Efficient and Cost-effective Drone – NDVI system for Precision Farming

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Abstract

The motive of the project is to develop a under budget system that automates the process of farming by interfacing cutting edge technologies like Drones and 'NDVI' to improve the level of productivity in Agriculture. Humans and satellites have a hard time beating a drone's eye for detail in scanning farming systems from above. Flying below the clouds, collecting and sending images in almost real-time, unmanned aerial vehicles (UAVs) gained ground quickly in agriculture in the last decade as part of so-called precision agriculture. Among their wide range of applications, they can help farmers check crops' health, track livestock, plan fertilization, assess damages, and map fields at high-resolution. But all this comes with a cost. Currently the models of drones used for such applications cost extensively higher, which makes it unfeasible for the small farmers, especially in India. The projects aim on designing a drone system that can work on both autonomous as well as manual mode and perform mapping, inspecting and spraying processes with efficiency accuracy and considerably good speed which can help boosting the profits of the farmers with large as well as small agricultural lands. As there are lots of restrictions on Drone flight in India. The project aims to follow and implements all the norms stated by the government. (e.g., Permission before flight). The project aims towards overcoming all the above-mentioned problems by automating the procedure.

Keywords— NDVI, UAV, Arduino, STM32, GPS, gyroscope

I. Introduction

Agriculture is the backbone of India's economy, which accounts for 18% of India's Gross Domestic Product (GDP) and hires about half of the country's workforce. More than 70% of rural families depend on agriculture for their livelihood. Housing about 17% of the total world population, India faces the challenge of fulfilling the demands of agricultural commodities for this ever-growing population.

Smart farming concepts like precision agriculture can be aptly deployed to achieve this goal. Precision farming is an integrated crop management system which uses remote sensing (RS), GPS, and geographical information system (GIS) to monitor the crop field at ground level. The first step in precision farming is Monitoring of crops. The best method for automated Monitoring of the farmland is by using the concept of NDVI in integration with either satellite imagery or suitable UAV hardware.

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II. Proposed design

A. NDVI (Normalized Distribution Vegetation Index)

Crop Monitoring is a perfect tool for tracking the health of crops. For this purpose, NDVI can be measured on the fly. By measuring the difference between near infrared (that vegetation reflects strongly) and red light (that is absorbed by vegetation), Normalised Difference Vegetation Index (NDVI) a dimensionless index qualifies vegetation.

In simple terms, NDVI is a measure of the state plant health based on how the plant reflects light at certain frequencies. The NDVI calculation result ranges from -1 to 1. The higher is the value of NDVI the greater is the health of the crop. If the NDVI value is equal to or less than 0.1, it represents that the land under inspection is either rock, barren, sand or snow. Whereas if the NDVI value ranges between 0.2-0.3 it indicates shrubs and grassland. If the NDVI values is 0.6 or above it corresponds to temperate and tropical rainforest.

