

DRONE BASED IMAGING SYSTEM FOR WASTE ASSESSMENT

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ABSTRACT

One of the paramount issues faced by cities and towns is related to the management of municipal solid waste (MSW). The waste quantity is increasing day by day; municipal authorities are unable to scale up the facilities required for proper management and disposal of waste. In many cities and towns, garbage is littered on roads and footpaths and spotted at dumping yards. Drone-based waste assessment can be critical in solid waste management and recycling as they can take aerial photos or videos of such sites. The proposed work is to build a drone that takes photographs of nearby waste sites and bins using a camera mounted on it. After that, the pictures can be examined with the help of Image Processing Techniques to deduce whether there is a need for garbage collection or not. The above steps can be possible using a flight controller mounted on it and an application.

Keywords: Garbage Assessment, Unmanned Aerial Vehicle, Image Processing

1 INTRODUCTION

Unmanned aerial vehicles (UAVs) are aircraft that fly autonomously, through the use of remote control, or both, and are outfitted with sensors, target designators, or electronic transmitters that communicate with the controller and provide information about the UAV. [1]

This model focuses on one such implementation making the use of the drone. The drone mainly uses imaging techniques to create a multipurpose project based on different applications. A few of its applications include 1) Traffic Management 2) Disaster Management 3) Waste Detection, Control, etc. Besides this, some other accidents such as landslides or fire incidents in multi-story buildings can be reported to the concerned authorities for immediate action through live video captured by this drone. The drone can be operated in two ways: manually and automatically. In manual flight mode, the drone receives instruction using a remote-controlled transmitter that sends a signal to the drone receiver, which aids in smooth control. Furthermore, the drone utilizes the Global positioning system to navigate through a predetermined path in the automatic flight mode. Besides this, there are certain prevention measures also, which can be implemented in case of loss of contact.

2 LITERATURE SURVEY

1. Using the movement of an unmanned aerial vehicle, [2] A system is established for recognizing solid waste (UAV). A drone is used to detect rubbish using image processing algorithms that identify waste-contaminated regions and send location information to the proper authorities. They've wired in an Arduino to take images, as well as GPS and GSM modules for tracking and communication. The project's goal is to identify large amounts of waste; there is no segregation.
2. In the context of a Smart Cities Logistics system, [3] A concept for a Drone System was submitted for Detecting, Classifying, and Monitoring Solid Wastes Using Computer Vision Techniques. Under the Logistics 4.0 paradigm, a drone is utilized to decide solid waste in real-time, which will affect the determination of solid waste patterns by employing an artificial vision system for detection, categorization, and monitoring of solid trash in an intelligent drone.
3. Garbage Waste Segregation Using Deep Learning Techniques was proposed [4] to reduce human interaction and increase the efficiency of the trash separation process. Using a Convolutional Neural Network, the suggested study was to create an image classifier that recognizes the item and classifies the sort of waste material.
4. The Autonomous Quadcopter Docking System [5] project was presented to create the systems and algorithms that would allow a quadcopter to identify and settle on a station target autonomously. The goal of this system was to sketch out the foundation for a quadcopter-based data gathering or surveillance system that takes into account the highly mobile devices' limited battery life by landing the UAV securely in a chosen spot to be recharged.

3 UNMANNED AERIAL VEHICLE SPECIFICATIONS

Because of the large number and variety of UAV models available, the unique attributes of the UAV employed in the studies are worth discussing. In the experiments described in this paper, a quadcopter model with a 2.4 GHz remote control, a 433 MHz telemetry channel, a GPS receiver, a Pixhawk flight controller, an ESP-32 Cam, and a Raspberry Pi are used.

