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หุ่นยนต์เก็บเกี่ยวผักไฮโดรโปนิคอัตโนมัติ

Automatic Hydroponic Harvesting Robot

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บทคัดย่อ

งานวิจัยนี้ได้มุ่งไปที่การพัฒนาหุ่นยนต์เก็บเกี่ยวผักไฮโดรโปนิกอัตโนมัติสำหรับเกษตรกร อินเตอร์เน็ตของสรรพสิ่งได้ถูกประยุกต์ใช้ในการควบคุมหุ่นยนต์นี้ จุดประสงค์ของงานวิจัยนี้คือการสนับสนุนเกษตรกรในด้านของการลดการใช้แรงงาน ค่าใช้จ่าย และเวลาที่ใช้ในการเก็บเกี่ยวผักไฮโดรโปนิก หุ่นยนต์นี้ง่ายต่อการใช้งานเพราะใช้ระบบอัตโนมัติในการเก็บเกี่ยว ผักที่ใช้ในการทดลองคือกรีนโอ๊ค ประสิทธิภาพการเก็บเกี่ยวของหุ่นยนต์นี้มีความสำเร็จในการเก็บเกี่ยวอยู่ที่ 75% และใช้เวลา 12.13 นาที เมื่อทดลองเก็บเกี่ยวจำนวน 10 ครั้ง ข้อมูลของผลิตภัณฑ์จะถูกส่งไปและเก็บไว้ที่เว็บเซิฟเวอร์ มากไปกว่านั้นเว็บแอพพลิชั่นได้ถูกจัดเตรียมเอาไว้เพื่อเฝ้าดูข้อมูล โดยข้อมูลเหล่านี้สามารถถูกเฝ้าดูได้ตลอดเวลาผ่านอินเตอร์เน็ต

คำสำคัญ: หุ่นยนต์, เก็บเกี่ยว, อินเตอร์เน็ตของสรรพสิ่ง

Abstract

This research focuses on developing an Automatic Hydroponic Harvesting Robot (AHHR) for farmers. The Internet of thing (IoT) is applied for AHHR controlling. The aim of this research are to support farrmers to reduce labours, expense, and time for harvesting in hydroponic farm. This robot is easy to use by using automatically in the harvesting. The green oak lettuce is used for demonstration. The efficiency of harvesting is 75% and the usage time is 12.13 for harvesting of 10 plants. The information of products are also sent and stored in a web server. In addition, the web application is provided to monitor resources. These information can be monitored anytime through the internet.

Keywords: Robot, Harvesting, Internet of thing

1 Introduction

Hydroponic vegetables are grown suspended in a liquid solution containing the minerals the plant needs to thrive (Chaiwongsa et al, 2018). In most cases, a hydroponic farms are enclosed within a greenhouse, but hydroponics systems can also be set up outdoors. The water usages in hydroponic farming can be recycled through the system. Because there is no exposure to the outdoors, hydroponic vegetables may not need the same levels of pesticides to protect the plants against insects or pathogens. Some hydroponic vegetables growers do not use pesticides, and they employ organic farming methods, which allow them to meet the standards requirement to be labeled as organic produce. Hydroponic vegetables are the most popular and widespread in Thailand. Hydroponic vegetables are planted by seed and waiting to grow to sapling. Then plant it at the table. Take cultivation about 2-3 weeks. Hydroponic vegetables can be cooked in many ways, for instance; salad or salad rolls. According from big hydroponic farms, the harvesting must use longer time and need the cost of hiring labor.

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Hydroponics is a subset of hydroculture. The meanings are the method of growing plants without soil, using mineral nutrient solutions in water as shown in Figure 1.

Figure 1 Hydroponic farm.

The word hydroponics came from two Greek words Hydro means water. Ponos means labor. The hydroponics growing, plants are grown without soil. This means they must get their nutrients from the nutrient solutions. The soil unusing in growing means that hydroponics systems must have some way of supporting the plants while still allowing the bare root system maximum exposure to the nutrient solution (Arjina and Bruce 2010).

