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Solar Powered Advanced Indigenous Multi-Purpose Remoteless Agro-Based Drone For Digital Farming

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***Abstract*— Agro-Drone is becoming a part of digital Farming. But its implementation is facing major difficulties in terms of cost, technical knowledge of users etc. An agrodrone with multifunction facility such as to irrigate, application of pesticides and classify diseased plants can become one of the solutions to all issues. Battery based drones can run up to 6 to 10 minutes and charging the battery is again an issue during its usage. Apart from these agro drones requires a technical drone pilot to handle them, therefore automated drones with advanced technical settings are required so that even a non-technical person is able to use them. All these are issues are taken care in this work by designing solar powered agro drone along with auto pilot mode. Machine learning algorithm is used along with image processing to classify the diseased plants.**

Keywords—Precision Farming Technologies, Solar Energy

I. INTRODUCTION

India is a land of agriculture and agricultural domain has its own problems and one such may be irrigation problem. Nearly 2/3rd of the India is affected by drought during 2020-22. And drought prone are has increased by 57% since 1997. The report has said that nearly 2 to 5 % reduction in GDP is due to drought conditions in the country. In February 2022, the Loksabha informed that over 17000 farmers between 2018 to 2022 committed suicides in different parts of India, It is national issue between the states of Karnataka and Tamilnadu for the Kaveri river water and Mahadayi project between Karnataka and Goa. One more astonishing observation is that the river Kaveri is drying up in Tamilnadu about 50 kms before reaching the Bay of Bengal Ocean. Similar problems may be all over India. National Commission for Integrated Water Resources Development Plan has made an estimate that by 2050 irrigation sector consumes around 79% of the available water resources. This triggers the requirement for reducing the water wastage in irrigation. As per Open Government Data (OGD) platform India, Drip irrigation leads to about 14 -52% increase in yield with 39- 62% reduction in water consumption. Hence drip irrigation gains more popularity among modern irrigation techniques. As per the experimental result by Sh.Baranchuluun[12], the total cost and benefit was calculated which lead to the calculation of net present value (NPV), benefit - cost ratio (BCR) and the internal rate of return (IRR) for 4 crops[Potatoes,radish,headed cabbage, Tomatoes] and 3 irrigation method (sprinkler, drip and furrow). For example the NPV for drip and sprinkler irrigation in potato are 117.3 and 76.5, which are thrive and twice than furrow irrigation. Drone poses 70% of water can be saved in comparison to traditional spraying methods. The same hold good for pesticide. Based on this analysis, the agro based drone can give Cost benefit of 198.9 which is almost 4 times the furrow irrigation.

With the drone technology amount of water consumption can be further reduced than drip irrigation. So drone technology is gaining its popularity due to its multi and extended functionality. But its usage and implementation restricted only to some people due to its high cost and non-technical knowledge of the users. This work tries to handle these two predominantly so that drones can be utilised for digital farming even by a non-technical agriculturist.

The structure of the paper is as follows: Section 1 introduces irrigation related problems and need of alternative arrangements. Section 2 surveys the solution in this regard. Section 3 mentions the specific problem which this work is dealing. Section 4 focuses on the plant disease identification followed by drone setup for autopilot mode in Section 5. Section 6 is related to methodology of the work and results in section 7 followed by conclusion and future scope in section 8

II. RELATED WORK AND PROBLEM STATEMENT

Now days, drone technology is not only available for military organizations [6] but also in public domain. Such accessibility of the drone technology makes it to extend its functionality and become niche in industries and even agriculture. Its usage has helped to reduce the manpower requirement, monthly cost required to raise and protect their livestock because of continuous monitoring of sky.

The paper [1] compares 2 Random and Distributed parasites' search algorithms. Artificial intelligence (AI) can automate cyber-physical systems and also agricultural processes [2]. Paper [3] check soil moisture which uses remote sensing and ANN for drought analysis in China between 2002 and 2019 which uses severity-area-duration (SAD) analysis.

Early detection of plant disease increases the crop yields which otherwise may impact negatively on the agro market. In research[10],to classify 4 different types of rice leaf diseases like Brown Spot Rice disease (BSR), Brown Spot Rice disease (BSR), Bacterial Leaf Blight disease (BLB) using image processing algorithm like Nai've-Baye , Random

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forest, Decision tree, Gradient Boosting classification algorithm.