3.1 2.4 GHZ Remote Control

The UAV and the remote control communicate using the FlySky X8r receiver. This accessory allows the UAV to be flown manually. It captures and transfers the produced remote-control signals before sending them to the remote control. Furthermore, rudimentary information of UAV data is sent to the controller, keeping the user informed about the UAV's status. It achieves these goals by making use of the whole 2.4 GHz ISM band. [6]

3.2 433 MHz Telemetry

To provide data from the UAV's remote control to a base station, such as inclination, direction, battery backup, velocity, elevation, flying mode, and much more is the task to be

done. It can also be provided instructions on how to do a task.

3.3 Flight Controller

The Pixhawk 4 flight controller collects data from sensors and interprets it to operate the UAV at a basic level. An accurate picture of the UAV status is produced by combining; sensor output data from the GPS, accelerometer, and gyroscope. This information is then used to keep the unmanned aerial vehicle stable and steerable. Pixhawk flight controller is used (which includes an Ardupilot firmware implementation) because it is an open-source solution that allows new protocols to be created and deployed on actual UAVs. The pair of transmitter and receiver are used for the communication between the UAV and Pixhawk.

3.4 Raspberry Pi

Raspberry Pi is a low-cost, small-sized computer module that runs on Linux. It also provides a set of GPIO pins allowing control of electronic components for physical computing and exploring the Internet of Things (IoT). Here, it is neither mounted on the drone nor used in the drone section for processing data related to Autonomous flight control. It provides access to the server and uploads images on the server. With the help of the LAMP (Linux, Apache, MySQL, PHP) server, processing of the captured image would be done.

3.5 ESP-32 CAM

ESP-32 CAM module is used for image capturing and is an IoT Image Capturing Device. Here, in this project, ESP-32 CAM is paired with the OV2640 Camera Module that supports the highest Camera Resolution up to 1600×1200 . The Camera module will capture Real-time dustbin images having a specific mark on its top. This mark will be detected using an Image processing algorithm later on.

3.6 GPS

GPS (Global Positioning System) is a radio navigation system that allows land, sea, and airborne users to determine their exact location. It is mounted on the drone and connected to the Pixhawk controller. With the help of the GPS module, coordinates are extracted in the mission planner software, and the exact location is determined. It plays an important role in Autonomous Flight Mode by deciding different locations as waypoints.

Figure 1. Drone Images

(a) Top view

(b) side view



(c) Side view



(d) bottom view



4 MISSION PLANNER

4.1 Prologue

Mission Planner is a drone, helicopter, and rover ground control station. It is only compatible with Windows. Any autonomous vehicle can employ Mission Planner as a setup tool or as a dynamic control supplement [7]. Mission Planner is used for a few things:

- Set up, configure, and optimize the vehicle for best results.
- Vehicle's status can be tracked in real time application.
- Simple spot-and-click way-point entry on Google may be used to plan, save, and load unmanned aerial operations into autopilot.

4.2 Connecting Mission Planner through Ardupilot

The first step in setting up a connection is establishing the communication protocol, followed by configuring the actual hardware and Windows system components. Following that, USB cables, Telemetry Radios, Bluetooth, IP connections, and other devices are connected to the PC.

The network and data rate are selected in Mission Planner. After the successful connection of USB or Telemetry Radio, A COM port number will be assigned by Windows,

which will appear in the drop-down selection.

To communicate with the autopilot, select the desired port and data rate and then press the Connect button. Following the connection, Mission Planner will collect autopilot parameters and the button will change to Disconnect.

4.3 Defining Mission

A location is set to a home position, where the vehicle for the Copter, Plane, and Rover was armed. Required command is selected from the dropdown options for each row. The column header will change to reflect the information, which was given by the command. By clicking on the map, Lat and Long are given as input. The height is measured with the launch altitude and the position of the aircraft. While creating new waypoints, Default Alt is the default altitude. The Mission Planner will utilize Google Earth topological data to alter target altitude at each Waypoint to match the height of the ground underneath. Furthermore, various parameters such as elevation from the ground, WP radius are needed to be analyzed; before uploading the mission for the autonomous flight of UAV. [8]

4.4 Uploading and execution of mission

After the completion of Mission planning, the data is transferred to APM and stored in EEPROM using the Write option. Multiple mission files can be saved to a local hard drive by selecting Save WP File in the right-click menu or read in by selecting Load WP File. Grid: This feature involves drawing a polygon (right-click) and having waypoints created for you automatically across the specified region. The command "Auto Grid" in Task Planner may automatically build a mission, which is ideal for mapping missions where the aircraft should travel back and forth in a "lawnmower" pattern over an area to take images.

