FARMBOT: Automated UAV-Based Sprayer of Rice Crops Fertilizer Based on Leaf Color Chart (LCC) Via Image Processing

A Project Study Presented to the Faculty of

Electronics Engineering Department

College of Engineering

Technological University of the Philippines

In Partial Fulfilment of the Requirements for the Degree

Bachelor of Science in Electronics Engineering

Submitted by:

Bayot, Jude Marco D.

Galvadores, Bryan Dayton Edward N.

Geollegue, Christian Jason G.

Nartea, Airielle Jan

Sumangil, Juan Lorenzo P.

Engr. Timothy M. Amado

Adviser

March 2019

ACKNOWLEDGEMENT

First and foremost, the proponents would like to thank the almighty God for granting them wisdom, fortitude and patience as they are making the project study.

Their sincerest gratitude must be extended also to their professors, exclusively to their adviser, Engr. Timothy M. Amado, for giving them unwavering support and encouragement during the times that they couldn't find their way through uncharted waters. And they are also grateful to the members of the panel, Engr. Aaron U. Aquino, Engr. Edmon O. Fernandez, and the department head of the ECE department Engr. Lean Karlo S. Tolentino, who guided them and believed in their capabilities.

This project study would not be possible, without the support of the family, relatives, and friends of the proponents. Furthermore, they would like to thank these individuals for their generosity and for inspiring them all the way through which made this even more meaningful to the proponents.

Abstract

Smart farming is about empowering today's farmers with the decision tools and automation measurement technologies. These seamlessly integrate products, knowledge and services for better productivity, quality and profit. The condition of our farmers under the scorching sun with bodies bent toward in farming and lifting heavy little tanks at their back in spraying chemicals should be aided with the fact of existence of today's technology. It is also significant to safeguard human health with the actuality of risk posted by spraying of chemicals and pesticide in the environment. Farmers are unable to distribute the right amount of fertilizer. Moreover, crops will experience fertilizer burn causing to it die and nutrients are taken out from the soil when too much fertilizer is applied. We are currently in the era of technology, to meet the needs of the rapid growth of people in our country the researchers explored the potentials of innovating the distribution of nitrogen fertilizers, improving the mode of distribution in the crops and made it more efficient compared to the conventional way of farming. The goal is to develop a quadcopter that is suitable on spraying fertilizer after capturing images of the field and analyzing the certain greenness of the crops using a raspberry pi and through image processing. The researchers also aimed to develop a notification system that is very reliable on user-to-machine communication. Statistical test was conducted to determine the significance of the study against the type of farming the country still using. Particularly with the help of previous reviews of related literature on the proper fertilizer application, leaf color chart, a proper fertilizer dispenser using a drone as a mode of distribution device was developed. Complete implementation of the study responded and resolved vital faming issues and led to a remarkable contribution on modern day farming. The project became meaningful in the optimization in the use of fertilizer while providing ease in farming today.

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Chapter 1

The Problem and Its Background

According to a survey conducted by the National Statistics Office, The Philippine population is projected to increase to 142 million by the year 2045 and it is particular that there is a long term scarce for food. Agriculture is the main source of food and live hood, this includes farming. Our country is still considered as an agricultural country, as our main crops are rice, corn, coconut, sugarcane, bananas, pineapple, coffee, mangoes, tobacco, and abaca.

Primarily, rice is the staple food for Filipino but rice farming is one major problem in the field of agriculture. It is a struggle for the farmers to reduce the inputs such as the pesticides, fertilizers and water having a constant amount of output obtained. Some mutual problems encountered by rice farmers are high cost of inputs, labor problem, Shortage for postharvest facilities, sustaining fertilizers, pest, diseases and irrigation system.

Present technology has taken charged in developing farming system and in crafting new equipment that could resolve these farming issues.

Based on the facts presented by Zamboanga Research Center of the Philippine Coconut Authority, the study showed statistics on how technology can remarkably aid coconut farmers to overcome poverty and give ease to the conventional way of farming.

When a minimal amount of technology was used, a regular farmer has earned an average annual net income per hectare of only P20,000 and by the help of micronutrients that gives about P2,400, the farmer made a net income of P57,600. Furthermore, the additional utilization of hybrid technology with a one-time investment of P2, 500 for the next 60 years, the net income jumped up to P125,100.

The focus of this study is to modify a drone with imaging capabilities and control it to detect the level of the crop in the rice field via image processing based on LCC (Leaf Color Chart) and will direct how much fertilizer is needed in every part of the rice field.

With the goal to provide an environmental-friendly farming, this study will aim to lessen the amount of fertilizer being sprayed in the field, targeting the right crop with the sufficient amount, posting less risk to human health. Optimizing the use of fertilizer, while yielding the same output.

1.1. Background of the Study

Proper management of crops ensures efficiency in the use of inputs such as water and fertilizer. With this, productivity, quality, and yield could be at its maximum. Efficient use of fertilizer conserves time and money. Reducing the inputs while having same output is what our agricultural system needs today. Countless technologies are born to optimize the use of fertilizer where some of which are using drones, image processing and spraying mechanisms.

In our country, Philippines was the 9th largest rice producer in the world, accounting for 2.8% of global rice production. In 2010, our country was recorded as the largest rice importer in the world. Rice is the main food consumed by Filipinos. With 18.15

million metric tons of rice plantation, it feeds a total of 105, 847,929 Filipino living while exporting some of it in other countries around the world. In this kind of rice plantation, we consider it enough or more than enough to supply every household.

However, the Food and Agriculture Organization (FAO) predicts that about 9.6 billion people will inhabit the world by the year 2050 (ISO 2017). This huge population count could bring enormous challenges to the agricultural sector. Due to the rapid growth of the population, there might be a scarcity in the resources that we need.

Some organizations like the Department of Science and Technology (DOST) and National Economic and Development Authority (NEDA) are conducting innovative researches that aims to develop new devices, machines and technologies that could give a helping hand to resolve the predicted rice crisis. One of the solutions that they look forward is the use of Smart Farming. Smart Farming represents the application of modern Information and Communication Technologies (ICT) into agriculture, leading to a thing that can be called as the Third Green Revolution (S&T Media Service. (n.d.). DOST bats for first "smart farm" in PH. Retrieved from http://www.dost.gov.ph/knowledge-resources/news/49-2018/1384-dost-bats-for-first-smart-farm-in-ph.html).

Being in the era of technology, we must meet the need of the rapid growth in our population. That is the reason why we are conducting a research project that aims to contribute in our society and this is by means of using a robot, FARMBOT. It is a drone which has the ability to fly according to the programmed flight pattern and capture aerial images of the rice field. By the use of image processing, it classifies the level of fertilizer needed by the crop and distribute the certain amount of fertilizer needed by the crops.

Other foreign studies that gives highlight for the further utilization of UAV's as a method for cultivation, production and protection processes in agriculture. The first study that utilizes the use of drone for agricultural approach is the FREYR drone: Pesticide spraying drone - an agricultural approach in 2017, this study uses the drone as a pesticide sprayer that uses Arduino board, the electronics prototype platform. It also uses GPS to route the land area, Wi-Fi module, accelerometer, Magnetometer and a wireless camera for image capturing and wireless photo transmission. The second study that highlights the use of UAV is entitled Deployment and Performance of a UAV for Crop Spraying, it uses UAV as a sprayer for a commercial scale. It has different series of spraying techniques for varying volume rates.

On the other hand, another study that had been done is the Automated Aerial Capturing and Identification of Crop Health using Normalized Difference Vegetation Index via Image Processing in March 2017 wirelessly transfers captured aerial images using UAV. It determines the health of crops using the Normalized Difference Vegetation Index. While the study entitled Determination of Green Leaves Density Using Normalized Difference Vegetation Index via Image Processing of In-Field Drone- Captured Image in March 2016 develops an algorithm that will identify the NDVI of the rice paddy that is performed through the use of MATLAB.

1.2. Statement of the Problem

Over the years, farmers are still dependent on the primitive or traditional way of farming that results into a less effective and less efficient outputs. The development on these aspects in our country would result into a great help in agriculture where most Filipino workers are into. Specifically, these farmers have the following agricultural difficulties:

1. Farmers are unable to distribute the precise amount of fertilizer needed by the crops. Moreover, crops will experience fertilizer burn due to excess application of fertilizer causing to it die and takes out nutrients from the soil.
2. Farmers often spends more due to excessive use of fertilizers rather that using the right amount of fertilizer.
3. Farmers are being exposed under the scorching sun for a long period of time that might result to health issues.
4. Some farmers also carry heavy little tanks behind their backs resulting into back pain and injuries.

1.3. Objectives

General Objective:

The study aims to develop a system for unmanned aerial vehicle device that can distribute the corresponding amount of fertilizer based on the captured images that identifies the relative greenness of the rice crop via image processing

Specific Objective:

1. To develop an algorithm that will control the motor driver of the tank at a specific height and spray the fertilizer according to the optimized flight pattern and to the certain level of greenness of the field.

2. To construct a monitoring system for the fertilizer level during the application process.

3. Compare the efficiency of the UAV-based fertilizer sprayer to the manual distribution of fertilizer.

1.4. Significance of the study

These farming issues has been the significant difficulties in our country and something needs to be done for there are more agricultural problems to conquer in the near future due to the rapid growth in the Philippines population.

This project will be meaningful in the optimization in the use of fertilizer while providing ease in today's farming.

The condition of our farmers under the scorching sun with bodies bent toward in farming and lifting heavy little tanks at their back in spraying chemicals should be aided with the fact of existence of today's technology. It would help the farmers to avoid health issues such as sunburns, skin cancer and injuries that could affect their ability to perform at work.

It is also significant to safeguard human health with the actuality of risk posted by spraying of chemicals and pesticide in the environment. According to the University of

Wisconsin in Madison, too much application of fertilizer in plants can result to multiple health issues such as contamination of water that could lead to hemoglobin disorder.

The competent implementation of this study will respond and resolve to vital faming issues and will lead to a remarkable contribution in the society considering the condition of farming as it plays an important role in the quality of life.

1.5. Scope and Limitations of the Study

This study will focus on developing a system that can determine and apply the corresponding amount of the fertilizer using an Unmanned Aerial Vehicle (UAV). It will focus mainly on one of the needs of the rice crop which is the Nitrogen fertilizer. This study will mainly focus on developing an algorithm that will control the motor driver that will switch the logic status of the tank to be able to distribute the desirable amount of fertilizer needed according to LCC that will be given to the crops. This study also focuses to the development of the tank monitoring system that will give an alert to the user about the status of the tank and this will also include the automated return flight of the drone to its user once the tank is almost empty and needs to be refilled.

This research is limited only to the needs of the rice crop and it will not cover other crop needs due to some research. The system will only determine the part of the field that needs N-fertilizer through the relative greenness of the leaves based on the Leaf Color Chart (LCC) and the amount it needs and it will not detect other problems such as pests and etc. By the use of LCC as the basis, the system will not detect other rice crop necessity like Phosphorus and Potassium because Nitrogen is the only responsible for the greenness of the leaf. And also, this study will not cover the automated refilling system of the tank, the tank is limited only to a 1 liter of N-fertilizer and the ability of the drone to determine the weather condition of the field.

1.6 Operational Definition of Terms

In the discussion of this study, the following technical terms are used. A fundamental understanding of the following terminologies will contribute a broad knowledge to the reader.