In similar work paper [4] detects and classifies the 6 plant leaves diseases like Cercospora leaf spot, Alternaria Alternata, Rust, Anthracnose, Powdery Mildew and Bacterial Blight. It is automated using supervised machine learning technique called multi-support vector machine (m-SVM) algorithm which can be used both for semi structured and unstructured data. Images for the test data were captured by drones.

The paper [5] classifies maize leaf blight leaves, corn rusty leaves, corn gray spot disease leaves, and corn healthy leaves using image processing and neural network. Early-stage wheat detection is done in paper [8] to classify ploughed land from bare lands in low-resolution satellite data. These data is fused with drone data along with machine-learning classifiers.

The paper [7] designs and tests quadrotor drone used in rice seed sowing process. This has spiral spinner which provides sufficient force to overcome any disturbances and rice seed sowing process is made more precise and uniform.

One of the vital plant characteristic parameter is Leaf Area Index (LAI),[9] is needed in monitoring vegetation growth and also to estimate surface vegetation productivity. This work low-altitude drones captures HD images of different varieties of rice and estimates LAI of rice using empirical and porosity model method.

The paper [11] proposes an algorithm to automate the process of ripeness check of fruits using Machine Learning and Computer Vision technology from drone image.

These show that the drones can be used in precision farming with extended functionality.

III. PROBLEM STATEMENT AND OBJECTIVES

The drone is one of the modern irrigation systems. India lags in its implementation because of current agro drone have huge Initial investment on drone. Only technical drone pilots can use the drone. Both these issues are treated in this work by Automated Drone. Present Drone requires remote controllers to route the path of drone which may not be handy by the non-technical farmer. Images of agricultural field are captured and region of interest is exported to the Smartphone. The app creates a best route (in terms of minimal distance and time) using software based routing algorithm which acts blueprint route map for the drone. Even the non-technical farmers can make use of the same handily. Agro drones have the potential to make agriculture more productive, to use time and resources more efficiently. It is more useful in the regions with huge water scarcity.

This work designs and implements an agro based drone with a view of Automated Drone where non-technical farmers can use without any ambiguity.

- Reducing the wastage of water.
- Reducing the amount of pesticides requirement.
- Cost effective drone.
- Crop analysis using image processing techniques.
- Digital Farming. Drought analysis.
- Use of renewable power resource(Solar)

These can be accomplished my making the following extensions to drones:

- Agro drones designed has multi-functionality
    - Irrigation
    - Pesticide
    - Drought analysis
    - Yield analysis
- Use of solar energy for the drone maintenance may make the drone more cost effective and eco-friendly
- Usually the drones for pesticide spraying will spray for entire area but this work will check the wellness of plant and the pesticides are sprayed only for diseased plants.
- Use of autopilot mode will select the preloaded area for which spraying is to be done and spraying is done only at respective area automatically with lesser human intervention
- Obstacle detection is used to handle the drone accidents while in auto-pilot mode

IV. PLANT DIESASE DETECTION USING IMAGE PREOCESSING

For an input image, the ultimate aim is to automatically identify and determine the particular class of plant disease. Initially, the input samples comprising different species and diseases of the plant are collected from the publically available dataset and from the real-world environment via using the drone camera.

