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SMART PEST IDENTIFICATION AND MANAGEMENT SYSTEM USING DRONE FOR MANGO FARMING

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ABSTRACT: This study assists the farmers by automatically identifying the pest through leaf and fruit markings with mobile and web applications that generate pest prevention and control. It also foresees weather using API for location-based weather prediction in crop management specifically in pesticide application. The use of the drone technology helps capture images of leaves at a high altitude. This project provides innovations on pest management of mango farms by storing data that can be used for future decisions through analytics.

KEYWORDS:*Mango Farming, Weather API, Pest Management, Mobile App, Drone Technology*

1.0 INTRODUCTION

Mangiferaindica, or mango in layman's term, is the Philippines' national fruit.According to the Philippine Statistics Authority, 'Carabao' Mango (also known as the Philippine Super Mango) is ranked 3rd among the most important fruit crop, next to banana and pineapple. Given its high ranking among the most important fruit crop, increasing its production has a big impact not only to the country, but for the public consumers due to lower price since it has a high supply, and for mango farms. Due to the pest infesting trees, the production of the mango dropped by 70% in 2018 which results to the need to match against this kind of contamination.According from a mango grower in Porac, Pampanga, the amount of money allocated for spraying pesticides was doubled since pestswere not eliminated and still infesting their farm. One factor is the influence of rainfall on pesticide efficiency. The researchers aimed to give the necessary convenience for the farmers/growers by providing the service to identify the pest and suggest dates of application.

Integrated Pest Management (IPM) is an approach in controlling the pests that is environmentally sensitive. It focuses on pest prevention and only uses pesticides when needed. IPM programs utilizes all appropriate pest management strategies including pesticide usage. The process includes observation, inspection, and monitoring, as well as the data that have been gathered to develop pest prevention and eradication needs in every circumstance. Identifying the most effective preventive measures and reducing the unnecessary usage of pesticides will be achieved by providing the correct pest identification[9].Because pesticides are sprayed on the trees, the wind may carry them to other fields, grazing area, human settlements and potentially affects other species. Problems of overdose and underdose of pesticides was solved, thus decreasing environmental pollution by detecting the specific type of the pest to lower the costing of buying chemicals and lessen the unused pesticide sprays that may also affect the health of human and environment [11].

One application is the Pest Smart App that helps finding environmentallysafe pesticide products to manage and to hopefully control household and garden pest. This application can be used for mobile and tablet devices to search for pesticide products [1].Sivapragasam, A. et al. researched and designed a Pest Smart intervention in Tra Hat village, Bac Lieu Province in Vietnam. Pest Smart train farmers on fundamental ecological principles, providing quick analysis of the current crop problems, and disseminate about plant health and different crop management advice to farmers. The research identifies about crop pest and disease management activities with specifically to the key crop of the researchers' country, Vietnam [12].

SenseFly by parrot group monitors the emergence right through to yield prediction and the next season's drainage planning. It also includes crop monitoring that enables farmers to precisely identify pest and other issues, and better target their field scouting, soil assessment, plant emergence & population, fertility, crop protection, insurance, irrigation and drainage, and harvest planning [5].Farmapp also developed an Integrated Pest Management (IPM) software-based service for crops. The software developed includes observing and fumigation application that utilizes sensors and improves agriculture sector by using automation devices of Internet of Things (IoT). By serving plant growers involvement with technology, smart farming revolutionizes and improves food production management. Its services include monitoring pests and diseases, soil sensors and weather stations for capturing real time data, as well as fumigation by utilizing a single map route to control applications of fertilizers with the quantity of the product supplied in the field [7].