- **Unmanned Aerial Vehicle (UAV) -** is an aircraft with no pilot on board. UAVs can be remote controlled aircraft or can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems.
- **Image processing** - is a method of performing some operations on an image, in order to get an output image that is either enhancement or to extract some useful details or information from the image itself. It is a type of signal processing in which the input on the system is an image and output can be an image or a characteristics/features related to that image.
- **Arduino** - is an open-source platform used for creating various electronic projects. It consists of both a physical programmable circuit board and a piece of software, or IDE (Integrated Development Environment) that can be used to program the project depending on the need of the user using C programming language that runs on your computer, used to write and upload computer code to the physical board.
- **Ultrasonic Sensor –** a measuring component that works by reading measurements of the distance using ultrasonic waves. The sensor emits sounds that will reflected back and measured as a data.

- **GSM Module -** Global System for Mobile Communications, originally Groupe Spécial Mobile or simply known as GSM module is a device that describes the protocol of second generation of digital cellular networks and can be used as a notification system.
- **Nozzle –** a device designed to control the direction of spraying in the process of application.
- **DC Pump –** a direct current powered pumps are small voltage pumps that generates pressures needed to be able to spray fertilizer to the field.
- **Ardupilot –** a software developed for an easier communication between the UAV or unmanned aerial vehicle and the user. Also gives ease in the automation of flight and path analyzation.

Chapter 2

Review of Related Literature and Studies

Conceptual Literature

2.1 Smart Farming

Smart Farming is a farming technique which uses technology to improve the quantity and quality of some agricultural products. Accordingly, the adaptation of such techniques and precise measurement within the field, farmers can powerfully increase the efficiency of fertilizers. Similarly, by using Smart Farming techniques, monitoring the needs of individual crops to prevent them to have diseases and lack in nutrients is much easier for the farmers. (FAO.org. (n.d.). Retrieved from http://www.fao.org/family-farming/detail/en/c/897026/).

2.2 Leaf Color Chart

Nitrogen fertilizers are important in production of rice. The application of N-type fertilizers several times during the process of nurturing the crops ensures that the crop's nitrogen need is provided. Using the Leaf Color Chart makes it easier to determine the nitrogen fertilizer needed by the rice crops. LCC has four green classifications, with color ranging from yellow green to dark green. It governs the greenness of the rice leaf, which indicates its nitrogen content.

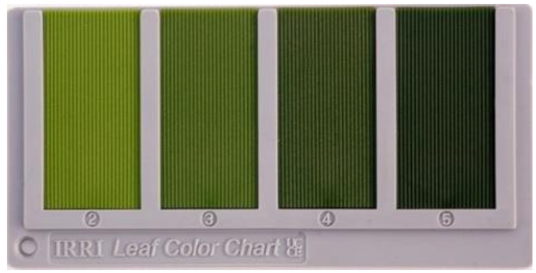


Figure 2.1: Leaf Color Chart (IRRI Rice Bank Knowledge)

According to the USAID, if the mean leaf color is midway between 3 and 4, distribute an average amount of fertilizer. If the mean leaf color is higher, apply less fertilizer than the usual amount needed. If the mean leaf color is lower, apply more fertilizer than the amount commonly needed (Leaf Color Chart. (n.d.). Retrieved from http://www.knowledgebank.irri.org/step-by-step-production/growth/soil-fertility/leaf-color-chart).

Table 2.1: Range of Fertilizer N (IRRI Rice Knowledge Bank) (ex. 315 sq. meter)

Rice		Total Fertilizer N in kg ha^{-1}			
Timing	**DAYS**	**Level 5 (40kg)**	**Level 4 (80kg)**	**Level 3 (120kg)**	**Level 2 (160kg)**
Basal (Preplant)			*	*	**0.162L**
Early Tillering	**14-20**	**0.162**	**0.203**	**0.284**	**0.284**
Midtillering	**20-35**	*	**0.203**	**0.324 (+/-) 0.081**	**0.365 (+/-) 0.081**
Panicle Initiation	**40-50**	**0.324**	**0.243**	**0.365 (+/-) 0.081**	**0.405 (+/-) 0.081**
Heading to first flowering	**60-70**	*	*	*	**0.122 -0.162**

2.3 Spraying

Spraying is one of the common terms when it comes to agriculture, it is a method of distribution of different fertilizer, chemicals or any compound materials needed by the crops. In spraying, the chemicals to be applied should be in water form or diluted in to liquid form or, less commonly, in an oil-based carrier. The mixture is then applied as a fine mist to plants, animals, soils, or products to be treated. The development of more effective sprays and their increasingly widespread use in agriculture have created concerns among biologists. New chemicals and new precautions have only partially reduced these dangers.

2.3.1. Tank

A tank is a container that holds liquid or gas. It will serve as the container for the fertilizer while the drone distributes the fertilizer to the crops (TANK | definition in the Cambridge English Dictionary.(n.d.) Retrieved from https://dictionary.cambridge.org/ us/dictionary/english/tank).

2.3.2. Fertilizer

Fertilizer can be presented in two forms, natural or artificial substances, containing the chemical elements that improve growth and gives nutrients. Fertilizers enhances the natural fertility of the soil or sometimes replace the chemical elements taken from the soil by the previous crops.

Modern chemical fertilizers contains one or more of the three components that are most essential in plant nutrition: nitrogen, phosphorus, and potassium. Of secondary importance are the elements of sulfur, magnesium, and calcium.

Nitrogen is one of the most important chemical that the plants must have. It is used for the growth and greenness of the leaves. Yellowish leaves indicate that the plant has insufficient nitrogen, so, the plants needed more nitrogen in order for it to be in a healthy condition (Britannica, T. E. (2019, January 10). Fertilizer. Retrieved from https://www.britannica.com/topic/fertilizer).

2.3.2.1. Type of Fertilizer

Urea

This type of fertilizer is available in a crystalline, organic forms. It is a fertilizer high in nitrogen concentration and made fairly hygroscopic. Urea is also produced in different forms such as granular or in pallet and is coated in a non-hygroscopic inert material. It can be soluble in water that can quickly penetrate the plant and also can quickly produce results. It is similar to ammonia that is pure in giving nitrogen on the fertilizer but it is highly suggested that it should not reach the seeds (Kurtz, L. (2018, September 03). How to Apply Urea Fertilizer. Retrieved from https://www.wikihow.com/Apply-Urea-Fertilizer).

Ammonia

This type of fertilizer is made of about 80% Nitrogen and comes in liquid form that can be easily distributed on the crops. Additional type is an 'aqueous ammonia', which came from the combination of Ammonia and water. The anhydrous liquid form of Ammonia is formed by mixing it into the irrigation water or by direct application into the soil from special containers. It is not very much recommended into home type gardeners for such use of ammonia as a fertilizer in much expensive ((n.d.). Retrieved from https://www.cropnutrition.com/ammonia).

2.3.3. Nozzle

A nozzle is a device designed to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them in a direction or characteristic of a flow as it moves towards outside the container itself.

A nozzle is either a open pipe or tube of varying sizes, and it can be used to directly modify the flow of a fluid.

The nozzle performs four basic functions:

1. Atomizes liquid into droplets.
2. Disperses the droplets in a specific pattern.
3. Meters liquid at a certain flow rate.
4. Provides hydraulic momentum (Nozzle. (2018, December 16). Retrieved from https://en.wikipedia.org/wiki/Nozzle).

2.3.3.1. Type of Nozzle

Full cone nozzles

- Axial-flow full cone nozzles extraordinarily distributes fertilizers compared to other nozzle type in terms of impact area of the liquid distribution, spray angles and droplet sizes. The high precision and accurate method of spraying is obtained by orienting the liquid inlet to the center of the swirl chamber of the nozzle.

- Full cone nozzles produce a solid circle of spray. These type of nozzles are used in distribution of fertilizer or any liquid that needs to cover a certain area (Lechler. (n.d.). Full cone nozzles. Retrieved from https://www.lechler.com/de-en/products/product-range/general-industry/full-cone-nozzles/).

2.3.4. Motor Driver

A motor driver is a little current amplifier; the function of motor drivers is to take a low-current signal and translate it into a high-current signal that can be used to control or operate a motor.

There are different kinds of motor drivers. Most common types are categorized by maximum supply voltage, maximum output current, rated power dissipation, load voltage, packaging type and number of outputs.

The most common values for maximum supply voltage are 36 V and 52 V. The number of outputs can be between 1 and 12, with the most common motor drivers having 1, 2 or 4 outputs (Buy Motor Drivers Products Online | Future Electronics. (n.d.). Retrieved from https://www.futureelectronics.com/c/semiconductors/analog--drivers--motor-drivers/products).

2.3.4.1. Pump

The main source of the sprayer and a major component for constructing the flow of liquid towards its output is by the use of a pump. Since in numerous circumstances requires unlike pressures or flowrate in order to achieve the desired result, a good use of the exact pump at the right time is very much needed. Furthermore, the pump should also be robust enough to endure toxic compounds that can cause excessive deterioration. Though pumps, added with chemical corrosion protections, are likely expensive, but they are much used due to its durability.

2.3.4.1.1. Type of Pump

Diaphragm pumps

These compact pumps are popular for use with abrasive and corrosive pesticides. Their oil-filled piston chambers protect the pump materials (Britannica, T. E. (2014, May 02). Pump. Retrieved from https://www.britannica.com/technology/pump).

2.4. Timing of Fertilizer Distribution

Timing and Frequency of Fertilizer Application in the crops bring significant effect. Proper timing of the fertilizer application reduces nutrient losses, increases nutrient use efficiency and prevents damage to the environment.

2.5. GPS

The Global Positioning System (GPS) is a satellite-based navigation system that utilizes about 24 satellites along the orbit of the earth. It works in any weather conditions, at any point at the world, 24/7, with no subscription fees or setup charges (GPS. (n.d.). Retrieved from https://techterms.com/definition/gps).

2.6. Fertilizer Level Sensor

Level sensors detects the amount or level of liquids and other chemicals and fluidized solids, including slurries, granular materials, and powders that exhibit an upper free surface in an open system or closed system. Substances that flow horizontally from their containers because of gravity whereas most solids moves at an angle of repose to the peak. The substance to be measured should be inside a container. The level measurement can be either continuous or point values. Continuous level sensors measures the amount of fertilizer or liquid within a specified range, while point-level sensors only indicate whether the substance is above or below the sensing point. Generally, the latter detect levels that are excessively high or low.

These sensors are connected to an output unit for sending out the results as a way of monitoring system. The present technologies uses wireless transmission of information for the notification system, which is very useful in important and hazardous locations that cannot be simply accessed by common workers (Different Types of Level Sensors and its Applications. (2018, March 15). Retrieved from https://www.elprocus.com/different-types-level-sensors-applications/).

Related Studies

2.7. Agriculture Drone for Spraying Fertilizer and Pesticides

Kale et. al. (2015) conducted a study entitled "Agriculture Drone for Spraying Fertilizer and Pesticides". The researchers used algorithm to adjust the Unmanned Aerial Vehicle (UAV) route under changes in wind intensity and direction for more stable flight of the drone. For means of communication, they used radio receiver. They mount Lithium batteries since this is the preferred power sources for most electric modelers today. The battery offer high discharge rates and a high energy storage/weight ratio. For flight control software they used Multi Wii since it is compatible with most of the sensors and hardware boards and can be connected to Arduino micro- controller boards.

2.8. An Automatically Controlled Drone Based Aerial Pesticide Sprayer

The project study of Hangal et. al. entitled "An Automatically Controlled Drone Based Aerial Pesticide Sprayer" used a device which is a combination of spraying mechanism on a quadcopter frame. This study used Arduino UNO microcontroller to control the on/ off of the sprayer and the buzzer if the level of the pesticide reach its threshold. In addition, they also installed a sonar for the altitude control along with the barometer.