Fig.1. show the clock diagram which is used detection diseased plants

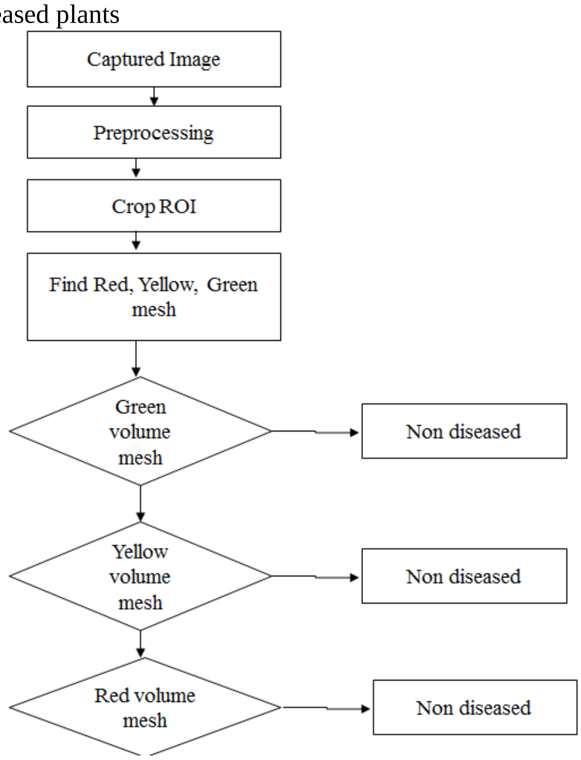

Fig.1: Overview of Plant disease detection

The pre-processed image is split into R,G,B planes . Average of each plane is calculated which gives the amount redness, blueness and greenness respectively. For any diseased plant usually the greenness is lesser. If the greenness

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is more than some threshold it classifies plant to be non-diseased. If the greenness is lesser it finds the yellowness and similarly with the redness.

V. DRONE SETUP AND AUTO PILOT MODE

The Cube autopilot is a further evolution of the Pixhawk autopilot. It is designed for commercial systems and manufacturers who wish to fully integrate a autopilot into their system. All Cube models are compatible with all carriers which allows users to choose an off the shelf carrier board that best suits their needs. System designers are able to integrate the Cube directly into their designs via published carrier board specifications. With respect to sensors, there are 3 redundant IMUs (Accelerometers/Gyroscopes), 2 Barometers and 1 Magnetometer. There is a provision to interface Telemetry, GPS, Drone Remote Unit, Thermal Camera, buzzer, u8 motors, Servo, IR sensor along with the battery.

Cube ArduPilot is an open source, unmanned vehicle Autopilot Software Suite, capable of controlling autonomous: Multirotor drones. The functionality can be altered as per the requirement using python programming language. Copter has 25 flight built-in flight modes, 10 of which are regularly used. Some of them are summarised in Tab.1.

.Tab.1: Some of modes in Autopilot

Mode	Operation
Stabilize	Fly your vehicle manually, but self-levels the roll and pitch axis.
Alt Hold	Holds altitude and self-levels the roll & pitch
Loiter	Like loiter, but manual roll and pitch when sticks not centred
RTL	Returns above take-off location, may also include landing
Auto	Executes pre-defined mission
Brake	Brings copter to an immediate stop
Simple/Super Simple	An add-on to flight modes to use pilot's view instead of yaw orientation

These can be controlled manually or can be by the programming with predefined conditions to activate the respective modes.

In ArduPilot, Polygon can be from to select the region of interest (ROI), and the drone can be made operate only in ROI. This polygon formation can be saved for future usage. Sample of the selection is shown in the Fig.2.In order to handle drone on flight telemetry system is to be activated. Control of the propellers through U8 motors is done by cube orange kit. Ardupilot also has the satellite count feature which gives the number of satellite which is connected to the board.

