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Applications of Unmanned Ariel Vehicles (UAV) in Agriculture: A Study

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Abstract: Today the Unmanned Aerial Vehicle (UAV) or also known as drones are used for many operations in agriculture for enhancing the crop yield and reducing the cost of production. UAV application in agriculture leverages the economy of farmers. The UAV powered by solar or wind mounted with imaging processing capabilities and other devices will enable efficient operations like crop monitoring, spraying of fertilizers and chemical. UAV are extensively used in precision farming in developed counties. The authors have carried out the review of literature on the applications of UAV in agricultural across the world.
Keywords: Drones, Precision Agriculture, Wireless Sensor Networks, Unmanned Aerial Vehicles (UAV)

I. INTRODUCTION

UAV are going to play an important role in the future of farming and could eventually become as abundant as tractors. UAVs are ideal for assignments that are too cloudy, dirty or hazardous for manned aircraft Source. The data collected from drones can be used for water management for crops and to find seepage in the irrigation system. UAV employed in precision agriculture for real-time monitoring and gathering important information like soil fertility, crop conditions, pests activity and disease status. This paper highlights the efficiency and the viability UAVs applications in agriculture context.

A. International Status

The International Association for UAV (IAU) predicts that farms will have ultimately 80% share of the marketable drones. The farmers will earn Return on investment of $12 for corn per acre and $2 to $3 for wheat soybeans per acre as per the estimates of American Farm Bureau Federation. Since few years. Canada has permitted drones usage in agriculture. UAV applications for agriculture are in their early stages in the United States. Drones are helping Rice growers in Japan since several years. The recent PwC analysis reported total market value of drone-powered applications in industries are about $127billion and $32.4 billion in agriculture for soil, field analysis, planting, crop spraying and crop monitoring.

II. REVIEW OF LITERATURE

Francesco Esposito, Giancarlo Rufino [1] and Paolo Tripicchio [2] et al. have designed a remote sensing system of compact airborne platforms for monitoring the forest fires. The core of this system has a set of electra-optical sensors integrated in multi/hyper-spectral imaging capabilities and superior capability for monitoring the forest fires. The sensor control system has an independent on-board processor to enable self-directed operations. This system also has the ability to exchange data with navigation and flight control system. The first experiment results highlighted the performance achievable by the system. The critical problems and the complications in data acquisition were examined and highlighted to focus on further research in future.

Laszlo Techy Craig A at el. [3] have studied the impact of threat agents which are biological in nature by aerobiological sampling in agricultural fields by synchronizing flight of two autonomous UAVs. The intermittent sampling job includes initialization at sampling intervals. Both UAV should follow an accurate ground track for aerobiological sampling strategies against the occurrence of constant winds throughout the sampling interval. Two vehicles should move to their corresponding initial states before the beginning of next sampling interval. The initialization interval should be as minimum in order to make the best use of the amount of air sampled by the UAVs. This method is applied for both UAVs to produce the paths to synchronize their movement in their corresponding paths in order to prevent accidents. The designated approaches have been verified throughout the aerobiological sampling concentrating on the plant pathogen. Authors proposed an analytical technique for flying in steady winds to produce minimum time paths in the framework of volume sampling in controlled situations for biological data gathering in air. Merging path planning method with an appropriate synchronization policy yields a real procedure for volume sampling of high dimensional aerobiological control. The methods established were applied for investigating and observation the motility of plant pathogen of high risk category which was tested in 2008 field experiments.

Jose A. J. Berni, Pablo J. Zarco-Tejada, Lola Suárez, and Elias Fereres [4] have discovered the two serious limitations for using present-day satellite sensors for management of crops are hostile revisit time, spectral resolutions and the absence of imagery with best spatial for utmost all crop strain discovery applications. An essential requirement for giving valuable products in agriculture for remote sensing is the capability to relate higher spatial resolution and swift work time. UAVs are fitted with remote sensing sensors to provide techniques to achieve the grave requirements of spatial, temporal and spectral resolutions at low cost. Authors have proposed a method for using UAV and helicopter to quantify the products of remote sensing fitted with low cost thermal and narrow band sensors of multi spectral imaging for precision farming applications.

Austin M. Jensena, Thomas Hardyb, Mac McKeea and Yang Quan Chena [5] have studied a remote sensing platform called AggieAirTM, a self-governing, unmanned, aerial vehicle. This AggieAirTM was designed and implemented by Utah State University to produce images of multi spectral taken from above the crop. This method is independent of an airstrip, less cost and swift working time for images making an effective technique for wetlands management and river bank areas. AggieAir has been applied for capturing aerial imagery of this area.

