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Semi-Auto Dosing Robot with Image Processing

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Abstract: This paper describes the Semi-Auto Dosing Robot with Image Processing (SADR-IP) that is applied in the agriculture field. The SADR-IP is developed mainly to automate and replace the human watering plants process. The concept and the design of this project are convenient, easy to activate, and monitor throughout the crop field. The image processing based on PyCharm is employed for this robot allows us to increase the speed and accuracy of the work. In addition, various types of crops can be identified by using this image processing technology so that the robot can dose the correct amount of water as needed. Two Arduino Uno boards are used to move the robot and dosing process with a servo motor. The results show that the SADR-IP is reliable to be implemented in the agriculture field. In addition, the use of PyCharm for Image Processing makes the robot design very new in the dosing robot category due to its practicality for detecting different types of crops.

Keywords: Arduino Uno, Image Processing, Dosing

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1. INTRODUCTION

Agriculture is an important sector in Malaysia. For many years, this sector has been the backbone of the Malaysian economy, producing agricultural products for domestic consumption. One of the main challenges faced by this sector is attributed to low productivity and quality of agricultural produce due to lacking manpower. Healthy plants can transpire a lot of water to increase the humidity [1]. Moreover, many people are busy with their careers and household chores. Hence, watering plants can be troublesome to maintain healthy plants if the transpiration process is inconsistent [2].

To resolve the above-mentioned issue, robots can play an essential role in the agricultural field for the farming process [3]. Many agriculture operations are automated and many automatic robots are commercially available. Many robots are invented based on semi-autonomous or fully autonomous systems to reduce the burden of human activities particularly in plantation [4] activity which will be highlighted in this paper. In more challenging tasks these robots assist in many other fields such as medical, military, and service.

This paper establishes a Semi-Auto Dosing Robot with Image Processing (SADR-IP). By using a SADR-IP, many people can use it as an assistant robot to water the plants at their house. In advanced application, the SADR system allows the productivity and quality of Malaysia's agricultural products. The first objective of this project is to develop a dosing robot based on image processing to detect and identify the crops. The second objective is to provide a safe semi-automatic dosing robot for the plant watering system. Other related work on the agricultural robot is depicted in Table 1.

Table 1: Related Projects

Author	Title of Project	Key Ideas
1. A.Singh 2. A.Gupta 3. A. Bhosale 1. 4. S. Poddar	"Agribot: An Agriculture Robot"[5]	The robot design for having the ability to find the grass in the field using image processing. The capture picture or images are then processed by the technique of image processing and send the data to the microcontroller unit for orders.
1. S. R. Zanwar 2. R. D. Kokate	"Advanced Agriculture System"[6]	The structure of the main body part of the robotic agriculture machine. Infrared sensor sets at the front part of the vehicle for sensing obstacles in the way of the vehicle as to provide instruction to

		the microcontroller to control the motion of wheels through DC motor. It is used to bring the seed, stored in the funnel, and controlled by the servo motor.
1. B. S. Shivaprasad 2. M. N. Ravishankar 3. B. N. Shoba	"Design and Implementation of Seeding and Fertilizing Agriculture Robot"[7]	Obstacle detecting sensor in the proposed system camera as it is used for live streaming instead of applying the line follower. Live streaming can be seen by the computer when typing the IP address of Raspberry Pi and password. Then it can control the robot by pressing the controlling key in the system. It can measure the pH, temperature, soil moisture using pH sensor, temperature sensor, and soil moisture sensor respectively.
1. A. Sulakhe 2. M. N. Karanjkar	"Design and Operation of Agriculture Based Pesticide Spraying Robot"[8]	The model adopts artificial supplementary light, and the whole production process is controlled by computers. Pesticide spraying robot builds to work in the Agriculture field which controls via Bluetooth using smartphones. The robot got a vision when a wireless camera is installed. The Camera is wired to a wireless transmitter and the signal travels between the camera and the receiver.
1. V. Narendran	"Autonomous Robot for E-farming Based on Fuzzy Logic Reasoning" [9]	The user sends input signals from mobile apps and it will further forward to the cloud through the internet so that Raspberry Pi could receive signals from it. Arduino connects to two L293 H-Bridge and two servo motors. The 12V DC motors us installed for the robot movement while the servo motors are for the plowing and seeding actions. An IR sensor is installed that is used to detect the presence of objects.
1. S. R. Kumar 2. H. S. Kalyan 3. K. D. Kumar 4. S. Dilip	"Design and Fabrication of Autonomous Robot for Precision Agriculture"[10]	The robot was designed for showing different types of seeds and the second phase includes watering and spraying of pesticides during operation. An ultrasonic sensor has been installed to detect the obstacle when the robot is operating.

