Drones for Normalized Difference Vegetation Index (NDVI), to Estimate Crop Health for Precision Agriculture: A Cheaper Alternative for Spatial Satellite Sensors

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Abstract—*Normalized Difference Vegetation Index (NDVI) data used to estimate the health of green vegetation and post processed high definition images for precision agriculture. Drone provide high-resolution image taken of crops, it compares the reflected intensities of near infrared (NIR) and visible light. Autonomous aircrafts are improved and cost effective instruments for data acquisition, real-time thermal imagery to the ground control station (GCS), and fastest medium for quick time and critical analysis of the crop. The paper represents an alternative and cheaper methodology to estimate the growing crop health and stress by acquisition of data using drone with modified airborne cameras and sensors. This paper represents an alternative and cheaper method to estimate the crop health/stress by acquisition of data using remotely piloted aircraft with airborne sensors.*

1. INTRODUCTION

Drones can fly autonomously with dedicated software which allows to make a flight plan and deploy the system with GPS and feed in various parameters such as speed, altitude, ROI (Region of Interest), geo-fence and fail-safe modes. Drones are preferred over full size aircrafts due to major factors like combination of high spatial resolution and fast turnaround capabilities together with low operation cost and easy to trigger. These features are required in precision agriculture where large areas are monitored and analyses are carried out in minimum time. Using of aerial vehicle is possible due to miniaturization of compact cameras and other sensors like infrared and sonar.

2. SYSTEM DESCRIPTION

2.1 Aerial Platform

Quad-rotor helicopter of 700mm diameter (see Fig. 1). This vehicle is capable of carrying 1kg payload with endurance of 35mins flight at top speed of 25Knots. The major advantage of this equipment is its vertical takeoff and landing capabilities and can operate from very confined places. This aircraft is automated using Arduino open source development board and an open source software (PIX4D) is used to plan the flight path (waypoints, altitude, heading direction & speed). User interface is simplified in such a way that anyone with two hours of training can operate this instrument and render useful information.

Fig. 1: Quadrotor helicopter and Gyro-stabilized High resolution camera.

2.2 Image Sensor

Commercially available cameras are small enough to fly on a drone platform and record in NIR, they are both expensive and low in resolution. This hurdle can be taken as an affront and the solution is to modify a canon SX220 camera into NDVI camera with very minimal modifications the output was a high resolution camera which could observe NIR at a reasonable cost.

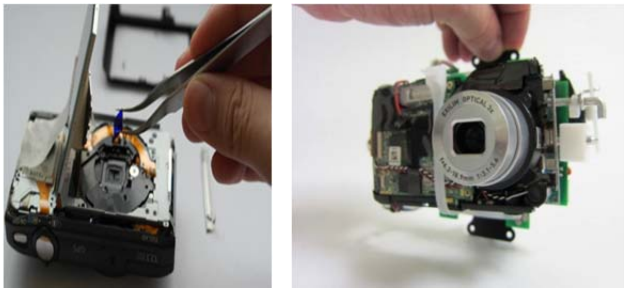

Fig. 2 (a.) Modified Canon SX260 camera (without the infrared filter)

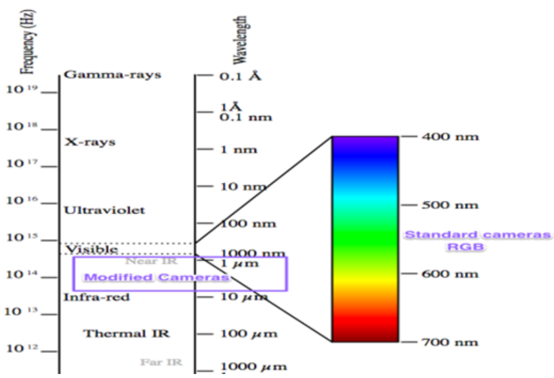

Fig. 2(b.) showing difference in wavelength capture between standard and modified cameras

Fig. 2(c.) Output of the modified camera (NDVI image)

Standard digital cameras capture RGB red, green and blue light. Modified cameras (see Fig. 2(a.)) captures the combination of near infrared, red, green and blue light (see Fig. 2(b.)). Removing infrared filter allows camera to capture near infrared image NIR (see Fig. 2(c.)). Normalization difference vegetation index is a simple metric which indicates the health of green vegetation. The basic theory is chlorophyll strongly reflects near infrared light (NIR, around 750nm) while red and blue are absorbed. Chlorophyll reflects strongly which is why plants appear green to us but reflection in NIR in even greater, this plays a very important role and helps in rendering precise data for analysis. The principle of NDVI relies on the fact that, due the spongy layers found on their backsides, leaves reflect a lot of light in the near infrared, in stark contrast with most non-plant object. When the plant becomes dehydrated or stressed, the spongy layer collapses and the leaves reflect less NIR light, but the same amount in the visible range. Thus, mathematically combining these two signals can help differentiate plant from non-plant and healthy plant from a sickly one.

