Smart Drones for Agriculture

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***Abstract*— World's population has tripled since 1950 and it is set to hit the 10 billion mark in 2050. Rise in population automatically raises demand for food and other resources. Agriculture industry has been meeting an increase in food demand for many years by leveraging advanced tools and scientific developments. We are under a crunch for agriculture resources and food demand has never been this high. Automating daily tasks and effectively increasing efficiency are pressing issues in agriculture. During the covid-19 pandemic, many countries are experiencing shortage of food due to lack of manpower in the agriculture industry. This problem can be solved by introducing autonomous drones in this area which will reduce the required manpower. As a next step, some of the common tasks in agriculture that a farmer faces during farming, such as lack of information about the agriculture field, monitoring the crop, and spraying pesticides can be tackled using autonomous drone technology. This paper likes to propose a smart autonomous drone which does the assessment of the agriculture field and climate of the region, automation of pest spraying and regular monitoring of the crop using mobile phones by the data collected and sent by drone to the cloud. Automating these problems in agriculture will improve food production.**

***Keywords*— UAV, MultiSpectral Imaging, Thermal sensing, precision Agriculture, Drones**

I. Introduction

Agriculture is the backbone of many countries in the world. The most concerning thing on this planet is the access to adequate food, apart from clean water. This is the sole reason for agriculture to be the most significant and largest industry in the world. The way of farming these days has changed a lot from the past few decades. Advanced technologies present in the market are helping the farmers to optimize each and every part of their operations from field supplying water to developing the crop and yielding. It is not only important for the country's balance of trade but also for the wellness and security of its people. Many unmanned aerial vehicles and other types of drones these days are not only capable of doing physical work but also contributing to factors such as agricultural development, helping farmers to analyse the data in depth to find the problems with the crop, find the infected crop and to perform a data analysis with mission planning. Collection of data and analyzing this data in real time results in tangible outcomes like good crop yield, optimal usage of resources and improved management decisions.

Routine tasks in farming involve various types of work which ranges from preparing land for plantation to monitoring the health of the crops. Agriculture is facing challenges in increasing production to meet always peaking food demands. These challenges include shortage of manual labour, reduction of population in rural areas, introduction and spread of new pathogens as well as diseases [1].

Checking planted crops for diseases, regular spray of pesticides are some of the daily activities in farming. These tasks have a great scope for automation due to their predictable nature. Unmanned Aerial Vehicles (UAV) which are also known as autonomous drones can be used for this purpose. UAVs are very easy to control and resilient against weather impact [2]. UAV can also be employed to perform routine tasks in agriculture.

This paper describes an autonomous drone based system which can be employed in agriculture to solve current issues and help in increasing food production with minimum manual efforts.

II. Solution Overview

Drone usage is becoming more prominent in the field of agriculture. The current capabilities of drones and onboard sensors are very limited. The time of flight will not be more than one hour and the maximum payload cannot be more than 50 Lbs. The time of flight for the drones is inversely proportional to payload handled by them.

Currently, research is going on to effectively calibrate multispectral and thermal onboard sensors to get the best image data. Several techniques such as OpenCV, image processing to extract necessary information like chlorophyll and vegetation index, are being used to understand the collected image data.

The solution proposed includes building advanced drones based on our design using graphene batteries, Graphite, and carbon polymers. The drones are designed and programmed to handle the flight time greater than 5 hrs and payload greater than 100 lbs. This drone will autonomously perform various tasks and interact with cloud servers through weather stations using data links. End users will be able to interact with drones by using mobile applications and this application can pass the GPS coordinates and actions to be performed by them.

Data from the drones will be received to the ground stations on regular intervals and this data will be relayed from the ground stations to cloud servers. Cloud servers will perform analysis on collected data using machine learning models and propose further plans of actions.

Usage of machine learning will help to detect the spread of pathogens, and sectors with low crop health in the early phase. Performance of machine learning models should increase over a period of time. There is no available data for each crop to train models beforehand [4]. Models will be updated for each season depending on weather conditions and based on region for each crop.

Usage of this system will decrease manual intervention in day-to-day activities and will help to monitor crop health.

III. Proposed Solution

System proposed has an autonomous drone. This drone is intended to perform three main tasks:

1. **Field Inspection :** Given GPS coordinates, inspect a specific area using field inspection ML models to identify landscape and suitability of crops.
2. **Pest Spraying :** Based on the disease detection model, selected areas of a crop will be sprayed with required pesticides.
3. **Crop Monitoring :** Depending on water requirement models and weed detection models, drones will perform irrigation and weed removal tasks.

The flying device is controlled by a mobile phone based application. Data received from the UAV is sent into a local storage i.e, ground station. Data stored in this local storage is transferred to the cloud to perform various data analysis using different machine learning techniques.

The proposed solution requires the below modules which perform the core functionality and contribute in delivering the end result.

Drone Design/Specifications :

For drone stabilization and angular motions, we use 3 axis accelerometer and gyroscope sensors. For getting all infra-red information about the crops and piece of land, we use thermal and multispectral imaging sensors. ML models can be trained to extract information from visible camera data. Apart from these, we also use GPS & distance sensors.