There are experiments related to smart farming. For example, Farmbot as shown in Figure 2. Farmbot can plant in a limited area. If current humidity levels are lower than desired humidity levels, the moisture sensors will send a signal to Raspberry Pi (Element14.com 2017). Then, the water pump will be turned on and pour water into plant filed. Farmbot can eliminate weeds. When vegetables are ready for harvesting, FarmBot will harvest automatically or manually.

Figure 2 Farmbot

The harvesting robot which is shown in Figure 3 can be reduced the worker cost by using a cucumber harvesting robot in a greenhouse (Biserka and Danilo 2016).

Figure 3 Cucumber harvesting robot.

The crops-robots: sweet pepper – protected cultivation is developed for harvesting. This harvesting robot has two camera systems. The cameras are mounted on the vehicle. They are used for the detection of the fruits. The aim of camera using is to determine of the ripeness and the quality of the sweet-peppers. The crops-robots: sweet pepper is shown in Figure 4 (Zaria, 2015). This robot works autonomously and uses cameras to evaluate the size, color, and ripeness of the sweet peppers to ensure that are ready for harvest.

Figure 4 Crops-Robots: sweet pepper – protected cultivation.

According from the former contents, this is the reason that a harvesting robot is developed. The aim of development is to reduce the time and labor of harvesting.

2 Materials and method

In this paper, IoT is used for automatic hydroponic harvesting robot. The objective of this paper is research and development the harvesting robot in prototype. There are 2 scopes of this paper. First, the hydroponic vegetable is green oak lettuce. Second, the average successful rate of harvesting must be over than 70% of 10 times harvesting. The goal of the automatic hydroponic harvesting robot is to reduce the cost of hiring labor.

2.1 Green oak lettuce

Green oak lettuce (Lactuca sativa) is a type of butter lettuce whose leaves are distinctively lobes. Its full grown cover 45 days of planting and 200 g of weight. Moreover, the green oak lettuce has its leaves which measure 4 to 10 inches when allowed to mature (cals.arizona.edu 2018).

2.2 Block Diagram

The block diagram with sub system is shown in Figure 5. First subsystem is sensor subsystem. Weight sensor is loadcell with 5 kg rating (Arduinoall.com 2017). The HX711 (Myarduino.net 2017), and RTC module (Arduinoall.com 2017) are used to send real-time of RTC-module and weight of vegetable from weight sensor. Second subsystem is processing subsystem. Raspberry Pi and NodeMCUs (Arduinoall.com) are used to transmit harvesting time data and control actuator subsystem. The third subsystem is actuator subsystem. This subsystem is included opto-isolated board (Hobbytronics.co.uk 2017), relay boards (Arduitronics.com. 2017), DC motor 12V with 20 rpm and 100 rpm (Arduinothai.com 2017), and servo motors (Arduinothai.com). Fourth subsystem is database subsystem. Database is used to collect data on cloud and can be display on the web application.

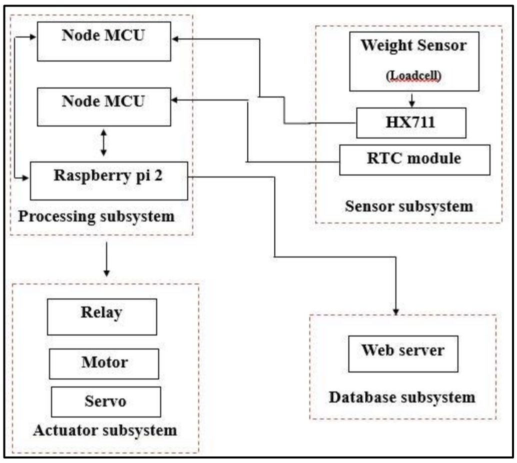

Figure 5 Block diagram.