$$NDVI = \frac{NIR - RED}{\mathrm{NIR} + \mathrm{RED}}$$

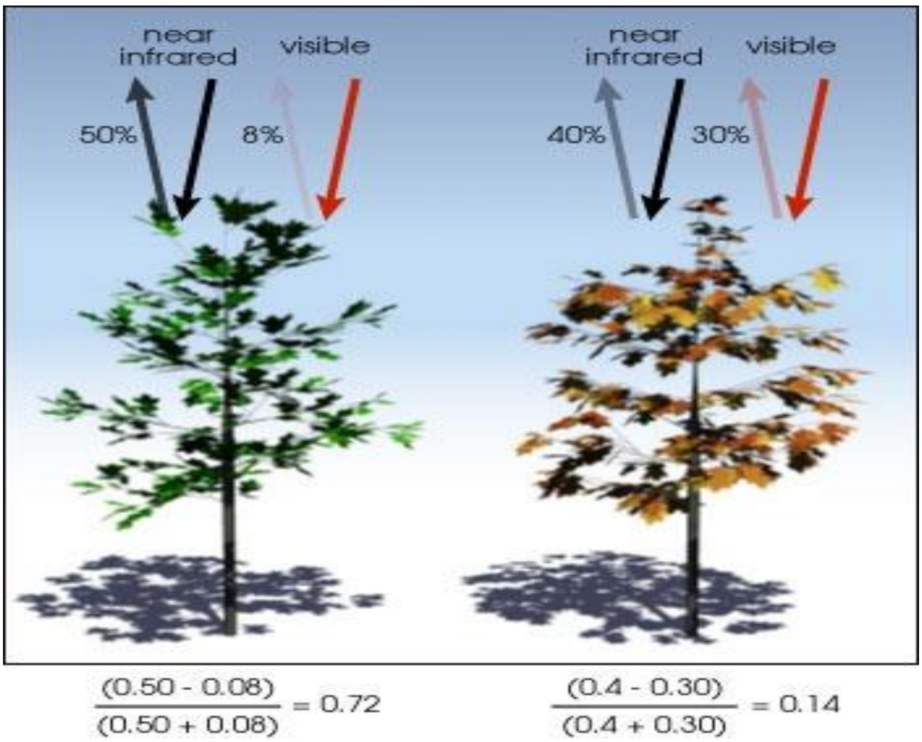

Figure 1. Concept of NDVI (Image souce: Google images)

This concept can be implemented by using satellite imaging or by using Specialized NDVI cameras with suitable hardware. The project focuses on using and improvising the second method that is using “UAV hardware with NDVI cameras” for generating NDVI images of the farm. The project aims at designing such a UAV that is cost effective, efficient and as user-friendly as possible.

B. Hardware design

Following are the specifications of the UAV hardware best suitable for the purpose. The configuration of drone used for the project is Quad X mode for better stability and optimum visibility of camera.

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Table.1 Selection of Hardware and Specifications

Part Name	Specification
Body Frame	Material: Carbon Fibre Size: 450mm diagonally
Motor (4 pieces)	Bldc 1400kv Current draw: 12A/60S Thrust produce per motor: 750gm-800gm
Propeller (4 pieces)	Size: 10 inch Pitch:- 4.5mm
Electronic Speed Controller (4 pieces)	ESC 40A Use in Range : 2S-4S Lithium Polymer Battery
Battery	Name: 4S Lithium Polymer Battery Capacity: 3300mA Battery Efficiency: 80%
Gimbals	2 Axis Servo Based Gimbals
Landing Gear	Material : Aluminium

C. Load Calculation

- Total estimated mass of drone along with pay load is 1.5KG
- Thrust produced by one motor is approximately 800gm
- Total thrust produced by 4 motor is (4×800gm) =3200gm =3.2KG
- Therefore, power to weight ratio is around 2:1

D. Flight Time calculation

- FPV drone flight times=(Battery Capacity * Battery Discharge /Average Amp Draw)*60
- E.g. Flight time = (3.3*0.8/5*4)*60 = 7.92 minute

Figure 2. Quadcopter 'X' Configuration

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III. Key Cost Optimizing Factors

A. Open source Flight controller

A flight controller (FC) is a small circuit board of varying complexity. Its function is to direct the RPM of each motor in response to input. A command from the pilot for the multi-rotor to move forward is fed into the flight controller, which determines how to manipulate the motors accordingly. It works on PID control system to maintain its position with maximum stability during the flight.

Generally, the cost of customizable flight controller with such high configuration is quite higher. This majorly adds to the costing of the drone. This can be avoided completely by building a flight controller with a open source micro-controller like Arduino, STM32 which can cut the cost of the project extensively. Moreover, it can be customized to infinite level.

Components attached to the flight controllers

- Signal Receiver
- Accelerometer, Gyroscope, ultrasonic, barometer sensor modules
- GPS modules
- Telemetry Transmitter.
- Gimbal circuitry
-

Functions and Characteristics of the flight controller**.**

- Self-balancing drone controller
- Autonomous flight control mode – This mode enables the drone to move to specific coordinates as preprogrammed without any manual interactions.
- It allows switching between Manual as well as Autonomous mode whenever required.
- It enables Telemetry communications which helps to display the visuals captured by the on-board camera at the remote station.
- It can be customized with different attachments for various applications.

