AERO DESIGN CHALLENGE 2021

VEGETATION MAPPING BY SEMI AUTONOMOUS UAV

APPLICATION REPORT

ADC20210114 – YODDHA

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2021 SAE AERO DESIGN CHALLENGE

STATEMENT OF COMPILANCE

CERTIFICATE OF QUALIFICATION

TEAM NAME	YODDHA
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As Faculty Advisor, I certify that the registered team members are enrolled in collegiate courses. This team has designed, constructed and modified the radio controlled airplane they use for the SAE Aero Design Challenge 2020 competition, without direct assistance from professional engineers, R/C model experts or pilots, or related professionals.

(Dr G. Thakar)

Signature of Faculty Advisor

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1. LITERATURE REVIEW

The turn of events and extension of urbanized zones around the urban areas brings new testing issues about the association, the checking, and the dispersion of green spaces inside the urban areas (for example, grass, trees, bushes, etc.). These spaces bring better life quality for the populace and safeguard biodiversity. Development of urban communities accompanies the appeal for assets, particularly land; anyway, this is not relatively accessible to the metropolitan populace's developing pace, which unavoidably brings about medium to enormous scope changes in the general climate's biological system.

Urban vegetation study is a crucial feature in landscape monitoring; it serves as an ecological regulator and provides many ecosystem services. The preservation and management of the green spaces require accurate mapping carried by field inspection, aerial photography interpretation, and other time and money-consuming methods.

This Urban Vegetation cover is much more divided and fragmented, which poses challenges for accurate localized mapping, extraction, and management of resources concerning vegetation, natural flora, and land-use pattern. Improper utilization of barren and other soil covers, dried-out flora in urban and non-urban areas remains a constant problem, posing a hindrance to the localized regions' proper development. Vegetation mapping and monitoring in an urban context by remote sensing, remains nevertheless, a challenging issue.

UAV's in the sector of mapping and surveillance have been of immense importance, as they even help to focus upon localized coordinates and sector-wise mapping. Thus, focusing on some of the present generation's significant problems and safeguarding their future, these problems need to be addressed. Therefore, our RC is most suited to work in the sector of vegetation mapping and determining the land-use pattern in urban areas.

2. SCOPE OF PROPOSED APPLICATION

Unmanned aerial vehicle (UAV) remote sensing has immense potential for vegetation mapping in complex urban landscapes due to high-resolution imagery acquired at low altitudes. UAVs' ability for the close, constant acquisition of high-resolution imagery has given both the chances and difficulties in vegetation planning and checking territory. Explicit utilizations of this innovation exist in surveillance, farming, and biological ecosystem research.

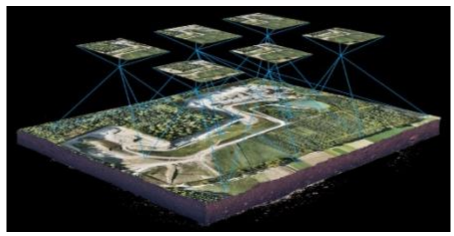

Fig 2.1

The extent of this issue incorporates, however, isn't restricted to, critical enhancements in sensor innovation, portrayals of preparing schemes and algorithms, improved understandings of vegetation measures, and the translation of worldly vegetation cover into utilizable form. Contributions should focus on RC-based approaches that aim at enhancing our logical comprehension of vegetation measures.

Because of RCs, the urban planners can gather a lot of forward-thinking information in a brief timeframe and with far fewer staff. The images/data delivered in this manner permits the organizers to analyze the locales' current social and environmental conditions and think about various scenarios. The government will be benefitted majorly because of the ease of data collection, with localized coordinates from a reliable source. The public authority will also have profit due to the simplicity of information assortment. The departments associated with urban planning and other official vegetation mapping and distribution could function effortlessly towards developing the localized regions, facilitating a better environment for upcoming generations.

