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Application of UAV (Drone) Technology in Solid Waste Management

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Abstract

In sectors, center around waste management, great investment in labor is required to minimize safety hazards. People are conventionally required to collect samples or manually dumping activities for accurate assessment. Aerial unmanned vehicles, known as drones, have changed the industry entirely. Human no longer have to play a critical role in painfully monitoring dumping landfills, which tend to come with a baggage of dangerous undertakings. Drones are useful and effective at managing waste sites more than humankind. A drone can operate tirelessly through the most remote places. Finally, Drones can take over as key counterparts in aspects of waste management that require laborious and dangerous work.

Key Words-Unmanned Aerial System, Safety hazard, Development, Technology, Monitoring, solid waste Management

Broad Area- Unmanned Aerial Vehicle.

Sub-Area- Solid Waste Management.

1. Introduction

Solid waste management has been a major concern for a long time. India produces 45 MT of Municipal Solid Waste annually at present. According to a recent consensus, the per capita waste generation in India is increasing at a rate of 1.3% per annum. Garbage generated, annually across the globe amounts to billions of tons today, with almost one lakh metric tons of garbage generated in India per day. This can cause a major impact on the environment. With urbanization in India, the scale of cities and the number of residents is rising and with it is increasing the amount of urban waste generated.

Often the presence of litter in a area results in the intentional throwing of litter at that particular spot as it gives the impression that it is a right place for discarding the waste. Throwing kitchen generated waste out of the window or chucking chewing gum wrappers along the roadside for instance, without realize the harmful effects it might have on the environment have become a commonplace. It costs residents, local, state and federal government have become a litter, reverse the effects of littering and prevent it. Municipal solid waste (MSW) at management includes collection, storage, transportation and disposal of solid waste. Per collection and inadequate transportation leads to help of MSW at many places, which causes health and environmental problems. While most urban waste management systems in place are designed for regular collection of waste from fixed locations at regular intervals, there are certain places (remotely located) which go unnoticed and are therefore, not cleaned. Many solutions have been designed for effective garbage management. A better solution designed for this problem is to use sensor for obtaining information about the level od garbage in containers and provide alert messages ti the garbage collector truck about the level of waste in a garbage container.

Through extensive background study and data collection, it can be concluded that most of the current automated waste management systems rely in IT and hardware devices such as infrared sensor, ultrasonic sensor, metal sensor etc. for detection of garbage and subsequent communication of the bin status. Other than this, there are waste sorting systems based on image processing which identify metal materials or other special types of waste. However, these become dysfunctional in case of paper and plastic products. Moreover, there are very few existing artificially intelligent systems which are self-sufficient for waste classification.

This system aims to achieve the following:

- To capture Aerial view images using Drone and further process the same to identify solid waste disposed at inappropriate places.
- To notify the respective person-in-charge for taking the necessary action to clean the litter/solid waste.
- Help maintain cleanliness in places such as beaches, institution, cities etc.

Figure 1: Waste Management

1.1 Background

A. UAV-

Drones are Unmanned Aerial Vehicles (UAV) which operate without a human pilot aboard. They can either be flown using a ground-based remote controller operated by a human or autonomously by onboard computers. They can mostly used in military, commercial, scientific, agriculture, peacekeeping and other applications. They have the ability to navigate through large and remote places which security cameras otherwise fail to cover. The drone that will be used in this project is an assembled flame wheel 450 mm model equipped with first-person-view camera. The utilization of the drone will allow for real time transmission of video image set to be analyzed by the litter detection deep learning framework.

B. Image Stitching-

Image Stitching is a technique used for attaining high-resolution panoramic image from multiple images combine together. Image stitching techniques can either be direct intensity-based or feature based.

Figure 2: Optimal Hardware

Snapshot from the live video feed captured with the help of the drone will be taken at regular intervals and stitched together for further analysis.

C. Deep Learning and Computer Vision-

Concepts of Deep Learning and Computer Vision have been used in this project to achieve the automated detection of litter.