2. METHODOLOGY

This section discussed the technique used to realize the SADR-IP. This includes the planning, procedures, steps to develop this project, and the expected outcome. Moreover, the system coding, flow chart, the circuit for the development of the robot, and experimental setup are also explained here.

2.1 System Operation

There are a total of three systems to operate the SADR-IP. Figure 1 illustrates the operation system by using Arduino Uno for the robot movement and dosing process. All system operations are powered by a power supply to energize other components. Two Arduino Uno boards with a DC voltage are used for the controller. When the system is ON, all components such as Arduino Uno boards and webcam will be activated. The webcam is used to capture images through Image Processing as a feedback signal to the controller. After receiving the signal and identified the crop, the dosing robot will be controlled via Bluetooth with a servo motor and dose on target.

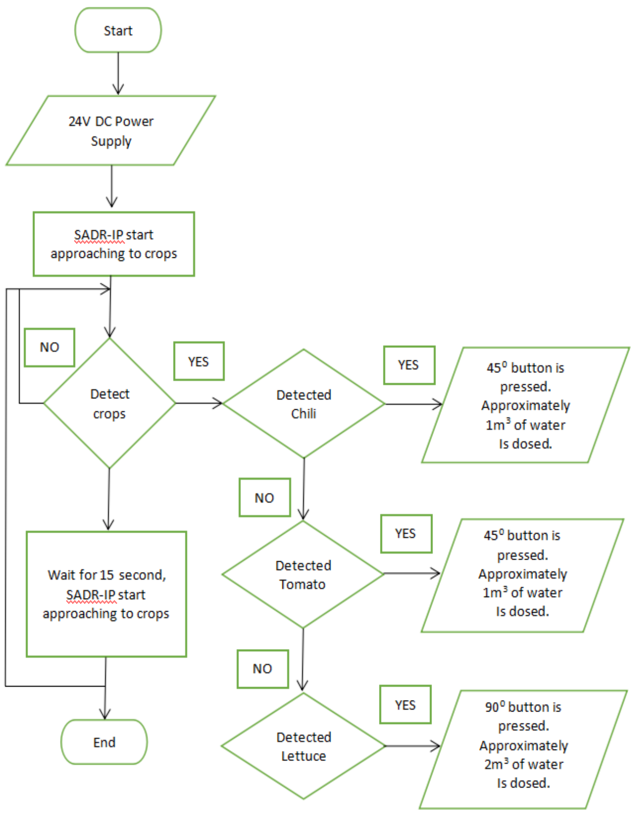


Figure 1: Flow Chart for SADR-IP

2.2 Experimental Setup

Figure 2 shows the experimental setup for the project. The 24V DC voltage supply is used to power up the whole system. The main operators employ the Arduino Uno to send a signal to the HC-05 Bluetooth Serial Port and L298N motor driver, while the webcam using the Image Processing received signals from pre-programmed python coding to capture images of crops.