2.3 Circuit Diagram

Figure 6 shows the circuit diagram of this project. All devices are connected by using this circuit diagram.

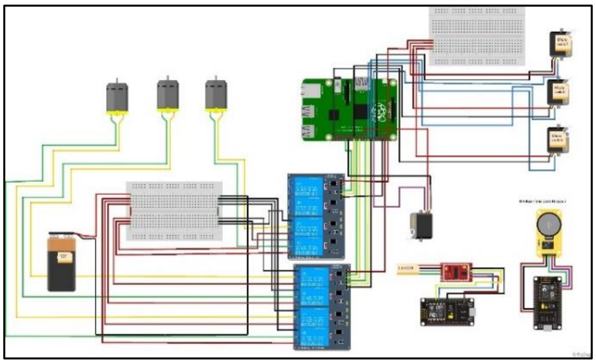

Figure 6 Circuit diagram.

2.4 Flowchart and algorithm

This system flowchart is shown in Figure 7. The system starts by receive real-time NodeMCU and send to Raspberry Pi. After that, motors are controller and the AHHR moves to the desired point. The arm of AHHR moves down and weights vegetables. If the weight of vegetables is more than 200 g, the robot will move to the head of the table for dropping vegetables in the basket. If the weight of vegetables is less than 200 g. The vegetables are put back to the hole. The motor controlling flowchart, weighting flowchart, and micro switch (Arduitronics.com 2017) for positioning flowchart are shown in Figure 8, 9, and 10, respectively.

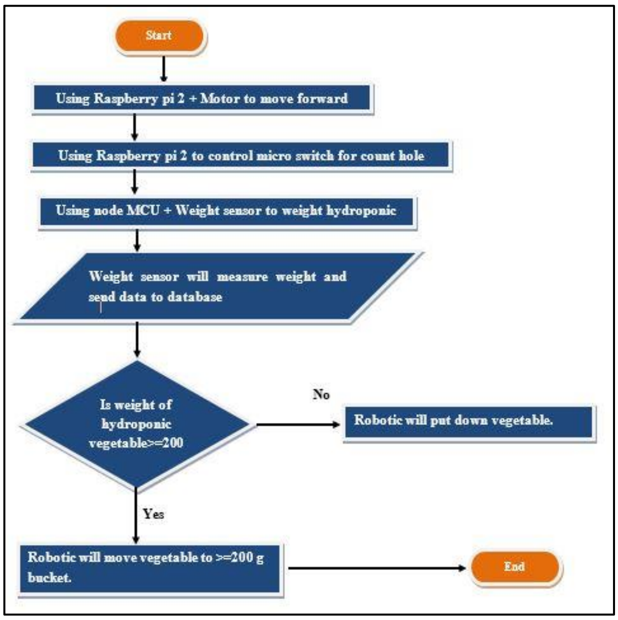

Figure 7 System flowchart.

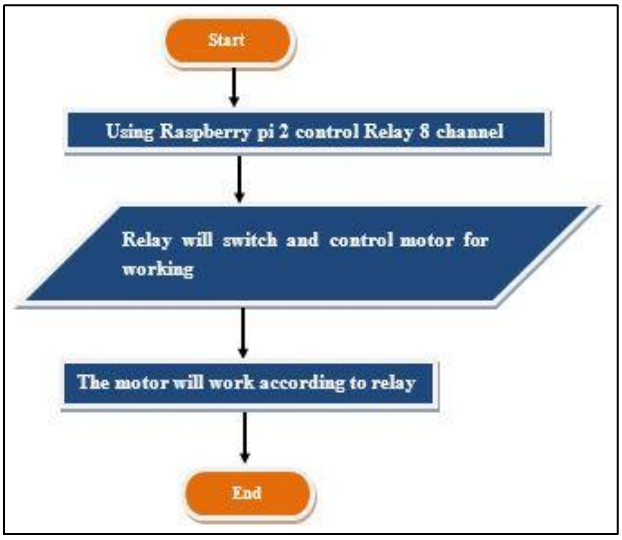

Figure 8 Motor controlling flowchart.