2.9. Development of a Spray System for an Unmanned Aerial Vehicle Platform

In the research of Huang et. al. (2009), they developed a low volume spray system for use on a fully autonomous Unmanned Aerial Vehicle for applying crop protection product on specified crop areas. The proponents used a UAV helicopter SR200 powered by a two-stroke gasoline engine. They developed an electronic control system to trigger spray release based on specified Global Positioning System (GPS) coordinates and pre- program spray locations for the spray mechanism.

2.10. Freyr drone: Pesticide/fertilizers spraying drone

In study of Spoorthi et. al. (2017) entitled “Freyr drone: Pesticide/fertilizers spraying drone” they used a drone connected into an android application for the user to easily control the drone. With the help of Wi- Fi Module (ESP 8266) they connect the interface of the drone to the mobile phone. Also, they accurately route the land area using GPS. Global Positioning System, or simply GPS, imparts the user with positioning, navigation, and timing. The FREYR drone also aims to safeguard public health to the threats of pesticides through the utilization of Arduino board, the open source electronics prototype platform

2.11. Quadcopter UAV Based Fertilizer and Pesticide Spraying System

According to World Health Organization (WHO) estimates, that there are about above 1 million pesticide cases every year. In that span, not more than one death in each year is recorded, especially in developing countries due to the pesticides sprayed by human being. Meivel et. al. (2016) has developed a project to resolve this problem. Their project can lift-off for about 8 kilogram in total. The drone is installed with multispectral camera which can provide an accurate multi-band data for agricultural remote sensing applications. This camera can take the images on following five band are Blue, Green, Red, Red Edge, Near-Infrared. Their sprayer is controlled by Radio Frequency which control the actuator of the sprayer module. The Nozzle of the sprayer part will be triggered by GPS device. This GPS having the designated GPS coordinates. The sprayer pump overflow rate is max, 1L/minutes. The maximum spraying altitude is about 4 meters. The flying speed is at a maximum of 5m/s. It covers about 2m range of green fields with compatible land edge.

Chapter 3

Methodology

This chapter presents the methods and procedures used in the development and implementation of the project. The proponents also included the Fertilizer distribution process of the UAV, the tank monitoring system, algorithm for automated return flight system and the design process.

3.1IPO

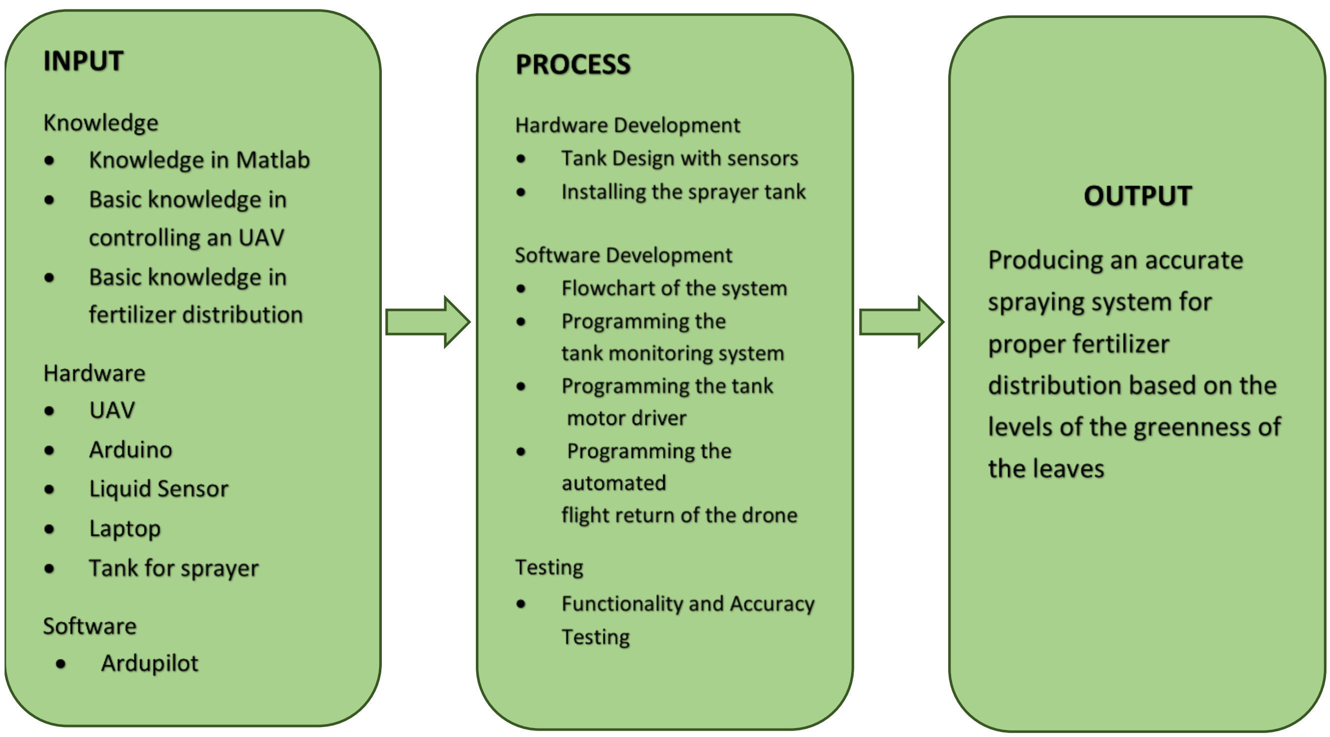


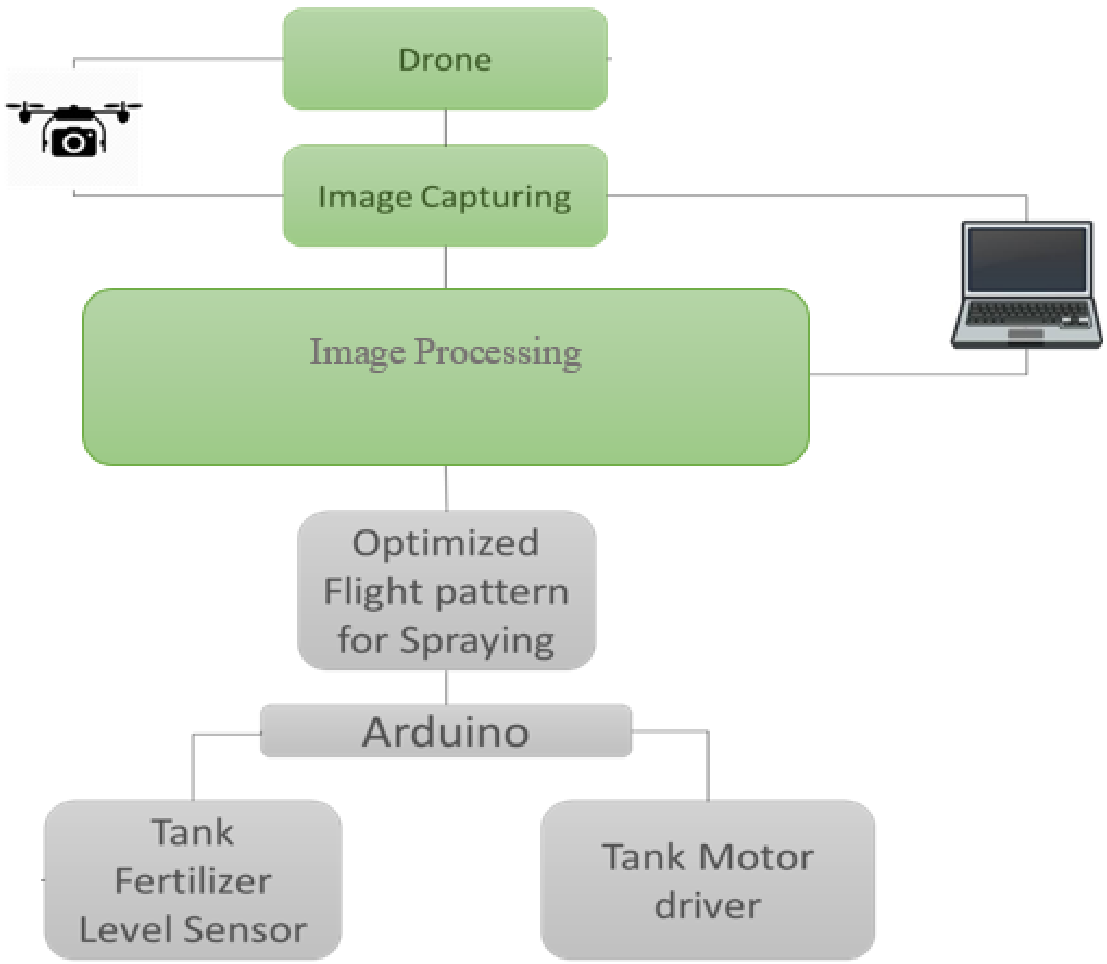
Figure 3.1: Input Process Output Diagram

Figure 3.1 shows that the input process output model of the study. For the inputs: knowledge in these particular sections are essential in the process of completing and gathering the desired output of the project study, these sections are namely Matlab (Matrix Laboratory), UAV controls and fertilizer distribution. For prototyping, UAV, Arduino, laptop, liquid sensor and a tank for sprayer are needed and on the programming part, a software such as Ardupilot is required.

The model of the study is divided into three parts: the hardware, software and testing. For the hardware the fertilizer tank is open for customization depending on the compatibility of it through the spraying process. Meanwhile for the software development, programming the automated flight return system, programming the tank monitoring system, programming the tank motor driver, programming the automated flight return system and programming the automated flight pattern for distribution of fertilizer should be developed. And for the output the UAV must distribute the fertilizers based on the levels of the greenness of the leaves following the flight in an automated manner.

3.2 Research Process

To further understand the process on how the FARMBOT will work a block diagram was made. This block diagrams are shown in figures 3.2



Figures 3.2: FARMBOT Block Diagram

In Figure 3.2 the UAV is controlled by the Android mobile application where the dimension of the field is an input. The UAV or drone is composed of two important part, the controller and the Sprayer mechanism.

a. ***Controller***

The controller is used to control the function of the drone such as the speed, the altitude, the pattern or the movements of the drone. The drone is also programmed in two modes. The manual mode and the autonomous mode.

- ***Flight Pattern Control***

The flight pattern control will depend on the stitched download photos processed by image processing system using Matlab.

- ***Motor Speed Control***

As per the adjustments in the values of various sensors the speed of the motors can be shifted to accomplish required task

b. ***Sprayer Mechanism***

The spraying mechanism performs the following functions:

- ***Spraying Speed Control***

Speed of spraying can be controlled by sending signal to the motor driver circuit using Arduino. By this way, too much application of fertilizer can be avoided.

- ***Optimized Flight Pattern for Spraying***

Once the processed image has been transferred to the drone, a program will be used to create an optimized flight pattern for proper distribution of fertilizer on the rice field.

- ***Tank status***

The status of the tank will be monitored using a non-contact digital liquid sensor. If the fertilizer level reaches a certain set level, it will go back to its set station and notify the operator with the alarm using the mobile application, then the operator can now refill the tank.