Fausto G. Costa et al. [6] have surveyed the applications of UAV and WSN in Agricultural operations. The spraying of fertilizers and pesticides in agriculture is most important to enhance crop production. This paper describes a framework based on UAV to automate the agricultural operations. The chemicals are applied over crops using UAV. The response signals obtained from WSN setup in the crop field will control the process of smearing the chemicals. This proposed solution supports short delays in the control loops to facilitate UAV to operate and manipulate the sensor. A step by step procedure has been evaluated by the authors to correct the UAV path deviations influenced by wind direction and intensity. The influence of number of interactions between UAV and the WSN are also assessed. The output statistics disclosed the need for fine-tuning the path according to the sensors response data to curtail the wastage of chemicals. Authors have intended to decrease the quantity of pesticides sprayed beyond the selected area, to make efficient use of the chemicals.

Pratap Tokekar el. Al. [7] have studied the case of synchronizing of Unmanned Ground Vehicle (UGV) with UAV in precision farming. The aerial and ground measurements are applied for approximating nitrogen (N) levels throughout the farm. Authors intended to make approximation of the N map in the crop to classify each and every point based on N shortage. This approximation has direct impact on the fertilizer usage. Spraying of fertilizer in correct quantity at correct time can radically decrease the required fertilizer quantity, saving money. Authors have designed a method to recognize the points whose likelihood of getting wrongly classified is above a maximum limit. Authors also studied the problem of visiting the maximum number of such points by UAV based on energy budget. The innovation is construction of the UGV to align with that of UAV positioning points. This enables the system to save the short-lived battery of an UAV. This paper also introduced a the problem of path design, taking measurements within a ring centered at each and every point covered by the UAV. The objective is to curtail the entire time spent in touring and measurement. This complete system is built using a hexacopter from MikroKopter and Clearpath Husky A200 ground robot. The extra features for self-governing, landing and soil sampling are essential to implement the algorithms

KuniakiUto, Haruyuki Seki, Genya Saito and Yukio Kosug [8] have designed a cost effective, tiny, less weight, sensor system with hyper spectral features which can be mounted on a UAV for acquiring aerial hyper spectral data. This UAV facilitates easy and safe monitoring under variable and poor illumination environment by means of very less weight and self-governing journey. This system is fitted with 256-band hyper spectral sensor screening ranging from 340-763nm, a GPS and a data logger with total weight of 400g. The time taken to collect the data of 768 bytes size is only 100ms. The rice crop hyper spectral areal data is collected at flying altitude of 10m from the ground at the sailing speed of 2m/s under cloudy conditions. The observational results prove that chlorophyll thickness can be computed with high precision, even under variable lighting levels, by constant observation of the chlorophyll indices and lighting levels at the RE and NIR spectral ranges.

Ugur Ozdemir et. al. [9] reviewed the literature on applications UAV since 1980 in military services such as engagement, investigation and tracking with active weapon for data gathering purpose. UAV are also finding commercial applications because of their benefits when compared with manned vehicles in design and adaptability, less fabricating and operational expenditure. The UAVs are well suited for highly hazardous and difficult missions for human pilots. UAV faces challenges like integration with manned flight, dependability and flight trustworthy. The commercial UAV constitutes only 3% of the total UAV market, the forecasts to acquire 10% market share in coming five years. UAV systems with their valuable sensors and accessories have been finding large applications in civil engineering. The observation and pursuit in the case of forest fires, emergency marine, pollution, agriculture, disaster management, waste management, wildlife, traffic monitoring, land registry, ecologic monitoring, and geology. UAV can reduce the cost and benefit to many applications in civil engineering, where it is dangerous and expensive to apply normal air vehicles.

Ankara I.O [10] studied the UAV with Vertical Take Off and Landing (VTOL) capabilities. This UAV needs an economical solution for applying in various civil applications. This UAV has portability, payload and programmability of operation particular to the usage. The primary aim of TURAC VTOL UAV is to design, test and produce the following features: vertical takeoff and landing, fixed-wing, high cruise speed, hovering like helicopter, multi-functions and designed for civilian applications. This project consists of two different versions. The TURAC A version is a completely electrical platform that comprises in the front, two tilt electric motors with a ducted fan and an electric motor at the backside. The TURAC B version applies fuel cells.

