobile robot will wander in the farm or garden and prevent weeds from growing further. Using unique design elements and a variety of sensors, the mobile robot patrols the garden daily, avoiding useful plants and obstacles while looking for weeds to eliminate. With the use of this mobile robot we can eliminate the use of harmful pesticides which can harm the crops.**

***Keywords*: Agriculture, Weeding, Mobile Robot, Sensors, Plants, Obstacles, Artificial Intelligence, Internet of Things.**

1. Introduction

In the recent past, robotics engineering has taken major attention in robotics research due to its efficiency and accuracy in assisting humans in different jobs at homes, hotels, restaurants, offices, hospitals, universities, warehouses and workshops, etc. Basically, mobile robots are distinguished on their different ability to perform various operations very well like gardening, floor mopping, dry vacuum cleaning etc. Some products are based on simple mechanism that blocks or stops avoidance using infrared sensors while some use laser mapping techniques. Each mechanism of robotic operation has its own advantages and disadvantages. For example, mobile robots using laser mapping technique are faster, time and energy efficient but expensive as compared to the robots that use simple obstacle avoidance techniques. The non-availability of these mobile robots at a greater extent forces an individual or a group to import them from different countries which ultimately increases the in-hand device cost. The primary objective of this work is to provide and understand a cost effective solution to the problem of high-end expensive mobile robots and inculcate a sense of developing these mobile robots in the local market while keeping the cost low. The important subject of this work is to understand and develop an autonomous mobile robot for exterminating the unwanted plants in a farm or a garden using the technologies such as Artificial Intelligence, Robotics and Internet of Things. A mobile robot is a robotic device that is capable of moving from one place to another in a specified area. Mobile robots have the ability to move around in their surrounding conditions and are not fixed to one physical location. Mobile robots can be "self-ruling" which means that they are capable of travelling safely through an uncontrolled environment without any physical or electro-mechanical guidance devices. The parts of a mobile robot are sensors, controller, control software, and mechanical pushing-pulling devices. The controller is generally a micro-processor, embedded micro-controller or a personal computer. The sensors used are dependent upon the requirements and the purpose of the mobile robot. The requirements could be navigation based on previous position, speed and direction, touch-related and closeness sensing, triangulation ranging, crash avoidance and other particular applications. Mobile robots are classified as :

- Unmanned Ground Vehicles (UGV) which are most commonly legged robots with two or more legs, also wheeled or tracked robots.
- Transportation and Delivery robots which move goods from one place to another in a factory or an industry.
- Drones or Aerial robots which are referred to as Unmanned Aerial Vehicles (UAV).
- Autonomous Underwater Vehicles (AUV) which are underwater mobile robots.

A. Objectives of weed plant cutter

- To eliminate the need of pesticides and herbicides.
- To exterminate the unwanted plants in the garden or a farm.
- The manual work is eliminated and continuous monitoring is not needed.
- Consumption of electricity is reduced by making use of solar energy.
- Capable of working in all weather conditions.

2. Review of literature

There are different types of weeding methods and tools that can be used for removing the unwanted plants. Weeds are removed using chemical, physical or mechanical methods, the chemical method includes use of herbicides and the physical methods are manual removal, tillage or ploughing, etc. The mechanical method used for weeding are weed pulling, mowing, mulching, etc. These methods are better than physical or chemical methods as they are more efficient and they do not harm the crops. The Table 1, shows a survey and study of different proposed weeding techniques and systems.

Table 1
Literature review

S. No.	Paper Name & Year	Advantages	Limitations	Technology/Algorithms
1.	Fully Convolutional Networks with Sequential Information for Robust Crop and Weed Detection in Precision Farming. (IEEE 2018)	1. Reducing the use of agrochemicals. 2. Targeted weed control	Inflexibility of handcrafted vision pipelines.	1. Deep Learning 2. Robotics 3. Convolutional Neural Networks(CNN)
2.	Efficacy of Mechanical Weeding Tools: A Study Into Alternative Weed Management Strategies Enabled by Robotics. (IEEE 2018)	1. Detection and classification of weeds. 2. Replacing large scale machinery.	Mechanical Weeding tools cannot be used for all types of crops.	1. Kaplan-Meier estimates 2. Greenwood's formula 3. ANOVA analysis
3.	IoT based Solar Powered Agribot for Irrigation and Farm Monitoring. (IEEE 2018)	1. Agriculture task automation and precision farming. 2. Harvests solar power while performing other tasks.	Data processing and signal processing operations are in time domain and implementation requires better processing hardware.	1. Internet of Things(IoT) 2. Wireless Fidelity (Wi-Fi) 3. Data Analytics 4. Gaussian Filtering 5. Weiner Filtering
4.	weedNet: Dense Semantic Weed Classification Using Multispectral Images and MAV for Smart Farming.(IEEE 2018)	1. Robotic systems uses flexible and cost-effective platforms. 2. Accurate datasets generated gives better classification.	Manually annotating each image would be a labor intensive task, therefore, construction of large dataset is required.	1. Convolutional Neural Network(CNN) 2. Robotics
5.	Solar Powered Weed Cutting Robot. (IRJET 2017)	1. Less energy consumption by making use of solar power. 2. Electric grass cutting machines are easy to use in gardens.	Weight of the robot can be reduced using light weight material and high quality blade cutter can make it applicable in agricultural sector.	1. Solar Panels 2. Photovoltaic principle 3. Controller 4. DC motors
6.	Self-Supervised Weed Detection in Vegetable Crops Using Ground Based Hyperspectral Imaging. (IEEE 2016)	1. Spectral vegetation signatures to discriminate crops and weeds. 2. Focus is on site specific weed management.	Classification performance of crops and weeds is average because real-time performance and online loop closure is not included.	1. Hyperspectral Imaging (HSI) 2. k-Nearest Neighbor (kNN) 3. Dataset generation algorithm

