IOT-Based Drone for Improvement of Crop Quality in Agricultural Field

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***Abstract*— Unmanned Aerial Vehicles are becoming more and more popular to meet the demands of increased population and agriculture. Drones equipped with appropriate cameras, sensors and integrating modules will help in achieving easy, efficient, precision agriculture. The proposed solutions related to these drones, if integrated with various Machine Learning and Internet of Things concepts, can help in increasing the scope of further improvement. In this paper, the related work in this field has been highlighted along with proposed solutions that can be integrated into the drone using Raspberry Pi 3 B module.**

Keywords—Internet of Things; Support Vector Machine; Unmanned Aerial Vehicle(UAV); RGB-D sensor; Agriculture.

I. INTRODUCTION

Unmanned Aerial Vehicles (UAV) have been in use since 1980 and their applications are expanding rapidly. To meet the demand of increased population and food production, the drone in agriculture is a viable solution due to their increased accuracy, efficiency and ability to overcome various obstacles that traditional machinery cannot and will improve this industry greatly through accurate measurements, real-time data gathering, and efficient crop management. As IoT (Internet of Things) becomes more commercialized, various IoT concepts can be integrated into agriculture drones to help improve agriculture industry. Drones are easier to use, efficient and can be operated by farmers to gather accurate, real-time data. By localization, mapping and analysis of high-resolution images captured by the drone, more efficient crop management can be made possible. In this paper, the related works of similar drones have been highlighted along with possible solutions. Using the most efficient and compatible technology, a few proposed solutions have been mentioned which can be integrated with Raspberry Pi to provide better drones for agriculture. Satellite images are used for applications such as the identifying sparse shrublands and grasslands for desertification monitoring with an accuracy of 79% and 66% respectively. However, to satisfy the need for precision agriculture, the drones must be used. The drones provide precise ground truth information, more accurate images as they are closer to the ground. By using drones, we can adjust and measure the distance from terrain, calculate depth level, measure water stress level of crops, physiological features of crops and many more applications. Thus, a drone properly equipped with adequate tools and technology can make efficient, precision agriculture possible.

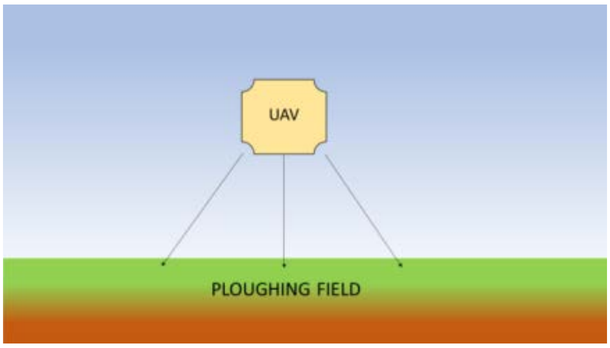

Fig. 1. Schematic of Agriculture Drone

II. RELATED WORK

Deepak Murugan et al. have proposed an approach for precision agriculture monitoring. It helps to distinguish between a sparse and a dense field using available data from the satellite and the drone. This approach works with image statistics of a region and helps to minimize drone activity. [2]

Paolo Tripicchio et al. have stressed on the popularity of drones used in agriculture. With the help of an RGB-D sensor connected to the drone, various ploughing techniques can be distinguished. Two different algorithms are used to differentiate between the ploughing fields. [3]

Rodrigo Filev Maia et al. have discussed about an IoT device which is used to monitor various agricultural parameters. The device uses a network of sensors for measuring the soil temperature, humidity, moisture etc. The test was carried out in Sao Paulo, Brazil. Reference climate data was taken to support various decisions on crop life and its sustainability. [4]

Marthinus Reinecke et al. have proposed the usage of drones for the betterment of crop quality. This could help the farmers increase their production by detecting the loopholes beforehand. The crops could be managed by using specific cameras connected to the drones to detect water shortages and harmful pests. [9]

Floriano De Rango e.t. al have proposed the usage of a simulator that is suited to the agricultural fields. This simulator would coordinate with the UAV and control the activity of the UAV in the presence of harmful insects in the crops. It would also consider various other parameters like energy and the communication range of the drones. [10]