Eobin Alex George atc [11] studied UAV for parametric quantity determination in Agriculture. Modern agriculture has transformed to a precision farming by the applications of genetically modified, highly productive and disease resistant crops. The genetically modified crops with productivity and at the same time they are very sensitive to other parameters such as nutrient composition and punctual irrigation of the farm. This makes it essential to monitor these parameters to ensure high productivity. Manually monitoring and maintaining these parameters is viable only to an area less than one acre, but it becomes almost very difficult constantly monitor the parameters in large areas. UAVs offers an accelerated and effective method of monitoring these field conditions automatically in large land farms. The UAV renders us a non visual orientation of agricultural farms that can significantly enhance agricultural precision by effective discovery of these parameters and approximation which needs immediate attention. These systems has been currently employed in Madhya Pradesh, Bhopal states of India. Money and time are saved using UAV for identifying the attacks of pest, nutrient and moisture content of the soil at an early stages alarming the farmer for corrective actions. The initial investment in this system is bit high to be a single farmer to invest. The government rebates and partnerships can using UAV in their fields approach a feasible way for better agricultural practice, and increase the income levels of the farmers in particular and national in general.

Carlos Cambraatc [12] have discovered three primary attributes that needs be satisfied to apply intelligent video sensing systems. High Definition video communication rendering required quality of video for image management. The wireless adhoc network that intelligently determines and concentrate on the problem to be identified and adequate accessible bandwidth providing HD quality video. Authors presented a protocol for communication between various mobile devices running on Linux and Android OS to render HD video communication. Observational results of AR Drones which are Wi-Fi enabled forms an adhoc network that demonstrates the large prospective for mobile networks. Authors have discussed the cases for using AR Drones for smart video sensing applications of image processing. This visualization helps to prevent dry intervals in particular areas in which the sprinklers might be obstructed by sand, dirt and corn leaf inside the pipes. Authors have checked the area during a flight of about 30 min with estimated magnitude of 1.5-2 ha/min. It provides a speedy visualization for monitoring the conditions of farm. This set up can be used to discover the fire or examine images with dry conditions or risk of catching fire which are common in Spain during summer season.

Mohamad Farid Misnan [13] have implemented UAV for for low altitude mapping using vision based sensor. This UAV has unique features like real time data processing with minimal procedure and minimum weight devices are used in the design of UAV for transportation. This UAV is equipped with a camera for the desirable perception in the front. The observational surface is examined by the analogue vision sensor for analysing the sensing quality used for attribute discovery purposes. The procedure is executed on16-bit micro controller. The front mounted vision sensor is utilized for feature detection in field measurement. The resulting image composed by vision based sensor is compared with the original image for performance analysis. This method produced a satisfactory error of image accuracy which is sufficient for applications of features detection on UAV. This experiment was conducted using low cost end and medium speed micro controller. The results showed that the image generated is same as with the image examined using the analog camera with the light brightness and dynamic height scanning.

David Anthony [14] have studied how remote sensing by UAV is influencing the agricultural activities by enhanced the spatial-temporal resolution of data gathered. Micro-UAVs will fly near crop to improve the collection of data at higher spatio-temporal resolution. The UAV of this experiment is equipped with measuring system that employs a laser scanner to calculate the height of crop which is an acute sign of health of the crop. This UAV analyzes, separates and transforms untidy range data in realistic time to regulate the distance between the top of the crop and the ground. Authors assessed this system both in the crop field and indoor test bed. Author's conclusions indicated that in spite of the thick canopy and extremely changeable sensor readings, UAV are capable of flying exactly over crops and measure its height with accuracy of 5cm. The suitable filtering and calculation facilitates the system to take advantage of small disparity in the crop greenery to straightaway sense the ground, which alters the UAV to fly at a fixed height, near to the crops. Flying adjacent to the fields intensely enhances the spatial resolution of the data when related to conventional readings, and permits littler and cheaper UAVs to be used in these applications.