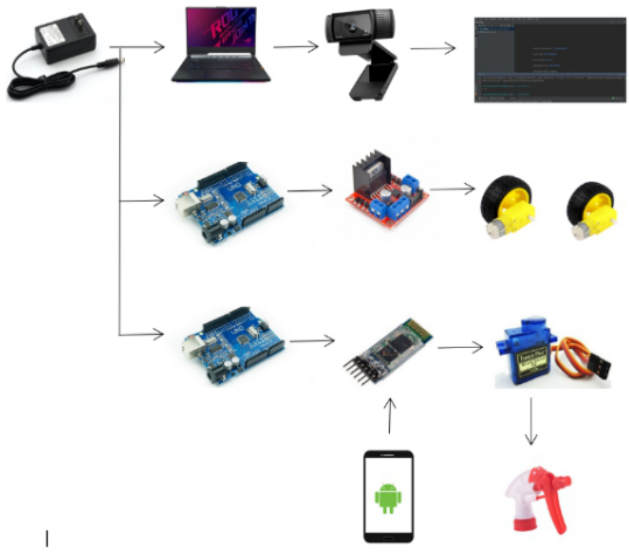


Figure 2: Experimental Setup

2.3 Components Requirement

The components used in the Semi-auto dosing robot with Image Processing has been listed in Table 2. The main controller used in this project is the Arduino Uno board which controls different actions of the robot. More specifically, two Arduino Uno boards are used to connect the motor driver and two DC motors, while another board is connected to a wireless Bluetooth serial port and a servo motor for dosing purposes. Moreover, the L293N motor driver is chosen for SADR-IP due to its small size which can easily fit into the robot. For the dosing part, the HC-05 wireless Bluetooth serial port is used to control the servo motor connected to a sprayer. An application called "BlueCore Tech Servo Control" is installed in an Android cellphone to control the angle of the servo motor to complete the dosing process.

Table 2: List of Components Required for SADR-IP

No.	Item	Description	Quantity
1.	Arduino board	Arduino Uno	2
2.	Arduino DC Motor Driver	L293N	1
3.	DC Motor	3-6V DC Motor	2
4.	DC Motor Tire	Motor Rubber Wheels	2
5.	Wireless Bluetooth	Arduino HC-05 Wireless Bluetooth Serial Port	1
6.	Servo Motor	Arduino Tower Pro SG90 Gear Servo Motor	1
7.	Spray	Water Sprayer	1
8.	Webcam	A4Tech Webcam	1
9.	Power Source	DC Power Source	2
10.	Robot Body	Robot Chassis Kit	1

Another important part to develop SADR-IP is Image Processing. The technique of Image Processing is proposed to identity selected crops with a webcam. The webcam is installed on the robot so that it could capture live images and send the captured image back to the PC.

2.4 Software Component Development

Three software applications are used to achieve the objectives of the project, which are Arduino IDE, PyCharm, and Android Bluetooth application. The Arduino IDE and Android Bluetooth applications are used for the coding and design that allow the dosing process by using a servo motor. Meanwhile, the PyCharm is used for the python coding to allow the webcam to identify the selected crops.

2.4.1 Arduino IDE

In this project, Arduino 1.8.8 is used to create or run program coding, compile, verify and upload the program coding via a USB cable. The Arduino Uno compatible board is used as the main controller for dosing purposes. The Arduino IDE supports several languages which included C, C++, and python language. The software library supplied by the Arduino IDE allows us to execute various type project in the future.

2.4.2 PyCharm

PyCharm is an integrated development environment (IDE) used in computer programming, specifically for the Python language. PyCharm provides smart code completion, code inspections, on-the-fly error highlighting for error detection, and quick-fixes capabilities. PyCharm is used to create and run the python coding that allows the webcam to identify selected crops. To succeed the Image Processing, a few packages and environments such as Keras, NumPy, Tensorflow, OpenCV, and h5py need to be installed before coding. Note that PyCharm provides a huge collection of tools that includes an integrated debugger and test runner, a built-in terminal, integration with major VCS, and built-in database tools.

2.4.3 Android Bluetooth Application

The Android platform includes support for the Bluetooth network stack, which allows a device such as Bluetooth on the cellphone to connect wireless to other Bluetooth devices, enabling point-to-point and multi-point wireless features. An Android cellphone is used to download the android Bluetooth application called BlueCore Tech Servo Control. It is then connected to Arduino Uno via an HC-05 wireless Bluetooth Serial Port to control the dosing process.

3. RESULTS

There are three different results to be discussed here which are Robot Development, Image Processing, and Arduino Uno.

3.1 Robot Development

The design of the proposed SADR-IP is constructed in 3D by using the SketchUp Pro 2018 as shown in Figure 3. A slight modification is required particularly for components position to allow better robot performance in real-time. Complete development of the SADR-IP prototype is shown in Figure 4.