3. Proposed system

The mobile robot will navigate in the farm or garden and prevent weeds from growing. Using unique design elements and a variety of sensors, the mobile robot patrols the farm or garden daily, avoiding useful plants and obstacles while looking for weeds to eliminate.

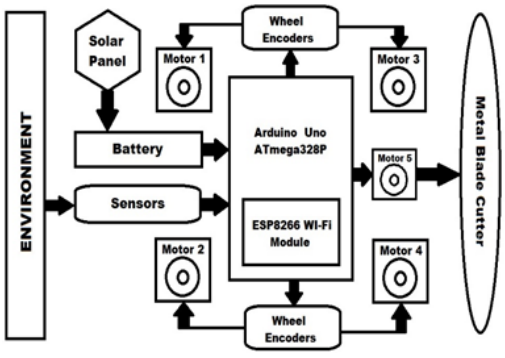

Fig. 1. System architecture for Device Module

The mobile robot has a very simple method of weed selection: weeds are short, plants are tall. A plant tall enough to touch the front of the robot's shell which activates a sensor that makes the robot turn away. A plant short enough to pass under the bot's shell, though, activates a particular sensor that turns on the weed cutter. Because the mobile robot's approach is height-based, we have to put one of the provided plant collars around short plants until they are tall enough for the mobile robot to recognize them. When it approaches the collar, it will recognize attached collar and turn away in another direction. The mobile robot whacks weeds using a spinning metal blade, which cuts the weed off near the ground. Because the mobile robot lives in your garden and goes looking for weeds every day, weeds are always small when the robot finds them. A whacked weed may sprout again, but sprouting takes energy stored in the seed or root. By coming back every day, the bot never lets a weed develop the leaves it needs to replenish this energy, so eventually the weed gives up from its root and never sprouts again.

4. System requirements

System requirements include software used and hardware integrated. System requirements are divided into software requirements and hardware requirements which are as follows:

A. Software requirements

1) EMSS framework

The EMSS (Environment Mapping Self Sustainable) iRobot Create framework is a collection of interacting modules written in C++ designed to support iRobot Create developers with a comprehensive set of controllers, Tasks, Schedulers, Movement Trackers, etc.. The framework provides not only an interface with the iRobot Create hardware, but also a completely emulated interface which mimics the hardware in

every sense. Along with core components for controlling the robot, the framework also features a set of GUI widgets for drawing maps and navigational paths as well as joysticks, control panels and more. The EMSS framework compiles on Linux, OS X, and Windows.

2) Android studio 3.0:

Android Studio is an Integrated Development Environment for developing Android applications. The project includes an Android application to view the statistical reports and images captured by the mobile robot after the day's work. Android application will be connected to the mobile robot by the Wi-Fi mechanism, so the user can observe the working of the robot remotely through the application.

3) Create.exe

Create.exe is a stand-alone application used to control an iRobot® Create via a Serial or TCP/IP connection. This application will connect directly to the Create Serial Port via a COM Port or TCP/IP. It will poll and display sensor data, and allow you send individual commands or send entire scripts to control the Create. If you don't have a microcontroller on the Create and simply have a Bluetooth or other wireless serial connection, then this application will allow you to play with your robot right away. It also has a map that will use the distance and angle sensor data to display where you are and have been on a 2D grid.