The technological advancement by using unmanned aerial vehicles (UAV) on capturing high resolution imagery is widely used for assessment on crops and crop protection. Procedures in data collection helped in identification of crops and targets during and after the crop growth period by having the accurate view of the problem to ensure levels of infestation damage [2]. Drones have been useful in analyzing and testing the soil for soil planting and crop management. Drones do help farmers profit by up to 75% and help lessen the expenditure by 85% [4].Inaudito et al. [6] also developed an Image Processing system which paves the way to differentiate beef marbling and fat. They tested various beef using Raspberry Pi to identify the fat

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content of the beef. They have also applied color segmentation, thresholding, blob detection and masking to check the accuracy of the program. In this method they can grade the beef according to its content with great accuracy.

Utilization of different technologies like IoT for integrated pest management is inevitable as it will help the agricultural sector since it involves various tools from biological, chemical, cultural, and mechanical field. A research from 2016 International Conference on Internet of Things [3] which focuses on using IoT for Integrated Pest Management revealed that dealing with the nature of being, ontology, is considered to be the best option in collecting and gathering information about pests and management, since it can be used by other automated systems in an agricultural field.

The general objective of this study is to design and develop a smart pest identification and management system. The specific objectives of the study are the following:

- Utilize the function of a drone camera to distinguish the pests using digital image processing and machine learning of MATLAB
- Create mobile and web applications to determine and view the pest or disease and generalize pest prevention and control with the use of the camera detection.
- Predict weather using online data analytics API for location-based weather prediction

Weather also takes an important role with the efficiency of the pesticide application. According to Jeff Gore [10], weather plays important role in spraying pesticides. It was suggested that pesticides and insecticides should stay at least 8-12 hours before the expected rain, but extended periods are the best.

The project was created to enhance the way farmers integrate pest management and control by identifying and locating the pest to lower the costing of buying chemicals and lessen the unused pesticide sprays that would also affect environment. Gaining information about the pests provides solution with the infestation to cure the mango tree which may also lead to future prevention of unwanted pests.

Figure 1 shows the conceptual framework where the inputs are the research data gathered from the related literature and studies, online resources, past researches, interviews and surveys, and software application along with the interface to database and the prototype. Figure 2 on the other hand, illustrates the software flowchart. Mobile application for administrators is used to access the system, upload image, display result and show weather forecasts. The second mobile application is made available and is published on google play for mango growers to view their transactions.

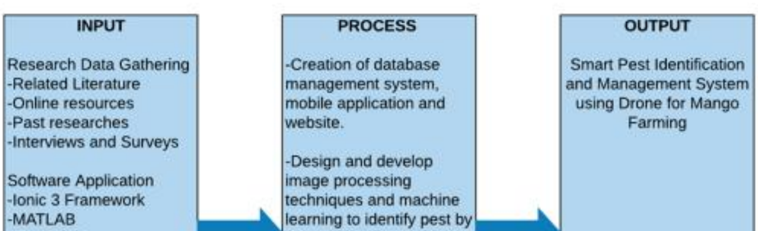

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Fig 1. Conceptual Framework

Web application can be used by the administrator to show the full list of all transactions made. Internet is a vital cog in this system because it serves as the gateway of all the functionalities of the project like the weather forecasts. The server is the one that holds the MATLAB machine learning algorithm which will identify the pest and send the results to the database.

