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Land Survey and Mapping for Agricultural Purpose using UAV

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Abstract

Unmanned Aerial Vehicles (UAVs) are a group of aerial vehicles that include drones. Agriculture has always been the backbone of India's sustained growth. Land surveying is the most challenging task in the agricultural field in terms of accuracy and time required for surveying using the traditional method. We have built a fully autonomous UAV and calibrated it for agricultural land survey purposes. The navigation and mapping process, in which a predefined path is provided to the UAV flight controller. During its autonomous flight, the drone's camera captures multiple images. Using a threshold-based segmentation method, the cultivated land and uncultivated land areas are determined using this system. Pre-processing of the images, land area segmentation, and post-processing of the images are carried out. The pre-processed image is divided into several distinct regions by applying a colour thresholding technique, which serves as the foundation for the segmentation of land. The results illustrate that the proposed method outperforms the existing method.

Keywords: UAV, Segmentation, Drone, Navigation, Mapping

1. Introduction

With the development of engineering and technology, it is necessary to develop a device that humans cannot, reach. It was necessary to have a device that could take aerial

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images. Unmanned aircraft systems, or unmanned aerial vehicles (UAVs), are more common names for drones. A drone is essentially a flying robot that uses software-controlled flight plans in its embedded systems to fly independently or remotely using onboard sensors and a global positioning system (GPS). Land survey and mapping using unmanned aerial vehicles (UAVs), also known as drones. The process of land surveying and mapping using UAVs involves several steps. First, the area of interest is identified, and the surveying and mapping objectives are defined. The UAV is then deployed to fly over the area and capture images and data using its onboard cameras and sensors.

Segmentation is the process of dividing an image's pixels into two categories: crops and weeds in the foreground, and soil in the background. In order to avoid misclassification for subsequent plant analysis, the segmentation needs to be carried out correctly. Land surveying and mapping using UAVs is a powerful tool that can enhance the accuracy, efficiency, and safety of land surveying and mapping processes. The article presents a color index-based thresholding method for segmenting the background and foreground of plant images. Colour index-based thresholding is a method used for agriculture surveys that involves analysing the colour information in images captured by UAVs or other sensors. The basic principle of this method is to use colour index values to distinguish between different types of objects or features in an image. A colour index is a mathematical formula that combines colour information from different channels in an image, such as red, green, and blue. By using different colour indices, it is possible to identify specific features in an image based on their colour characteristics. For the colour indices to distinguish between the foreground (a green plant) and the background (soil), two fixed threshold approaches are proposed. By providing detailed and accurate information about agricultural fields, colour index-based thresholding can help farmers and agronomists make informed decisions and improve crop management practices.

The objectives of the proposed work are: To build a fully autonomous UAV for agricultural land surveying purposes. To segment the crops and land covered using colour index-based threshold image processing technique. We have created an autonomous drone for agricultural land surveys. It follows a predefined flight path and captures images with its camera. We use a threshold-based method to distinguish between cultivated and uncultivated areas. First, we process the images, then we segment the land, and finally, we post-process the segmented images.

Contribution: In this paper land survey and mapping for agricultural purpose using UAVs is proposed. During its autonomous flight, the drone's camera captures multiple images. Some steps are included in the segmentation approach for land survey using UAVs and image processing techniques: pre-processing of the images, land area segmentation, and post-processing of the images. The pre-processed image is divided into several distinct regions by applying a clustering algorithm, which serves as the foundation for the segmentation step.

Organisation: section 1 gives a brief introduction of Unmanned aircraft systems or unmanned aerial vehicles. The related work of existing techniques described in section 2. The proposed model is described in section 3. In section 4 results are discussed. The conclusion is given in section 5.

2. Related Work

P.R. Sriram etal. [1] suggested a study project that focuses on employing a Pixhawk flight controller to operate an autonomous unmanned aerial vehicle (UAV). The quadcopter is designed to follow a predetermined path and is capable of navigating without any real-time input from the user. The program makes it possible for a quadcopter to fly itself, watch its course, move gracefully, and conduct an exact altitude hold. Pietro Tosato etal. [2] presented a study to address the contemporary requirement for gas sensing; tiny and mobile sensors have been used in a variety of applications, such as remote-controlled cars. Unmanned aerial vehicles (UAVs) hold great promise for this kind of measurement since they can sense locations that are difficult to access without putting the operator at risk. They demonstrated a coordinated swarm of unmanned aerial vehicles (UAVs) fitted with gas sensors for monitoring industrial air pollution in this article. They created a coverage algorithm that explains and allocates the routes to every drone that the swarm manager controls throughout the mission. Miguel A. Castillo-Martinez, et.al [3] have proposed a colour index-based thresholding method for background and foreground segmentation of plant images presented. The suggested method makes use of the color index methodology; two color indices have been altered to better reflect the information about the plants. For the color indices, two fixed threshold techniques are suggested to distinguish between the background (dirt) and foreground (green plant).