B. Hardware requirements

- *Tires:* All terrain M2 2.2/3.0 Mounted Course Tires are required which will enable the robot to move in any type of land surface easily.
- *Battery and Solar Panel:* To provide electric power to the robot we require a Kinexsis F-Tek 4000mAH 6s 22.2v LiPo battery, and we require a 18-20 watt solar panel.
- *Motors:* To provide power to the wheels we require a Turnigy TrackStar SCT sensored brushless motor.
- *Frame:* We require a DIY 4WD chassis kit with speed encoder to develop the main frame of the robot.
- *Sensors:* We require sensors like InfraRed sensor, Proximity Sensor, Magnetometer, Cliff Sensor, GPS chip, Camera.
- *Circuit Board/Processor:* Arduino Uno Rev3 with ATmega328P processor and a ESP8266 Wi-Fi module connected to it.

5. System implementation

The work of this paper is a part of project management which relates to the use of schedules such as Gantt charts to plan and subsequently monitor report progress within the project environment. A descriptive Gantt chart is presented in the Fig. 2 below to display various targets achieved in the mean time of 4 months. The Gantt chart shows the project planning right from the beginning when the topic was finalized till the designing and implementation part is completed. Functional requirements are considered as requirements which are related to the technical functionality of the system whereas Non-Functional requirements are considered as requirement that specifies criteria that can be used to monitor the mechanism of a system in particular scenarios, rather than specific behaviors.

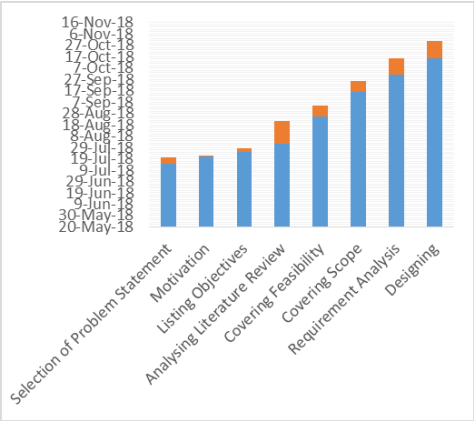

Fig. 1. Gantt chart

A. Functional requirements

User Module

- The mobile robot generates a day to day report of its daily operations or task which it performs.
- The user needs to interact robot with the help of an android application.
- The statistics and analysis report will be generated on the application.

Device Module

- This module will help the mobile robot to perform the task of weeding.
- The robot will detect the unwanted plants and it will eliminate the same after detection.
- The day to day report will send by the robot to user through android application.

B. Non-functional requirements

Performance:

- Making the product user friendly is very crucial task as it is to be used by the users. Users should be able to use the android app and the device easily.
- System should have the ability to exchange information and communicate with internal and external applications and systems and must be able exchange information both internally and externally.
- System should be reliable to do the specified task and deliver the necessary service.
- The system should have the ability to perform and deliver specified service whenever required.

Safety:

- The device should be considered for maintenance at least once a week to protect internal module from dust and water, otherwise it may malfunction.

- As the mobile robot consists of a metal blade, it is advised to cover the blade with a plastic cap after use.

Security:

- The android application will have a Login Module to authenticate and authorize the owner of the mobile robot.
- The mobile robot will have strong connectivity through Wi-Fi mechanism to Wi-Fi adapter so that the User can have the surety of proper working of the robot.
- The garden or farm should be well-fenced to prevent the mobile robot from stealing cases.

6. Advantages

- By patiently and continuously chopping the weed plants when they are small, the mobile robot will remove it from its root destroying it permanently.
- As the mobile robot is autonomous, there is no need of continuous monitoring of a human for the device.
- All the resources such as water, sunlight, fertilizers will be completely utilized by the actual plant, as the unwanted weed plants are exterminated.
- The user can receive the updates and images from the mobile robot of its day-to-day work through an android application.
- The consumption of electricity will be efficient as the mobile robot will make use of solar power through the solar panels mounted on the device.
- Instead of plucking the weed plant, the mobile robot will finely slice it from its stem leaving the leftovers on the ground which will slowly degrade and can act as a manure for the crop itself.

7. Limitations

- The small plants which we want to keep in the garden needs to be protected so that the bot may not slice them away.
- If due to some reasons or circumstances the bot gets rolled over then it cannot get back to its original position by itself.
- After the day's work the user needs to invest some minimum amount of time to perform the maintenance of the robot.
- As the mobile robot is a wheeled robot, the garden or farm surface should be plain.

8. Applications

- Households can use the robot to regularly exterminate the grass in their lawns or their private gardens.
- The mobile robot can also perform regular checking on the garden instead of cutting grass.
- In farms, the mobile robot can send the images of its nearby locations identifying the dangerous insects or reptiles, warning the user to not go in that part of the farm.

9. Future work

There are two different robotic devices for weed cutting and floor cleaning purposes respectively. But the proposed system can be extended to be integrated with a floor cleaning module along with weed cutting module thereby increasing the features and performance of the mobile robot. Thus, the mobile robot can perform in indoor as well as outdoor environments.

10. Conclusion

This paper presented the WPC-1.0 the Weed Plant Cutter

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