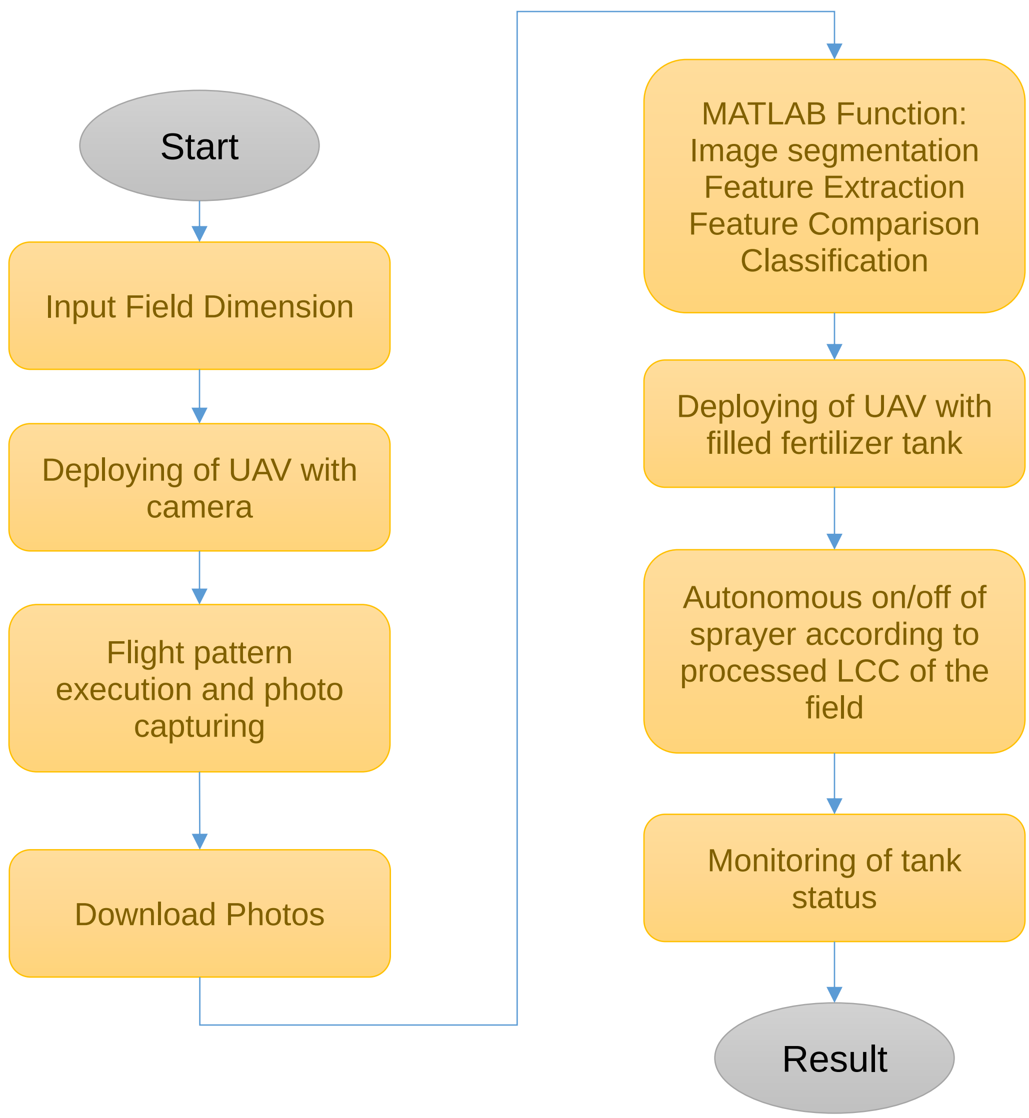


Figure 3.3: Process Flowchart

A. Image Processing

To the input field dimension, the UAV with camera will follow the programmed pattern to capture the photos of the field, the photos will be downloaded to MATLAB, in there the image processing occur.

- ***Image Segmentation***

Image segmentation is the process of dividing an image into multiple parts. This is typically used to identify objects or other relevant information in digital images

- ***Feature Extraction***

Feature extraction is a set of methods that map input features to new output feature. The image undergoes color analysis and differentiate the different levels of the leaf based on the Color Leaf Chart LCC, which has four levels.

- ***Feature Comparison***

The color level of the leaf will be the basis on how much fertilizer does the area, with particular color level, needed.

B. Fertilizer Tank

- ***Motor Driver***

The control of the pump upon its flight on the field will be controlled by the motor driver depending on the need for fertilizer by each level.

- ***Tank Monitoring system***

The tank monitoring system will be essential in triggering the Flight Return pattern of the UAV. It will determine the amount of N-fertilizer inside the tank and alert the user on the status of the tank. The sensor will control the movement of the drone if it sensed that the amount left inside the tank is not enough. It will automatically stop its flight pattern and move to return to its set destination to be refilled manually by the user and continue the process of spraying.

3.3 Algorithm Development for Spraying

As we aim to develop an algorithm that will take control of the tank motor driver at a specific height and spray fertilizers according to the certain level of needed for the field a visual representation of the step by step function of the system is required.

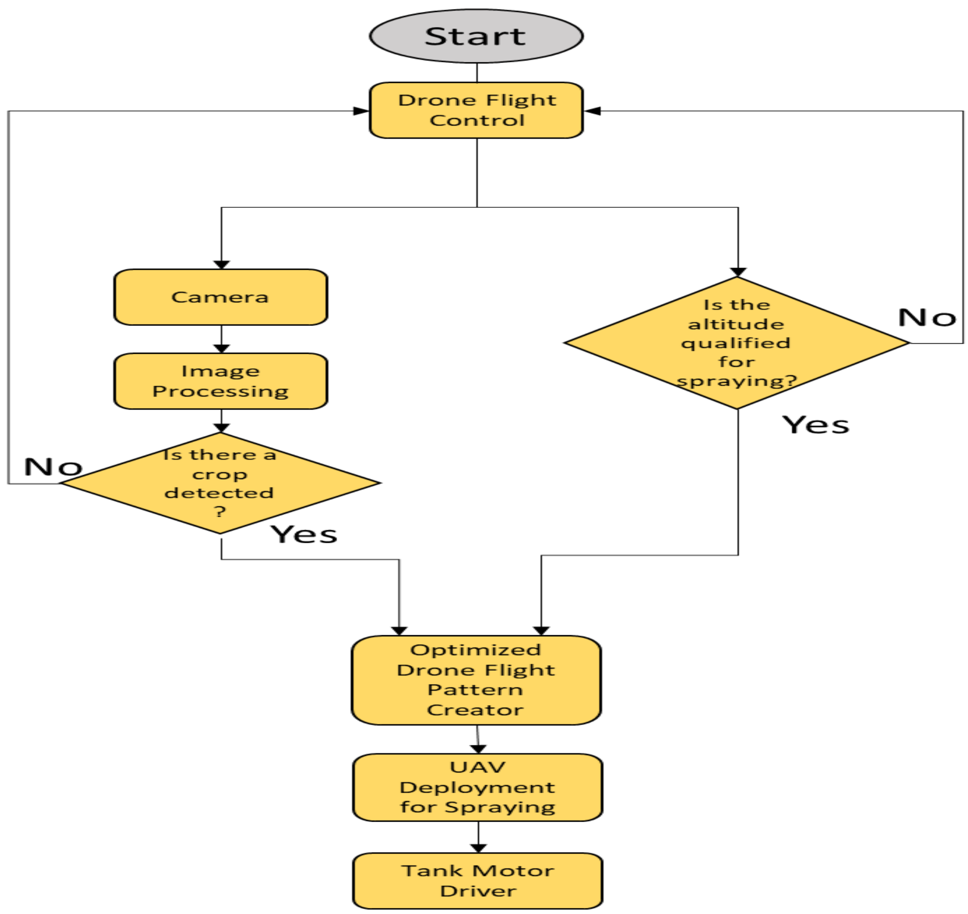
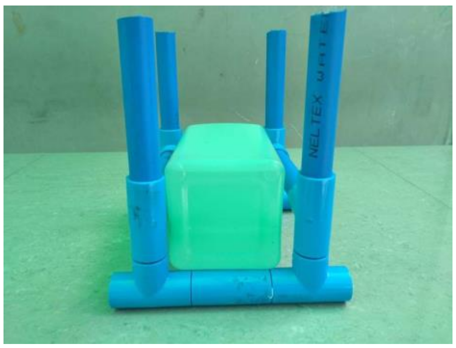


Figure 3.4: Flowchart for the Motor Driver

In the figure 3.4, we can see that the process of spraying the fertilizer into the field starts by capturing images and determining the level of the crops present in the field. Then, a logic program is used to determine the altitude of the system and alert the user if the programmed altitude is not qualified for fertilizer spraying. Once the altitude qualifies for the spraying and crops are detected, a program will start to analyze the processed image and create an optimized path for the drone to take and then the drone will be deployed once more and will start to take its optimized flight pattern. Since the captured images already underwent image processing the motor tank driver will control the on and off function of the pump to equally distribute the fertilizer to the rice crops.

3.3.1 Tank Design



(a) (b)

Fig. 3.5 Tank Design (a) Bare tank design (b) Colored tank design

The design of the tank is essential to the effectivity of the project. The weight and the compatibility of the tank once it was placed into the drone. There are several things to consider such as the flight stability and the altitude control of the system once it starts to fly. The tank design that will be used is made of plastic to minimize the weight being carried by the UAV.

The outside appearance of the box will be an edgeless container with open top for the manual refill. This box will be customized and subjected to further adjustments depending on the ability and capability of the drone to carry this tank.

The nozzles will be aligned parallel to the path of the drone to avoid repetitive application of fertilizer that might result to fertilizer burn. The pump that will be controlled is a micro 12V dc pump.

3.3.2 Fertilizer Spraying

(a)

(b)

Fig. 3.6 Spraying Materials (a) Nozzles and hose (b) 12V DC pump (retrieved from https://www.lazada.com.ph/products/12v-dc-5lmin-60w-micro-car-diaphragm-high-pressure-water-pump-i254653897-s350020353.html?)

For the fertilizer spraying, a program will be created to control the on and off function of the tank using Arduino. This program will be based on the processed image by the use of MATLAB. Once the drone starts to fly and the nozzles are paralleled with the path the Arduino will start to control the pump and spray fertilizers on the path depending on the needs of the crops based on its relative greenness on the Leaf Color Chart.

3.3.3 Optimized Flight Pattern Creator

Fig. 3.7 Ardupilot Software

The program will be utilized in order to create an optimized flight pattern for the drone to take. This program will be essential due to the energy and time conservation that it could give. The path of the drone upon spraying will depend on the processed image and the relative greenness of the field crops.

3.4 Tank Monitoring System

In this part of the project, the idea of creating of a monitoring system for the amount of fertilizers left inside the tank is aimed to achieve. Also, the automated flight return system of the drone once the set level of fertilizer inside is left. The process of the tank monitoring system is shown in figure 3.8;

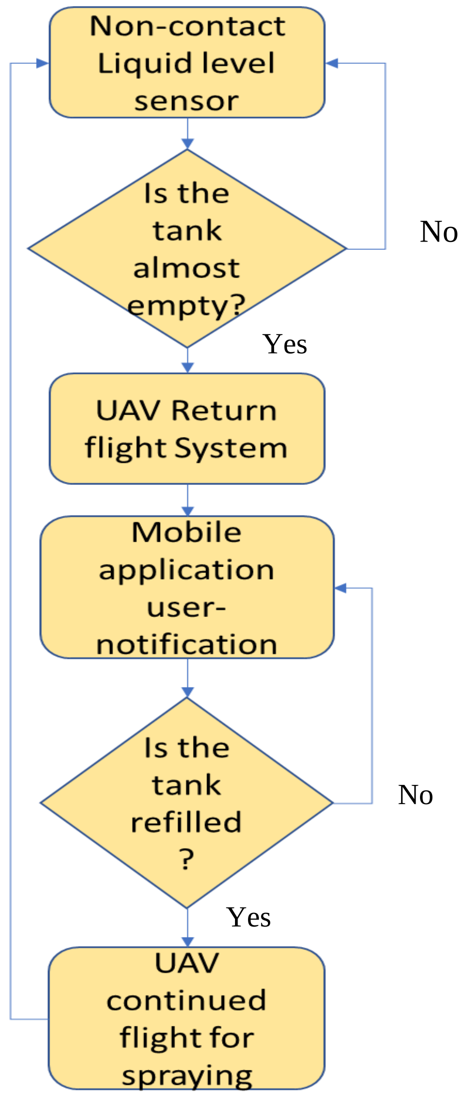


Figure 3.8: Flowchart of the Tank Monitoring System

It is shown in the figure that the non-contact liquid level sensor and the ultrasonic sensor are the main piece of the monitoring system since these sensors will act as the first piece to know the amount of fertilizer left inside the tank. After knowing the amount of fertilizer remaining, a program will be used in determining if the amount left is still suitable for applying fertilizer into the field. Once the amount is short, the UAV return flight system will be used in order for it to approach the set place for it to land and be refilled. Once it has landed the user will be notified using the mobile application and another program will be used to determine if the tank was already refilled by the user.