3. ADVANTAGES AND CHALLENGES OF USING YOUR PROPOSED DESIGN IN APPLICATION

3.1. ADVANTAGES:

- UAV is kept semi-autonomous and highly maneuverable due to twin tail, in pursuit of its safety, considering collision with still and moving obstacles. It can be operated manually through live-streaming.
- This UAV design will obtain a good resolution, fairly accurate, and real-time data.
- Our design includes mapping through stereo-camera and processing data simultaneously using a microprocessor, which makes it efficient.
- For better navigation, we will use a stereo camera for live-streaming for the flyer's assistance. Another high-resolution stereo camera fixed at gimbal has been used for stable and accurate data.
- In the proposed design, two motors are mounted on the wing rather than the fuselage's nose to ascertain clear capture of images. Thus, two motors provide high thrust value, which results in high payload capacity.

3.2. CHALLENGES:

- The handling of the plane is a challenging task as it cannot attain high altitude. Thus, the pilot needs to be careful of the poles, buildings, and other obstacles while operating the plane.
- The landing of the aircraft should be smooth, or it would damage the hardware parts used.
- Operating a plane in extreme weather conditions is challenging and difficult; this must be avoided.
- The proposed UAV has a limited range, so it might lose control after some particular range due to loss of signal.

4. MISSION PROFILE

Global climate change and sustained urban growth have increased the necessity of assessing urban vegetation's role in the urban ecosystem services. The environmental studies still lack methods to characterize urban vegetation with adequate details and across large areas. Urban vegetation mapping is necessary to determine the land texture and flora distribution, thus maintaining sustainable ecological balance.

Thus, our mission profile lies in the agricultural sector, ensuring sustainable development and balance of nature and simultaneously incorporating technological advancement. RC remote-sensing has great potential for vegetation mapping in complex urban, and rural landscapes due to high-resolution imagery acquired even at low altitudes and bearing an advantage of localized-coordinates and sector-wise mapping of vegetation.

The semi-autonomous RC ensures that the data is collected and processed simultaneously, using an in-built CPU processor of Raspberry Pi. Live-streaming using the stereo camera is incorporated to facilitate obstacle-avoidance. The necessary data then obtained can be procured instantly using a Wi-Fi module, thus ensuring information safety.

Thus, our mission is specifically focused on the agricultural domain, as this is the growing concern of urban and rural areas and becoming a threat for our future generations. Hence, a sustainable method needs to be worked upon to analyze the distribution, texture, and necessities of flora, soil, and land pattern to be performed simultaneously.

"What we are doing to the fauna of the world is but a mirror reflection of what we are doing to ourselves and one another."