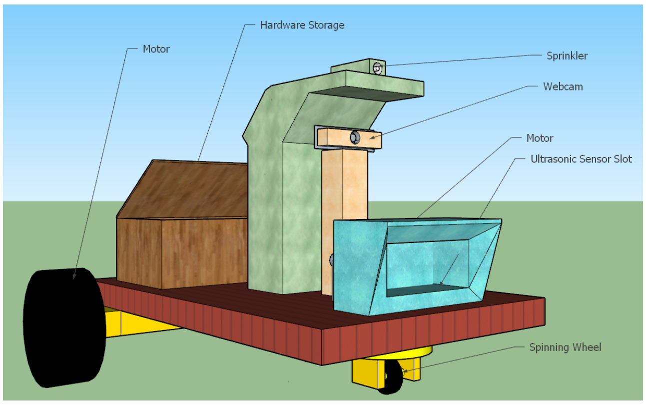


Figure 3: The Construction SADR-IP by Using Sketch Up.

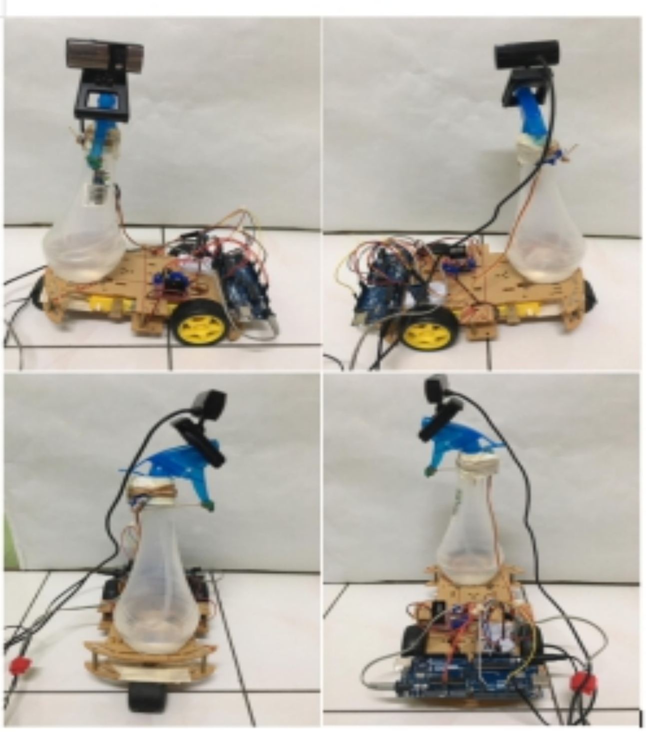


Figure 4: Semi-Auto Dosing Robot with Image Processing (SADR-IP)

3.2 Image Processing

The concept of Image Processing developed here is to have live streaming by using the webcam to detect selected crops. The webcam will be activated after receiving the pre-programmed instruction from PyCharm. Subsequently, it will automatically capture the images when the targeted image is detected.

3.2.1 Webcam Training Progress

To achieve good webcam identification, the training process of the webcam is required. Before program coding, some packages and environments are necessary to be installed in PyCharm such as OpenCV-python version 4.4.0.46, Keras version 2.3.1, h5py version 2.10, and NumPy version 1.20.0rc1 in Python Interpreter. (See Figure 5).

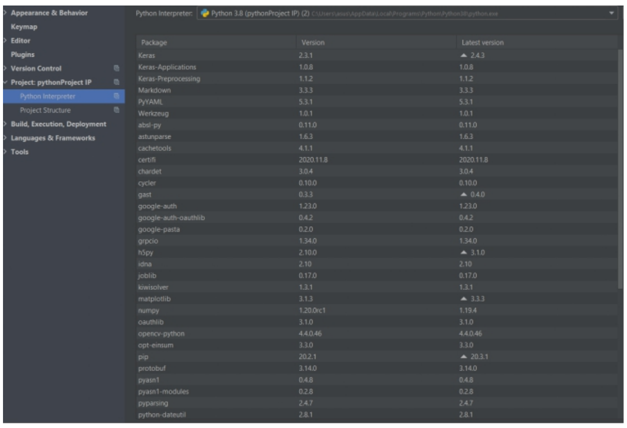


Figure 5: Installation of Packages And Environments

Plenty of images of the selected crops which are chili, tomato, and lettuce are required to be trained by using PyCharm. 20-30 images of each crop are considered. To increase the accuracy of the webcam identification, PyCharm has trained a total of 10 sets, each set will train up to 2000 times. The more the images, the more the accuracy of the webcam. The maximum value of the accuracy is 1.0 while the minimum value will be 0.0. The higher the value of the webcam can be captured, the more the accuracy to successfully identify the crops. An example of a training process with a test accuracy of 0.7392 is shown in Figure 6.