3. HARDWARE AND SOFTWARE TECHNOLOGIES

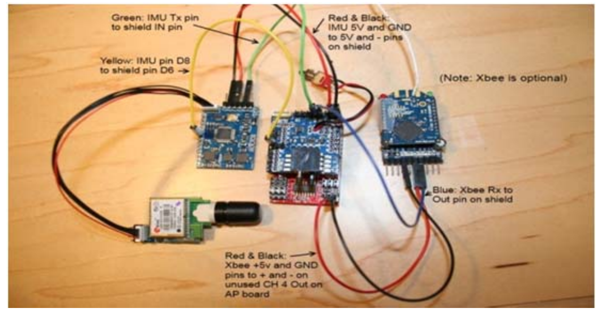

Fig. 3(a.) Autopilot unit, GPS, Radio Link

Fig. 3(b.) GCS software for flight planning

Technology used in Drone is very sophisticated and advanced as it has to compensate the absence of the pilot and thus enable the flight of unmanned aerial vehicle and its autonomous behavior. They are mainly based on sensors and microcontrollers, communication system, artificial intelligence. Drone is an automated system and is separated into two parts. Hardware control unit of the machine is called Autopilot System, which is used to control the flight and various characteristics. Autopilot unit consist of waypoint navigation with altitude and airspeed, fully integrated IMU (gyro, acc.), GPS system, Barometer pressure sensor. All these MEMS (micro-electro mechanical systems) are integrated on the board (see Fig. 3(a.)). All the sensors have independent fail-safe program, in case of failure such as altitude, position, communication modem, aircraft will start heading towards the actual takeoff point, flight path and recorded data will be saved in the autopilot chipset and can be easily downloaded on the ground station computer for post flight analysis. Other Modem (downlink) is connected to the Ground Control Station Software updating the real time data of the aircraft. (see Fig. 3(b.)) GCS provides an interface between aircraft and computer. It enables flight programming, pre-flight simulations, tracking the flight path and monitoring its heading and position on the map. It also generates a log file for post flight analysis.

4. PRECISION AGRICULTURE USING UAS

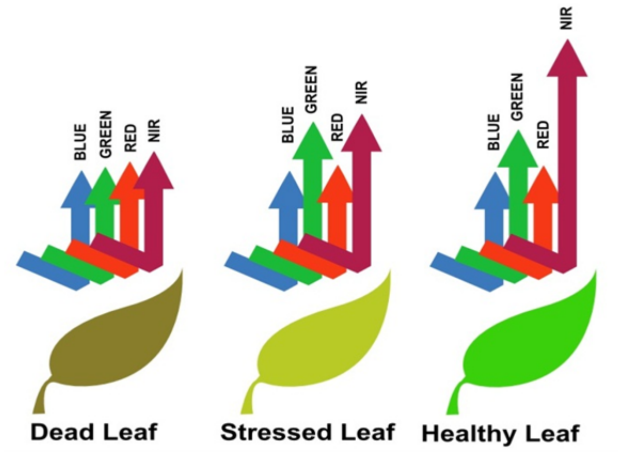

Fig. 4(a.) NIR analysis of Leaf Area Index

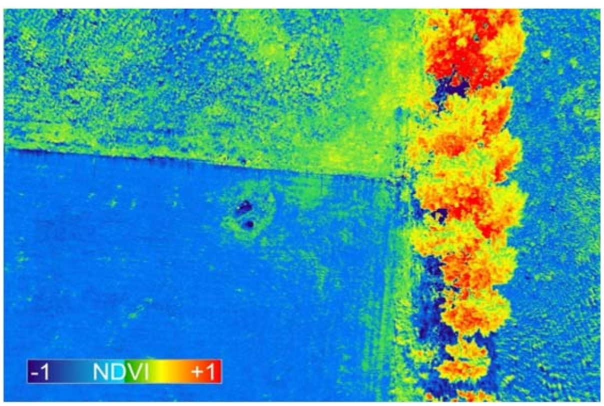

Fig. 4(b.) NDVI image of a playground

Vegetation indices in remote sensing is very common, some indices use the RGB spectral bands. Indices used are :

Green Red Ratio Vegetation Index (GRRVI)

Or

Normalized Green Red Difference Index (NGRDI) reflectance in green and red part of the spectrum.

