Enhancing Security Measures through Colour Detection Algorithm Implemented with ESP32 Cam

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Abstract: Drones, unmanned aerial vehicles (UAVs), have gained widespread use in various domains such as food delivery, photography, and surveillance. However, their deployment in capturing information from unknown areas at borders raises unethical behaviors. To address this issue, in this study an approach has been proposed for detecting the object with respect to its color which plays very prominent and important role in security purpose, air surveillance, etc.This study proposes the implementation of a color detection algorithm using ESP32 CAM, an embedded system equipped with a camera module. This research contributes to enhancing security measures and mitigating the unethical use of drones. The color detection algorithm aims to identify specific colors associated with unethical drone behaviors, such as unauthorized surveillance or intrusion. By analyzing the captured images or video frames, the algorithm detects the presence of predefined colors and triggers appropriate actions, such as sending alerts or activating counter measures. The ESP32 CAM offers significant advantages for this application, including its powerful processing capabilities, integrated Wi-Fi and Bluetooth connectivity, and compact form factor. These features enable real-time color detection and facilitate seamless integration with other security systems or networks. By leveraging the ESP32 CAM's capabilities, the proposed color detection technique enhances the ability to detect and prevent unethical drone behaviors. It provides a proactive approach to identify potential threats and take timely actions to mitigate risks associated with drone misuse.

1 INTRODUCTION

Drones have become a source of concern due to privacy violations, particularly in military and border contexts where unidentified drones from objects present challenges. To overcome these limitations, unknown areas pose a spying threat. Ensuring security in such scenarios necessitates the proper implementation of technology, including radars and counter-Unmanned Aerial Vehicle (UAV) systems, have been employed for drone detection and mitigation However, these solutions often have limitations in detecting stationary objects. While radar systems are commonly used in military aircraft for target identification and navigation, their limited range and inability to detect stationary additional security systems such as counter-UAS technology and drone monitoring equipment are employed. The color detection technique complements these systems by efficiently identifying malicious objects, enhancing reliability, and reducing reliance on radar-based approaches.

By incorporating color detection into the existing radar and counter-UAV systems, the proposed approach provides a more comprehensive and accurate means of identifying and tracking drones. While radars and counter-UAV systems primarily rely

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on RF signals and motion detection, the addition of color detection using ESP32 CAM offers an additional layer of analysis based on visual cues. By combining radars, counter-UAV systems, and color detection using ESP32 CAM, this integrated solution aims to provide a more robust and reliable approach to detect and mitigate the unethical use of drones. It enhances the overall effectiveness of drone detection systems, allowing for more accurate identification, tracking, and response to unauthorized drone activities.

(Smith, J., & Johnson ,2019) has proposed a radar-based drone detection and tracking systems. It provides different radar technologies and their capabilities in detecting drones. It also explains the limitations of radar systems, particularly in differentiating drones from other objects and detecting stationary drones. It emphasizes the need for complementary technologies, such as color detection using cameras, to enhance the effectiveness of drone detection systems.

Brown, M., & Davis A (2020) as proposed Counter-Unmanned Aerial System (C-UAS) technology. C-UAS technologies are designed to detect, track, and mitigate unauthorized drones. It provides an overview of various C-UAS techniques, including radar-based systems, RF detection, and optical sensors. The survey explores the strengths and weaknesses of these technologies in identifying drones with unethical intentions. It highlights the potential benefits of integrating color detection using cameras, such as ESP32 CAM, to enhance the accuracy and reliability of C-UAS systems. Garcia,(2020) has proposed an Anti-drone system: A visual-based drone detection using neural networks that proposes visual sensing by simulation to detect drones by faster R-CNN (Region-based Convolutional Neural Network) with Res-Net-101 (Residual Neural Network-101) networks.

