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Real Time Forest Flora Monitoring System

Manjunatha Babu P[1], Kaushik Gowda H N[2], Kushagra Dhawan[3], Kacharla Balasai Nikhil[4], Govardhan[5]

[1]Assistant Professor, [2,3,4,5] UG Student, Dept. of Electrical and Electronics Engineering, BMS Institute of Technology, Bengaluru, Karnataka, India

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Abstract - *A new system to monitor the forest floor is proposed which entails the use of a UAV (Unmanned Aerial Vehicle) equipped with a dedicated set of systems and sub-systems that is used to obtain data from the forest in the form of images and other electrical signals that is later processed to infer important metrics about the same. The information obtained at the end has to be stored and constantly updated over time in the form of a database.*

Introduction:

Due to the rapid change in the modern-day world it becomes essential to monitor and analyze the attributes and compositions of one of the most important components of nature — Forests.

Fig-1: Forest area

As the world seeks to slow the pace of climate change, preserve wildlife, and support billions of people, trees inevitably hold a major part of the answer. Yet the mass destruction of trees—deforestation—continues, sacrificing the long-term benefits of standing trees for short-term gain. Forests still cover about 30 percent of the world's land area, but they are disappearing at an alarming rate. Between 1990 and 2016, the world lost 502,000 square miles (1.3 million square kilometers) of forest, according to the World Bank—an area larger than South Africa. Since humans started cutting down forests, 46 percent of trees have been filed, according to a 2015 study in the journal Nature. About 17 percent of the Amazonian rainforest has been destroyed over the past 50 years, and losses recently have been on the rise.

This calls for a reason to monitor forests so that preventative and curative measures can be implemented.
To sum it up studying the forest floor can help us achieve the following agenda: (1) to maintain a huge database of different types of the trees (2) Forest fire studies (3) Invasive species mapping (4) Discovering the new species of trees (5) Biodiversity studies (6) Prevention of the extinction of rare trees by evaluating their threat level (7) Evolution/Variation in life of trees based on the changes in climate.

When we look into the existing methods that are used for such purposes we can understand what they lack and come up with a more effective solution (1). The survey of the forest was manually done by the Department of Forest Survey of India (FSI).This consumes a lot of manual labor and takes a plethora of time in order to get adequate information about the forest floor in the least (2). VHR Satellite imaging is the more nominally opted-for method as it is easier to maintain and hyperspectral image of a very large area can be obtained. However, even such a method finds its flaws when it demands a huge seed capital and the information obtained is approximated thereby reducing its precision. It also makes it impossible to control and revisit places as the satellite is in orbit in any case of emergency (3). Outdated statistical techniques that were predominantly used tend to have a lot of error in the predictions and are also harder to apply for a large real-time dataset. On the contrary, the newer methods introduced are not only more accurate but can also deduce more information and can be modeled on a computing machine (4). Database is updated less frequently and on paper which is harder to access and maintain. These issues can be overcome by using a software database which has a large memory, can be processed easily and much simpler to integrate in an autonomous system.

The solution that we would like to propose is using a UAV (Unmanned aerial vehicle or drone) as a fully/semi-automated tree cover reconnaissance device. This UAV is equipped with the following sub-systems.

1. Raw Data Acquisition
2. Feature Extraction
3. Composite Database
4. Statistical Data Analysis
5. End user interface

1. Raw Data Acquisition:

The UAV is the main part of this part of the proposed monitoring system which consists of parts such as flight controller, subsystem controller, sensors, communication modules, Power supply system etc. The main job of the drone is to navigate the desired area under study whilst carrying the camera and other physical parameter sensors that are used to obtain the raw data.

In our case we will be using a quadcopter as our designated UAV equipped with Arduino as the primary subsystem controller.

The quadcopter consists of propellers equipped with brushless dc motors connected to electronic speed controllers on each wing. The UAV will be powered using lithium polymer / lithium ion rechargeable batteries. To distribute the right amount of power to both the Arduino controller and the drone, we are using a power distribution board.

Fig-2 Unmanned aerial vehicle

Our main controller is connected with required sensors such as GPS, Gyroscope, Accelerometer, Temperature and Pressure sensors. A high definition camera is fixed onto the drone to take clear pictures for further processing. For the purpose of communication and transmission the data obtained from sensors and the camera we use a radio frequency trans-receiver. A thermocouple is used to measure the surrounding temperature. A humidity sensor is also integrated to obtain the corresponding and instantaneous humidity value of the surrounding.