3.4.1 Installation of the Non-contact Liquid Level Sensor

Fig. 3.9 Non-Contact Liquid Level Sensor (retrieved from https://www.makerlab-electronics.com/product/non-contact-digital-liquid-level-sensor/)

The Non-contact liquid level sensor is an advanced technology sensor where it only identifies the amount of liquid inside a tank depending on the placement of the sensor outside the tank. This is connected to an Arduino Uno which will control the output sent by the sensor. This sensor is useful even for hazardous applications of chemicals. It is an advantage to other types of sensors that is commonly installed inside the container.

3.4.2 Programming the Arduino and GSM module

(a)

(b)

Fig. 3.10 (a) GSM module (retrieved from http://www.e-gizmo.net/oc/index.php?route=product/product&product_id=1270) (b) Ultrasonic Sensor (retrieved from http://www.e-gizmo.net/oc/index.php?route=product/product&product_id=1385&search=ultrasonic+sensor)

A program will be developed to interpret the data sent by the ultrasonic sensor. This data will undergo several commands which will be sent to the user's mobile phone via GSM module or through a text message.

This data will be sent to the mobile phone by the use of the GSM module connected in the Arduino Uno. The GSM module gives access to mobile networks. It is a cheap device that can make your project more powerful and it will also act as a mode for information transmission from the microcontroller to a device.

3.5 Testing Procedure

The testing procedure involves testing the functionality and reliability of the system. Functionality testing involves the following:

3.5.1 Hardware Testing

Testing the flight system, if the unmanned aerial vehicle can perform the desired flight pattern of the user.

For the motor tank driver, the images taken by the camera will beused to control the on and off of the pump to distribute fertilizers on the field.The amount of fertilizer will be checked and may be tend the adjustment of the motor driver.

The non-contact digital liquid sensor present outside the tank will be tested for the resistance and connection of the circuit which will be essential in determining the tank status.

3.5.2 Motor Tank Driver Test

1. To determine the ability of the motor driver to control the pump on and off system based on the Leaf Color Chart (LCC);
2. To determine if the algorithm created to do such task is properly working and;
3. To obtain the desired result in the plants health caused by the perfect execution and application of fertilizer into the plants.

3.5.3 Accuracy Test

1. 2 rice fields will be prepared for testing

2. Each 2 sq.m corners of the two plots were prepared for testing.

3. A test run using the application will be done at the required height.

3.5.5 Statistical Treatment of Data

The required reliability for the system is 95%. To compute for the reliability, first compute for the required number of successful trials. Using the Fundamental Formula of Gambling,

$$N = \frac{\log(1-DC)}{\log(1-p)} \tag{1}$$

Where:

N is the number of successful trials required

DC is the degree of certainty that the event will occur (95%)

p is the probability of the event (50%)

$$N = \frac{\log(1-0.95)}{\log(1-0.50)} = \mathbf{4.32} \tag{2}$$

Therefore, to achieve 95% reliability, the system must achieve at least 5 successful trials.

3.6 Technical Evaluation

Aside from functionality and reliability testing, the project will be also evaluated by deploying it to the community. The purpose of this is to determine the project's effectiveness and possibility of being marketed by having it evaluated by experts.

3.7 Gantt Chart

The following table shows the entire time table of the thesis development.

Table 3.3: Gantt Chart

TOPIC/TASK	Dec. 2017	Jan. 2018	February	March	April	May	June	July	August	Septembe	October	Novembe	December	Jan. 2019	February	March
Conceptualization of Topic for Project Study					■											
Research of Problem for Topic Defense					■											
Drafting and Finalization of Presentation for Topic Defense					■											
Topic Defense					■											
Proposal Writing for The Problem and its Setting					■	■										
Proposal Writing for Related Literature and Studies						■										
Proposal Writing for Methodology						■										
Project Research and Consultation for Title Proposal						■										
Initial Hardware and Software Design of the Project						■										
Finalization of Chapters 1 to 3, Documentation and Presentation						■										
Title Defense						■										
Consultation for the Hardware Design						■	■									
Canvass and Purchase of Components and Materials						■	■									
Final Hardware and Software Design and Programming								■	■							
Project Assembly										■	■					
Testing and Evaluation of the Project											■					
Documentation of the Project for Pre-Final Defense											■					
Pre-Final Defense											■					
Further Project improvement												■				
Deployment of the Project													■	■	■	
Final Evaluation of the Project															■	
Preparation for Final Defense															■	
Final Defense															■	
Final Revision of the Project Document and Bookbinding															■	■

Chapter 4

Results and Discussions

4.1 General Functionality Results

FARMBOT is an automated drone-based sprayer of fertilizer that analyzes the field through image processing and defines the level of greenness of each crop. After the analyzation process, a path will be developed depending on the level of the crop where the drone will automatically take flight and distribute the amount of fertilizer. In an instance where the amount of fertilizer is insufficient to continuously spray on the field, the GSM module will then be triggered by the ultrasonic sensor and the non-contact liquid level sensor to send a text message to the user or operator that the drone will automatically fly back to the designated home position to be refilled. Once the drone is refilled, the drone will continue its flight from the point where the spraying process was postponed.

These presented data are the results from the test conducted for FARMBOT. Particular results are separated into two to show the significance of the project. Expected results shall be cleared of any failed response from the project. The amount of fertilizer being sprayed and the total time being saved using the project are all evaluated.

4.1.1. Volume of the fertilizer sprayed on the field

Table 4.1: Fertilizer Volume per Test

Flight Trial No.	No. of Flights	Actual Land Size	Amount of fertilizer typically used by the farmers	Ideal Amount of Fertilizer Based on LCC (mL)	Actual Amount of Fertilizer Used (mL)	Amount of Fertilizer Saved Compared to Manual Farming
Test 1	1	17 meters by 14 meters	893	527	546	347
Test 2	1	15 meters by 11 meters	620	527	538	82
Test 3	1	21 meters by 15 meters	948	527	600	348
Test 4	2	21 meters by 15 meters	948	527	300/320	328

***NOTE: According to the Philippine Rice Research Institute, the total amount of fertilizer being sprayed in a hectare of field is 30L of N-type fertilizer.**

Table 4.1 shows the amount of fertilizer used by FARMBOT in each test compared to the volume of fertilizer used in manual method of farming. In test 1 of the project, a land size of 238 sq. meter is used. It is shown that the amount used in manual farming is about 948 milliliter of liquid nitrogen fertilizer, compared to the amount of fertilizer used by FARMBOT that is about 600 milliliters of fertilizer. About 36.71% of fertilizer was saved using the project and has shown efficient use of fertilizer that can be a vital thing to help the farmers in the current system of the conventional farming in the country.