5. FLOW CHART CONTAINING ALLTHE REQUIRED STEPS/PROCEDURE TO IMPLEMENT THE MISSION FROM START TO FINISH:

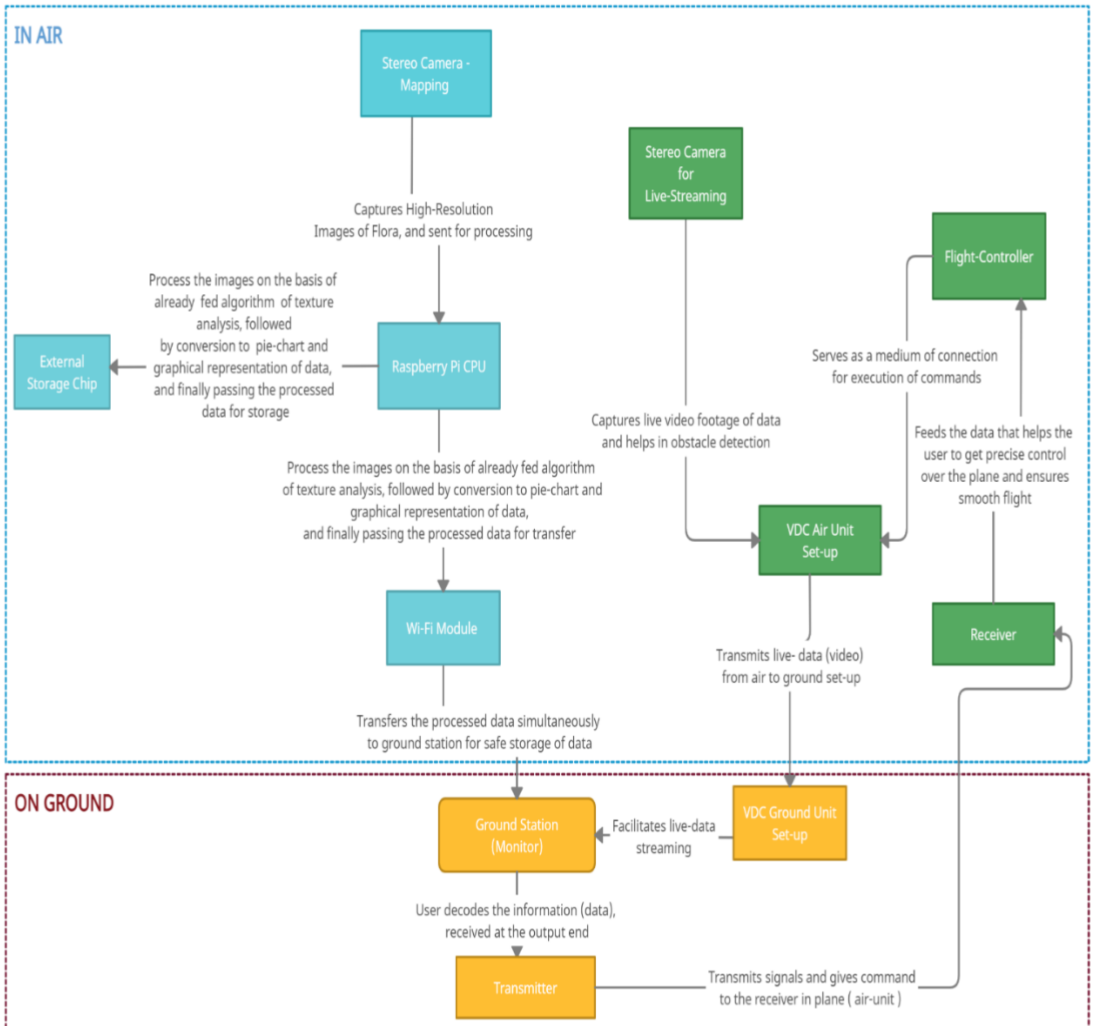

Fig 5.1

6. SPECIFICATION AND COST OF HARDWARE AND SOFTWARE COMPONENTS REQUIRED TO IMPLEMENT THE APPLICATION

6.1. SOFTWARE COMPONENTS:

- Raspberry Pi Software set-up (CPU for image capturing and processing)

  Raspbian: The processing part has been done in the Raspberry Pi with the Raspbian operating system. Raspberry Pi is a fast, convenient OS and can be installed easily.

6.2. HARDWARE COMPONENTS:

- **Raspberry Pi** - Raspberry Pi Model 3 B+

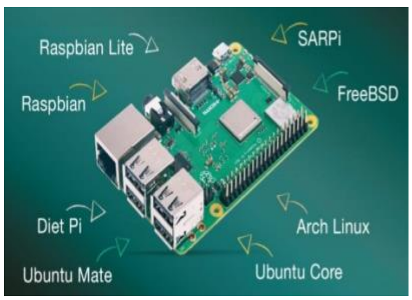

Fig. 6.2.1.