(Patel, R., & Shah ,2021) has developed a color-based object detection using ESP32 CAM for unmanned aerial vehicle surveillance. This study further focuses specifically on color-based object detection using ESP32 CAM for unmanned aerial vehicle (UAV) surveillance. It presents a case study where ESP32 CAM is utilized to detect predefined colors associated with unauthorized drone activities. This mainly discusses the implementation details, including image processing techniques and integration with the overall surveillance system. It demonstrates the effectiveness of color detection using ESP32 CAM in enhancing UAV surveillance capabilities and potentially preventing unethical drone behaviors.

(Samadzadegan, et.*al*,2022) has developed a detection and recognition of drones, based on a Deep Convolutional Neural Network Using Visible Imagery. Drones are often confused with birds because of their physical and behavioural similarity. The proposed method is not only able to detect the presence or absence of drones in an area but also to recognize and distinguish between two types of drones, as well as distinguish them from birds. The dataset used in this work to train the network consists of 10,000 visible images containing two types of drones as multi-rotors, helicopters, and also birds.

(Ahmad, et.*al* ,2020) has proposed a Machine Learning Approach for Detecting Unauthorized Drone Operators. It is mainly about detecting unauthorized drone operators through RF communication Technology, GPS tracking or RADAR by Machine Learning approach. A comprehensive analysis is conducted to find the optimal machine learning approach to classify the UAV operator in terms of accuracy, sensitivity, and prediction time. The utilized dataset consists of recorded flying sessions of 20 different pilots based on four features, thrust, yaw, pitch, and roll. To balance the dataset, the Synthetic Minority Over-sampling Technique (SMOTE) is utilized.

The study presents a noteworthy development in the form color detection which utilizes advanced technology to detect drones and promptly issue security alerts through an alarm system. Key to this detection capability is the integration of an ESP32 microcontroller, known for its powerful processing capabilities and built-in Wi-Fi and Bluetooth connectivity. With real-time monitoring and analysis facilitated by the ESP32, the system effectively distinguishes drones from other airborne objects, employing a comprehensive drone detection algorithm that combines visual and acoustic sensors. Overall, this study contributes significantly to the field of color detection for security by providing a reliable and environmentally friendly solution for drone detection and real-time security alerts using specific libraries, enhancing safety in diverse settings. This paper is organised as follows. Methodology of the study has been given in section II, which explains about incorporating color and tracking parameters of defined colors in section III. Section IV concludes the paper. built-in Wi-Fi and Bluetooth functionality, eliminating the need for an additional Ethernet shield for connectivity. For colour or image detection, the ESP32 CAM module is particularly significant malicious behaviour is detected, no notification detection into the existing radar and counter-UAV systems, the proposed approach provides a more comprehensive and accurate means of identifying and tracking drones. Results of the study with a pictorial representation of a specific colors of an object has been shown along with the defined ranges Fig 1 depicts the block diagram of proposed methodology for finding the object is malicious or not. Solar power panels are used in this study, where the power has been taken. In recent trends, there is a depletion of fossil fuel and on the other hand the power demand is increasing at load centers. In this study, renewable power generation source has been used. By utilizing solar energy to power a system designed for drone identification. The system incorporates an ESP32 CAM, which enables the analysis of the behaviour of detected objects. If an object is identified as malicious, an alarm is triggered to alert the user. Conversely, if no malicious behaviour is detected, no notification is sent to the user. This entire process is powered by solar energy, promoting sustainable and environmentally friendly operations.

1.1 Methodology

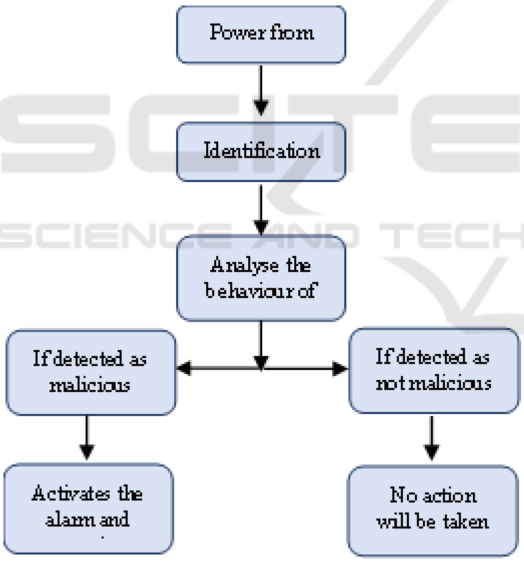


Figure1: Block diagram.