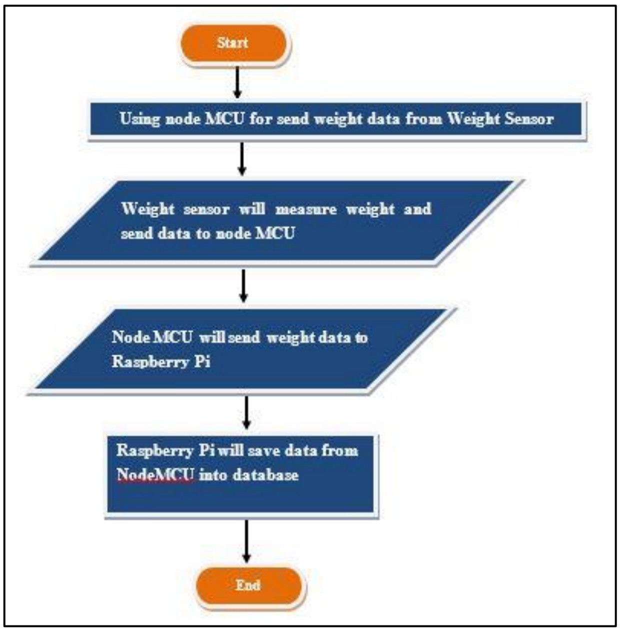

Figure 9 Weighting flowchart.

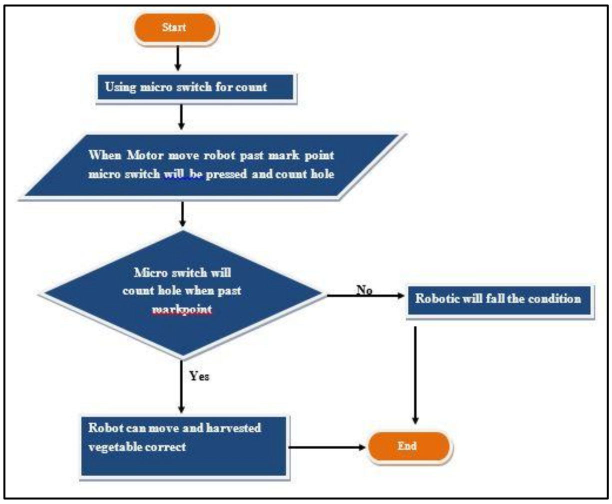

Figure 10 Micro switch for positioning flowchart.

2.5 Automatic hydroponic harvesting robot model

In this part, the front view 3D model, side view 3D model, and top view 3D model of AHHR are shown in Figure 11, 12, and 13, respectively.

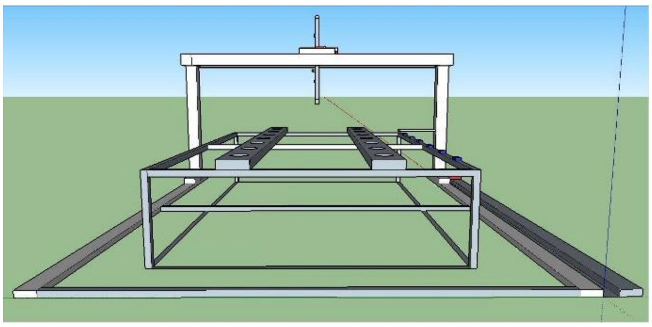

Figure 11 Front View 3D model of AHHR.

Size of AHHR are as follow: Height: 160 m., Width: 2 m and Length: 3.5 m. The table is 1x1.5x0.75 cm. The dimension of plant rail is 3 inch width and 1.5 inch height. The distance between each rail plant is 0.2 m. the distance of each plant hole is 0.25 m.