- Deep learning is a sub part of Artificial Intelligent (AI) which is concerned with emulating the learning approach that humans use gain knowledge from data patterns. In contras to machine learning algorithm, deep which are supervised and linear abstraction.
- The advantage of deep learning is that the program builds the feature set by itself without any sort of human supervision and hence are generally faster and more accurate.
- A Deep Natural Network (DNN) is a neural network with a certain level of complexity, they have multiple layers between the input and output layers.
- The DNN finds the correct mathematical manipulation to turn the input into the output. Deep learning within the field of Computer vision is concerned with the automatic derivation of useful information from visual data.

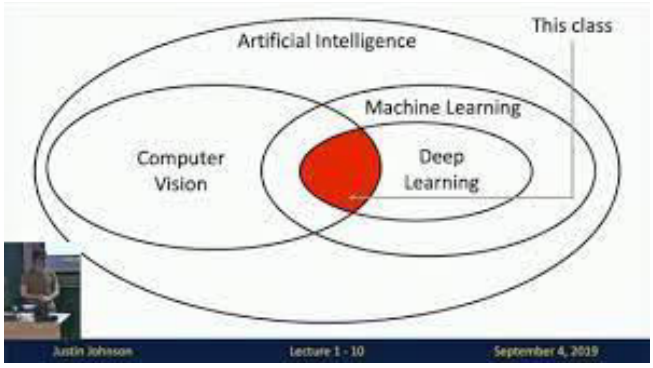

Figure 3: Drone Type

D. Python-

Python is a high-level object-oriented programming language with emphasis on code readability and built-in libraries to provide various functionalities. Being a general-purpose programming language, it provides powerful implementations to facilitate large data and advanced calculations with libraries such as TensorFlow SciPy, Scikit-Learn, and NumPy. TensorFlow and scikit-Learn are libraries that provide various machine learning framework and algorithms, such as neural networks and support vector machines. Tensor Board is a suite of visualization tools that make it easier to understand, debug and optimize TensorFlow programs. NumPy and optimize TensorFlow programs. NumPy is a library for applying various advanced mathematical functions with arrays and matrices, both key components of machine learning algorithms. SciPy is the optimized core package for scientific routines in Python; it is meant to operate efficiently on NumPy arrays, so that NumPy and SciPy work hand in hand. To use computer vision, Python was also implemented with Scikit-Image and OpenCV. These libraries provide important image manipulation tools computer vision techniques, such as features extraction and image classification.

E. Hardware Components

Arduino is a programmable controller which can be used handling file transfer operations. It can "talk", (transmit or receive data) via a serial channel, so any other device with serial capabilities can communicate with an Arduino.

- The drone will be fixed with an Arduino to facilitate the interfacing of other hardware components such as Global System for Mobile Communication (GSM) and Global Positioning System (GPS) modules.
- The GSM can be integrated with the Arduino to connect with the computer system over a network and communicate.
- A GPS module integrated with the drone will fetch coordinates (latitude and longitude) of the places that the drone will fly through.

F. Cloud Platform-

A cloud platform allows for date storage, remote access and encapsulates various tools for data analytics and machine learning. A cloud platform such as Amazon Web Services (AWS) Elastic cloud 2 (EC2) instance will be used to store the serially transmitted location coordinates (record by the GPS module) sent via the GSM module integrated with the drone. The use of cloud is to allow remote file transfer and further processing of the data recorded for comparison purposes.

1.2 Existing System

A. Waste Monitoring and Management Systems-

In the past decade, many smart solutions for waste detection and involving the use of IoT have emerged. These systems use mechanisms to check for the status of garbage containers and eventually indicate the same to the respective in-charge. RFID technology is used for collection of data regarding garbage container in. RFID tag works to detect within the frequency range and when any tag comes to the range of RFID reader, it automatically reads data from RFID reader, then filters collected data and arranges it into specific formatted SMS. Subsequently, the data is sent to central server sends the information to the web server as well as authorized person's mobile phone. A similar system design is described in is which user RFID reader, the sensor will check the status of the bin and send it to the web server.