5 FLIGHT METHODOLOGIES

5.1 Manual flight mode

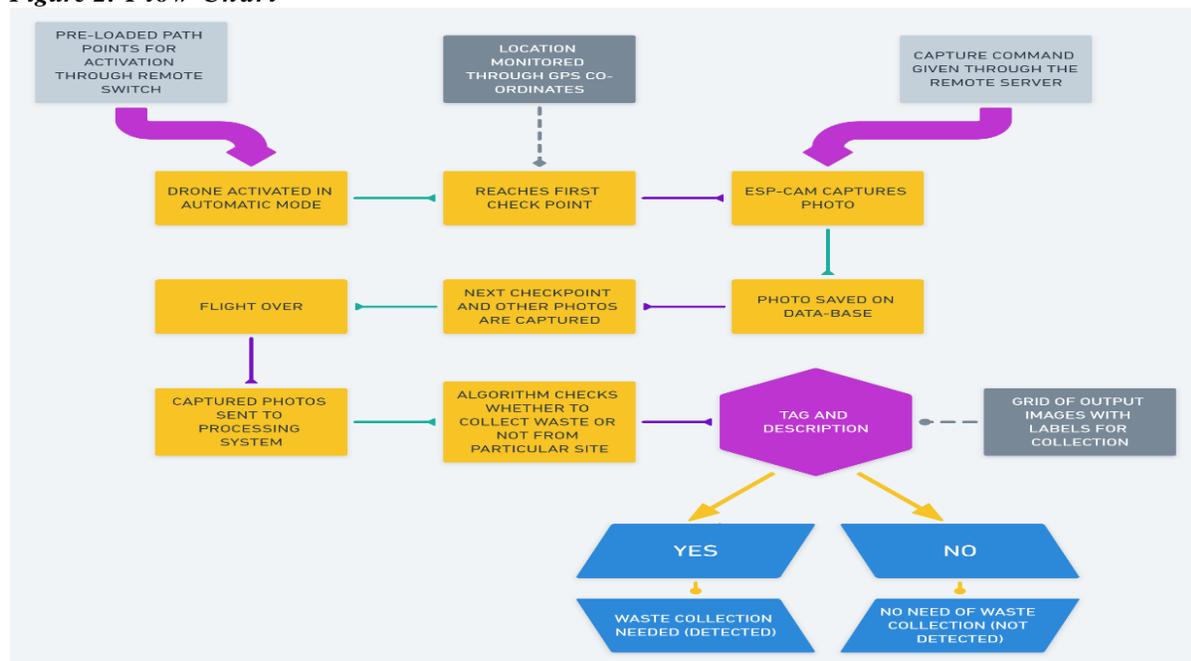
The drone has a Pixhawk flight controller mounted below it. It is connected to a receiver that receives the signal from the remote transmitter from the ground station. The flight controller controls the current flowing through the Electric Speed controllers (ESCs), which are responsible for the movement of the motors and consequently the propellers. A global positioning system mounted on top of the drone has been used to keep track of the position. To locate it, in case of an accident. All the above things are possible using the Mission Planner application. It helps in monitoring a plethora of parameters such as ground speed (m/s), vertical speed (m/s), altitude (m), yaw (deg), and many more. In Manual flight, there are multiple modes available: Loiter, Alt Hold and Stabilize, to name but a few. Each flight mode has its functionality. [9]

