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Review Article

REVIEW ON APPLICATION OF DRONES FOR CROP HEALTH MONITORING AND SPRAYING PESTICIDES AND FERTILIZER

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Abstract
Agricultural drones are one of the important innovations for increasing productivity of the crops in Indian agriculture field. The monitoring of the crops and the need for spraying pesticides and fertilizers at the correct moment and at the exact location of plants is an important parameter to increase the productivity of the crops. Unmanned Aerial Vehicle (UAV) can be used in agricultural sectors which will reduce the time and the hazardous effects that can cause due to the spraying of pesticides and fertilizers. This paper reviews briefly the implementation of UAVs for crop monitoring and pesticide spraying.

Keywords: Unmanned Aerial Vehicle(UAV), Camera, GPS, crop monitoring, spraying system, ESC, BLDC,RF transmitter, flight controller.

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INTRODUCTION

India is an agriculture based country, where more than 50% of the population is dependent on agriculture field. The increase in population leads to improvement in productivity and protective level in agriculture. The insects tend to damage the crops , which decreases the productivity and hence are killed by use of some pesticides. Frequently, the agriculture field faces destruction losses due to the disease in crops. The pesticides and fertilizers are important component to kill insects and growth a crop. Manually spraying the pesticides, and fertilizers affects humans leading to cancer, hypersensitivity, asthma, and other disorders. Hence , automatic control of fertilizer spraying, and crop monitoring can be done with quadcopter , which is also used for many applications such as search and rescue, Hazmat, police, code inspections, Emergency Management, fire. Additional quadrotor benefits are swift maneuverability, increased payload, high lifting power and stability. The control of quad copter is easier than other aircraft. Quad copter is used in risky areas as well as used in indoor and outdoor. It contains universal sprayer that the sprayer the liquid as well as the solid contents. The global nozzle is spraying the both pesticides and fertilizers but stress pump is used in the pesticide spraying, and have not used in the fertilizer spraying. The GPS can be put to use automatically guide the quad copter and remotely control in large areas. A quad copter controlled by autopilot controller and payload is controlled by RF Transmitter and motors. The figure 1 illustrates the diagram of the monitoring of crops using UAV.

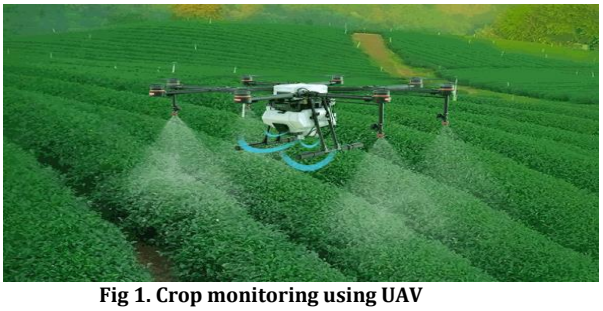

Fig 1. Crop monitoring using UAV

In present year's crop health monitoring is an important role in agriculture field. Diseases can be identified by camera mounted UAV (Unmanned Aerial Vehicle). The UAV is controlled by the Transmitter Channel they are consist of mode1 and mode 2.Crops are to be monitored row wise using raspberry pi. Various diseases and damages in the crop are identified by the camera mounted on UAV. After monitoring the crops , it is let to spray the fertilizer and pesticides based on the crop damages. Our approach to develop this method in Indian agriculture field tend to increase protective and productivity of crop and improve the crop's growth towards fertilizer and pesticides spraying based on the crops damage.

RELATED WORK

Shilpa Kedari et al [6] proposed the Quadcopter(QC) system which is low cost, and lightweight. The quadcopter is also known as Unmanned Aerial Vehicle (UAV). These quadcopter is small size, and this system can be used for indoor crops as well as outdoor crops. Quadcopter is an autonomous flight for spraying pesticides and fertilizer using the android device. Between the quadcopter and android device communication is done by Bluetooth device in real time operation. This system is used to reduce agriculture field related problems, and also increases the yield of agriculture.

