Abstract

Currently, farming robots have become increasingly for households. The combination of modern technology and agriculture that is automatic system design, it is extremely accurate but also cost less than hiring human labor to work. All processes of the farming robot must be organic. The development of Cartesian Coordinate Robot (CCR) can operate in the multi-function such as tillage, applying fertilizer, sowing, and watering plants. In this research, which focuses on image processing to detect the plants and eliminate the weeds. The OpenCV library was used to detect the color green from the plant leaves, and from that, the program will do the rest. The elimination part of the system was constructed based on a brand-new idea. From all the experiments done, the conclusion looked promising, the blades were able to function at 80 percent efficiency.

Keywords: Smart farm, Cartesian robot, Weed detection.

1. Introduction

Supply and demand are the factors of an economic model that involves having enough supplies to meet the demands. Food is mainly grown in the agriculture industry. Agriculture utilizes the farming of land to produce crops, that will eventually become food for consumption. Fig. 1 shows a graph that breaks down all the usage of the entire land mass on this Earth. The figure shows that a huge portion of land is unusable due to its terrain. The land is made up of only 30% of the Earth’s surface. That means that land is a limited resource on the Earth. To increase the area for growing crops, the world will have to sacrifice other portions of land. That is what makes the land a limited resource and therefore limited supply. The largest portion of demand for crops come from humans. Humans are the biggest consumers of food on Earth. Fig.2 represents the projected population growth as well as the population today and in the past. Assuming the graph is correct, the projected increase in the human population will cause more demands for the limited supply [1]. Currently, the robotics and automation systems are the most important and growing technology that can increase productivity in business and
reduce the working time of the workforce. It is fascinating if the researchers or inventors can apply their knowledge of robotics and automation technology to develop with together the agriculture industries. Therefore, that is the reasons, why the robots are imported to the agriculture industry is supply and demand. There are many researchers who proposed the new technologies combined with the agriculture industry, such as Wolfert et al. who propose the cyber-physical management cycle of the Smart Farming enhanced by cloud-based event and data management [2]. In the meanwhile, some researchers attempt to apply the image processing technic for recognizing different between weeds and crops for controlling weeds [3] – [5].

Recently, FarmBot [6] is designed to use in Smart Farming. The system is able to move in three axes; X, Y, and Z. This robot is done with a similar technology that has been a 3D printer and CNC milling machine and Fig.3 that shows FarmBot mechanic diagram. The main goal of FarmBot system is created to become a completely automated system from adding the seed in the soil, water the plant, detection the weeds and elimination them.

This research, which is divided into two parts. The first part is the hardware of the cartesian farming robot that is created similar to the FarmBot but, the tool head is redesigned for ease of use in farming. The second part is the software for controlling the cartesian farming robot. The robot can operate in the multi-function such as tillage, applying fertilizer, sowing, and watering plants. Moreover, the image processing is developed to detect the plants and eliminate the weeds. Our paper is organized as follows: the structure of the cartesian farming robot is explained in Chapter 2. In Chapter 3, the results are shown how the robot can operate and move to the target point accurately, and also the weed detection and elimination are verified. In the final section, we conclude the paper and describe our future works.

2. Structure of Cartesian Farming Robot

The main components of the hardware of cartesian farming robot are the motors, aluminum profiles, tool head, wheels, plastic containers, web camera, and control box. Fig. 4 shows how all components were assembled. The motors were a very important part because the mechanical parts are the ones receiving the heaviest load and control all the moving parts. There is a total of four motors that are used in this prototype. A rubber drive belts are used to line the track in the middle of the aluminum profile because rubber has high friction, and with the added gear like features of the drive belt, it makes it easier for the motor to turn the belt. The motors (X-axis and Y-Axis) are attached to a wheel and when that wheel is turned, it will not turn the belt, making only
the mechanism to move along the axis of the aluminum profile. The container is used to put soil in grew some plants. The material for the container is plastic because it is light yet very strong. The multi-tools head of the robot has the seed injector, watering nozzle, soil sensor and Weeder which were designed in the compact tool head. The web-camera was used to detect the plants and weeds and all weeds will be eliminated by using Weeder.