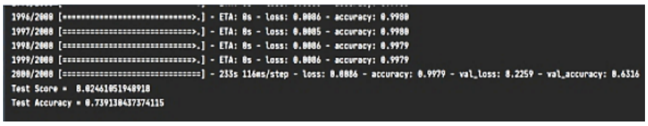


Figure 6: Accuracy Test = 0.7392

3.2.2 Detection of Webcam

After several of the training process, the webcam is now able to identify the selected crops. The pre-programmed coding as given in Table 3 states that the output or the terminal will show the name of the crops which are chili, lettuce, or tomato. The accuracy of identification process ranging from 0.0 (i.e poor) to 1.0 (i.e. good). On the contrary, when there is nothing or an unrecognized object is detected, the output will define as 'null' with no accuracy as shown in Figure 7. Meanwhile, Figure 8 illustrates the vegetables that were successfully recognized namely chili, tomato, and lettuce. The accuracy of chili, tomato, and lettuce are 0.99972683, 1.0, and 0.99570495 respectively.

Table 3: Differentiate The Output of The Crops In The Terminal

Crops	Coding	Description
Chili	if classIndex == 7: print('Chili ' + str(probVal))	7th file with images of chili. Terminal showing "Chili" and the accuracy
Lettuce	elif classIndex == 8: print('Lettuce ' + str(probVal))	8th file with images of lettuce. Terminal showing "Lettuce" and the accuracy
Tomato	elif classIndex == 9: print('Tomato ' + str(probVal))	9th file with images of tomato. Terminal showing "Tomato" and the accuracy
Other objects	else: print('null')	Terminal showing "null" with no accuracy

Figure 7: Terminal Showing 'NULL' When Other Objects (Computer And Cables) are In Front Of The Webcam

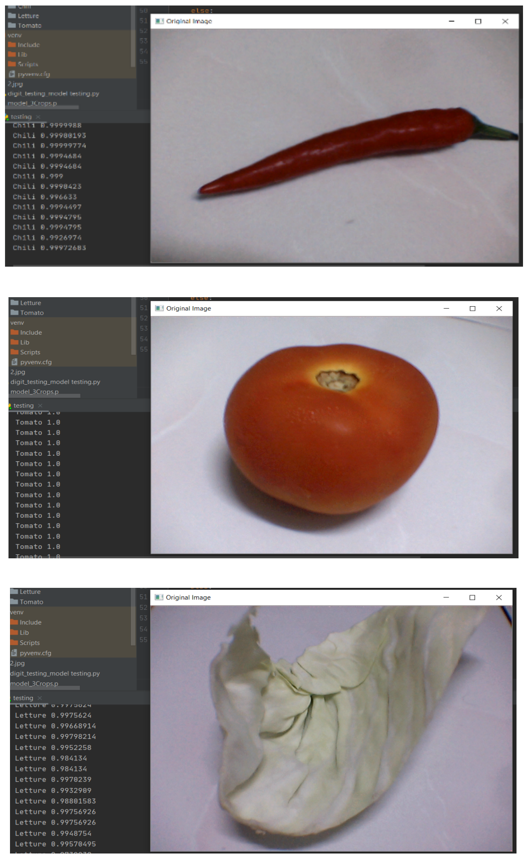


Figure 8: Terminal Shows "Chili", "Tomato", and "Lettuce" Followed by The Accuracy

3.3 Arduino Uno

Another important function of Arduino Uno is to control the movement of the robot and servo motor for dosing purposes. Two Arduino Uno boards are installed on the robot to control different systems respectively.