S.Sabikan et al [14] implemented USP platform that were used to develop the autonomous Remotely Piloted Vehicle (RPV) quadcopter to fit for any application. The development of quadcopter test bed configuration, capable of performing autonomous flight mission is presented in this paper. It is an easy, fast, and effectual approach to build up a quadcopter test bed for any research purposes. Among the many Open Source Project(OSP) Arducopter platform is considered and basic functions of each component for both software and hardware were explained in detail. The unreserved Source Project platform is the most successful approach because of their flexibility in both hardware and software. This developed module was experimented in the outdoor real environment to test the elemental features of flight performances, to calculate the

parameter such as altitude and attitude, trajectory mapping generation. Finally, the USP quadcopter platform is the complete framework of the developed quadrotor for any outdoor application or research application.

Sadhana B et al [15] further modified the above approaches and developed the quadcopter UAV and shower module that is easy for pesticides spraying mechanism in the agriculture field to increase production as well as protection materials. Total payload of this project quad copter lift of weight is 1 kg and used for spraying pesticide from low altitude as shown in figure 2. This quadcopter are controlled by the Arduino UNO AT mega328 and Brushless Direct Current (BLDC), Electronic speed control (ESC), MPU-6050 consisting of MEMS accelerometer and a MEMS gyro in a single chip, Radio receiver, LIPO battery and pesticide spraying module.

Fig 2: Pesticide spraying mechanism

Munmun Ghosal et al [5] developed a system to track the location where the air pollution is remarkable with GPS module to find the longitude and latitude. This system monitors the data using various sensors such as temperature sensor (LM35), humidity sensor (AM1001), MQ6 for smoke, MQ135 for CO2, LDR for light intensity, and GPS L80 for location tracking and controlled by the Arduino board. The parameters that are monitored are smoke, CO2, temperature, the intensity of light and humidity. The quality index of air is evaluated and displayed on the web server using the Apache server to find the area where the pollution is remarkable and can be treated before the risky situation arrives. It is low cost and better efficient model, therefore, it can be concluded which can be used to monitor the air for small application.

Yallappa D et al [20] developed a drone mounted sprayer consisting of six BLDC motors mounted to hexa-copter frame to lift 5 kg payload capacity, LiPo (Lithium polymer) batteries, pesticide tank, pump, and supporting frame. The total weight of the drone mounted sprayer were calculated based on the parameters such as payload capacity, design of supporting frame, landing gear, design of fluid tank, selection motors, battery, propeller, flight controller, transmitter and receiver. This sprayer is very useful for spraying of chemicals on rice fields and orchard crops that reduces the cost of pesticide application and environmental pollution Further analysis were also done on the discharge and stress rate of the pesticides to determine the rate at which the fertilizer is sprayed uniformly to ensure it sprays everywhere in the crops. This method is handy because the human intervention of spraying the chemicals is reduced. The fig 3 shows the drone developed by the above method for spraying crops.

Fig 3. Drone mounted sprayer in paddy and groundnut crop

Parth N. Patel et al [9] modified the above system by placing the infrared digicam to the quad copter for surveying the plants. The image captured was processed to distinguish between inflamed or diseased crop and matured crop based on the color property. To ease the transportation of drones the design concept of quadcopter was modified such that two arms of the quad copter arms can be folded for removing the propeller and the camera attachment. This method focused on reducing the size of UAV.

Tejas S. Kabra et al [7] introduced a quadcopter [QC] of low cost and low weight by further focusing on the arm design to enhance the farming efficiency. The quadcopter developed with lightweight aluminum body and simple arrangements lessen the issues in the farming field and to increase the precision in agriculture. These methods also reduce medical issues which are produced by manual splashing. This paper presented part of quadcopter with unique design of propeller, sprayer and piping system, pesticide container and stand serves to optimize the time of spraying and the weight of quad copter.

Weicai Qin et al [10] studied the impact of UAV (UAV N-3) spraying parameters at different working height and varying concentration of spraying pesticide on the wheat canopy and the prevention of powdery mildew in Asian countries. The experiments were conducted with UAV spraying the field with fixed width at a distance of 3.5 m, 5.0 m height and spraying speed at 4 m/s in water sensitive paper (25 mm×75 mm) at the top (the second leaf) and bottom (25 cm above ground) on the crop by paper clips and the spread of the pesticide was analyzed. To put off wheat powdery mildew which occurs when the crop is infected with serious disease, an auxiliary agent will be added with pesticide to increase the withholding capacity on the plant surface .This work focused on more optimization in design, up gradation of the performance by analyzing at varying height and concentration, to avoid serious disease and to enhance the application of small UAV sprayers.