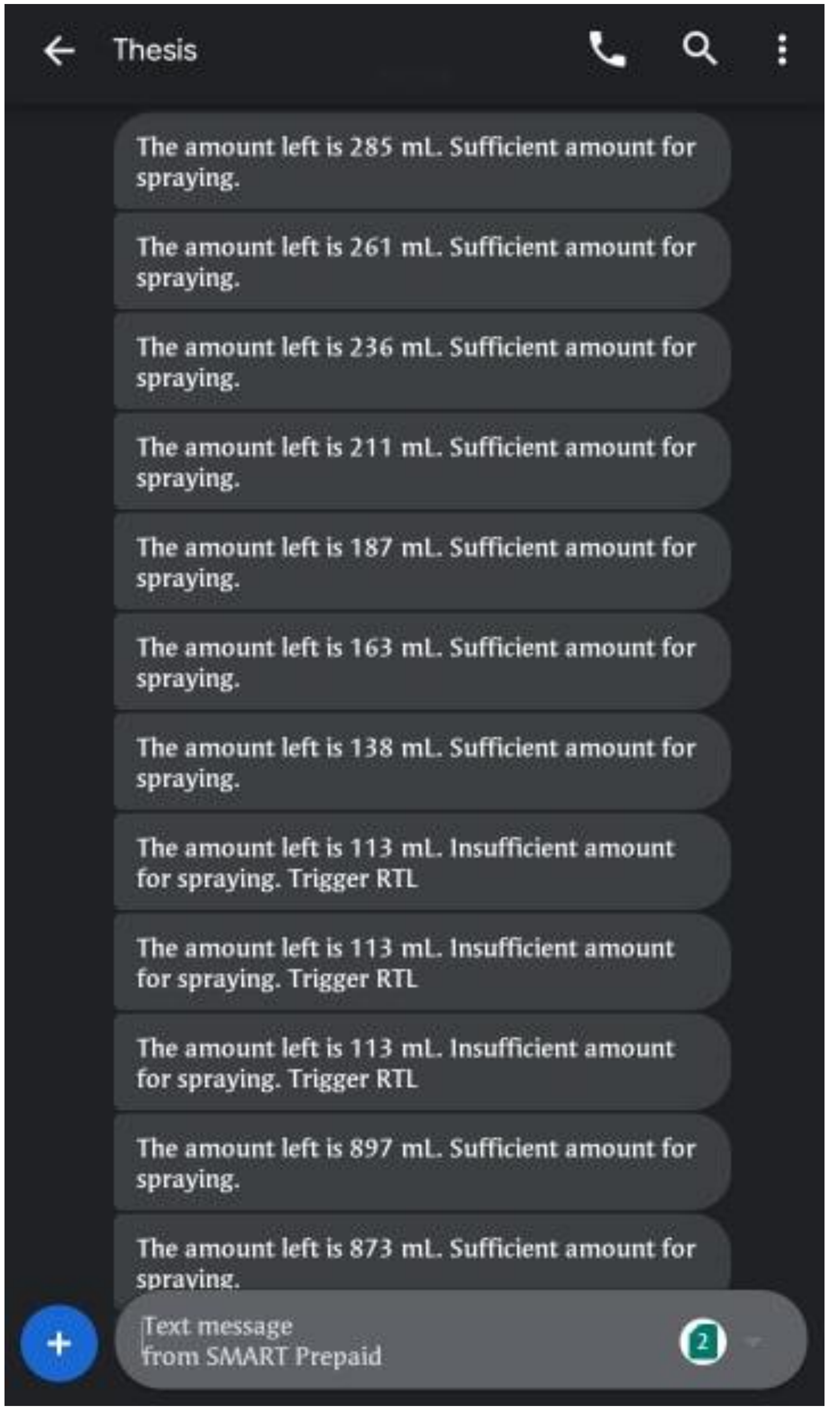


Fig. 4.1 FARMBOT User Notification using GSM Module

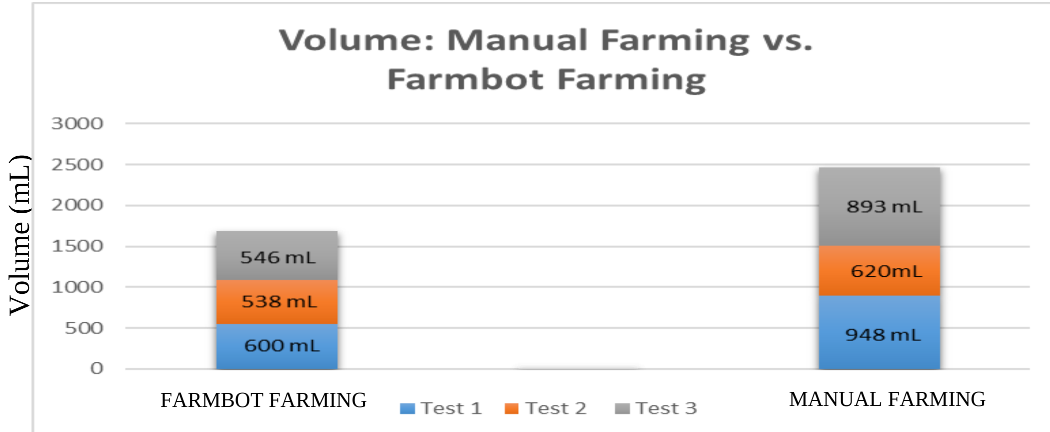


Fig. 4.2 Amount of fertilizer used in the field vs. used fertilizer using manual

4.1.2. Total time spent on spraying fertilizer using FARMBOT vs. Manual Farming

Table 4.2 Total time spent on the overall process

Flight Trial No.	No. of Flight	Image Capturing Time (seconds)	Spraying Time (seconds)	Manual farming (seconds)	Total time saved (seconds)
Test 1	1	104 secs	101.55 secs	435 secs	229.45 secs
Test 2	1	120 secs	117 secs	371 secs	134 secs
Test 3	1	167 secs	146.8 secs	708 secs	394.2 secs
Test 4	2	170 secs	95.4/74.6 secs	708 secs	368 secs

*NOTE: According to the Philippine Rice Research Institute, the total area of the field covered by spraying fertilizer is about 0.8ha/day. (http://www.philrice.gov.ph/?s=nitrogen+fertilizer , http://www.philrice.gov.ph/databases/references/, http://www.philrice.gov.ph/services/infotxt-e-info/)

Table 4.2 shows the time that the FARMBOT spends in spraying fertilizer for each test compared to the time spent for manual farming. In test 1 of the project, only uses about 205.55 seconds compared to the manual way of farming that takes about 435 seconds or approximately 7.25 minutes to finish the spraying of fertilizer on the field.

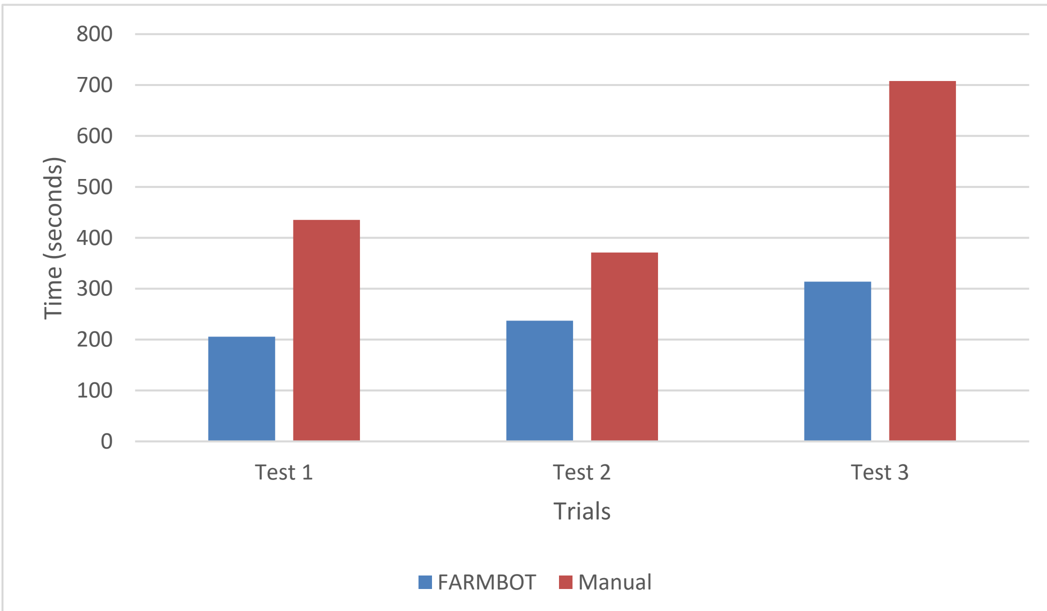


Fig. 4.3: Total time spent in seconds

4.2 Volume Test Results

Table 4.3 T-test analysis of the amount of fertilizer used by FARMBOT vs. Manual farming

Volume to manual		
t Stat	2.508004917	
P(T<=t) one-tail	0.033099081	
t Critical one-tail	2.131846786	

Table 4.3 above are the values gathered that will be used in analyzing the significance of the study. The following data are used in showing how significant the study compared to the manual method of farming.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}} \quad (3)$$

$$= \frac{820.3333333 - 561.3333333}{\sqrt{\frac{(3-1)175.6597089^2+(3-1)33.72437299^2}{3+3-2}\left(\frac{1}{3}+\frac{1}{3}\right)}} = 2.508 \quad (4)$$

The following computation was made using the values and the formula itself. Since the critical value for the right-tailed test is 2.132, it can be observed that t=2.508>t, c=2.132, it is then concluded that the null hypothesis is rejected.

Using also the P-value approach: the p-value is p=0.0331 and since 0.0331<0.05 it is concluded that the null hypothesis is rejected.

4.3 Total Time Test Results

Table 4.4 T-test analysis of the total time spent on spraying fertilizer by FARMBOT vs. Manual farming

Manual farming and FARMBOT farming time		
t Stat	2.333721004	
P(T<=t) one-tail	0.039962856	
t Critical one-tail	2.131846786	

Table 4.4 shows the values gathered that will be used in analyzing the significance of the study. These data are used in the confirmation process of the significance of the study in terms of efficient use of time in spraying the amount of fertilizer needed by the crops.

The data gathered defines the significance of the study. Since the critical value for the right tailed test is 2.132, where we can see that $t=2.334>t, c=2.132$, it is then concluded that the null hypothesis that the null hypothesis should be rejected.

Also using the P-value approach: we can notice that the p-value is 0.03996. And since the p-value is < 0.05 or 5%, it is concluded that the study is significant and the null hypothesis should be rejected.

Chapter 5

Summary of findings, Conclusion and Recommendations

Summary of findings

With the continuous improvement of the UAV industry, they are now used as a solution to solve various problems in the industry. The agricultural industry is one sector wherein this kind of technology can be applied. In this paper, presents the utilization of an unmanned aerial vehicle in rice crop analysis and fertilizer spraying.

The present way of spraying fertilizer requires a lot of effort and it is very time consuming. Proper management of crops ensures efficiency in the use of inputs such as water and fertilizer. With this, productivity, quality, and yield could be at its maximum. Efficient use of fertilizer conserves time and money. Reducing the inputs while having same output is what our agricultural system needs today. Countless technologies are born to optimize the use of fertilizer where some of which are using drones, image processing and spraying mechanisms.

Conclusion

In this study a new method of farming was proposed and implemented for the image detection and spraying of the needed amount of fertilizer using the leaf color chart (LCC). The following are the conclusion drawn out by the proponents:

- Spraying the right amount of fertilizer using FARMBOT is much more efficient compared to the manual farming.
- FARMBOT effectively uses the fertilizer to balance the greenness of the field.
- FARMBOT efficiently uses time in spraying compared to the natural way of farming.

Recommendations

The project is prepared with full effort to make sure that it would be efficient, dependable, safe and user-friendly. But there are still some recommendations for supplementary improvements. The following are for future researchers.

- Use of another type of fertilizer that will not just correct the certain greenness of the crops but also gives the nutrients needed.
- Use a larger drone that could lift a much heavier payload is much recommended in order for the next study to be able to increase the area which the study could cover.
- A use of a battery with much higher voltage capacity could also be helpful for the future studies for them to operate in a longer period.

Appendix A

Bill of materials

Materials and Equipment

For this project study, the following indicated materials and equipment are needed for the full functionality and to achieve desired output.

Qty.	Specification	Description	Amount (Php)
1 pc.		MATLAB	1450
1 pack	4mmx6mm	Silicone Food Grade Translucent Tube Beer Air Hose Pipe and nozzles	600
1 pc.		DC 12V Professional Automatic Switch Water Pump Automatic Switch 5L/min	1120
1 pc.		Gravity: Non-contact Digital Water/ Liquid Level Sensor for Arduino	495
1 pc.		GSM SIM800L Shield	800

Qty.	Specification	Description	Amount (Php)
1 pc.		Arduino Uno R3	1200
1 pc.		Fertilizer Tank	200
1 pc.		Ultrasonic Sensor HC-SR04	120
120 pcs.		Jump Wires 20cm	140
100 pcs.		Plastic Zip Tie Self-locking Nylon Cable	165
1 pc.		Acrylic Spray Paint (Black)	120
3 meters		PVC Pipe	300

Qty.	Specification	Description	Amount (Php)
1	Package 1: Frame (ST 800 carbon fiber) Esc- 6pcs. (40A ESC hobbywing) Motors- 6 pcs. (MT 4114 motorv 340 kv) Propellers- 6pcs. Carbon fiber 15x5.5 Battery- 2pcs. (5200mah each) Package 2:	UAV	36,600
1	Package 2: Flight controller (pixhawk) Radio controller (fs i6 txrx) Charger (imax B6 AC V2)	UAV	14,630
Total			57,940

Appendix B

Data

COMPARISON BETWEEN THE TOTAL TIME OF MANUAL FARMING VS. FARMBOT

Test 1
Actual Land Size: 17 meters by 14 meters
Actual height of UAV: 3 meters
Number of photos/waypoints: 20 waypoints

Flight Path	Travel Per Waypoint	Delay Time for Spraying	Ideal time traveled	Actual Flight Time
Per level				
Level 2	0	0	0	0
Level 3	7 sec (7 waypoints) + 25 secs (return to lunch) = 32 secs	7 x 2 secs (Loitering) = 14 sec	46 secs	49.24 secs
Level 4	8 sec (8 waypoints) + 25 secs (return to lunch) = 33secs	8 x 2 secs (Loitering) = 16 sec	49 secs	52.31 secs
Level 5	0	0	0	0
		Total	95 secs	101.55 secs

Test 2
Actual Land Size: 15 meters by 11 meters
Actual height of UAV: 3 meters
Number of photos/waypoints: 18 waypoints

Flight Path	Travel Per Waypoint	Delay Time for Spraying	Ideal time traveled	Actual Flight Time
Per level				
Level 2	0	0	0	0
Level 3	9 sec (9 waypoints) + 30 secs (return to lunch) = 39 secs	9 x 2 secs (Loitering) = 18 sec	57 secs	63.8 secs
Level 4	7 sec (7 waypoints) + 30 secs (return to lunch) = 37secs	7 x 2 secs (Loitering) = 14 sec	51 secs	53.2 secs
Level 5	0	0	0	0
		Total	108 secs	117 secs

Test 3
Actual Land Size: 21 meters by 15 meters
Actual height of UAV: 3 meters
Number of photos/waypoints: 36 waypoints