The Next step for us in solving this problem is automating the drone. Keeping in mind the vast geographical area a forest would cover, it is ideal that we use an automated drone with a predetermined / pre-planned flight plan which would effectively reduce our manpower and resources burned.

Here we have used a drone to monitor an area of, let's say 1km x 1km. We use the CC3D flight controller as it is powerful and affordable and has a small form factor. If we use this along with a GPS module, we can even design a waypoint based flight.

We use a small complex circuit board. It gets an input and drives it to the RPM of each motor. As pilots, we can drive the motors accordingly.

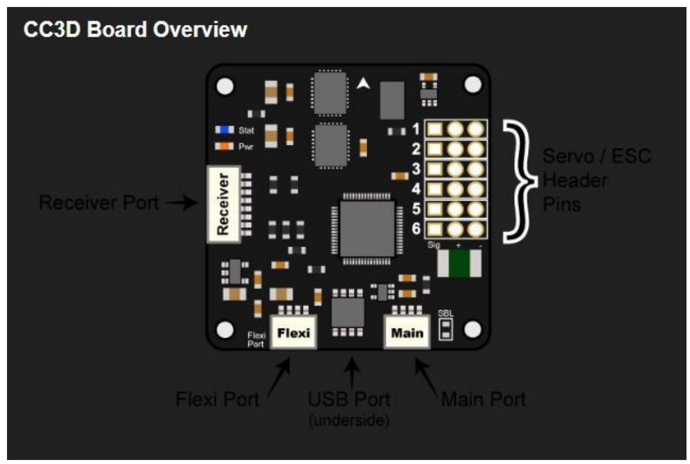

Fig-3 Flight controller

Quite a lot of flight controllers make use of sensors to aid their results. GPS can also be used for auto-pilot. To elaborate the previous statement: (1). Accelerometer is used to provide the vibration, acceleration force which the drone is subjected to in all three axes X, Y and Z, the tilt angle and the triple axes linear acceleration which can be used to calculate velocity, direction and even rate of change of altitude of the drone. These parameters play an important role in the flight navigation (2). Gyroscope is used to detect the angular velocity in three axis, meaning it can detect rate of change of angle in pitch, roll and yaw which can provide stability to the drone and prevents it from wobbling (3). Magnetic compass gives the sense of direction to the throne (4). Barometer detects the atmospheric pressure and gives altitude (5). Ultrasound is used to detect and avoid objects (6). GPS module- The comparison of the actual position of the drone with its destination (both of which are obtained using the GPS module) using the PID controller, the drone can be instructed to move as intended.

Any good UAV designed or built for the purpose of flora monitoring should comprise of the following features (ideally):

- Good stability.
- Precision in terms of covering certain distance, velocity, acceleration, direction, altitude.
- Resistance to external factors such as rain, heat, etc.
- Should conserve power/maximum efficiency.
- Low power to weight and volume ratio.
- Good capability of maneuvering.
- Position hold, which lets the drone maintain a fixed location at a set altitude.
- Return-to-home navigation, wherein a drone returns automatically on the press of a button based on its take-off location.
- Autonomous flight, where the flight path is set based on GPS/GNSS waypoints which the drone will follow using autopilot functions.

2. Feature Extraction:

The feature extraction module is essentially a program that can obtain meaningful data with respect to the parameters under study from the raw data images obtained from the camera. For this purpose, a Convolutional Neural Network (CNN) Algorithm can be implemented, which has theoretically been proven to predict and classify image data to a high accuracy. The same application can be seen in our plant species recognition which can then be mapped to other parameters such as the geographic co-ordinates etc.

CNNs are technically made up of "neurons" with learnable weights and biases. Each specific neuron receives numerous inputs and then takes a weighted sum over them, where it passes it through an activation function and responds back with an output. Here the input corresponds to the pixel value of the image data array. The process of self-updating of these weights is usually hidden and occurs through a process called learning. To train a CNN model we need to supply it with standard known dataset which consists of many images with different orientations and variety. A CNN model is theorized to improve its prediction accuracy over time as it is a self-learning algorithm. This method of learning is usually referred as supervised learning as we know the parameters that are under study beforehand. The CNN model also consists of a lot of hidden layers through each of which a convolution operation is performed.