Song Yuheng and Yan Hao [4] presented a study on image segmentation technology, which is extensively utilized in face recognition, pedestrian detection, medical image processing, and other fields. Among the methods for segmenting images are segmentation based on weaklysupervised learning in CNN, segmentation based on clustering, segmentation based on edge detection, and region-based segmentation. This work examines and contrasts the benefits and drawbacks of several picture segmentation techniques, as well as analyzes and summarizes them. Paweł Smyczyński etal. [5] introduced a broad system architecture approach that is supported by a functional, real-world model created for tracking and landing on moving targets. A visual system is used to detect landing areas. For marker detection, the contour shape analysis approach combined with Cranny's edge detection algorithm is employed. Utilizing the Lucas-Kanade optical flow algorithm, the identified pattern is tracked. UAVs combined with artificial intelligence (AI) for autonomous payload transport have been investigated by Reem Alshanbari et al. [6]. They have created an algorithm that enables multi-phase target recognition on the ground, releasing the payload when the target is identified. Over a predetermined period of time, they have managed to achieve an astounding average frame rate of 19.4010717352 frames per second (fps). Chin Lu etal. [7] have unveiled a brand-new, ground-feature-focused path-planning strategy for UAV mapping. Estimating the distribution of ground feature points from a lower-resolution image is the first step used in this work. After that, image footprints are chosen using a three-step optimization procedure and solving the "grouped traveling salesman" to determine the UAV's flying path.

Pie-Chun Chen etal. [8] have focused on five townships located in the Chianan Plain of Chiayi County, Taiwan. Approximately 100 hectares of farmland in each township were designated as sample areas for investigation. To collect data, a combination of quadcopters and handheld fixed-wing drones were employed, capturing both visible-light and multispectral images. The survey took place during the period from August to October of 2018. The UAV platform was utilized in their research study by Weicheng Xu et al, [9] for gathering farmland visible light remote sensing images in order to track and extract data about area, shape, and location. Employing the object-oriented method, the study focused on determining the optimal parameters for cultivated land area extraction based on texture information, vegetation index, as well as shape details within the visible light spectrum. A survey to comprehensively explore a variety of aspects related to UAV applications, encompassing diverse UAV types, research domains, deployment architectures, and sensors, have been done by authors [10]. Zheng Xu [11] has done research on the design of UAVs with an emphasis on IoT (Internet of Things) integration for data collection methodologies. The aim of the study is to create IoT-connected autonomous flying vehicles for improved site safety and health applications.

Martin Peter Christiansen etal. [12] have created a new UAV design and mapping for agricultural research, productivity estimation, and environmental condition monitoring. They have used 3D LiDAR to map winter wheat with a 0.12 m row distance at a 6 m altitude. Using textural analysis, they have determined the total plant volume and soil surface for every crop parcel. The authors [13] have conducted a thorough examination of the current advancements in unmanned Aerial Vehicles (UAVs), encompassing contributions from both academic and industrial domains. They have also done academic research on UAV types, classifications, standardizations, swarm dynamics, and charging methodologies. Rishab Gupta et al. [14] have explored how drones are used in agriculture. They have provided an overview of current drone technology in agriculture, covering aspects such as monitoring crop health and performing farm operations like managing weeds, estimating evapotranspiration, and spraying. Abderahman Rejeb etal. [15] conducted an examination based on bibliometric methods to consolidate and organize the prevailing academic literature, employing bibliometric techniques. They scrutinize the literature pertaining to agricultural drones to provide a concise summary and evaluation of prior research.

3. Proposed Work

Figure.1 shows the block diagram of the proposed. The power module, which is connected to the PDB (Power Division Board), is connected to the LiPo battery. The devices get the power they need from PDB. The UAV's speed, direction, and altitude are all controlled by the flight controller, which is a Pixhawk. ESC (Electronic Speed Regulator) controls the speed of the engine in light of the sign given by the flight regulator. GPS is used for mapping and making a path. During the UAV's flight, telemetry provides the precise location of the ground station. Battery, combustion engine, hydrofuel cell, solar, laser beam power, and cable tube power supply are just a few of the many power sources available to a drone. The lithium polymer battery is the most common source of power used in drones.