Y. Tanga et al.[17] investigated further the deposition of droplets of pesticide in the citrus tree by considering the height in which the UAV is operating. The model that were developed was studied in citrus tree of height 1.2m in which the tree was divided into six parts and the amount of droplet that was deposited also was also considered to evaluate the efficiency. The results signify that there is a uniform distributions of droplets in front, middle, rear, left and centre parts but there is a deviation in the distribution in right part of the inverted triangle-shaped trees. This deviation might have is due to the deviated flight route when operated manually or due to the velocity of the wind originating from the right. The spraying module is comprised of a pesticide tank with a capacity of 15L, miniature direct current diaphragm pump operated with a DC 22–25 V and that will produce 3.5 l per minute, two appropriately identified nozzles equidistantly dispersed along the spray boom with a spacing of 1.4 m and electronic speed control.

Vrushabh Mohane et al.[18] developed an agricultural sprinkler drone, a pesticide spraying machine to reduce the work of farmers. The UAV is operated manually and triggered by RF

controlled nozzle. Multispectral camera will capture the image of the green crops to track the growth and edges are segmented for further analysis. The QGIS software is used to analyze the remote sensing images. The drone can be controlled using an android app which is receives the information using Wi-Fi module that is interfaced to the drone.

Shaik.Khamuruddeen et al. [16] proposed this paper to overcome the traditional spraying system using drone. These drones are used to spray the pesticides. It works with a set of revolving twisted cord Aerofoil so, it is also called rotor crafts. In this paper new remark of PSQ provides useful spraying of pesticides are achieved by removing the effect of more toxins which are present in the pesticides.

T. Duana et al.[3] applied the technology of Normalized Difference Vegetation Index NDVI to monitor the growth of wheat. NDVI technique is a graphical indicator to compute the photosynthetic capability and assess the condition and live green vegetation of plant canopies. The 5 images are captured by a multi-spectral camera (RedEdge) at low elevation that will occur as a result of the reflectance from 5 bands spanning from red to near infra red wavelength and by UAV (PhenoCopter). The PhenoCopter captured the images covering multiple bands at seven different stages of the growing season. NDVI were measured during various stages of the growth by the normalized transformed ratio between the reflectance measured at the red wavelength range and NIR wavelength range. NDVI calculated by UAV and camera was fused with data measured by hand-held sensor (e.g. Green Seeker). The validation of values proved that during the flowering period they were a higher correlation with final yield. This paper concludes that data fusion from multiple sources can provide more information that can be adapted for the growth mechanism of crops.

Marthinus Reinecke et al.[11] focused his work to study the benefits, limitations and features of drone for maximizing the harvest and managing the crops. Two different technologies were considered, first one drone camera technology – UVIRCO and the second Aerobotics. The study concluded that more farmers invest in drone technology to enhance the productivity of the crops. Drones can generate a digital map of a field, distinguish healthy and non healthy crop, and reveal the missing stock, detecting the leakage in irrigation systems, alerting the farmer in case of fire and for spraying the pesticides.

Rahul Desale et al. [12] proposed a method for spraying pesticides using the UAV. This method is used to increase the crop yield range and crop surveillance using the basic drone mechanism.

Nived Chebrolu et al. [2] presented a method using image registration technique with the crop images captured by the UAV in the agriculture field and also introduced the procedure to calculate temporally aligned 3D point clouds of the field. This paper utilized the inherent geometry of the arrangement of crops in the agriculture field that will not change over the time. This method is mainly based on extracting the geometry information of the crop images as once the tree is planted, the central point will remain fixed and row wise plantation is considered. To compute the central point the sequence of steps such as calculation of vegetation index, applying Hough transform, calculating the histogram and then identification of peaks of the histogram which serves as the central point. The 3D point cloud method is using for monitoring the individual plants, and also monitoring the position of the crops as well as crops gaps.