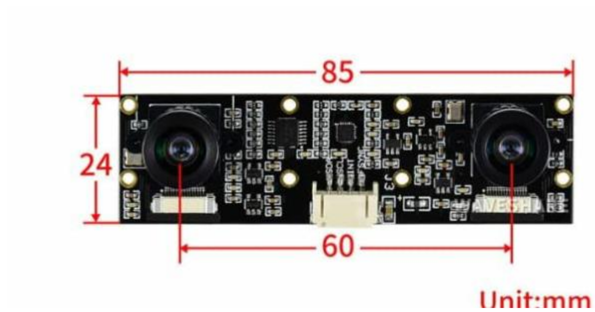

Fig.6.2.2

- **Stereo Camera-**Quantity-2, Weight-23gm each, Dimensions- 24X85 mm, Resolution-3280X2464 (per camera), 8 Mega-Pixel, Focal Length – 2.6mm
- **SD Card – 8 Gb**
- **Transmitter-**Avionic RCB OS-10, 10 Channel 2.4 GHz transmitter
- **Receiver –** Avionic RZ10, 10 channel SBus compatible Receiver
- **VDC (Video Display Controller) Set-up**

  AIR UNIT:

  - Air Unit (Receiver) X 1, Air Unit Antenna X 2, Power/UART Cable X 1, HDMI Cable, Flight-Controller X 1, Receiver
  - Air Unit – Weight- 98.5gm, Size- 93.5 X 54.5 X 15.5 mm

GROUND UNIT:

- Ground Unit X 1, Fibre-Glass Antennae X 2, HDMI Cable, Ground Station (Monitor)
- Ground Unit – Weight – 121.4 gm, Size - 93.5 X 63.5 X 18 mm

Fig 6.2.3

- **COST OF HARDWARE'S USED FOR THIS APPLICATION :**

COMPONENTS	UNITS	PRICE
1. Stereo camera	2	9364/-
2. Raspberry Pi (3B+)	1	3100/-
3. SD Card (SanDisk)	1	335/-
4. VDC setup (air + ground)	1	80466/-
5. Flight controller	1	6300/-
6. Receiver + Transmitter	1	6000/-
TOTAL		**105765/-**

Fig 6.2.4

7. DETAILED DESCRIPTION AND STEPS INVOLVED IN USING THE SOFTWARE AND HARDWARE TO ARRIVE AT FINAL OUTPUT ANF COMPLETING THE MISSION.

Our application based on vegetation mapping requires various software and hardware to carry out our mission successfully. This involves two different set-ups, one on the ground and the other in the air.

7.1. HARDWARE AND SOFTWARE DEVICES THAT WILL BE USED IN AIR

The air set-up includes various software and hardware components that will be present inside the UAV. It will be collecting and transferring data to the ground station.

- **Stereo Camera**- Two stereo cameras are being used, one for vegetation mapping and the other for live streaming. The camera for live streaming is placed on the fuselage's nose, whereas another for mapping will be installed through a gimbal for independent movement and better capture of images.

  A stereo camera was chosen because it detects depth information of a subject using the parallax of two cameras aligned left and right.

- **VDC Air Unit** - VDC-7/VDC-15, designed for the drone, is a wireless FHD video and data transmission system. The system can transmit live-streamed data, FHD video, flight control data, gimbal control data, and RC control data simultaneously to our ground station. And thus, this VDC Technology assists in better control of the plane.

  Reason for using VDC Technology:

  VDC-7/VDC-15 can achieve low latency, high-resolution video transmission, with accuracy. It is light and compact and thus complements our design and application need.

- **Flight Controller** - The flight controller is the brain of the aircraft. It's a circuit board with a range of sensors that detect movement of the plane and user commands and thus helps in increasing the aircraft's stability. Nearly all flight controllers have necessary sensors such as Gyroscope and Accelerometer. Some FC includes more advanced sensors such as Barometer (barometric pressure sensors) and magnetometer (compass).

- **Raspberry Pi**-The Raspberry Pi is a small-sized and low-cost computer that we will be using in our design to process the data and transfer it to the ground station. The Raspberry Pi has a dedicated camera input port that facilitates us to record HD video and high-resolution photos, which is required in our application for accurate mapping of vegetation. Using Python and specific libraries are written for the Pi, users can create tools that take photos and video and analyze them in real-time or save them for later processing.