UAVs incorporate computerized electronic speed regulators associated with motors, propellers, servo engines, and others. The use of drones necessitates the use of autopilot software. Most robots utilize radio recurrence between the remote and robot, which can work independently or semi-independently. One of the following sources can send signals to the operator's side of the remote control: Ground control is a radio transmitter controlled by human beings, a PDA, PC, or comparable control framework. The output to servos and motors can be enabled or disabled with a safety switch. Through the 6-position cable, the Pixhawk power module provides clean power from a LiPo battery and measures the battery voltage and the current consumption for the Pixhawk flight controller.

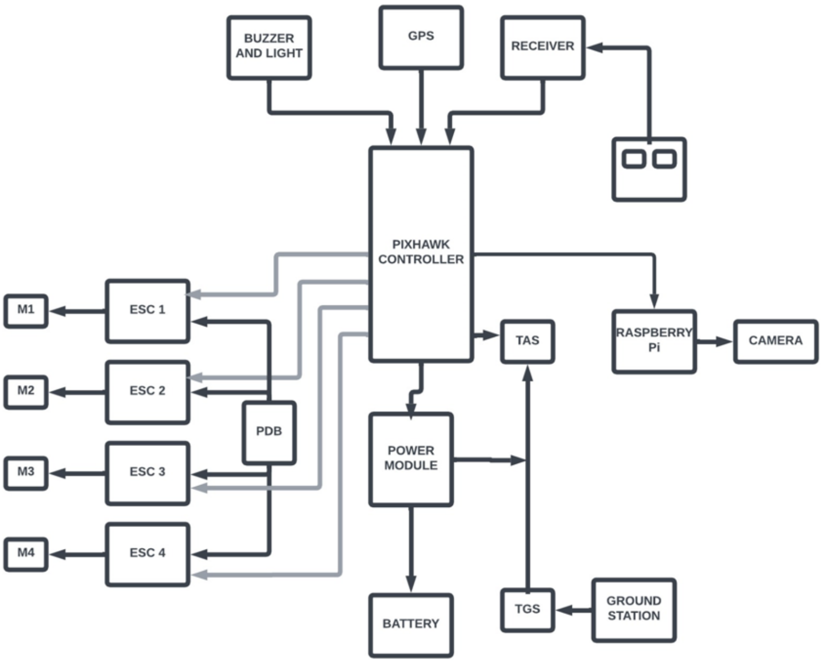

Figure 1. Block Diagram of Proposed Work

Pixhawk and autopilot use a buzzer to announce milestones. The signal remembers a two-position DF14 connector on one side that plugs straightforwardly into the Pixhawk. The Pixhawk flight controller is connected to a microcontroller, such as a Raspberry Pi, which is powered by the LiPo battery, which provides power to the entire UAV. During surveillance, the images are captured by connecting the USB camera to the Raspberry Pi. Based on the information obtained and the program unloaded on the Raspberry Pi, the division cycle is performed.

3.1 Hardware Modules used in the Proposed Work

(a) Quadcopter Frame

Figure 2. Frame

The Glass fiber Q450 frame shown in Figure 2 above is known for its toughness and durability. They have arms made of extremely durable polyamide nylon. The arms have support edges on them, which further develops dependability and gives quicker forward flight. Because the Q450 has integrated PCB connections, it is possible to directly solder the ESCs.

(b) Power Distribution Board

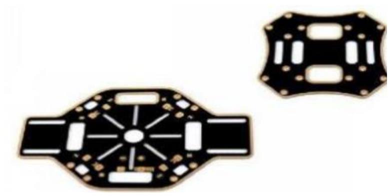

Figure 3. Power Distribution Board

PDBs in Figure 3 are a vital component of multirotor drones. There are many kinds of PDBs, each designed for a different kind of vehicle. This is generally mounted on the casing of the UAV, where it supplies capacity to every one of the four engines through a single line of force.

(c) LiPo Battery

Figure 4. LiPo Battery

LiPo batteries, shown in Figure 4, are used in quadcopters because they can store and transmit a lot of power. The batteries in RC are made of individual cells connected in series. Checking the battery discharge C rating is the best option for your drone because each cell has a normal voltage, which is 3.7V.

(d) Brushless Motors and Propellers

Figure 5. Brushless Motors and Propellers

Brushless multirotor shown in Figure 5 are typically grouped together using a four-digit number. The crucial parameter is KV. It is the hypothetical increment of engine rpm when the voltage goes up by 1 volt without a load. For instance, most of the time, the 1000KV electric motors running on a 3S LiPo battery are brushless.