Leila Hassan Esfahaniatc [15] have estimated topsoil moisture for using UAV multispectral imagery precision agriculture. Nowadays the crop yield management judgments are based on examination of high definition aerial images captured from UAV in precision Agriculture. This paper proposes AggieAirTM, a small, UAV equipped with multispectral cameras to collect aerial imagery throughout pre-defined flights. AggieAir facilitates to collect aerial images at superior temporal and spatial resolution when compared to many manned aircraft and satellites. The AggieAir platform is being confidently utilized in backing of a various natural and water resources management areas. Authors discussed the results of their current research for the usage of images from AggieAir for estimating the top soil moisture using remote sensing for huge fields managed by a central pivot sprinkler irrigation system. The approximations at such resolutions in time and space are much better than existing remote sensing technologies.

Annop Ruangwiset atc [16] surveyed recent precision agriculture technology in economic crop cassava planting of Thailand. The UAV is a used for inspecting the crop development in bulky cultivated fields. Author has developed and flight tested the prototype UAV for this project. The flight route of UAV is selected and optimized based on data for power utilization of propulsion system. The analysis of results showed power consumption has no significant dependence on the flight altitude and payload weight. UAV consumes much power through crosswinds to sustain the ordered speed and altitude to avoid from sliding away from the preferred path of automated way points. These experiments of UAV for agriculture mission demonstrates that UAV should fly in crosswinds to minimum extent to reduce the power consumption and to increase the durability and the range.

Sandeep Konam [17] has discovered that the current manual Mango cultivation techniques are not efficient and cost effective. Authors have designed an Agriculture robot for cutting Mangos (AAM) that could be engaged for precision mango cutting. AAM is a quad copter equipped with vision, cutter and essential ancillaries. AAM will fly over the trees, identifies the riped mangoes, cuts and collects them. AAM robot is the first of its kind that once realized could pave way to the advanced agricultural robots that are able to increase the agricultural crop production. This paper concludes that Agricultural Aid for Mango cutting (AAM) may be used by small farmers at affordable prices.

Bruno S. Faiçalatc. [18] have studied the spraying pesticides for protecting crops and to maintain the quality and quantity of crop yield. The application of these pesticides by using aerial vehicles increases the speed of the activity and avoids packing of the soil. The wind direction and velocity will influence the efficiency of application of pesticides in a desired area. There is a possibility of pesticide getting spread in to neighbouring crop fields and only small quantity of pesticide will be applied in the desired area making the operation in efficient in utilization of pesticides. The enhanced accuracy in spraying will decrease the quantity of pesticide applied and increase the quality of crop yield thus causing little damage to environment. Authors suggested Particle Swarm Optimization (PSO) techniques for improving the accuracy of control rules during the spraying algorithm. This procedure can be applied for achieving better results by considering the weather conditions communicated by a Wireless Sensor Network (WSN). In this experiment UAV is playing the role of a mobile node.

Manlio Bacco, Erina Ferro and Alberto Gotta [19] have discussed communication between UAV acting as mobile nodes and ground wireless sensor networks using radio waves. A representative application model is the agriculture. The main attempt of this experiment is in emphasize that the standard two-ray path loss model is not accurate enough to consider all the diverse parameters while using UAV to interact and manage a ground Wireless Sensor Network. The effects of speed, height, roll angles and pitch of the UAV during the flight are take care of. The relationship between the gathered set of data and the two ray path loss model is to be identified clearly thus showing the need of a new model or of correcting factors, that are taken into account. The authors claimed this experiment is unique and first attempt.

Caroline M. Gevaert [20] discussed about the precision agriculture which requires elaborated information on crop condition at higher resolution of space and time using remote one sensor readings, which are frequently incompetent to gather all requirements of data. Spectral–temporal response surfaces (STRSs) render uninterrupted reflectance spectra at higher temporal intervals. The authors have presented a innovative method to build a 4-D STRS, which is composed of nonstop surface reflectance data along temporal and spectral dimensions. This paper exhibits the prospects of accurately combining spectral and temporal dimensions, hyper spectral and multispectral data using a Bayesian method to STRS.

III. CONCLUSIONS

This paper has reviewed about 20 selected papers that presented the applications of UAV in monitoring the forest fires, aerobiological sampling, prevent dry intervals in particular areas,. Monitoring and control of nutrients for genetically modified crops in large farms is an unique applications of UAV. Research on Vertical Take Off and Landing UAV is worth noting. Mapping of nitrogen levels of a crop using UAV is an an other applications of precision farming. The UAV coupled with Wireless Sensor

Networks on the ground can make the crop monitoring and control more effective. There are challenges like Energy consumption, cross winds, image resolution and high cost needs to addressed to make UAV an effective and viable solutions to farmers and overcome labour shortage.

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