Flight Path	Travel Per Waypoint	Delay Time for Spraying	Ideal time traveled	Actual Flight Time
Per level				
Level 2	0	0	0	0
Level 3	11 sec (11 waypoints) + 30 secs (return to lunch) = 41 secs	11 x 2 secs (Loitering) = 22 sec	63secs	65.8 secs
Level 4	15 sec (15 waypoints) + 30 secs (return to lunch) = 45 secs	11 x 2 secs (Loitering) = 22 sec	67 secs	81 secs
Level 5	0	0	0	0
		Total	130 secs	146.8 secs

COMPARISON BETWEEN THE AMOUNT OF FERTILIZER USED BY THE MANUAL FARMING VS. FARMBOT

Test 1

Flight Path	Initial Volume (mL)	Volume After Spraying (mL)	Amount Sprayed (mL)
Per level			
Level 2	0	0	0
Level 3 (7 waypoints)	950 mL	616 mL	334 mL
Level 4 (8 waypoints)	616 mL	404 mL	212 mL
Level 5 (5 waypoints)	0	0	0
Total			546 mL

Test 2

Flight Path	Initial Volume (mL)	Volume After Spraying (mL)	Amount Sprayed (mL)
Per level			
Level 2	0	0	0
Level 3 (9 waypoints)	972 mL	652 mL	320 mL
Level 4 (7 waypoints)	652 mL	434 mL	218 mL
Level 5 (2 waypoints)	0	0	0
Total			538 mL

Test 3

Flight Path 3	Initial Volume (mL)	Volume After Spraying (mL)	Amount Sprayed (mL)
Per level			
Level 2	0	0	0
Level 3 (11 waypoints)	980 mL	628 mL	352 mL
Level 4 (15 waypoints)	628 mL	400 mL	248 mL
Level 5 (10 waypoints)	0	0	0
Total			600 mL

Appendix C

Codes

For the GSM Module

```
#include <GSM.h>

#include <NewPing.h>

#define TRIGGER_PIN 11

#define ECHO_PIN 12

#define MAX_DISTANCE 200

GSM gsmAccess;

GSM_SMS sms;

char remoteNumber[20]="+639566802992";

int b=8;

int bb;

char txtMsg[200]="The amount left is "Volume" mL. Sufficient amount for spraying";

NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE);

void setup() {

  // put your setup code here, to run once:

Serial.begin(9600);

pinMode(bb,INPUT);

Serial.println("SMS Messages Sender");

}

void loop() {

  // put your main code here, to run repeatedly:

bb= sonar.ping_cm();

unsigned int Percent=(((bb+2)/10)*100);

unsigned int Volume=Percent*1000;

if (bb > 2){
```

```
sms.beginSMS(remoteNumber);

sms.print(txtMsg);

sms.endSMS();

  Serial.println("The amount left is "Volume" mL. Sufficient amount for spraying");

delay(1000);

}

else{

  Serial.println("The amount left is "Volume" mL. Insufficient amount for spraying. Trigger
RTL");

  delay(2000)

 ;

    Serial.print(bb);

   Serial.println("cm");

}

}
```

For the Non-contact liquid level sensor

```
void setup(){
  //start serial connection
  Serial.begin(9600);
  pinMode(2, INPUT);
  pinMode(13, OUTPUT);
}

void loop(){
  //read the switch value into a variable
  int sensorVal = digitalRead(2);
  //print out the value of the liquid level
  Serial.println(sensorVal);
  if (sensorVal == HIGH) {
    digitalWrite(13, LOW);
  }
  else {
    digitalWrite(13, HIGH);
  }
}
```

Appendix D

Specifications

Non-contact Liquid Level Sensor XKC-Y25-T12V SKU: SEN0204

Introduction

The non-contact liquid level sensor utilizes advanced signal processing technology by using a powerful chip with high-speed operation capacity to achieve non-contact liquid level detection. No contact with liquid makes the module suitable for hazardous applications such as detecting toxic substances, strong acid, strong alkali and all kinds of liquid in an airtight container under high pressure. There are no special requirements for the liquid or container and the sensor is easy to use and easy to install.

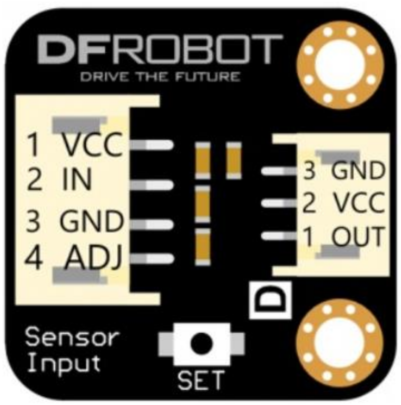
The liquid level sensor is equipped with an interface adapter that makes it compatible with DFRobot "Gravity" interface. There are 4 levels of sensitivity which are set by pressing the SET button.

Specification

Operating Voltage (InVCC) :	DC 5 ~ 24 v
Current consumption:	5 mA
Output voltage (high level) :	InVCC
Output voltage (low level) :	0V
Output current:	1 ~ 50 mA
Response time:	500 ms
Operating Temperature :	0 ~ 105 ℃
Range for thickness of induction (sensitivity):	0 ~ 13 mm
Humidity:	5% ~ 100%
Material:	ABS.
Waterproof performance:	IP67
Dimension :	28 * 28 mm / 1.1 * 1.1 inches

Pin Description

Non-contact Liquid Level Sensor probe XKC-Y25-T12V



Non-contact Liquid Level Sensor Adapter

Liquid Level Sensor-XKC-Y25-T12V Pin defination

Num.	Name	Description
1 (Brown)	VCC	InVCC (range: +5V~+24V)
2 (Yellow)	OUT	Liquid level sensor signal output
3 (Blue)	GND	GND
4 (Black)	ADJ	Sensor sensitivity adjusting switch (Adjust the sensor sensitivity, 4 modes in all. Click the **SET** button on the adapter to set the sensor sensitivity.)

Liquid Level Sensor-XKC-Y25-T12V Pin defination

Num.	Name	Description
Left_1	VCC	InVCC (range: +5V~+24V)
Left_2	OUT	Liquid level sensor signal output
Left_3	GND	GND
Left_4	ADJ	Sensor sensitivity adjusting switch (Adjust the sensor sensitivity, 4 modes in all. Click the **SET** button on the adapter to set the sensor sensitivity.)
Right_1	OUT	Signal
Right_2	VCC	InVCC
Right_3	GND	GND

DC 12V 60W High Pressure Water Pump Automatic Switch 5L/min Pump

Specification:

Model: 0142YB-12-60
Voltage : DC 12V
Amps : 5A
Rate power: 60W
Pressure: 0.8MPA(MAX 120PSI)
The largest flow: 5L/MIN
Medium temperature: 0 ℃ -100 ℃
Inlet and outlet size: 10mm
Size: 16.5 x 10 x 6.2cm
Working medium: no oil, no strong corrosive, non-acid and alkali, without solid particles of liquid;

Features:

1.Diaphragm pump combines the advantages of self-priming pump and chemical pump. Installed in a dry, well-ventilated location; pumps cannot work in water.
2.Using a variety of imported corrosion-resistant materials, self-priming, thermal protection, smooth operation, long-time continuous idling, long-time continuous load operation.
3.Totally sealed, high stable pressure.
4.Rubber bracket can absorb vibration from the pump when working.
5.When the water pressure is too high, pump will protect themselves and normal work, water pipes will not burst, it is safe and durable.
6.Pressure protection: pressure switch power protection.
7.The maximum flow of 5 L / min, flow rate can be adjusted from 0.1 to 5 liters / min depending on the needs.
Maximum pressure 120PSI (8.0 kg) of pressure can be adjusted from 75PSI (5 Gongjin) - 120PSI (8.0 Kg) according to different needs.
8.The work: intermittent service (continuous working at different working pressures at different times)
9.The use of media: water or solvent PH value 5--8, oil. Service life: more than 500-1000 hours of continuous work.
10.Pressure Switch Type Features: When the water turned off, it will automatically cut off power, the motor is stopped. After the water turned on, will automatically power on, motor running.

GSM SIM800L Shield

Features:

- With power saving technique for low current consumption.

- Audio channel which includes two microphone input, a receiver output and a speaker output.

- External antenna pad

Specifications:

External Input Power Supply	+5VDC
Current Required	1A-2.6A(MAX)
Band Frequency	Quad-band
Default baud rate	9600bps
Working Temperature range	-40 °C ~ +85 °C
SIM Interface	1.3V, 3V
Timing Functions	Use AT Commands Set
PCB Dimensions	53mmx70mm

Arduino Uno R3

Specifications:

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-9V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P)
	of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Ultrasonic Sensor HC-SR04

The ultrasonic sensor HC-SR04 uses sonar to determine distance to an object. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package. From 2cm to 400 cm or 1” to 13 feet. It operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect). It comes complete with ultrasonic transmitter and receiver module.

Features:

Power Supply :	+5V DC
Quiescent Current :	<2mA
Working Current:	15mA
Effectual Angle:	<15°
Ranging Distance :	2cm – 400 cm/1″ – 13ft
Resolution :	0.3 cm
Measuring Angle:	30 degree
Trigger Input Pulse width:	10uS
Dimension:	45mm x 20mm x 15mm

Appendix E

Documentation

System Development

System Development

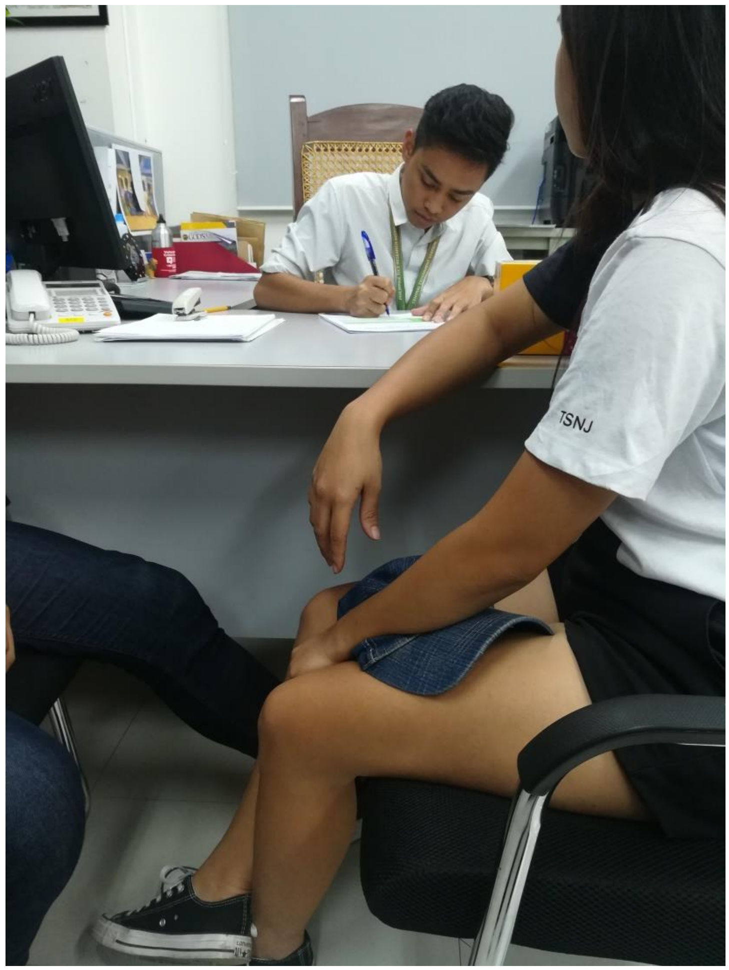
System Development

System Development

System Development

System Development

Verification of Data Gathered



Appendix F

Vitae

JUDE MARCO D. BAYOT
1st Street corner Main Street, Paco, Manila
Contact no.: 0909-815-0196/ 0975-133-8048
E-mail Address: judemarco1996@gmail.com