Adhao Asmita Sarangdhar et al. [1] presented a system to identify and control the disease in the cotton leaf. In addition to that quality of the soil is also monitored by sensors interfaced with Raspberry Pi as it plays an important factor for the growth of the crops. These methods use the concept of support vector machine for the identification and classification among five cotton leaf disease. The identified disease along with its remedies will be provided to the framer, soil parameters values such as humidity, moisture, and temperature along with the water level in a tank will be transmitted to the Farmers mobile. The overall classification accuracy of this proposed system is 83.26%.

Mohamed Kerkech et al. [8] addressed a system based on Convolutional neural network (CNN) and color information to detect the ESCA disease in grapevine using UAV images in the visible domain. The performances of CNNs using diverse color spaces, vegetation indices, as well as the combination of both information were compared. This method is processed using six steps, capturing of image, dividing the image into blocks, two sliding window schemes, color conversion from RGB to HSV, LAB and YUV for separating the intensity information from chrominance, CNN prediction and Classification based on 4 classes ground, health, potentially diseased and diseased class, diseases map generation and finally the post processing steps such as mathematical morphology, elimination of small areas, contours detection and diseases map overlapped on RGB image. The figure 4 illustrates the testing and training phase from color conversion till the creation of CNN model and calculating the accuracy.

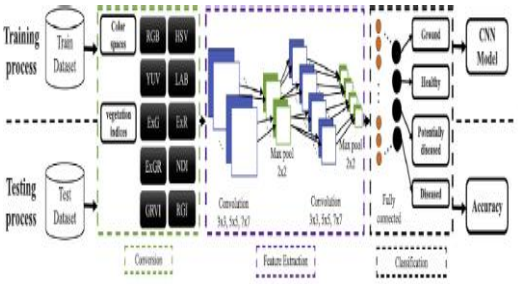

Fig 4. Training and testing procedures of CNN based on LeNet-5 architecture.

Konstantinos P. et al.[4] developed an automated plant disease diagnosis and identification system using deep learning concepts trained with CNN model for identifying the crop diseases. The diagnosis was done with images of small leaves from healthy or damage plants. The five nets that were used for training are (i) AlexNet (ii) AlexNetOWTBn (iii) GoogLeNet (iv) Overfeat and (v) VGG. The previous work focused only on grapevine but this system was implemented in open database of 87,848 images, which covers 25 different categories of plants in a set of 58 distinct classes of [plant, disease] combinations, including healthy plants. The result shows that a VGG convolutional neural network shows good result success rate of 99.53% .

Ristorto et al.[13] addressed on ease of use and the cost associated with the monitoring of rice field. The performance was analyzed with Remotely Piloted Aircraft Systems (RPAS) which is a Q4P-Rotor developed by MAVTech, for precision agriculture to monitor the crop. The system was implemented with two types of sensor, active sensor is OptRx® crop sensor from AG Leader and the passive sensor is Ximea Hyper spectral Line Scanner. The performance was monitored with the following steps in a rectangular shaped rice field 1) flight pattern 1) Validation of flight steps 3) Effectiveness of the system for daily usage and finally cost was estimated. The result concluded that Ximea configuration covers more hectares with a predetermined speed in comparison with OptRx crop sensor.

Francisco Aguera Vega et al.[19] determine the effectives of capturing multitemporal sunflower crop images of the UAV inbuilt with multispectral sensors(red, green and near infrared bands). To calculate the NDVI different measurements were

made at various times with different resolutions on four different dates during the cropping season for the effectiveness of the implementation of the agricultural techniques to enhance the productivity.