D. Yallappa et al have proposed the design of a drone which would be helpful for spraying necessary chemicals on crops. This helps reduce the cost of pesticide application. The proposed sprayer is said to consist of 6 BLDC motors. A 5L capacity conical chamber was used to hold the pesticide solution. A DC motor coupled with a pump was used to pressurize the solution into fine droplets by means of four nozzles. The entire process was controlled with the help of a transmitter at ground level. A camera was used to monitor the live spraying operation.[11]

III. SENSORS AND MODULE USED

A. Gas Sensor:

An electronic nose or e-nose is an electronic device which replaces and does the work of a biological nose. With the help of an array of electronic sensors and neural networks (for pattern recognition), e-noses can detect the specific components of an odour. Another problem that farmers can face is the untimely ripening of fruits and the farmers need to know the exact time when a fruit needs to be plucked and this can be achieved by using sensors. This can be achieved by using China-made Taguchi sensors for sensing specific gases. In Taguchi sensors, the oxygen from the air adsorbs on the surface of a tin semiconductor diode causing the resistance to decrease. After the heated sensor comes in contact with a combustible gas, the gas reacts with oxygen, thus removing the oxygen from the sensor surface. It can be used to sense gases like ethylene, propane, methane.

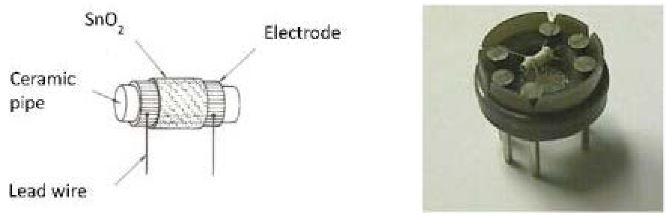

Fig. 2. Taguchi Sensor

B. RGB-D Sensor

RGB-D is a specific kind of depth sensing device (depth sensor), which works in association with an RGB camera. It adds to the conventional image, depth information, on a per-pixel basis. An infrared sensor provides the depth data which is coordinated with a calibrated RGB camera. This produces an RGB image with a depth associated with each pixel. The IR projector emits predefined dotted patterns and the sidelong shift between the projector and the sensor marks a shift in the pattern dots which in turn determines the depth of the region being examined. An amalgamated representation of this data is the point cloud, which is a collection of points in three - dimensional space. Here every single point can have certain extra features, which in case of the RGB-D sensor is the colour. This technology is licensed to be used in the commercially available sensors like the Asus Xtion PRO and Microsoft Kinect.

Fig. 3. RGB-D Sensor

C. Adafruit AMG8833 IR Thermal Camera

Adafruit AMG8833 IR Thermal Camera Breakout is an 8x8 array of thermal sensors which can be integrated with Raspberry Pi. It returns an array of 64 individual temperature readings over 12C when it is integrated with the Raspberry Pi module. This can measure temperatures starting from 0°C to 80°C (32°F to 176°F) with an accuracy of +- 2.5°C (4.5°F). It can detect a human from a distance of up to 7 meters (23) feet.

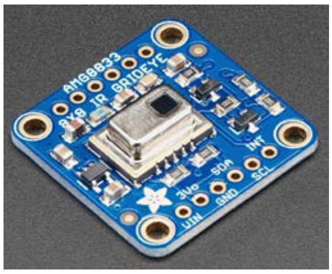

Fig. 4. Adafruit AMG8833 IR Thermal Camera

D. Raspberry Pi Model 3 B

This is the latest model of the third generation of raspberry pi. It is an ARM-based low cost and tiny SBC (Single Board Computer) which was created by Raspberry Pi Foundation. Through this module, we can send the obtained converted digital equivalents of the parameters over the internet, to any cloud-based storage area. The saved data so obtained finds a use for monitoring purposes as well as in analysing the information. The RGB-D sensor can be embedded in the Raspberry Pi model so as to send data acquired through it to Cloud storage.