Another paper on waste management uses ultrasonic sensor to detect the level of garbage in the bin and communicates to control room using GSM system. Four IR sensor s are used to detect the level of the garbage bin. When the bin is full the output is given to micro-controller to send a message to control room through GSM. A similar system consists of waste bins equipped with ultrasonic sensor which are interfaced with Arduino Uno and a Wi-Fi module which collect the waste fill level status and upload the data to database. This data appears in the android application which notifies the appropriate collector client based on their location once the bin gets filled up introduces an Android app, Spot Garbage that can automatically detect and localize regions containing garbage in user-clicked unconstrained Geo-tagged real-world images. The app utilizes the proposed fully convolution network, Garb Net for coarsely
segmenting image regions containing garbage and the locations of the images classified as garbage
are marked and plotted on Google Maps.

G. Surveillance Systems-

Drones are unmanned aerial vehicles which often find their application in surveillance and monitoring of wide areas and remote places which are otherwise inaccessible. Describe a smart transport infrastructure system based on drones and feature extraction techniques to determine the level of traffic

congestion on roads and also indicates vacant parking slots in a particular area. This system is an instance of the accuracy and feasibility if using drone-based image processing to achieve useful results. Where a custom-built drone is used to capture images, processing is used for classification of images with reference to a predefined train database.

1.3 Proposed System

As part of the proposed solution, the focus of this project is to build a system which takes a live video feed (or multiple images) captured by a drone as its inputs and extracts information from the images in order to identify places contaminated with solid waste/litter. The drone would capture a wide area such as a college campus or a locality and provide an aerial view of the location. The drone will be made to transfer the visual data recorded by it to the local server which is a computer system performing the processing the operations. Arduino will be used for handling file transfer operations which will allow for real time retrieval of captured images. GSM and GPS module placed over the drone would provide the functionality of mobile communication and real time location referencing. With the help of image stitching techniques, the live video feed will be stitched based on similar features producing panoramic images of a place. This data can then be processed using Deep-Learning image processing algorithms coded in Python. The predefined dataset would encompass images of litter such as waste metal cans, bottles, crumpled paper, plastic bags etc. By testing the input data against the classes/categories of the predefined dataset in Tensor Flow framework, the algorithm will produce an output which assigns a distinct class to the given input image. The end goel is to send a notification which contains geographic coordinates (GPS based location) of the place contaminated with garbage to the respective person-in-charge prompting him/her to take the necessary action. The place coordinates corresponding to the timestamp of the output image (where litter was detected) will be fetched and subsequent message will be sent. The key components for this system include the following:

- Remote controlled Drone for surveillance and capturing images.
- Arduino for managing the captured images and handling file operations.
- Python IDE to run Python based programs. Interfacing circuitry for making the connections
- GPS and GSM module for position tracking and communication respectively.

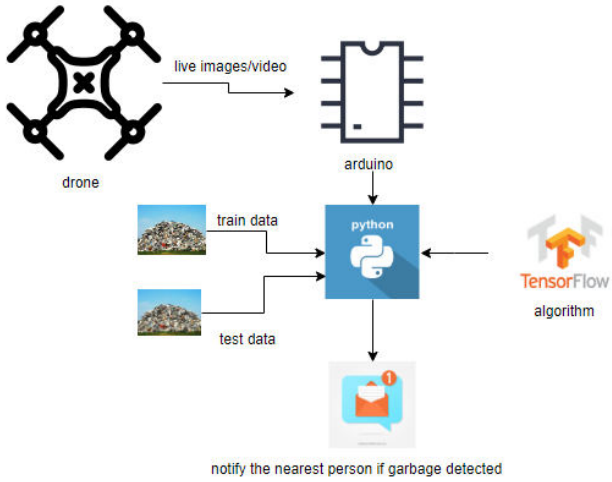

Figure 4: Mapping Landfill

2. Drones for Waste Management –

Waste management is a crucial part of maintaining a clean and well-functioning society. As humans produce more waste, this can be a challenging task, but drone can help. As this technology becomes more prevalent, more companies and governments realize the potential of drones for waste management. Several government and companies have explicitly discovered UAVs potential and have employed them for the following applications:

a) Collecting Garbage- Littered plastics can harm marine wildlife, but finding and collecting them by hand is labor-intensive and inefficient. Drones can cover the same area in a fraction of the time, speeding up the litter collection process.

b) Mapping Landfill: Drones can capture high-resolution images and create 3D models to help in monitoring landfills. With aerial access from drones, managers no longer have to trudge their feet across the unsteady terrain. On the whole, landfill mapping by drone has proven to be more time-efficient and less labor-intensive.