B. Servo based 2 axis gimbal

The final result of the crop monitoring is represented in the form of a color distribution map. For this mapping purpose a much-stabilized video footage of the field is must. Thus, a Gimbal system is attached to the drone to get a smooth video. Gimbal is basically used to prevent the shaking of the camera. It damps around 80%-90% of the vibration occurred due to movement of drone, wind or another external factor. The Gimbal system consists of two brushless servomotor that aim to prevent vibration. It is based on the feedback generated from on board gyroscope and accelerometer. The whole logic of the system is to create a reverse motion in the opposite direction of the vibration so that the vibration can be resolved and a smooth footage of the field can be captured.

C. Modified Ndvi Camera

The cost of specialized NDVI camera is quite higher, this can be optimized by using two methods

1. Modifying the currently available 15–20-megapixel video cameras by replacing the normal lens by NDVI lens. E.g.- Go pro Hero 4 with NDVI lens
2. By modifying the conventional camera to NIR camera by removing the infrared filter from the camera.

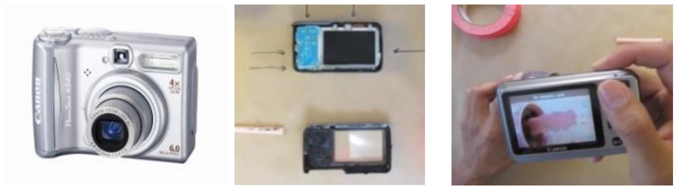

Figure 3 .(a) Consumer camera – Canon A450, .(b) Removal of infrared Filter, (c)Modified Camera Output (Image Source: YouTube)

D. Open source supporting softwares

The software used for programming the flight controller is a open source software “Arduino ide” which open ups a lot of possibilities of improvement and modification in the project.

A waypoint mapping software is needed to plan the autonomous flight of the UAV. This can be done either by developing a software in visual studio or by using an open-source software such as Ground control station software. This method is highly efficient and cost effective for the project. Further for generation of NDVI images of the farmland a software is required that compiles the images shot by the on-board camera and compile it into final NDVI map of the farm. This can be done using an open-source software like PIX4D which gives quite accurate results.

IV. Implementation

The monitoring of the farm is done with the help of Autonomous or manual mode. In Manual mode the operator skills is required in photo coverage of whole farm. Whereas in Autonomous mode, the path of the drone is pre-designed and can be fed to the drone by any open-source software or self-designed app. The live location of the drone can be tracked via GPS (Global Positioning System) signal transmitted by the on-board GPS module and the location can be displayed on the Open-source software like ‘GCS’ which has integrated map option in it.

Figure.4 Waypoint path mapping on Ardupilot

(Image Source: https://ardupilot.org/planner/)

The below figure clearly displays the precision of the NDVI image where the green color displays good quality crops (crops with high levels of chlorophyll) and the part in red color displays the discontinuity of plants or bad

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quality / spoilt plants (due to lack of chlorophyll). The image displays the results of 2 different dates with an interval of 30 days performed by authors of reference paper [2].

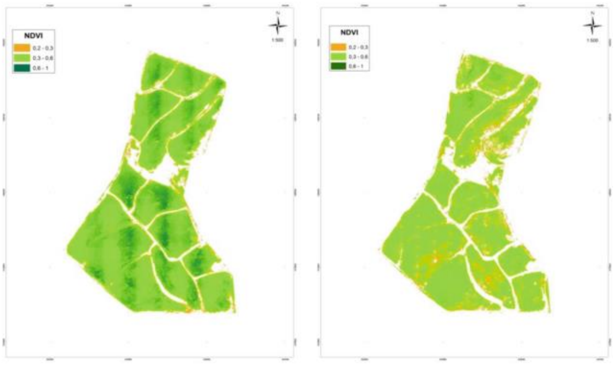

Figure.6 NDVI Output results of a between a period of 30 days [2]

V. Expected Outcomes

- NDVI gives powerful insights and makes it easier to visualize crop health that the naked eye can't see. It shows you where the problem is in advance so you can fix it faster.
- NDVI technology does not replace humans, but it does help make your job easier. And with drone mapping software, it's becoming one of the most successful methods to easily and quickly assess plant and crop health and improve farm yields.

The project might appear expensive for individual farmers in India, but it can be economically justified by using it as a government project adopting the whole village or can be contributed amongst several farmers and can also be rented. This is possible because of its faster operating speed and wide range.

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