The ESP32, developed by Espressif Systems, is a microcontroller that incorporates a range of System on a Chip (SoC) modules. It stands out for its affordability and low power consumption. Unlike many other boards, the ESP32 includes.

Set up the ESP32 CAM module by connecting it to the ESP32 development board and ensuring that the required libraries and dependencies are installed. Capture images using the ESP32 CAM module, utilizing the provided functions or methods to capture frames from the camera. Preprocess the captured image to enhance color detection accuracy.

This can involve operations like resizing, cropping, or adjusting the image's color space. Convert the image from the default RGB color space to a color space suitable for color detection, such as HSV (hue saturation value) or LAB. Define the color range(s) to detect by specifying lower and upper thresholds for each color component in the chosen color space.

For example, specify HSV (hue saturation value) or LAB values that correspond to the color red. Apply thresholding techniques to Segment the image based on the defined color range(s). This will separate the desired colors from the rest of the image. Thresholding techniques include simple thresholding, adaptive thresholding, or morphological operations. Use contour detection algorithms to identify the boundaries of the color regions in the segmented image. This will provide location and shape information for the detected colors. Analyze the detected color regions based on specific requirements.

Calculate properties such as centroid, area, or perimeter of the color regions. Once the color segmentation is performed, the resulting color regions can be analyzed. Various properties of the color regions can be calculated, such as the centroid (the center of mass of the region), area (number of pixels in the region), or perimeter (length of the region's boundary). These properties provide information about the detected colors. To differentiate colors, the properties of the detected color regions can be compared. For example, compare the centroids of different color regions to determine their relative positions or distances. Additionally, can analyze other properties, such as the dominant color within a region or the relative sizes of color regions. Perform desired actions based on the color detection results.

This can include activating alarms, controlling external devices, or sending notifications to users. Test the color detection algorithm in different lighting conditions and with various color samples to evaluate its accuracy and reliability.