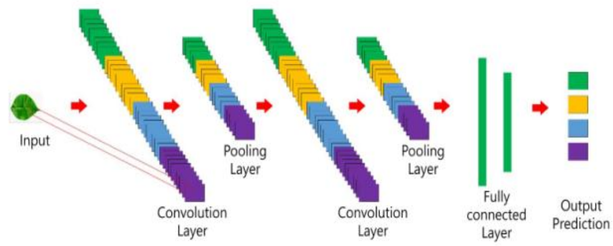

Fig-4 CNN model

Features such as contour, color, orientation, etc. are obtained by the CNN model which it uses to determine the species of the tree. This is the end output of the CNN that is given to the database for further processing. A small unsupervised model can also be implemented to detect any abnormality in the image data. The remaining raw data parameters that are obtained are from the sensors which might need certain preprocessing steps such as filtering, thresholding, correcting, scaling etc.

3. Composite Database:

A composite and flexible digital database needs to be created in order to store all the data required for the survey which can be analysed and also whose output can be stored in the same.

3.1 Maintaining the data:

All the data which is received by different sensors as well as the camera images which are processed by the feature extraction module are stored in a database automatically with respective date and time. This database keeps the all logs of all the retrieved and processed information. We are implementing an SQL database in our case.

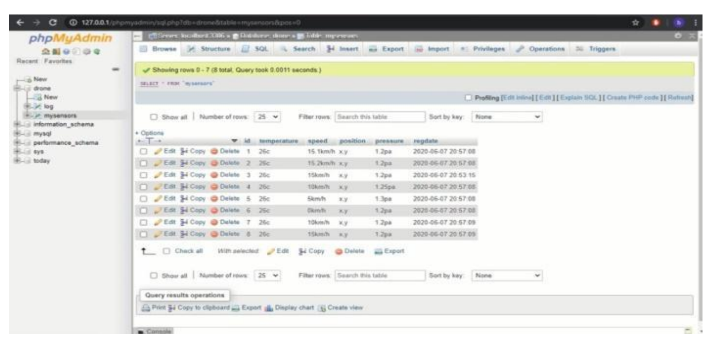

Fig-5 Database

3.2 Retrieving the data:

Once the data is stored in the database, we can retrieve the same at any time on a web page as demonstrated in the figure. This web page was created for this purpose exclusively and can be accessed universally with a single click, but presently we are running it on a local host which restricts us from doing so. The data stored varies by parameters and across time that ranges from the end to end cycle of operation of the drone.

Fig-6 Data retrieved from database

4. Statistical Data Analysis:

Statistical data analysis is the science of collecting, exploring and presenting large data sets to detect patterns and trends. The large amount of data is to be collected by the end user interface such as name of the species, scientific name, and number of trees, height, width, temperature, humidity and other atmospheric conditions. This data is then analyzed using different nonlinear regression algorithms to understand the behavior of the species with their respective habitat.

This analysis also helps us to understand the correlation between the different atmospheric conditions and the flora conditions also allows us to understand why tree canopy density is high in certain parts of the world. This analysis involves the use of neural networks, where we use back propagation techniques to predict the growth of certain kinds of trees with respects to changing atmospheric conditions. The data collected from the study is plotted. From the graphs we can interpret the kind of trees which grow in different seasons and those trees which are evergreen. The data collected by the drone is to be updated frequently to the database in order to have efficient analysis of the area under study.

4.1 Forest cover:

One of the major reasons for the survey is to monitor deforestation. This can be done by analyzing the forest cover over a given area. Forest cover is basically a density of tree canopy in a given plot. Forest cover can be classified in terms of density of tree canopy as,

*Very Dense Forest (VDF): tree canopy density greater than 70 percent.
*Moderately Dense Forest (MDF): tree canopy density greater than 40 percent less than 70 percent.
*Open Forest (OF): tree canopy density greater 10 percent and less than *40 percent.
*Scrub: forest land canopy density less than 10 percent
*Non-Forest: areas not included in above classes (e.g.-water).

Class	**Area (Sq. km)**	**Percentage of Geographic area**
Very Dense Forest	418	7.4
Moderately Dense Forest	782	13.8
Open Forrest	512	9.06
Total Forest Cover*	1712	30.31
Scrubs	252	4.46
Non-Forest	3684	65.22
Total	5648	100

Table-1: Classification of forest area

4.2 Graphical analysis & Prevention of the extinction of rare tree:

Consider a sample data for demonstration. The following table represents the forest cover analysis over an area. A sample data was considered for this demonstration. The tree population density data obtained is plotted and shown in the graph. We can infer the species that are headed towards, or below the endangered threat threshold line. It can also be declared that species has been extinct if the curve touches the x axis of the graph in that area of study. In the following graph Banyan tree is on the verge of extinction which is now marked and protected.

