Autonomous Navigation and Environment Mapping for Robot Weed Detection

Jisha George   
School of Computer Science  
University of LincolnLincoln, United Knigdom  
13488071@students.lincoln.ac.uk

*Abstract*—

Keywords— Autonomous Robot, Mapping, Navigation, ROS, Weed Detection

# Introduction

Weeding is a laborious job particularly for humans. Identifying weeds from the plants can be a difficult task, especially when the weeds and the plants have similarly shaped leaves, and/or colour. Once the weeds have been identified the person would have to manually spray the weed with herbicide or carefully remove the weed from the ground, both of which can be very time consuming and not at all profitable for the farmer [1]. By introducing robots to do both the weed identification process as well as spraying herbicides, a lot of time can be saved and the overall cost would be cheaper for framers.

The aim of the project was to create a system that could autonomously navigate a robot through a dynamic farming environment, while detecting weeds that were growing between the rows of crops and spraying the weeds with herbicide.

The objectives of the project were as follows:

1. To effectively detect weeds in the ground using image processing.
2. To make the robot autonomously navigate through the environment.
3. To implement an object avoidance system to ensure the robot does not collide into other objects in the field.

# Related Works

## Image Processing

Weeds are plants that are considered to be undesirable [2]. Depending on the type of weed and the crops that are growing, the image processing system needed to distinguish weed from crop can vary. If the weed has a different colour to the crops being grown then a simple filtering process would be enough to distinguish the crop from the weed, as the saturation, hue or intensity of the crop would differ to the weed.

# Methodology

## Image Processing

To achieve the first objective of having a weed detecting system, a simple image processing pipeline was implemented. When implementing the system, a weed was considered to be any plant in the row that was not the desired crop. The image processing portion of the system was implemented first, as this was the core aspect of the robot, since the robot would have to detect weeds before it can spray the weeds with herbicide.

In the gazebo environment there were three types of crops being grown (basil, cabbage and onion), each with different types of weeds growing between the plants. In the basil patch, the colour of the basil was distinctively brighter than the weeds that were growing in the rows. In the cabbage row, the colour of the weed and the colour of the cabbage different have enough variation to distinguish between the two, however the sizes of the two plants differed, as cabbages in the row were a lot bigger than the weeds that were growing around it. Finally, in the onion row, there were two distinctive regions, one region had little to no weeds in the row. However, the second region was covered in weeds, making them almost indistinguishable from the onion crops. The methodology will only tackle the how the weed detection was done for the cabbage and basil.

To combat weeds which have a distinct colour to the desired plants, an inter plant weed detection method was implemented. This method of detection can identify weeds that grow between the plants [2]. The method was implemented by extracting the image from the camera attached to the robot, filtering out the hue of the basil and the ground from the image, leaving only the weeds. Once an image with only weeds was obtained, the image was filled to remove any holes that may have appeared during the filtering, afterwards the image was eroded with a kernel size of 1 by 1 to remove small pixels that could have been identified as a weed by the system. Fig OOO shows the final result of the basil mask

For times when a simple colour filtering process is not enough to isolate the weeds from the crops, other morphological methods of image processing has to be used. Once again the image is extracted from the camera, but this time the image is converted into a binary image, and filled to remove holes. Afterwards, the binary image was eroded with a kernel size of 25 by 25, this was done to remove all the weeds in the image leaving only the cabbages in the image. Once the eroding process was finished, the image was reconstructed using the original image and the new mask, the reconstruction process builds a new image by putting the original image under the eroded mask. The final output was achieved by removing the reconstructed image from the cabbage only mask leaving a mask with only weeds. This was an inter row method of weed detection [2] as weeds that were growing between the plants were classed as crops or ignored. Fig OOO shows the final result of the cabbage mask

Once the masks for both the basil and the cabbage crops were created, the sum of both the masks were checked to see which one was greater, this was done because the cabbage mask recognized the basil crops as weeds due to the size of basil being smaller than the size of cabbage. A similar problem occurred with the basil mask identifying cabbage as a weed, this was because the basil mask was done on colour filtering and the colour of the cabbage and the colour of the weeds did not have a noticeable change. The mask with the smaller sum was passed into a function which would align the robot to spray the weed.

## Navigation

To achieve the second and third objectives of having the robot autonomously navigate through the environment while avoiding obstacles the package MOVE\_BASE was implemented. Move\_base has a built-in marking and clearing system that was used as a mapping system for the robot so that it would create a costmap of the environment surround the robot. The move\_base package sends move commands to the robot to move safely in the environment while avoiding obstacles in the environment both stationary and moving [3].

A launch file was used to run the move\_base package, the launch file runs move\_base by getting its configurations from four specified YAML files which states the parameters needed for move\_base such as the robot’s footprint, what sensors should be used for marking, tolerances for movement etc. The YAML files used for the move\_base package are the costmap\_common\_params, the global\_costmap\_params, the local\_costmap\_params and the planner. These four files are used for the path planning and autonomous navigation of the robot [3].

Some aspects of the environment were not being detected by the move\_base marking system or the gmapping system that was used to create a map of the environment while the robot was moving. The reason why gmapping did not work was because of the height of the laser sensor. The position of the laser sensor can cause many problems when it comes to mapping and navigation, on the Thorvald robot the laser scan was the same height as the base of the robot, this meant that any objects that were lower or higher than the base of the Thorvald robot were undetected by the robot, which could lead to the robot colliding with undetected objects. The issue was countered by using a package called VELODYNE\_LASERSCAN, which worked by extracting a ring of velodyne points from the robot and converting pointcloud data into laserscan data. The velodyne laserscan then had to be filtered so that it would only detect objects that were smaller than average distance from the chosen velodyne ring, otherwise the velodyne will detect the floor as an obstacle as seen in Fig OOOO

## Spraying

The second part of the first objective was to have the robot spray herbicide directly onto the weeds. The spraying function would only activate when the sum mask was greater than a specified threshold value. If that was the case then the system would take a snapshot of the mask is taken, if there is nothing in front of the robot that is less 1 meter then the robot will move forward one meter, which is the distance of the sprayer from the camera, once the robot assumes the sprayer is aligned with the weed it will spray the weed and move backwards to the previous position and align itself to the row.

# Evaluation

##### References

1. T. E. Madsen, and H. L. Jakobsen, “Mobile robot for weeding,” MSc. Thesis, Dept. Control and Eng. design, Tech. Uni. Denmark, Denmark, 2001.
2. M. Latha, A. Poojith, B. A. Reddy and G.V. Kumar, “Image processing in agriculture,” Int. Jnl. of innovative Res. in Elect., electronics, instrumentation and control Eng., vol. 2, no. 6, 2014
3. S. Zaman, W. Slany, and G. Steinbauer, “ROS-based mapping, localization and autonomous navigation using a Pioneer 3-DX robot and their relevant issues,” Saudi Int. Electronics, Communications and Photonics Conf. (SIECPC), pp. 1-5, April. 2011.