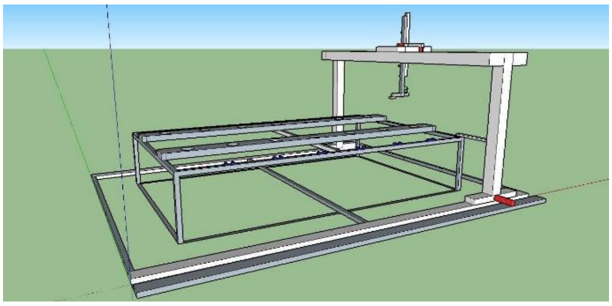

Figure 12 Side view 3D model of AHHR.

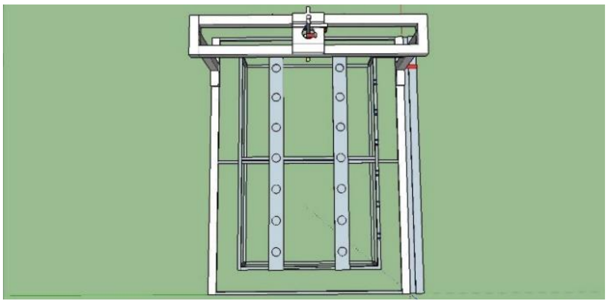

Figure 13 Top View 3D model of AHHR.

3 Results and discussion

After the AHHR model is designed. The AHHR is build. The weight sensors are calibrated by using the cylindrical weights 5 kg. First, the 5 kg weight is placed on the AHHR arm, on the load cell. After that, the NodeMCU get the voltage level for 5 kg and store this voltage level into the program. Next, the cylindrical weights 200 g is placed on loadcell. This voltage level from loadcell is used to define the voltage level of 200 g for NodeMCU.

Figure 14 and 15 show the controlled box and setting page, respectively.

Figure 14 Controlled box.

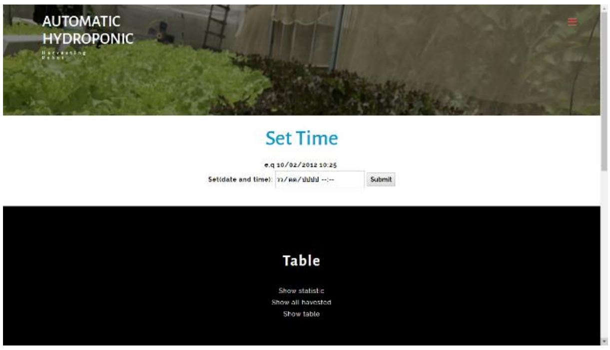

Figure 15 Setting page.

Figure 16 shows statistics page.

Figure 16 Statistics page.

Figure 17 shows plant holes on the rail.

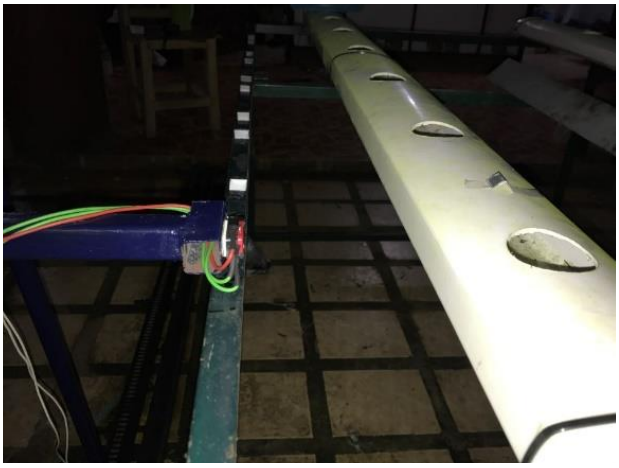

Figure 17 Plant holes on the rail.

Figure 18 shows AHHR arm.

Figure 18 AHHR arm.

Figure 19 shows row changer module.