3. Verification of the Cartesian Farming Robot

The proposed paper that presents the cartesian farming robot, which is designed and created to crop the plants and control the weeds automatically.

3.1. Verification I

- Accuracy and Repeatability testing

![Fig.5 The results of robot movement in X-axis and Y-axis](image)

As for the experimental method of accuracy and repeatability testing, the tool head is modified to attach the permanent pen. The robot is controlled to draw the point on the test plate (repeating 100 times for 1 target position). Fig.5 shows the results of the accuracy and repeatability testing that can confirm the effectiveness of the robot movement.

3.2. Verification II

- Detection plants and weeds

The detection software utilized the OpenCV library to help detect the pigments of the plants and weeds. The process was to have an ordinary web camera take a photo of the plant at the position that was predetermined and then has the OpenCV library program detected the pigments of the plants and the weeds in that frame. The diameters of the plants and the weeds were also found. After both of the diameters were found, a point of the center could be determined for each circle. It was important to locate the center point because it will be the point on the x-axis and y-axis that the program will be referencing to eliminate the weeds. After the program had determined all the diameters of the color green, the program will determine which circle was the plants and which circle was the weeds and will mark all the plants with blue circles and the weeds circles in red.

![Fig.6 Detection program](image)

<table>
<thead>
<tr>
<th>No.</th>
<th>Hand Measure (x, y) cm</th>
<th>Program Measure (x, y) cm</th>
<th>% Error (%X, %Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(53, 15)</td>
<td>(54, 17)</td>
<td>(1.89, 13.33)</td>
</tr>
<tr>
<td>2</td>
<td>(64, 1)</td>
<td>(65, 0.5)</td>
<td>(1.56, 50)</td>
</tr>
<tr>
<td>3</td>
<td>(50, 15)</td>
<td>(52, 13)</td>
<td>(4, 13.33)</td>
</tr>
<tr>
<td>4</td>
<td>(66, 10)</td>
<td>(64, 12)</td>
<td>(3.03, 20)</td>
</tr>
<tr>
<td>5</td>
<td>(70, 68)</td>
<td>(73, 67)</td>
<td>(4.29, 1.47)</td>
</tr>
</tbody>
</table>

![Table I: Plants Measurement](image)
The experiment was about testing the accuracy of the program. The first step was measuring the actual position of where the plants were by hand and compared that to what the data showed. Table I and Fig. 6 is the chart that showed the results and an example of what the camera saw when it took a picture. The results were based on the origin of the tool head when it was at the home position.

- Elimination Weeds

Then, in order to completely terminated the weeds, it will not be advisable to pierce the tool head into the soil only once. Instead, it will better to create multiple points around an area where the program had detected the weeds. Fig. 7 shows that there will be a total of nine points around the area where the tool head (4 blades) was going to pierce the soil. This experiment was to test the elimination of weeds in ten different spots. The definition of elimination was when all leaves were separated from their stems. Fig. 8 presents a picture of the weeds that were going to be destroyed by the four blades.

4. Conclusion

The research started by studying why weeds are such a destructive force for crops, and it was found that weeds were any unwanted plant species that were undesirable. This problem occurred because weeds would take nutrients away from the main crops, not allowing it to grow at its maximum capacity. There are two main components, the camera and the tool head for weed elimination. The camera was just an ordinary web camera because the software did most of the work and not the camera. The second component was the tool head for weeds elimination. The tool head had four thin blades attachment on the bottom in order to cut the weeds. The z-axis moved downward very slowly and with very little force, so the blades had to be extremely sharp in order to cut the weeds. From all the experiments done, that confirm the automatic cartesian farming robot can operate in the multi-function accurately and correctly.

5. Acknowledgment

This research was funded by King Mongkut’s University of Technology North Bangkok. Contract no. KMUTNB-62-NEW-17.

6. References