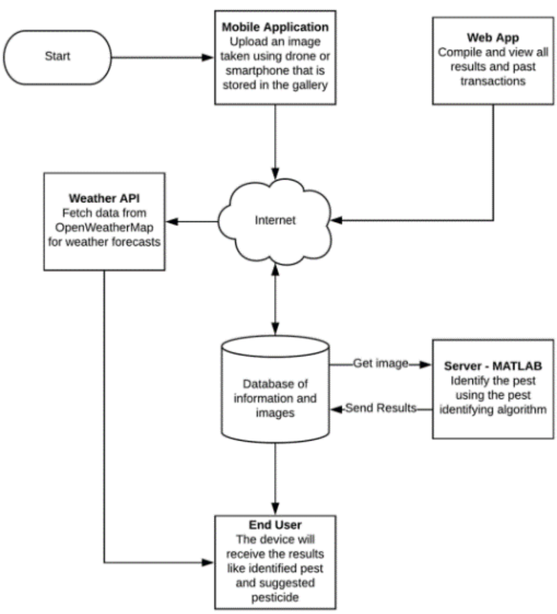

Fig 2.System Flowchart

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In figure 3, camera is used to capture image, whether drone or smartphone. Through current internet technology, the app is connected to the server PC, the one that identifies the pest by running the image to the MATLAB algorithm. Portable printer is used as a contingency and optional receipt for the mango growers to give them tangible results. Figure 4 explains the flow of the MATLAB code.

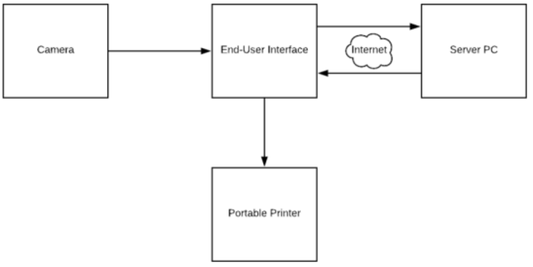

Fig 3. System Operation – Hardware Block Diagram

2.0 METHODOLOGY

2.1 Research Design

The researchers used the descriptive-qualitative research design method. This method involves various collection of quantitative information like scores or test results. In this study, it was be used to measure products that are being harvested every season. The researchers observed and conducted comparison on the types of pest captured from infected farms.

2.2 Procedures

The primary requirement for the development of the project wasthe identification of the resources needed for the hardware and software design and development of the research.For the hardware development, the researchers used a commercially available drone which is the DJI Spark used to capture images and share them to the android application in order to identify and detect the pest using image processing algorithm and machine learning. For the contingency of unavailable internet connectivity, the researchers opted to use a mobile printer named PAPERANG P1 Portable Bluetooth Printer to give the printed receipts of results to the mango growers for each transaction.

For the software development, the researchers utilized MATLAB image processing toolbox to identify the pest and its characteristics using an algorithm and machine learning. The Android Programming was used for the end user. Ionic 3 Framework, is a mobile application development framework that is mostly HTML and TypeScript to generate hybrid mobile applications available for both android and IOS. MATLAB

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runs in the Server PC to process the image sent by the application to the google firebase real-time database system. For the database management, Google Firebase Realtime Database, Authentication and Storage were used to create, read and update data.
The captured images from DJI Spark drone is on JPEG format, which is in RGB with image sizes of 3968x2976, 1440x1080 (ShallowFocus), 2300x1280 (Pano-horizontal), 960x1280 (Pano-vertical).

During requirement gathering, the researchers have searched for a problem that needed solution. Mango farms all over the Philippines, especially in Ilocos and Central Luzon regions, are having difficulty to increase production. This is attributed to the incidence of cecid fly, capsid bug and other fruit flies. To increase production of the mango trees, the researchers identified that a drone can be used to capture images of a mango tree leaf. However, if the images captured only markings, there must be some algorithm to identify the pest when it is unknown. Hence, a pest identifying algorithm and machine learning must be done to smartly identify the pest by only using its leaf markings. A mobile app is also necessary to ease the access of exploring the system and other helpful functions. To ensure availability of the algorithm and to store other data, a server must be built to have access even in other places.

2.3 Sources of Data

The primary sources of data came from the testing of the pest identifier drone and surveys that were generated from survey results and interviews of local mango farmers and researchers from the Department of Agriculture Regional Field Unit III and PRMSU (President Ramon Magsaysay State University) who are currently taking part in the advancement of the Philippine Mango Industry in cooperation with DOST-PCAARRD (Department of Science and Technology - Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development) due to the problems of declining yields and quality associated with the incidence of pest and diseases, alongside with the high cost of production due to inefficient pesticide application.

3.0 RESULTS

The results were obtained from the series of tests of some system parts and hardware. Thesucceeding tables show the testing of the devices and application used.