Figure 5: Mapping Landfill

c) Monitoring waste treatment: With the assistance of drone technology, waste management organization can take one step further and control the waste through drones equipped with select cameras.

d) Cleaning Power Lines: Another application for drone technology for waste management organization is cleaning power lines. Chinese firms have employed drones furnished with flamethrowers that burn any garbage attached to the power lines. Drone technology, coupled with the Internet Of Things (IOT) has advanced application in the industry like separating recyclable and non-recyclable garbage.

e) Managing Cells: A landfills primary aim is to saturate as much scrap as possible in a single cell and to utilize the space effectively. This is accomplished by calculating the most suitable compaction rate for every individual cell. By employing drones, organization can determine the compaction rate while inspecting a landfill more accurately.

f) Calculating Landfill Capacity: According to specific Rules and regulation waste management techniques, landfills require to maintain waste below a particular elevation level, and so often need to overfill particular cells. With the help of Drone technology, landfill owners can now conclude the cells to fill with waste without prompting any contamination to their surroundings.

g) Observing Protected Areas: A significant role in waste management systems is to guarantee the sanctuary of environmental locations surrounding the landfill areas. With the application of UAVs, companies can ensure that landfills and recycling hubs don't pollute their neighboring regions.

h) Monitoring Methane Emission: The third largest cause of heightened methane production in the United States is solid waste landfills. Drones furnished with thermal cameras are employed at landfill to monitor the colorless and odorless gas. Application of Drone technology companies can monitor and keep methane emissions under control from a protected distance.

i) Airspace Calculation: According to the Top-Of-Waste level, waste management firms can pick definite cells to overfill if deemed necessary. Utilization of Drone can help measure a cell's overfill potential and available airspace. The airspace in the landfill cells is monitored using 3D models for waste overfill volume visualization and the cross-section os cells or the complete landfill.

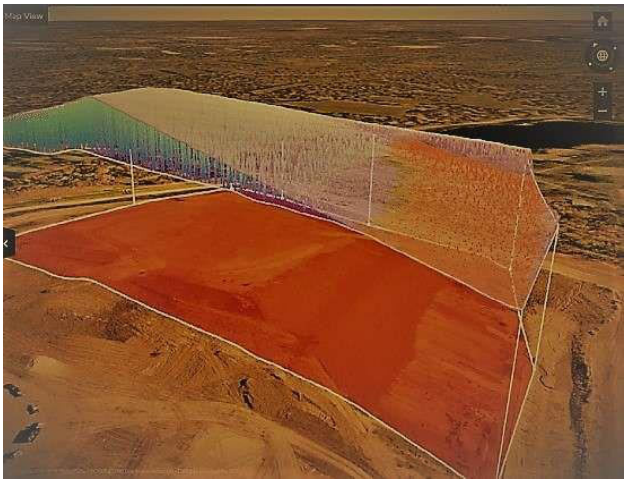

Figure 9: Airspace calculation

3. CONCLUSION

As this system is entirely automated, it will be efficient and applicable to all environments. The use of a drone adds to effective monitoring of waste as it removes the need for humans to manually travel to places for surveillance. This system offers the benefits of maintaining cleanliness in the surroundings and the environment. Waste accumulation in undesirable places can be minimized, even eliminated and waste management can be improved to a great extent. The implementation of this system will also assist organizations in effectively managing waste in remote places.

However, despite its benefits, this project specifically focuses on waste monitoring while waste disposal and cleaning remain out of its scope. Therefore, future works can be based on developing and automated robotic system to handle the waste detected. A robotic garbage collector can be integrated with the drone. The collector can be programmed to receive inputs from the drone about type of garbage detected upon which the collector will clean-up the litter, segregate the waste into recyclable and non-recyclable materials. Disposal of this waste will also be looked after by the robotic garbage collector. Such an integrated system would complete the entire process of the waste detection and collection single handely without requiring human interference.

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