	coconut	sandalwood	teak	peepal tree	banyan tree
1985	100	35	40	87	10
1990	120	30	45	85	8
1995	90	38	50	81	6
2000	105	40	38	90	6
2005	106	32	42	95	6
2010	80	34	45	80	6

Table-2: Count of trees in different years

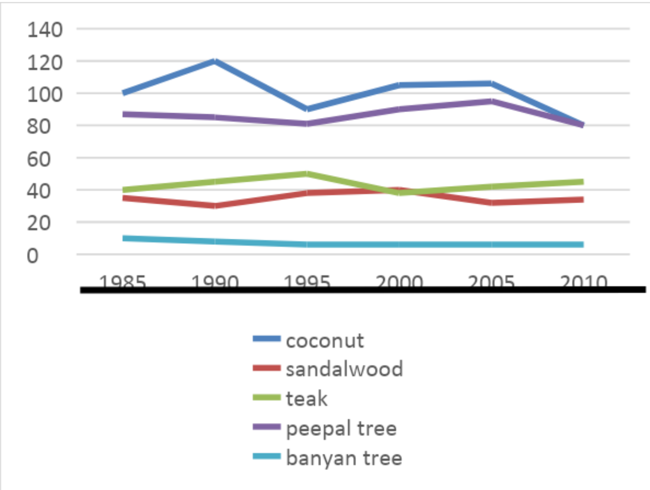

Chart-1: Endangered species trends

5. End User Interface:

We propose the idea of developing a GUI based software that:

- Aids in the overall operation/ control/ maintenance of the drone.
- Runs the CNN model and collects its output predictions.
- Performs statistical analysis.
- Provides Graphic Output.
- Maintains a solid database of all the acquired data.

SCOPE:

This proposed solution to monitor forests can be adopted by the agencies and organizations that study and survey forest flora respectively, independent researchers who cannot afford means like satellite imaging, farmers who own extremely large plots for agricultural purposes, forest department as a preventative measure of forest fires etc. The same implementation can be improved in the following way:

- Optimized drone operation (power efficiency, greater load carrying, more physical endurance, fully automated flight navigation).
- A neural network that functions more accurately for tree classification.
- End user interface enhancements.
- Budget cut down from all information acquired from the R & D phase.

CONCLUSION:

The act of conserving nature is a fundamental duty bestowed upon whoever takes aid from it and as humans we should do everything in our power to make sure the millions of years of evolution it took for these beautiful forests to spawn not to get destroyed in vain. Integrating an autonomous survey system into a forest flora ecosystem can harbour a lot of good by preserving and improving the natural state of the forest. One of the biggest areas of change can quickly be observed in the species extinction threat analysis which can be corrected by taking the required measures by the respective authorities. We can also prevent undesirable effects of nature such as forest fires, species invasion, climate change etc. By analysing the data from our proposed solution.

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BIOGRAPHIES:

Manjunatha Babu P obtained his B.E and M.E from Visvesvaraya Technological University and Bangalore University. Presently working as Assistant Professor in the Dept of Electrical and Electronics Engineering at BMS Institute of Technology, Bangalore, India His interests are in the area of power and Energy systems. Power System Operation and Control, Power Transmission and Distributions System Studies, FACTS Controllers

Kaushik Gowda H N is currently pursuing a Bachelor of Engineering degree majoring in Electrical and Electronics and is in his final year at BMS Institute of Technology. His interest lies in the fields of DSP, embedded systems, control systems, and data sciences. He is looking forward to working in projects under autonomous systems

Kushagra Dhawan is currently pursuing a Bachelor of Engineering degree majoring in Electrical and Electronics and is in his final year at BMS Institute of Technology. His research interests are in the field of DSP, Control Systems, Avionics, Electronic Warfare and Data Science.

Kacharla Balasai Nikhil is currently pursuing a Bachelor of Engineering degree majoring in Electrical and Electronics and is in his final year at BMS Institute of Technology. His interest lies in the fields of Embedded systems , IoT, and Web development. He is looking forward to working in projects on web development.

Govardhan is currently pursuing a Bachelor of Engineering degree majoring in Electrical and Electronics and is in his final year at BMS Institute of Technology. He is a member of the civil defence committee. His interests are electrical motors, embedded systems, coding. He is also a person caring for nature and preserving. which was one of the main reasons which motivated us to initiate this project.