5.2 Automatic flight mode

The autonomous mode is a vital part of our work. The main aim is for the drone to take photos simultaneously without any influence on a predetermined path. It is possible to use the auto mode of the Pixhawk Flight Controller (PFC) and the GPS; the combination of

both will pave the way for smooth automatic operation. The drone will make a stop at some coordinates; lower its altitude decided by us. Then it will take pictures while maintaining the current position and the height. After that, it will move to a different location and follow the same procedure until it is called to the ground station [10]. For safety purposes of the drone, a fail-safe mode is also deployed. In case of loss of contact or windy weather, the drone will land safely at a secure location using the Return to Land command (RTL) [11]. It provides proper landing of the drone and safety in case of discharged battery condition to avoid any devastating consequences.

Figure 2: Flow Chart



6 IMAGE CAPTURING

6.1 Capturing

AI-Thinker developed the ESP32 camera module. The controller is based on a 32-bit CPU has a combined WiFi + Bluetooth/BLE Chip. The module comes with the OV2640 Camera Module, which supports the highest Camera Resolution up to 1600×1200 . It is used broadly in many IoT applications such as wireless video streaming, home smart devices, and many more. Camera module is connected to a router to command and run the ESP32-CAM web server; to capture the images. The router operates as an access point for the camera module, which acts as a station [12]. The webserver was designed with the help of HTML, JavaScript, and CSS. Furthermore, it contains three buttons: Rotate, Capture photo, and Refresh Page. Each photo-capturing process run different JavaScript functions: RotatePhoto, CapturePhoto, and Reload. The RotatePhoto button rotates the picture. The CapturePhoto button sends a request on the /capture URL to the ESP32, so it captures a new photo. On clicking the Refresh button, it will load the latest.

6.2 Uploading

A LAMP server will be used to process the image that is captured. The open-source Web development platform LAMP is well-known. It depicts a Linux-based operating system with an Apache web server, site data stored in a MySQL relational database management system, and dynamic content handled by PHP. [13] Between a client and a server, the Hypertext Transfer Protocol (HTTP) serves as a request-response protocol. An HTTP request is sent to a server by the ESP32 (client). The HTTP POST method is used to submit information to a server in order to create or update a resource. The ESP32 receives a response from the server (client). [14] Uploads.php is a distinct file that is responsible for receiving the images from the ESP32-CAM.

6.3 Storing

LAMP is a remote server, where jpeg/jpg images are stored, so that one can access it from anywhere in the Local Area Network. The LAMP server is hosted on the Raspberry pi, which works as a backend device to access/display the images on the webserver. After that, the images can be stored in a folder so that it can be accessed from a folder named gallery.php using the php script. Apache server is used to handle requests from clients to server by means of TCP/IP protocol. [15]

Furthermore, it will generate a document in the form of a php script. Images are stored on Raspberry-Pi by the means of upload.php file, which further facilitates the accessing of images through webserver-hosted using gallery.php script.

7 IMAGE PROCESSING

7.1 Computer vision

It is a field of science that works with computers to extract a high-level perception from images and videos. An open-source computer vision library named Open-CV is used to implement Computer Vision in Python. It enables a user to work at the pixel level in an image. Furthermore, it also allows extracting high-frequency and low-frequency data from the image; to get the desired output. For this, Computer Vision has various built-in functions and user-defined functions, such as edge detection algorithms, image denoising techniques, contour detection, and many more [16]. To retrieve paths, which match similar patterns, a library named glob is used. Consequently, to read the image, those paths are used. Moreover, these images can be pre-processed later.