(e) ESC

Figure 6. ESC

An electronic circuit that regulates and controls an electric motor's speed, known as an electronic speed control (ESC), is shown in Figure 6 above. An ESC controls the amount of power delivered to the motor it is paired with in its most basic form.

(f) Flight Controller

Figure 7. Flight Controller

The flight regulator utilized in this work is Pixhawk 2.4.8, shown in Figure 7. This is the heart or the brain of the flight control system; it is an inserted PC (run on Linux) that has custom programming to control the airplane. At times , the client is reprogrammable through a software improvement kit (SDK).

(g)Transmitter and Receiver

Figure 8. Transmitter and Receiver

Transmitters range in complexity from simple devices like two joysticks for a remote-control system to intricate electronics with sophisticated programming to accommodate various aircraft configurations, trainer ports, expandable model memory, and telemetry, as illustrated in Figure 8. For many electronic toys and entry-level UAVs, the "transmitter" is just a mobile app and a tablet or smartphone with Wi-Fi capability. This lets the user choose the best device for their needs and budget. It is important to note: Since these are usually proprietary, you will probably need a Fly-Sky fsi6-compatible transmitter with a fsia6-B receiver.

(h) GPS and Telemetry Radio

Figure 9 illustrates the usage of GPS (M8N), commonly referred to as GNSS, on multi-rotor aircraft. GPS provides (relatively) exact location data, enabling flying modes such as fixed hovering, auto-return home, orientation control, and safety that limit the UAV's proximity to the pilot. GPS offers an even greater degree of granularity, which further enhances flying stability.

Figure 9. GPS system and Telemetry

(i)Raspberry Pi

Figure 10. Raspberry Pi

The Raspberry Pi depicted in Figure 10 has a Broadcom BCM2835 System on Chip module. It is powered by an ARM1176JZF-S processor. The Raspberry Pi utilizes a Broadcom SOC. The real-world performance of the Raspberry Pi is equivalent to 0.041 GFLOPS when the operating frequency is 700 Mhz. Whereas the GPU offers 1 Gpixel/s, 1.5 Gtexel/s, or 24 GFLOPS of general-purpose compute, and the Raspberry Pi's graphics capabilities are about on par with the Xbox of 2001 in terms of performance. In terms of performance, it's on par with a Pentium II running at 300 MHz between 1997 and 1999. The Default frequency is 700 MHz.

3.2 Mission Planner

The software that controls the UAV's actions or functions is called mission planner, as shown in Figure 11. Mission Planner is compatible with the Windows operating system. Mission Planner can be used to configure autonomous vehicles. Here are only a couple of things you can do with mission planner. Tt is likewise the ground control station for plane copter, and meanwhile, it tends to be utilized as a powerful control supplement for independent vehicle. It can stack the firmware into the autopilot load-up that controls the vehicle, arrangement design and tune the vehicle, plan, save, and the independent mission into the pilot with basic, download and disseminate the log view, and investigate the telemetry log.

Figure 11. Mission Planner

3.3 Calibration Process

(a) Compass Calibration

Compass calibration in Mission Planner is an essential step to ensure accurate and reliable navigation of unmanned aerial vehicles (UAVs). A compass is a sensor that measures the earth's magnetic field and provides orientation information to the UAV's flight controller. Compass calibration involves rotating the UAV along all three axes to collect data and create a calibration profile that corrects for these errors.

(b) Radio Control Calibration

Radio control calibration is an important step in preparing a drone for a mission, as it ensures that the drone is properly configured to respond to remote control inputs from the ground station. Mission Planner is a software tool that can be used to calibrate the radio control settings of a drone, allowing for precise and accurate control during flight.

(c)Accelerometer Calibration

Accelerometer calibration is an important step in setting up a drone for flight. Mission Planner, a popular open-source ground control station software, provides a user-friendly interface to calibrate the accelerometers of a drone. The accelerometer measures the drone's acceleration and tilt and is used to stabilize the drone during flight. The calibration process involves placing the drone on a level surface and allowing the software to record the sensor readings. Mission Planner guides the user through the process, providing step-by-step instructions to ensure accurate and reliable calibration

(d) Flight Mode Calibration

Calibration flight mode configuration in Mission Planner is a process used to fine-tune the flight characteristics of a UAV, such as its stability, responsiveness, and overall performance. This process involves adjusting various parameters and settings in the UAV's flight controller, such as the gains for the pitch, roll, and yaw axes, as well as the throttle response and maximum pitch and roll angles. The goal of calibration flight mode configuration is to optimize the UAV's flight characteristics for a specific application or mission, such as aerial photography, surveying, or search and rescue operations, and ensure safe and reliable operation in the field.