OBJECTIVE

- To be able to acquire an On-the-Job Training that will enhance my knowledge and skills in the field of Electronics and Communications Engineering

SKILLS

- Microsoft Office, Microsoft Presentation & Microsoft Excel
- Knowledgeable in MATLAB, AutoCAD Fusion 360 and many other software tools
- Knowledgeable in electrical equipment and circuit construction techniques
- Good Video Editing Skills

PERSONAL INFORMATION

Date of Birth	:	October 02, 1996
Age	:	22 years old
Gender	:	Male
Height	:	5' 3"
Weight	:	115 lbs.
Religion	:	Roman Catholic
Civil Status	:	Single
Citizenship	:	Filipino

EDUCATIONAL ATTAINMENT

TERTIARY : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES - MANILA
Bachelor of Science Major in Electronics and Communications Engineering
AY: 2013-Present

SECONDARY : FRANCISCO P. TOLENTINO MEMORIAL NATIONAL HIGH SCHOOL
Tolentino West, Tagaytay City, Cavite
SY: 2009-2013
5th Honorable Mention

PRIMARY : MAHARLIKA ELEMENTARY SCHOOL
Maharlika East, Tagaytay City, Cavite
SY: 2003-2009
9th Honorable Mention

SEMINARS/TRAININGS

July 23, 2013 "Expanding Electronics Engineers' Horizon"
IRTC Conference Hall,
Technological University of the Philippines- Manila

March 05, 2014	"Bakit ECE? Eh meron namang iba; Expanding Electronics Engineers' Horizon" RTC Conference Hall, Technological University of the Philippines- Manila
February 10, 2018	"Autodesk Fusion 360 Workshop" De La Salle Santiago University Avenue, Ayala Alabang Village, Muntinlupa City
July 30, 2018	"TRENDS: Topic for Research in Electronics, Networking and Data Sourcing" IRTC Conference Hall, Technological University of the Philippines- Manila

CHARACTER REFERENCE

ENGR. LEAN KARLO S. TOLENTINO
Officer in Charge, Electronics Engineering Department
Technological University of the Philippines-Manila
0995-892-5845

MR. GREGORIO LOVERIA SANGALANG
Adviser of FPTMNHS School Publication
Francisco P. Tolentino Memorial National High School
0919-773-3529

I hereby certify that the above information is true and correct to the best of my knowledge and ability.

Applicant's Signature

BRYAN DAYTON EDWARD NORIEL GALVADORES
38 Cadena de Amor Vergonville Subdivision
Pulanglupa II Las Pinas City
09081556036
bryangalvadores1127@gmail.com

GALVADORES, BRYAN DAYTON EDWARD N.

OBJECTIVE

- Pursuing opportunity which will allow me to grow professionally, while effectively utilizing my versatile skill set to help promote your corporate mission and exceed team goals.
- To learn and gain experience in able to improve skills in the field of Electronics Engineering by undergoing internship in this company.

PERSONAL SKILLS

- Can communicate well
- Passionate and driven to learn new things
- Collaborative and able to work in teams or groups
- Independent and self-sufficient in handling tasks
- Apply safety practices
- Highly motivated, dedicates and welcomes new challenges
- Hardware proficient in digital logic trainer and with basic knowledge in PCB designing and soldering.

PERSONAL INFORMATION

Date of Birth: November 27, 1996
Place of Birth: Paranaque City
Age: 21
Citizenship: Filipino
Civil status: Single
Father's name: Dondale J. Galvadores
Mother's name: Nancy N. Galvadores

EDUCATIONAL ATTAINMENT

TERTIARY	**:**	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Bachelor of Science in Electronics Engineering Ayala Blvd. Ermita, Manila AY: 2013-Present
SECONDARY	**:**	Las Pinas North National High School Aurora Drive, Vergonville Subdivision, Las Pinas City 2009 – 2013
PRIMARY	**:**	Holy Rosary Academy Naga Road, Pulanlupa II, Las Pinas City 2003 – 2009

ORGANIZATION

June 2014-Present	Organization of Electronics Engineering Students (OECES) Member College of Engineering Technological University of the Philippines
June 2014-Present	Institute of Electronics Engineers of the Philippines Inc. (IECEP) Member

SEMINARS

- Bakit ECE? Eh meron namang iba. Expanding Electronics Engineers' Horizon
  IRTC Conference Hall TUP Manila
  March 5, 2014
- Expanding Electronics Engineers' Horizon
  IRTC Conference Hall TUP Manila
  July 23, 2013
- ENGINEERING LEADERSHIP CONFERENCE
  Melchor Hall, UP – Diliman, Quezon City
  January 27, 2018

CHARACTER REFERENCES

ENGR. August C. Thio-ac
Professor, ECE Department
TUP- Manila
Contact No.: 0917 841 3616, +639423963404

ENGR. LEAN KARLO S. TOLENTINO
Instructor 1, Department of Electronics Engineering
College of Engineering, TUP-Manila
(+63)995-892-5845

I hereby certify that the above information is true and correct to the best of my knowledge and ability.

Applicant's Signature

CHRISTIAN JASON G. GEOLLEGUE
1200 Wagas St. Tondo, Manila
Contact no.: 09566802990/09219620680
E-mail Address: jasongocotano@gmail.com

OBJECTIVE

- To obtain a supervisory position that will enable me to use my skills, and ability to work well with people in the field of engineering
- To pursue opportunity which will allow me to grow professionally, while effectively utilizing my versatile skill set to help promote the company's corporate mission and exceed team goals

SKILLS

- Microsoft Office, Microsoft Presentation & Microsoft Excel
- Knowledgeable in MATLAB, AutoCAD Fusion 360 and many other software tools
- Knowledgeable in electrical equipment and circuit construction techniques
- C# and Java Programming Languages

PERSONAL INFORMATION

Date of Birth	:	May 29, 1998
Age	:	20 years old
Gender	:	Male
Height	:	5' 7"
Weight	:	145 lbs.
Religion	:	Roman Catholic
Civil Status	:	Single
Citizenship	:	Filipino

EDUCATIONAL ATTAINMENT

TERTIARY : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES - MANILA
Bachelor of Science Major in Electronics and Communications Engineering
AY: 2014-Present

SECONDARY : LAKAN DULA HIGH SCHOOL
Juan Luna St. Tondo, Manila
SY: 2010-2014

PRIMARY : FRANCISCO BENITEZ ELEMENTARY SCHOOL
Solis St. Tondo, Manila
SY: 2004-2010

SEMINARS/TRAININGS

July 23, 2014	"Expanding Electronics Engineers' Horizon" IRTC Conference Hall, Technological University of the Philippines- Manila
March 05, 2014	"Bakit ECE? Eh meron namang iba; Expanding Electronics Engineers' Horizon" RTC Conference Hall, Technological University of the Philippines- Manila
February 10, 2018	"Autodesk Fusion 360 Workshop" De La Salle Santiago University Avenue, Ayala Alabang Village, Muntinlupa City
July 30, 2018	"TRENDS: Topic for Research in Electronics, Networking and Data Sourcing" IRTC Conference Hall, Technological University of the Philippines- Manila

CHARACTER REFERENCE

ENGR. LEAN KARLO S. TOLENTINO
Officer in Charge, Electronics Engineering Department
Technological University of the Philippines-Manila
0995-892-5845

MR. JEREMY TERRENCE ERNI
Student
Technological University of the Philippines-Manila
09327716637

I hereby certify that the above information is true and correct to the best of my knowledge and ability.

Applicant's Signature

AIRIELLE JAN NARTEA
Purok 9, Lalaan 2nd, Silang, Cavite
Contact no.: 09473862040
E-mail Address: airnartea@gmail.com

OBJECTIVE

- To obtain a supervisory position that will enable me to use my skills, and ability to work well with people in the field of engineering
- To pursue opportunity which will allow me to grow professionally, while effectively utilizing my versatile skill set to help promote the company's corporate mission and exceed team goals

SKILLS

- Microsoft Office, Microsoft Presentation & Microsoft Excel
- Knowledgeable in MATLAB, AutoCAD Fusion 360 and many other software tools
- Knowledgeable in electrical equipment and circuit construction techniques
- C#, R, Python and Java Programming Languages

PERSONAL INFORMATION

Date of Birth	:	September 30, 1997
Age	:	21 years old
Gender	:	Male
Height	:	5′ 6″
Weight	:	135 lbs.
Religion	:	Roman Catholic
Civil Status	:	Single
Citizenship	:	Filipino

EDUCATIONAL ATTAINMENT

TERTIARY : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES - MANILA
Bachelor of Science Major in Electronics and Communications Engineering
AY: 2014-Present

SECONDARY : TAGAYTAY CITY SCIENCE NATIONAL HIGH SCHOOL
Tagaytay City, Cavite
SY: 2010-2014

PRIMARY : LALAAN CENTRAL ELEMENTARY SCHOOL
Lalaan 2nd, Silang, Cavite
SY: 2004-2010

SEMINARS/TRAININGS

July 23, 2014	"Expanding Electronics Engineers' Horizon" IRTC Conference Hall, Technological University of the Philippines- Manila
March 05, 2014	"Bakit ECE? Eh meron namang iba; Expanding Electronics Engineers' Horizon" RTC Conference Hall, Technological University of the Philippines- Manila
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July 30, 2018	"TRENDS: Topic for Research in Electronics, Networking and Data Sourcing" IRTC Conference Hall, Technological University of the Philippines- Manila

CHARACTER REFERENCE

ENGR. LEAN KARLO S. TOLENTINO
Officer in Charge, Electronics Engineering Department
Technological University of the Philippines-Manila
0995-892-5845

MS. GIRLIE REYES
Student
Technological University of the Philippines-Manila
09269037015

I hereby certify that the above information is true and correct to the best of my knowledge and ability.

Applicant's Signature

JUAN LORENZO P. SUMANGIL
831 Teresa St., Ermita, Manila
Contact no.: 0927-913-1708
E-mail Address: juanlorenzo.sumangil@tup.edu.ph

OBJECTIVE

• To be able to acquire an On-the-Job Training that will enhance my knowledge and skills in the field of Electronics and Communications Engineering

SKILLS

- Microsoft Office, Microsoft Presentation & Microsoft Excel
- Knowledgeable in MATLAB, Arduino, Python and many other software tools
- Knowledgeable in electrical equipment and circuit construction techniques
- Good Video Editing Skills

PERSONAL INFORMATION

Date of Birth	:	February 19, 1998
Age	:	21 years old
Gender	:	Male
Height	:	5′ 7″
Weight	:	106 lbs.
Religion	:	Roman Catholic
Civil Status	:	Single
Citizenship	:	Filipino

EDUCATIONAL ATTAINMENT

TERTIARY	**:**	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES - MANILA Bachelor of Science Major in Electronics and Communications Engineering AY: 2014-Present
SECONDARY	**:**	BATASAN HILLS NATIONAL HIGH SCHOOL IBP Road, Batasan Hills, Quezon City SY: 2010-2014
PRIMARY	**:**	DILIMAN PREPARATORY SCHOOL Commonwealth Ave, Diliman, Quezon City SY: 2004-2010

SEMINARS/TRAININGS

July 30, 2018	"TRENDS: Topic for Research in Electronics, Networking and Data Sourcing" IRTC Conference Hall, Technological University of the Philippines - Manila

CHARACTER REFERENCE

ENGR. LEAN KARLO S. TOLENTINO
Officer in Charge, Electronics Engineering Department
Technological University of the Philippines-Manila
0995-892-5845

I hereby certify that the above information is true and correct to the best of my knowledge and ability.

Applicant's Signature