Fig. 5. Raspberry Pi Model 3 B

IV. METHODOLOGY

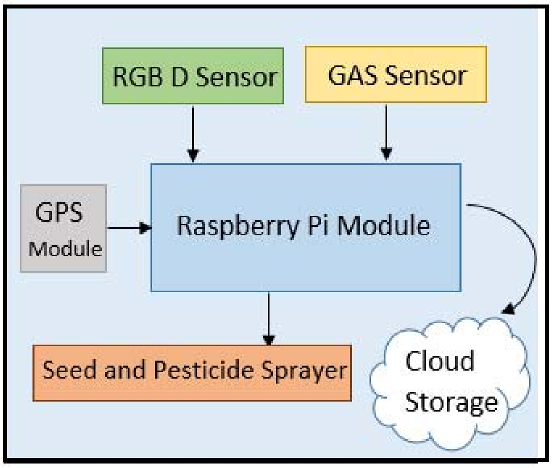

Fig. 6. Block Diagram of Proposed Model

- In the UAV, rather than using conventional multispectral techniques, hyperspectral imaging is a better solution for providing accurate data as it is 10 times more powerful. Hyperspectral imaging is much more difficult to implement and is the only imaging format that enables the use of artificial intelligence for crop yield forecasting, accurate application of pesticides and fertilizer and other inputs such as labour and water. Also, when compared to other techniques, hyperspectral imaging allows capturing of more detailed images in both spectral and spatial ranges. The hyperspectral sensors have a capacity to measure hundreds of bands and hyperspectral imaging has resulted in the emergence of lighter and more compact UAV systems which can be integrated into modern agriculture.

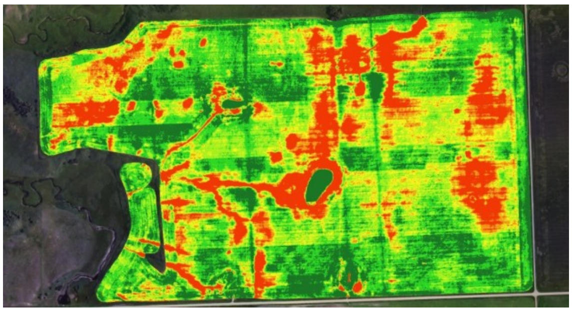

Fig. 7. Hyperspectral Imaging Technique

- Use of thermal or heat-seeking cameras can help agriculture management greatly by monitoring thermal properties of plants and crops and by also detecting the presence of harmful wildlife in the crop fields. Also, thermal imaging helps us to monitor plant diseases, lack of water and other physiological processes. The Workswell WIRIS system is an example of such a system to enable users to perform these tasks. Another system which can be integrated with Raspberry Pi is the Adafruit AMG8833 IR Thermal Camera Breakout which is an 8x8 array of thermal sensors. It returns an array of 64 individual temperature readings over 12C when it is integrated with the Raspberry Pi module.

- Another feature that can be installed in the proposed model is an RGB-D camera for capturing real-time images and processing the images. It can be employed both in a fixed-wing drone and in a rotatory wing system. The choice of using this type of commercial sensor has the advantage of being relatively cost-effective compared to a prototype solution as it doesn't require dedicated acquiring electronic components and can be embedded in many aerial vehicles. [8]

- For the navigation mechanism of the proposed system, the classic sensor fusion technique involving GPS integration with Inertial Navigation Systems (INS) is used. These two sensing modalities are extremely complimentary: the GPS module provides a slow update positional information with a bounded error, while the INS system provides unbounded integration error, but with a fast update rate. Combining the two, it is possible to achieve high-fidelity localization estimation. [6]