7.2. HARDWARE AND SOFTWARE DEVICES THAT WILL BE USED IN GROUND

The ground set-up includes various software and hardware components present on the ground, facilitating in receiving data and external communication with the UAV in the air.

- **Ground Control Stations (GCS**) - These are sets of ground-based hardware and software that allow UAV operators to communicate with and control a drone and its payloads, either by setting parameters for autonomous operation or enabling direct control of UAV.
- **Monitor -** This has been used to stream and analyze the live video data received from the VDC ground unit. Thus, it helps in handling the plane by obstacle avoidance. Simultaneously, it receives processed mapping data obtained through a Wi-Fi module from a stereo camera fixed in a gimbal and facilitates data storage.

- **VDC ground unit** - A part of the VDC set-up used for live transmitting of data. This receives live video data from the VDC air unit via antenna and transfers it to the desktop.

7.3. STEPS INVOLVED IN USING THE HARDWARE AND SOFTWARE, TO ARRIVE AT FINAL OUTPUT

The process begins when the plane reaches a certain height in the air and begins its operations. We make sure the plane flies so that it covers all the localized areas of that region.

7.3.1. STEPS FOR COMPLETING THE MISSION FOR MAPPING OF VEGETATION:

- The stereo camera on the gimbal starts shooting the localized area's aerial footage, for mapping of vegetation.
- The processor will make use of video mosaic technology to map the traversed area.
- Simultaneously one instant of the map will be fed to the program responsible for vegetation detection in regular intervals.
- Detection of vegetation is primarily based on the texture analysis of pixels in the map. Texture analysis is vital in the project since it is responsible for calculating the vegetation over the land and differentiate among the trees, shrubs, and herbs.
- Computed data is then supposed to be transmitted via Wi-Fi to the ground station.

7.3.2. STEPS FOR COMPLETING THE MISSION FOR LIVE STREAMING:

- The stereo camera used for live-streaming of data is nose-fitted in the UAV.
- The VDC Air unit and antennas, which facilitate live-streaming, are placed in RC's fuselage.
- The camera would be attached through HDMI cable to the VDC transmitter unit.

- Connecting the Fibre-glass antennae to the ground unit, which assists in transmission, and further, HDMI interface of the ground unit to monitor with HDMI cable.
- After the device is powered on, the power indicator is on, and then it starts working.
- About 15 seconds after the device is powered on, and a wireless connection is automatically established. The established connection indicator will always indicate that the air unit and the ground unit have been successfully connected by the wireless network.
- After the next 15 seconds, the Receiver can output the video transmitted by the transmitter.
- The flight controller, connected to the VDC air-unit set-up and the Receiver, provides stability and helps control and maneuvering the plane.
- The Air Unit antenna sends video data for streaming, which is received by the ground unit antenna (fiber-glass antenna) and then is transferred to the ground unit.
- The data is further transferred to the desktop, where the streaming begins, and the pilot can safely fly the plane without colliding with obstacles. And thus, the entire process facilitates obstacle-avoidance by the UAV.

7.4. VDC AIR UNIT HAS DIFFERENT COMPONENTS, AND EACH COMPONENT HAS ITS OWN PURPOSE:

- One is a set of antennas mounted on air unit, which helps in the transmission of data.

- ➢ Others are HDMI cables that facilitate interconnections between the camera and gimbal. Through them, the camera/gimbal is connected and SBUS &UART with other cables for connecting the flight controller.

8. GLOSSARY

- **Aerial photography:** The taking of photographs from an aircraft or other flying object
- **Gimbal:** A pivoting support that allows you to rotate an object along three axes.
- **Remote sensing:** The process of detecting and monitoring the physical characteristics of an area
- **SBUS:** It is a digital communication protocol used in R/C receivers. It includes digital serial data communication technology to transmit control signals between receiver and servos.
- **VDC:** Video Display Controller

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