Table.1 Different methodologies and controllers of UAV

Author	Implementation Details	Components	Controller	Nozzle Type	Remarks	Load (L-Litres)
Tejas S. Kabra et al.(2017)	Proposed to introduce Quad Copter [QC]. The quad copter lessen to identify farming field issue	BLDC	-	-	This method is used to reduce the medical issue which are produced by manual splashing.	1.5 to 3 L
Tanga et al.(2018)	To determine the droplet deposition in different shapes.	Digital temperature, Humidity indicator, Water sensitive Sensors. Anemometer, Filter papers.	UAV ZHKU-0404-01	Flat fan	To measure the speed of wind. The indicator is used to measure the moisture in the air.	15 L
Shilpa Kedari et al. (2016)	Android device is implemented to the quad copter. These android applications are used to control the quad copter for spraying pesticides and fertilizer.	IMU , barometer, accelerometer, gyroscope.	Arduino board	-	Reduces the health issues to face the farmers during spraying pesticides and fertilizer.	-
Sabikan et al.(2016)	Implemented the Open Source Project platform for the autonomous of UAV quad copter.	IMU, 2.4GHz telemetry, ESC.	ArduPilotMega (APM) 2.6	-	The OSP quad copter is the complete framework in both hardware and software and it also flexibility design for research purpose or project purpose.	-
Sadhana B et al.(2017)	Developed the quad copter and sprayer module	ESC, BLDC, MPU 6050 sensor.	Arduino Uno ATmega328	Mini nozzle	High stability and more lifting power. Compare to helicopter model or vehicle quad copter control is easy.	1kg
Munmun Ghosal et al.(2018)	Tracking the precise location where the air pollution is remarkable with GPS module.	ESC, BLDC motor, sensor such as LM35, AM1001, LDR, MQ6, and MQ135.	Arduino Uno ATmega328	-	It is low cost and better efficient model.	-
Yallappa D et al.(2018)	Develop the droplet density and size of the hexa copter mounted sprayer.	Camera, Gyro, GPS, BLDC, ESC.	FC	Flat fan	It is used to spraying the crops without human intervention.	5 L
Parth N. Patel et al. (2016)	The quad copter allow to develop the design of innovative foldable frame for transported safely and it easy to packing cylindrical shaped cushioned box	Accelerometer, gyroscope, IMU, Infrared camera, BLDC, ESC	Atmel AVR microcontroller	-	It flexible, allow changing the function performance and also allowing the integration of the technology.	-
Weicai Qin et al (2019)	Study the impact of the spraying system in different height and different sprayer.	GPS, digital temperature, humidity indicator, water sensitive.	N-3 type	Rotary atomizer	In this UAV was firstly used for low altitude and low volume pesticides application.	25 lit

Vrushabh Mohane et al (2019)	To design and develop the UAV quad copter for agricultural field. And the agricultural sprinkler is used to spray the pesticides.	Accelerometer ADXL 335, WIFI module ESP 8266, GPS module 6050, servo motor.	Arduino mega 2560	-	The quad copter is used friendly for framer and also reduce his work.	-
Shaik.Khamuruddeen et al (2019)	This model is used to spray the pesticides using quad copter.	BLDC, ESC, Transceiver, Infrared Camera.	PID Micro Controller	-	To find fewer labors where there are by using PSQ.	-
Rahul Desale et al (2019)	This project is used UAV for spraying pesticides in agriculture field.	BLDC, ESC, ratio controller, Transmitter.	Flight Controller	Fog nozzle	Advantage of this project to framer to spray the pesticides using drone to operate in safe position.	-

Table.2 Different Techniques used in crop monitoring

Author	Implementation Details	Techniques	Remarks
Duana et al (2017)	Implementation of monitoring the crop using by multispectral camera on UAV and also implement to the NDVI technology.	Normalized Difference Vegetation Index(NDVI)	multi-spectral camera on UAV.
Marthinus Reinecke et al (2017)	Implemented using both UVIRCO camera on the drone and Aerobotics for monitoring the crop health and crop harvest size.	Georeference Orthomosaics, NDIV	UVIRCO corona camera, GPS
Mohamed Kerkech et al (2018)	Use of UAV RGB image and deep learning method for detect ESCA disease in the vineyard field.	Deep learning method of CNNs	UAVimages, YUV color shapes ,vegetation indices

CONCLUSION

The survey shown in the table 1 helps in spraying the pesticides and fertilizer in the agricultural field on different crops using Unmanned Aerial Vehicle (UAV) in different quadcopter, and it also aids to develop the precision agriculture technique. Table 2 helps in monitoring different crops using camera mounted UAV. Overall performance of this method will increase by using quadcopter which will spray the pesticides and monitoring the crop. This method will reduce the amount of pesticides and fertilizer used in agricultural field and also increase crop yield.

Conflict of Interest

Declared none.

Source of Funding

The authors declare that they have no known financial interests in this review paper.

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