Figure 19 Row changer module.

Figure 20 shows arm controller module.

Figure 20 Arm controller module.

Figure 21 shows movement module and path.

Figure 21 Movement module and path.

The experimental contents 10 times batch running. Each running, the AHHR is used to harvest 10 green oak lettuces. In first running, there is no 200 g green oak lettuce. There are only less than 200 g green oak letttuces. Next, the 200 g green oak lettuce is increased in each sub-running. That means in tenth row, all green oak lettuces are 200 g green oak lettuces.

The experimental results contents 3 parts as follow.

3.1 Percentage of one complete

This percentage of one complete is experiment by running the system 10 times per 1 case. The overall running is 10 cases. After that, the percentage calculating of one complete is evaluated.

The percentage of one complete has a little bit errors. These errors are occurred by the movement of the AHHR. Some movements have probably fall out of the path line that cause AHHR cannot move toward.

AHHR need manual fixing for through back to normal operation.

3.2. Percentage of successful rate

The percent of success is experiment by running the system 10 times per 1 case. The overall running is 10 cases. The number of randomize of number of vegetable less than 200 g per 1 case is set. After that, the percentage calculating of successful harvested are evaluated. The highest percentage of success is on “number of vegetable < 200 g” equals 7. The overall percentage which is at least 80 are on “number of vegetable < 200 g” equal 4, 6, 7, 8, 9, and 10. The “number of vegetable < 200 grams” equal 0, 1, 2, 3, and 5 have lower percentage of success than another set. The errors are occurred from the misfunction of AHHR arm. The AHHR arm has some mistake. Some operation, the arm cannot hold the vegetable pallete. The pallete is fall out from the arm which is made the error of arm operation. Figure 22 shows testing of AHHR (Paramee, 2017).

Figure 22 Testing of AHHR.

3.3 Average of times.

The average of the times is experiment by running the system 10 times per 1 case. The overall running is 10 cases. After that, the time harvested calculating is evaluated.

The average time is about 10-13 min. Most of time is used for weighting by weight sensor to weigh the vegetables. The usage time seem too high. Due to reliability setting of weight sensor, the system is set to get the weight until the weight signal is steady. The movement time of AHHR is a small part of all usage time.

All results of AHHR testing are shown in Table 1.

Table 1 All results of AHHR testing.

Percentage of successful rate	Number of vegetable < 200 g	Percentage of success	Average times (min)
	0	70	13.225
	1	70	13.018
	2	70	12.824
	3	70	12.556
	4	80	12.214
75	5	70	12.613
	6	80	12.404
	7	90	11.701
	8	80	11.514
	9	80	11.240
	10	80	10.191

The successful rating by using cylindrical weights 200 g is 90%. The 10% error came from AHHR mechanic. According from the observation of AHHR mechanic, there are few error of mechanic while the AHHR arm is lifting the green oak lettuce. These cause the fail of lifiting, error of weight measuring, and other error of mechanic operating. The average power comsumption is 15 W.

4 Conclusion

The Automatic Hydroponic Harvesting Robot (AHHR) is implemented. The IoT boards, motor controller modules, weight sensors, and necessary devices are equiped. In addition, the DC motors are the main device to push AHHR toward. This AHHR is designed to work in fully automatical mode. The AHHR can move to the destination point by using limit switchs to indicate the location which has green oak lettuce. After that, the AHHR lift the green oak lettuce and weight, send the weight information to NodeMCU. If the weight of green oak lettuce is more than 200 g, the AHHR harvest that lettuce. If not, the AHHR put that lettuce back into the rail.

The overall results show that percentage of successful rate is 75. Some errors still occur by the AHHR mechanism in both arm movements and direction movement. Therefore, this AHHR can be improved further by upgrade device and improve the robot strength for perfectly pick up hydroponic vegetable and its movements. Other sensors can be added to collect more data. Lastly, a further development of this limitation can be corrected in the future.

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