3.1. KT Analysis

Kepner-Tregoe Analysis is a systematic method used to analyze a problem and understand the root cause of the issue to come up with the best answer or choice by making concrete comparison based on facts. Although it has become very popular in IT and technical fields, it can still be applied to a wide range of problems to solve [8]. Each factor weighs differently based on the researchers' needs, and the analysis shows that DJI Spark is the best choice among the two other competitors.

Table 1: Selection of Drone USING KT ANALYSIS

	DJI Spark	Zerotech Dobby	MJX Bugs 5w
Availability – 10%	10%	9.5%	8%
Scalability – 20%	18%	13%	15%
Camera – 25%	12 MP with 2-axis gimbal 22%	13MP – 24%	8 MP – 20%
Flight Time – 10%	2970 mAhLiPo 3s 16 min – 9.5%	970 mAhLiPo 2S 9 min – 5%	1800 mAh 15 min – 8.8%
Durability – 5%	4.7%	3.5%	4.7%
Dimensions – 10%	143x143x55mm – 10%	135x145x36.8mm – 10%	350x350x95mm – 9%
Takeoff Weight – 10%	300g – 9%	199g – 9%	397g – 8.5%
Features – 5%	Obstacle Avoidance – 5%	-	Additional Gimbal – 5%
Cost – 5%	24,400php – 3%	13,500php – 4%	11,990php – 5%
Total: 100%	91.2%	78%	84%

3.2Hardware Testing

Table 2: Camera distance

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Distance of Drone to the Leaf	Image Description
6 inches	Too Blurry
1 foot	Too Blurry
1.5 feet	Blurred
2 feet	Blurred
3 feet	Blurred
4 feet	Cannot see leaf markings
5 feet	Cannot see leaf markings
6 feet	Cannot see leaf markings

Table 3: Drone Flight Time

Trial	Flight Time
1	14 minutes
2	13 minutes
3	14 minutes
4	14 minutes
5	13 minutes
6	12 minutes
7	12 minutes
8	11 minutes
9	13 minutes
10	13 minutes
Average	12.9 minutes

3.3 Software Testing

Before starting the entire application, the researchers tested if the users were able to successfully install application to the researcher's smartphone having the welcome page and menu page (less memory, faster build test). This gaveresearchers an assurance to continue using Ionic 3 framework.

TABLE 4: DEPLOYMENT OF SAMPLE APPLICATION TESTING ON ANDROID VERSION 7.1.1

Trial	Build	Installation
1	Unsuccessful	Failed
2	Unsuccessful	Failed
3	Successful	Corrupted apk
4	Successful	Corrupted apk
5	Successful	Installed

TABLE5: WEATHER API

Trial	Weather API Forecast	Actual Weather Condition
1	January 08, 2019 23.6°c - 31.5°c light rain	January 08, 2019 24°c - 26°c partly cloudy to at times cloudy

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2	January 09, 2019 24.6°c - 28.9°c light rain	January 09, 2019 24.3°c - 29°c partly cloudy skies
3	January 10, 2019 24.7°c - 28.5°c scattered clouds	January 10, 2019 23°c - 30°c partly cloudy skies
4	January 11, 2019 21.1°c - 30.7°c light rain	January 11, 2019 23°c - 29°c partly cloudy to cloudy skies with isolated
5	January 12, 2019 22.7°c - 31.5°c light rain	January 12, 2019 23°c - 30°c partly cloudy skies
6	January 13, 2019 19°c - 31.5°c light rain	January 13, 2019 24°c - 29°c partly cloudy skies
7	January 14, 2019 19.2°c - 31.6°c sky is clear	January 14, 2019 23°c - 29°c partly cloudy skies