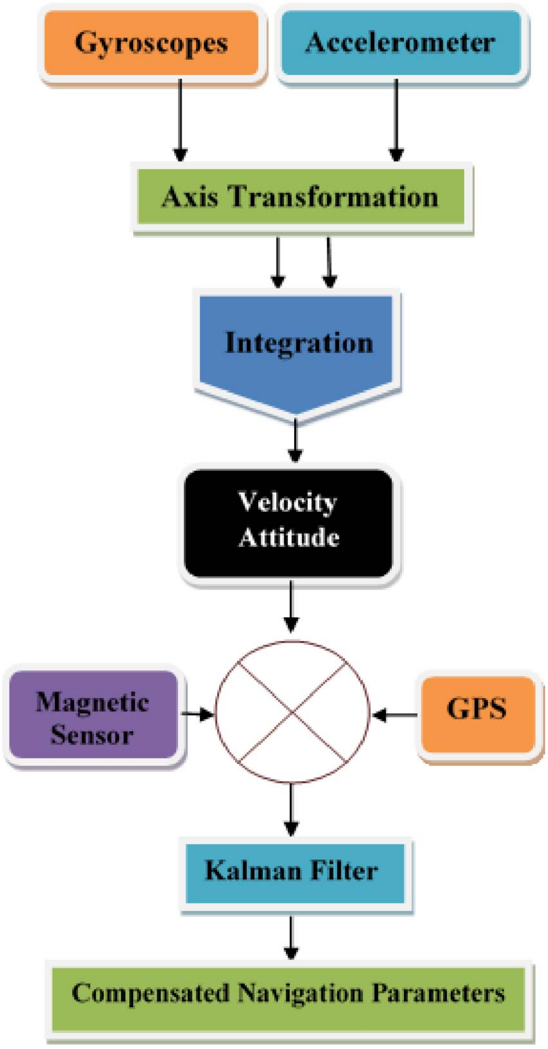

Fig. 8. Block Diagram of Inertial Navigation System

Optical data captured from drone are generally affected by cloud. For applications such as agriculture monitoring, which is to be performed in real-time, this poses a problem as the cloud affected data might lead to misleading information due to altered reflectance values. So, there is a need to mask cloud-affected data before proceeding for further analysis. Landsat 8 data are provided with a quality assessment band, which consist of 16 flag bits. High state i.e., ‘1' in the 14th and 15th flag bits indicates the presence of a cloud in the selected pixel, and the mask is thus created using this information. The obtained mask is verified with the mask obtained using cloud detection technique as described.

For the classification and analyzing of data that is uploaded in cloud, support vector machine or SVM is used, which is a supervised learning model, integrated with machine learning algorithm that mainly focuses on regression and classification problems. The main objective of the SVM is to train a model such that it assigns the new objects to a specific category. It starts by modelling the situation which creates a feature space (vector space of finite dimension) wherein each dimension depicts a "feature" of a certain object. SVM selects the most optimal solution. The SVM can also be used in precision agriculture using UAV. The SVM can work on a public dataset of crops and plants and can further predict its results with increased accuracy. The image data and odour data collected from the sensors is put into SVM to accurately predict the condition of the fruit or crop. [12][13][14]

V. FUTURE WORK

In this paper, many possible solutions have been highlighted and combined to produce a comprehensive solution for the betterment of agriculture drones. For, future work, a proposed method is the installation of solar panels on the drone itself. By installing solar panels, the need for external charging is eliminated and the drone can charge during the day when it is operating on the field. Another future application may be the use of the Support Vector Machine (SVM) for classification of crops and plants according to yield. The SVM can work on a given database of crops and their respective physiological characteristics and time of yield. Using this, the SVM can predict appropriate yield times of the planted crops, or it could predict the time of ripening of fruits with sufficient accuracy.

VI. CONCLUSION

Thus, we can conclude that drones or UAVs will be of immense help in the field of agriculture with the increase in population as they are essential at the very beginning of a crop cycle. It will not only reduce time but also yield better cultivation based on analyzed data. Crop management will be more efficient due to systematic monitoring. With the upcoming technologies, the production rate will increase rapidly with lesser consumption of energy. Drones are not just used in the analysis of soil and fields but also in planting seeds and shooting plant nutrients in the soil. Crop monitoring obstacles faced previously can also be done away with the help of drones. The application of drones does not stop here when embedded with hyper spectral, thermal-spectral or multispectral sensors, drones can identify which parts of the land are dry and thereby assessing an irrigation plan becomes easier. Additionally, drones also find use in assessing the crop health by scanning them using near-infrared and visible light. Thus, drones serve as a perfect aerial platform for gathering the data needed in precision agriculture.

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