7.2 Image Preprocessing

7.2.1 Hybrid algorithm

In this algorithm, the captured images are processed using two different techniques. Firstly, the obtained image in the RGB image model into the parameters of the HSV image model. The parameters are Hue, Saturation, and Value. [18] Hue is the dominant color plane, Saturation is the white light amount associated with Hue, and Value is the measurement of intensity, which refers to tone. Therefore, splitting an image into three different channels will produce three separate images with information in each. Out of these, the image obtained using the Value channel will contain information regarding the edges. Furthermore, the Adaptive Thresholding method on the image will eliminate noise and enhance the details of required edges by working on the pixel intensities of each region. [19] Secondly, to reduce the redundant data and to get the information from the captured images, it is convolved with the kernel, which changes the value of any given pixel by combining it with different amounts of the adjacent pixels. The convolution operation with this kernel has an averaging effect, which makes the resulting image smooth and sharp. As a consequence, the information extraction process becomes smooth. Furthermore, it is changed into a gray-scale format, and a Gaussian filter which is a low pass filter, is used for blurring the image, but here it is used twice, and then the resultant image is subtracted from the original image that will do the work of unsharp masking. It will facilitate the process of edge detection by removing noise and enhancing the edges. After this canny operator is applied to detect the edges, which helps in controlling the amount of detail that appears in the final image.

7.3 Contour Detector

It is a technique, which joins a curve to all the points (along with the boundary), having the same color or intensity. Contours are intellectual collections of points as well as segments that correspond to the edges or shape of the objects in an image. Due to this, one can count the number of contours and use them to categorize the shapes of objects. To ameliorate the accuracy of detecting the contours on the given image, the RGB image is converted into a single channel gray-scale image. [21] Furthermore, the contour approximation method is used to store all (x, y) coordinates of the boundary of a shape. To draw the contours, Area and Perimeter are defined to specify whether it is a closed contour or just a curve. After that, a built-in function from OpenCV is used to approximate the shape of polygonal curves to the specified precision. [22] The approximated contour, which is the same as the input curve. Finally, the determined shape of the contours is drawn on the original image to get user-friendly interface of the output.

8 RESULTS

The hybrid model produces two output images: hybrid output 1 and hybrid output 2, which are sent to the contour detector. It will perform the computations to find the symbol in the image to check whether there is a need for waste collection or not. Every image is sent to the contour detector for this purpose. Furthermore, the detector will return the labelled grid of images. These two grids are then combined to find the final sites, which need waste collection.

Figure 3: Hybrid outcome-1



Figure 4: Hybrid outcome-2



Figure 5: Final Result



9 ANALYSIS

The shape that is detected from captured images symbolizes the need to collect the waste from the location. This shape is mounted on the top of a dustbin, which will facilitate the process of automated waste assessment. The hybrid method is used here for preprocessing works on an image in two different methods for removing the different types of noise from an image. The combined method of deciding the outcome for waste collection enhances the accuracy of the overall model to a greater extent. Furthermore, this model works well with pictures that are taken not only in the low light environment as but also in the high light environment.

10 CONCLUSION

The paper defines an automated waste assessment system. The proposed drone system is integrated with a very low-power ESP-32 Camera module which significantly reduces the power consumption. The low power consumption increases the flight time to 25 minutes. Furthermore, the drone is made comparatively compact and lightweight due to the integration of the IoT-based ESP-32 camera module, which is controlled remotely with the help of WLAN protocols instead of mounting a microcontroller along with it. The drone can be operated in autonomous mode as well as manual mode. In autonomous mode, the drone can fly on its own, which includes landing and take-off. In case of a malfunction, the drone can be switched back to manual mode instantly to avoid any accidents. The image processing is done manually using a hybrid algorithm which is implemented in python. The algorithm tries to extract a symbol from the captured images, which is mounted on the top of a dustbin. The symbol signifies the need for waste collection. If the symbol is detected in the image, then the waste needs to be collected from that site.

11 FUTURE WORK

There are few constraints of this system. Firstly, it is completely dependent on the symbol for waste detection. This can be solved by using deep learning modeling techniques, which can detect the waste irrespective of the symbol and the location of the waste. Secondly, the range of the camera depends upon the WLAN, which varies on a case-to-case basis. To overcome this, IoT-based protocols can be used which can mitigate the problem of dependency on the range of WLAN, and the capturing process can be done remotely.

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