TABLE 6: AVERAGE RESPONSE TIME OF PROCESSES

Process	Description	Average Response Time
Uploading the captured image	Uploading the image taken from the drone or the phone to be used by the algorithm	~3 seconds *may vary, depending on the speed of user's internet connection
Running of pest identifying algorithm	Opening the MATLAB and running the algorithm (using the proposed server PC with at least 4GB RAM)	~15 seconds
Identifying the Pest	Fetching the image from database and image processing from enhancing contrast, segmentation and clustering, multi-SVM and GLCM	~5 seconds
Show results	Fetching the data about the results and suggestions on	<1 second

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	which pesticide to be used	
Print results *Optional	Print the results using a mobile printer	~15 seconds
		Total Average Response Time: ~39 seconds

4.0 DISCUSSION

In the hardware testing, the researchers tested mainly the flight time and camera. During the testing of flight duration, the trials ranged 11 to 14 minutes. The tested flight time was near the official and product flight time as specified in the official DJI website, which was 16 minutes. The researchers believed that the tested flight time was lower than the said flight time because the drone landed when it alerted the drone operator with a low battery warning at the lowest of 15% battery. Another factor about the flight time was the idle time or the time when the drone was turned on but was not flying. Even though idle time did not lower the battery level as fast as when flying, it still wastes battery.

During the camera testing, the researchers observed that the drone camera worked better when capturing images of objects at the range of 1.5 feet to 2 feet from the drone camera. However, the drone should be able capture images closer to be able to have a better, clearer, and closer look of the leaves. The researchers tried to capture images at a closer distance at less than 1 foot by bypassing the obstacle avoidance feature of the drone. However, the results were not good, and images were too blurry, as the camera had difficulties capturing the drone closer than the recommended distance due to the fixed distance of the lens of the camera. The camera takes too blurry images at less than or equal to 1-foot distance from the camera, while it cannot see the leaf markings from 4 feet beyond. The ‘Goldilocks Zone’ of the drone’s camera is a zone where it takes not too blurry images and can still see the leaf markings, ranging from 1.5 feet to 3 feet.

In using the mobile app, the response time of uploading the image to the server took around 3-5 seconds, depending on the speed of the user’s internet connection. Opening the MATLAB and running the pest identifying algorithm in the proposed server PC with at least 4GB RAM was around 10-20 seconds. Identifying the pest usually took around 5-10 seconds using the MATLAB-coded algorithm. Getting or fetching the data about the results and information of the farmers was tested to be less than 1 second response time. For tangible results, the portable printer was used to print the results that takes around 15 seconds to finish depending on the lists of transaction

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needed to be printed out. Overall, the whole system's flow to identify a certain pest usually took 33 to 50 seconds.

The system used weather API OpenWeatherMap which has an average of 1.34° difference in the API's forecasted lowest temperature compared to PAGASA's forecasted lowest temperature, and an average of 1.74° difference in the API's forecasted highest temperature compared to PAGASA's forecasted highest temperature. The weather API got 3outof7 or a 42.86% accuracy in predicting whether it rains or not in a 7-day forecast while 2outof5 or 40% accuracy in a 5-day forecast. According to National Oceanic and Atmospheric Administration - SciJinks, a 7-day forecast usually predict the weather accurately at about 80% of the time, five-day forecast at 90% accuracy and, 10-day or longer forecasts accurately predict weather only about half the time. Using the SciJinks statistics for the reliability of weather forecast, the weather API's accuracy was not very reliable.

5.0 CONCLUSION

The researchers have concluded that this project is an effective measure to identify the pest. However, the system wasnot tested to its full potential since to the project was still on-going during the mango season and the project was done after the pests have infested the mango farms in the region. If given the chance to test it in one full mango season, the researchers can give more data about the effects of availing the research project's services.

The camera played a crucial part in the system's process flow. The researchers wanted to capture images as clear as possible to avoid misidentification. Since the drone's camera was optimized for sceneries, the researchers opted to replace the camera to a small one for drones that have optical zoom to clearly capture the images at a close distance.

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