Leaf Area Index (LAI) it characterizes plant canopies. One sided green leaf area per unit ground surface area. (LAI = leaf area/ground area).

NDVI ratio of reflectance in near infrared and red portions of the electromagnetic spectrum (Fig. 2(b.)).

5. PHOTOGRAMMETRIC WORKFLOW

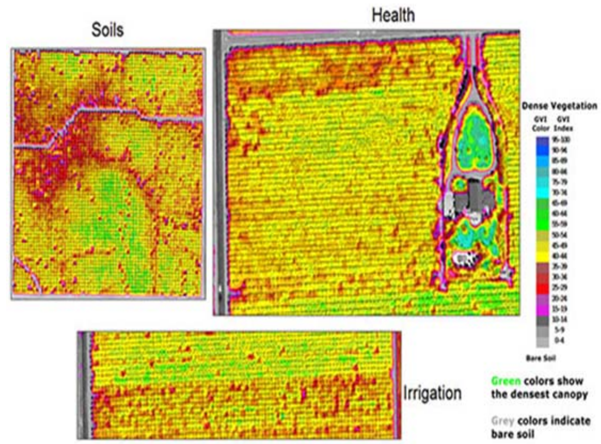

Fig. 5(a.) NDVI image of Sugarcane Field

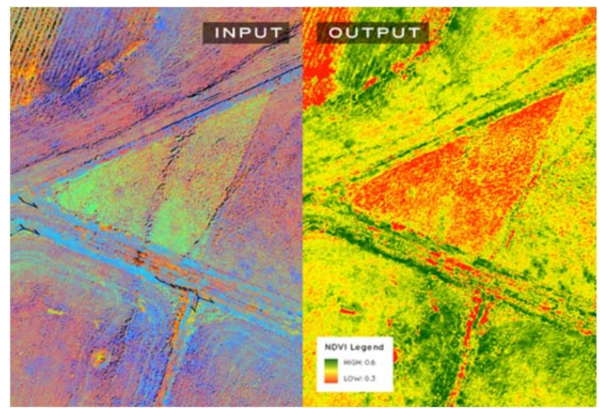

Fig. 5(b.) Input NIR image, Output PIX4D image.

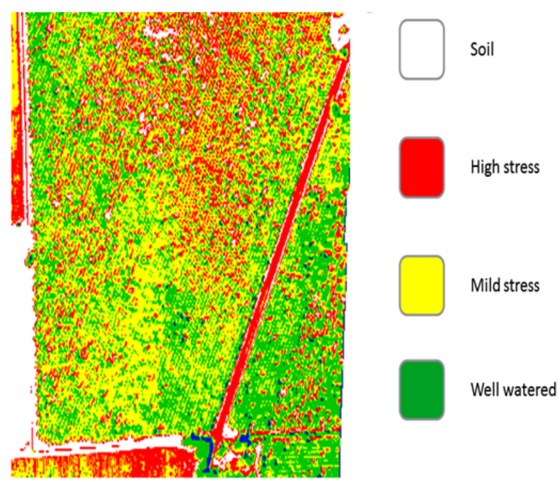

Fig. 5 (c.) NDVI image showing stressed and well watered crop.

6. CONCLUSION

Use of Drone technology is beneficial in agriculture. The output is encouraging the development and use of drones in agriculture as a tool for site specific precision farming in small field area. These can be used by farmers for data acquisition and analysis, continuously monitoring fields for learning and developing modern farm management skills. NDVI is a method to absorb healthy vegetation into a picture the stressed vegetation due to water stress, nutrition deficiency, other than the diseased plants. This information is kind of actionable intelligence that should be delivered to the farming community. Currently drone analysis shows the variation in agriculture production, new generation systems will not only show the variations but also what is causing these variations in the agricultural production. Drone will produce high precision data to become the key components of the agriculture industry. The future of agriculture industry is bright with drones as a valuable tool that will increase profitability and healthy crop production.

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