(e) ESC Calibration

ESC (Electronic Speed Control) calibration is a process that ensures the proper functioning and synchronization of the motors in a multirotor drone. Calibration involves setting the minimum and maximum throttle values for each ESC, ensuring that all motors spin at the same speed and in the correct direction. Mission Planner is a software tool used for configuring and monitoring drones, and it includes a built-in ESC calibration feature. This feature guides the user through the calibration process step-by-step, providing instructions on how to connect the ESCs to the flight controller and how to enter the necessary parameters in the software.

3.4 Mapping

A mission planner begins with an auto-takeoff to 20 meters of altitude, travels to waypoint 2, gaining 100 meters of altitude along the way, waits 10 seconds, then travels to waypoint 3, gaining 50 meters of altitude, and then returns to launch. The vehicle will take off and come to a stop. The mission is predicated on the home position as the launch position. We can enter waypoints and different orders, as shown in Figure 12, In the drop-down menus on each line, select the order that is required. The section heading will change to show information about the order's expectations. Clicking anywhere on the map will trigger a prompt for you to input latitude and longitude coordinates. If our launch altitude or home position is set at 100 meters, for instance, the system will automatically adjust to fly at an altitude 100 meters above ground level. When inputting new waypoints, the default altitude is labelled as "Default Alt," and we can consult standard elevation data to determine precise height definitions.

The Mission Planner will use Google Earth topology data to adjust the desired altitude at each waypoint to match the ground's height when you select "Verify Height." Therefore, if this option is selected, the waypoint is on a hill. The height of the hill will be set by the mission planner to increase the altitude. This is a good way to prevent the vehicle from colliding with the mountains. Select Write when we are finished with our mission, and it will be sent to APM and stored in EEPROM.

Figure 12. Mission Planning Example

3.5 Threshold Segmentation

Thresholding in colour detection refers to the process of classifying pixels in an image based on their colour values using a predefined threshold. It is commonly used in computer vision and image processing applications to extract specific objects or regions based on their colour characteristics. One of the most widely used parallel segmentation techniques is threshold segmentation, which is the simplest method of image segmentation. It is a typical division calculation which straightforwardly separates the image dim scale data handling in view of the dark worth of various targets.

4. Results and Discussion

Quadcopter Pixhawk 2.4.8 is successfully constructed, configured, and stabilized, as shown in Figure 13, and can be controlled from the ground station using Mission Planer software in Auto mode. The quadcopter is fully autonomous where waypoints are predefined where the UAV must cover the region for the further surveying of the cultivated land. The fully autonomous quadcopter offers an easier and highly efficient mapping and land surveying.

The results depicted in the above Figures 14 and 15 give out the co-regions covered with green regions or vegetation. The results are based on the threshold-based color detection system. Here the results are showcased in matrix form, where the region covered by the green region or cultivated land is represented by "1," whereas the uncultivated land or bare land is represented as "0" in the matrix.

Figure 13. Stabilized Drone

Figure 14. Sample Image and Generated Output

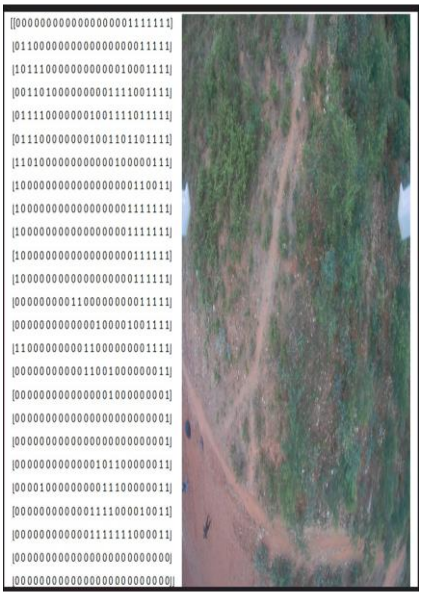

Figure 15. Sample Image and Generated Output

5. Conclusion

This research involved the process of assembling a drone and uploading of firmware to a flight controller. The hardware components were calibrated in accordance with the Ardupilot software, encompassing aspects such as acceleration, radio, compass, flight mode, and ESC calibration. The navigation and mapping process entailed providing a predefined flight path to the UAV's flight controller. The results clearly demonstrate that the system is capable of autonomously executing a complete flight in all three spatial dimensions, from take-off to landing, without the need for human intervention. Furthermore, the research successfully captured and processed images of the designated region, effectively distinguishing between green-covered areas and infertile land. By implementing this technique on UAVs, we can enhance efficiency and precision in land classification and monitoring.

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