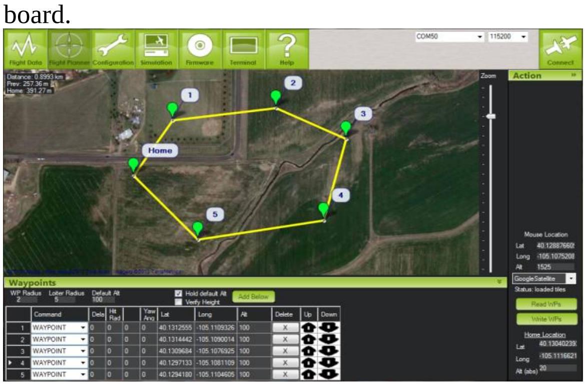

Fig.2: Polygon formation to locate ROI

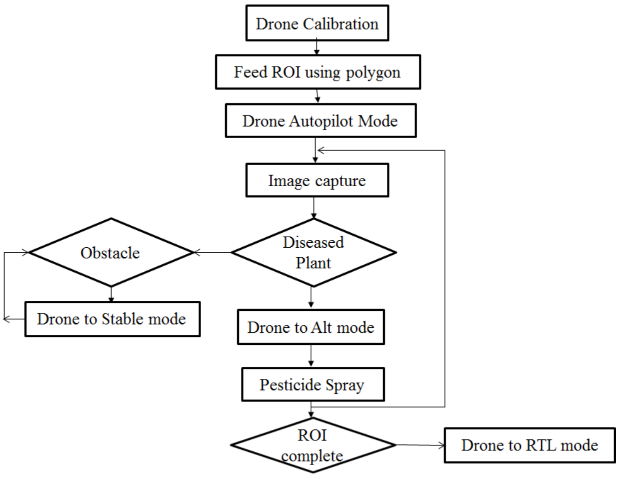

Fig.3: Overview of Pesticide Spraying operation

VI. METHODOLOGY

Before any flight all sorts calibration including GPS, telemetry is done. Polygon is formed to locate ROI in this case it the land around which agro drone is to operate. Drone will operate only in the ROI. Camera is being connected to take real-time images. All the operations pertaining to motor, camera etc. is coordinated by cube orange.

Pesticide spraying:

- Captured image is preprocessed and classification of diseased plant is done based on section 3.
- If the plant is found to be diseased then drone come to Alt Hold mode and then pesticide is sprayed.
- Outflow of the pesticide or water (From the tank is mounted in the drone cabinet) is controlled by motor.
- Obstacle detection sensor with 6m range is placed to sense any obstacle during drone flight. If any obstacle is found then again the drone comes to Alt Hold from stabilize mode.

Overview of the working is summarized in the Fig.3

Irrigation:

This is also done as pesticide spraying but the absence of water is checked by amount of blue and redness.(rather than greenness as in plants)

Solar Powered:

Lithium ion battery is mounted into the drone cabinet to power the drone operation. Apart from solar panel can be used to run drone if it is wired.

Drought analysis:

This is applicable if the land size is more. The camera in the drone will capture the entire ROI by image tailoring. If the present test image has lesser greeness compared to trained image and amount of diseased plants are more then it identifies the condition to be drought.

VII. RESULTS

Data set used here to evaluate performance of plant disease detection /classification is PlantVillage database [13] is online dataset with 54,306 samples of 32 classes and 14 different species of plants like Tomato, Strawberry, Grape, and Orange. Out of which 26 and 14 classes are diseased and healthy plants. For simplicity and due to limitation so RGB camera only 2 classes of plants are considered. The algorithm is checked with accuracy and F1 score parameters.

- Accuracy=$\frac{T_p+T_n}{T_p+T_n+F_p+F_n}$
- F1=2x$\frac{PR}{P+R}$
- Precision, P=$\frac{T_p}{T_p+F_p}$
- Recall, R= $\frac{T_p}{T_p+F_n}$

Where Tp,Tn,Fp,Fn are true positive,True negative, False positive and False negative respectively. Tab.2. gives the summary of the results for considered 2 plants:

Tab.2: Some of modes in Autopilot

Mode	Accuracy	true positive rate (TPR)
Tomato	89.84	89.54
Potato	89.80	89.60

The table shows that the Accuracy is around 90% and TPR rate is also around 90. Sample python output of the disease plant is shown in figure 3.

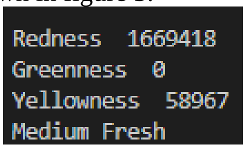

Fig.3: Output of the disease identification

For Green coloured Leaves more Green indicates Fresh and Yellow diseased.

Fig. 4 show one of drone flight in autopilot mode.

VIII. CONCLUSION

- Cost: Low(Existing: drones are High cost).
- Make: Indigenous make (Existing: Most of the deliverable are imported).
- Usage of drone: Even for Non-technical farmers (Existing drones are used Only by technical people).
- Purpose: Irrigation, Pesticide, Crop wealth analysis, Drought analysis (Existing does only Irrigation).
- Drone Accident Control: Yes (Existing has No Control over accidents).
- Control of amount of spray: Automatic (not Manual).
- 14 -52% increase in Yield compared to traditional method.
- Reduction in water consumption compared with traditional method upto 85%.
- Upto 97% reduction in fertilizer cost compared to traditional farming
- Time and manual work reduction.
- Existing drones do not use solar power.

In future

- Multispectral camera can be used and disease classification can be done
- Deviation in the drone path can be automated upon obstacle detection instead of alt mode in this work

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