3.3.1 HC-05 Wireless Bluetooth Serial Port with Servo

To complete the process of dosing, a servo motor, a sprayer, and an HC-05 wireless Bluetooth serial port cooperate effectively. Arduino Uno is the main brain of this system. Pre-programmed coding is transferred to Arduino Uno via a USB cable. An Android cellphone is used to install an application to control the angle of the servo motor. Since three selected crops can be identified which are chili, tomato, and lettuce, thus, the amount of water for each crop will be different. In this case, chili and tomato used the same amount of water while lettuce needs a large amount of water. The rotation angle of the servo motor will determine the amount of water required for each crop. Here, due to the smaller size of chili and tomato, only 45^0 rotations of a servo motor are required to sufficiently watering these crops (i.e 1 m^3 amount of water sprayed). Meanwhile, for a larger crop such as lettuce, about 90^0 rotations of the servo motor are required for the watering process (i.e 2 m^3 amount of water sprayed). Figure 9 illustrates the servo motor initial position (0^0), 45^0 rotations, and 90^0 rotations respectively. Meanwhile, Table 4 indicates the amount of water used for different crops.

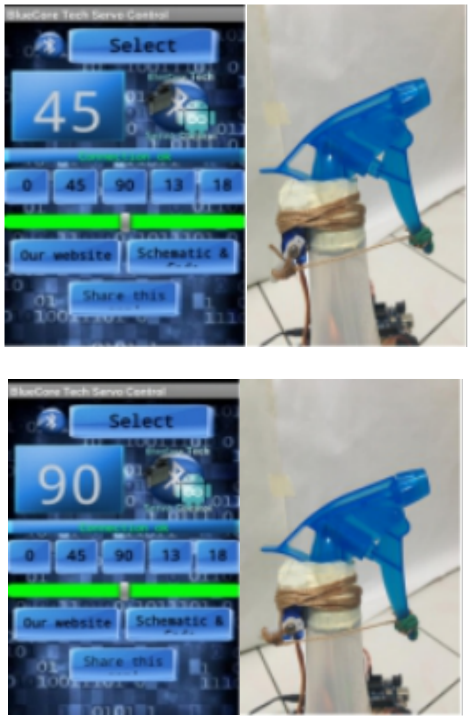
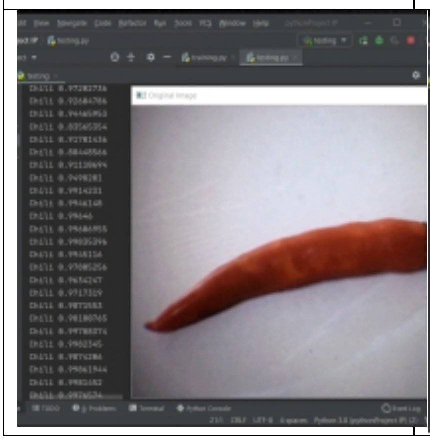
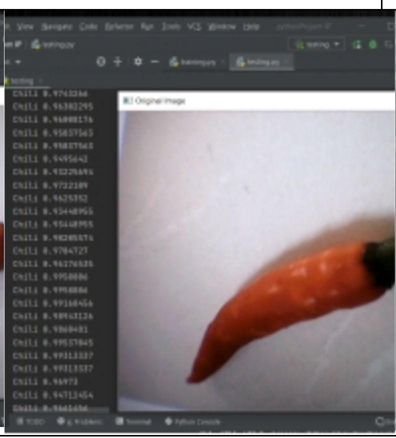
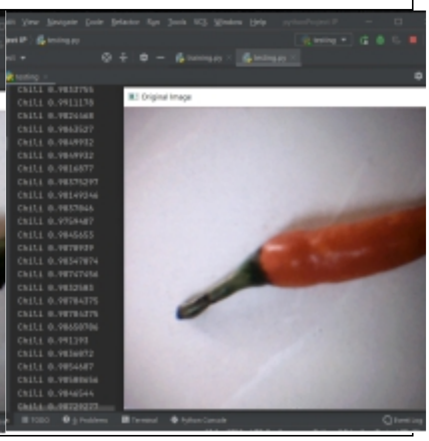


Figure 9: Servo Motor is Connected with 0^0 Initial States, 45^0, And 90^0

Table 3: Different Views From Crops with Mean Accuracy

Different views from crops		
Chili, Tomato, and Lettuce (Front view)	Chili, Tomato, and Lettuce (Side view)	Chili, Tomato, and Lettuce (Rear view)
		