Batteries are of Graphene technology which provide better battery life & fast charging capabilities comparable to Lithium-ion batteries. Drone structure, rotors will be made of graphite, and carbon polymers for increasing the current performance and flight dynamics of the drone. There are a total 10 rotors and each rotor length is ½ feet and the entire length of each wing is 1 meter. Generally, drones fly around the range of 150 -200 meters altitudes[4] and can not cover larger areas at higher altitudes. The major reasons to choose multi rotary design are to get enhanced images of the crop at low altitudes and better control of the drone.

Ground Stations :

Ground stations will play a crucial role in effectively transferring data to the cloud and act as a hub for drones. Data gathered through sensors for 1 Acre of land can go upto TB's of data. This huge data can not be transferred directly to the cloud from a drone due to onboard computation limitations and should have optimised data-link. To solve this problem, ground stations will provide the required computation power to compress the data and send it to the cloud. Basic pattern recognition and classification algorithms will be running at ground stations apart from acting as a local storage.

Machine Learning Models :

We use various types of data from drones such as multiple spectral images, thermal imaging, normal images and videos of the agriculture crop, to train the machine learning models to perform the necessary tasks.

1. **Field Inspection Model :** Using multiple spectral and thermal images, we can apply computer vision techniques which give a landscape of the field. This information will help us choose the best crop for cultivation.
2. **Disease Detection Model :** This model identifies the critical section of the field which is infected by various insects and pests. On detecting this area, we mark the coordinates to the drone to spray the pesticides.
3. **Water Detection Model :** This model detects the area of the plants shortage in water and notifies the farmer to water the plants.
4. **Weed detection :** Based on the available imaging data, we train models to classify weed in larger fields in various crops.

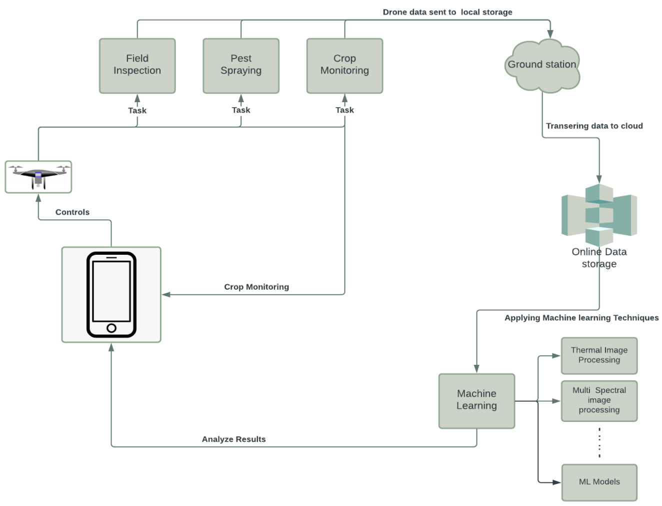

Fig 1: Smart drone flow and architecture

IV. Relevance

Our application is relevant to mobile computing as we are leveraging the use of drone technology. We use different types of sensors such as thermal and multispectral cameras, to collect information about the field. In our proposed solution, we use a mobile based application to control the drone to perform tasks and to store data in a ground station which is located near the farm. We also apply various machine learning algorithms for analyzing the collected data to make the right decision such as watering the necessary crop at the necessary location and time, and spraying the required pesticides on the chosen crop area. The farmer controls the drone using the mobile application which can regularly monitor the crop and perform tasks based on the analysis results. We are also using the ground station to save the images, and videos recorded by drone before transmitting to the cloud. This will help decrease the latency of video transmission to the cloud by connecting to the wireless networks around. The above mentioned features are characteristics of mobile computing applications.

V. Feasibility

In drones, with the current state of art, the amount of work performed by them is very limited. The use of drones in agriculture is very minimal and it’s not possible to implement our proposed solution in the near time. To capture the real-time images, videos and to transmit this information we need high computational and battery efficient drones. We are in aways to researching the type of batteries to be used in drones to ensure they have long flight time. Most of the batteries used in drones are lithium batteries which are not as power efficient when compared to graphene batteries in terms of long battery life. Graphene batteries are not available in the market yet, which are expected to be available in the upcoming 2-3 years. At present drones are transmitting the data to ground stations near the farms but in the near future, we propose to use satellite internet like StarLink for transmitting the data efficiently to the cloud.

The machine learning models being used in the field of agriculture are minimal. With access to more real-time data, more types of efficient ML models can be developed in the next 3-5 years. Having access to a large pool of data, there is a lot of scope in adding new features to drones to solve many more problems in agriculture in order to improve food production.

VI. Conclusion

The goal of the paper is to understand the importance of using autonomous drones in the field of agriculture. We provided a solution to effectively use smart drones to perform various tasks using multispectral imaging data and ML models.

Each module of the proposed system has been discussed. This system can solve the food production issues in the long term and proves that technology has a big impact on human lives when used in the correct way.

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