Mean accuracy (Top 5 highest accuracy/5)		
Chili front view = 0.9943597 Chili side view = 0.9936805 Chili back view = 0.9887964	Tomato front view = 0.9999538 Tomato side view = 1.0 Tomato back view = 1.0	Lettuce front view = 1.0 Lettuce side view = 0.9999336 Lettuce back view = 0.9970725

Table 4: Angle of Servo Motor for Selected Crops

Crops	**The angle of the servo motor**	**Approximately amount of water sprayed (m^3)**
Chili	45^0	1
Tomato	45^0	1
Lettuce	90^0	2

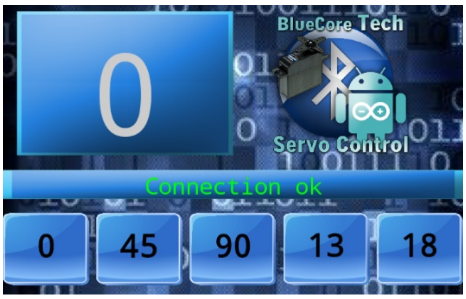


Figure 10: Connection Ok is Shown Between HC-05 Bluetooth Serial Port And an Android Cell-Phone

3.4 Overall Process

The 24V DC voltage is used to power On the SADR-IP. Figure 10 shows the connection between the HC-05 Bluetooth serial port and an Android cell phone. The robot will stop every 15 seconds to identify the crop and to dose the crop via Bluetooth application by pressing the angle of the servo motor. The captured image can be seen on the monitor of the laptop approximately 2m apart from the SADR-IP. After 15 seconds, the robot will move forward again to the next crop and keep repeating the process. Figure 11 shows the process of identifying and dosing crops.

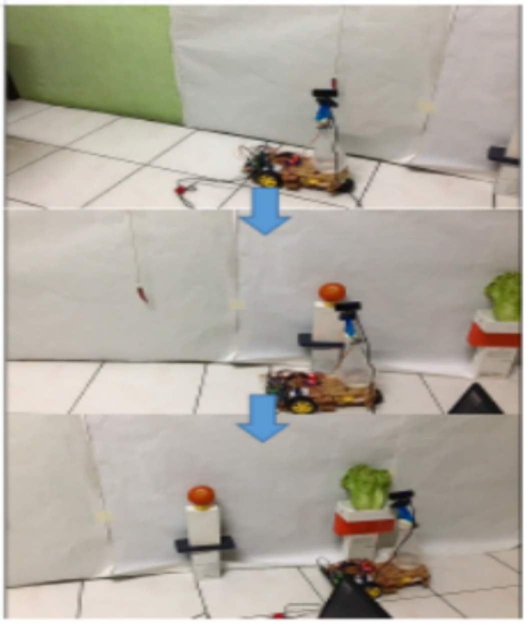


Figure 11: Process of Identifying and Dosing Crops.

4. CONCLUSION

The Semi-Auto Dosing Robot with Image Processing (SADR-IP) has been successfully developed. The webcam can detect the selected crops accurately at the monitor from 1 meter as the HC-05 Bluetooth module can be only operated within 1 meter. The user can dose the correct amount of water from the robot via Bluetooth after identifying the crop. The overall system was functioning successfully. The SADR-IP can benefit to minimize the workload of labor. Apart from increasing the effectiveness and accuracy of the work, the SADR-IP can also reduce the period for the crop plantation process. Nonetheless, the SADR-IP can be further improved to increase its effectiveness and efficiency. The following suggestions are recommended to enhance SADR-IP performance.

i. It is recommended to add an ultrasonic sensor to avoid any obstacles in front of the robot.
ii. The robot structure can be designed professionally with the simulation analysis to increase the stability of the robot, to increase the thrust and reduce the drag force while moving, and to fully utilize the space of the robot.
iii. A more advanced microcontroller is suggested to replace Arduino Uno to combine two or more systems in one single microcontroller such as Raspberry Pi 3 Model B.
iv. More pictures in different angles of crops to be trained to increase the webcam accuracy.
v. Emply a higher resolution and pixels of the webcam to improve the quality of images.

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