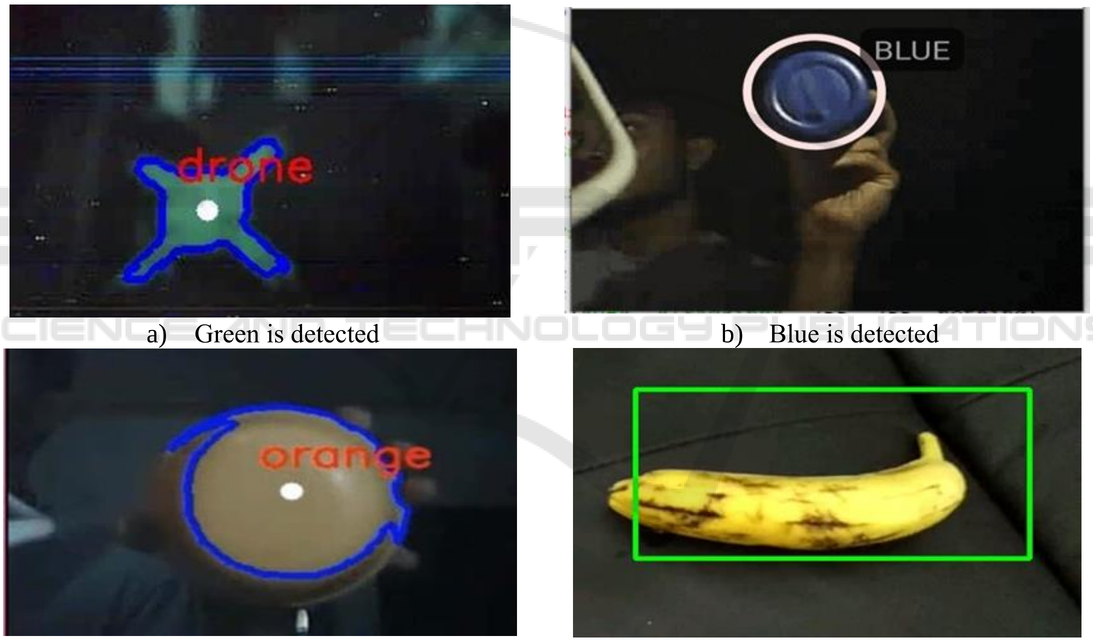
2 RESULTS

The color detection algorithm successfully identified several colors in the captured image. The algorithm accurately determined the presence of specific colors based on their defined color ranges. In the captured image, the algorithm detected regions or areas where the identified colors were found. It provided information about the position, size, and shape of these color regions, allowing for a detailed understanding of their distribution within the image. Moreover, the algorithm provided additional properties of the detected color regions. This included the centroid coordinates, which indicate the central point of each color region. The area of each color region, measured in terms of the number of pixels it occupies, was also determined. Additionally, the algorithm calculated the perimeter of the color regions, providing insights into their boundary lengths.

To demonstrate the results, a pictorial representation was generated. The representation visually depicted the detected colors and their corresponding regions within the image. This visualization allowed for a clear and intuitive understanding of the algorithm's performance.

Furthermore, the algorithm provided the flexibility to adjust the tracking parameters. In the presented frame, the green color was specifically tracked and is shown in Fig 2. As shown in the Fig 3, By manipulating the LH (Lower Hue), LS (Lower Saturation), LV (Lower Value), UH (Upper Hue), and UV (Upper Value) values using the provided tracking bars and different colors could be targeted and detected for different colors like blue, orange and yellow depicted in Fig 2. This adjustable feature enabled the algorithm to adapt to various color detection requirements and cater to specific application needs.

The prototype of the color detection is shown in Fig 4, the prototype mainly consists of rotating pole of 360 degrees and a camera has been attached to it, so that it can detect the UAV or drones based on color detection algorithm. The code for changing the color ranges and detecting the colors is shown in Fig 5.



a) Green is detected

b) Blue is detected

c) Orange is detected

d) Yellow is detected

Figure 1: Colordetection of different objects.

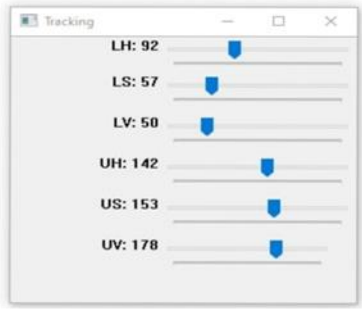


Figure 2: Tracking bar.

```
import cv2
import urllib.request
import numpy as np

def nothing(x):
    pass

url='http://192.168.1.61/cam-lo.jpg'
##'''cam.bmp / cam-lo.jpg /cam-hi.jpg / ca
cv2.namedWindow("live transmission", cv2.W

l_h, l_s, l_v = 92, 57, 50
u_h, u_s, u_v = 142, 153, 178

while True:
    img_resp=urllib.request.urlopen(url)
    imgnp=np.array(bytearray(img_resp.reac
    frame=cv2.imdecode(imgnp,-1)
    #_, frame = cap.read()

    hsv = cv2.cvtColor(frame, cv2.COLOR_BC

    l_b = np.array([l_h, l_s, l_v])
    u_b = np.array([u_h, u_s, u_v])

    mask = cv2.inRange(hsv, l_b, u_b)

    cnts, _ = cv2.findContours(mask,cv2.RE

    for c in cnts:
        area=cv2.contourArea(c)
        if area>2000:
            cv2.drawContours(frame,[c],-1,
            M=cv2.moments(c)
            cx=int(M["m10"]/M["m00"])
            cy=int(M["m01"]/M["m00"])

            cv2.circle(frame,(cx,cy),7,(25
            cv2.putText(frame,"blue",(cx-2

    res = cv2.bitwise_and(frame, frame, ma

    cv2.imshow("live transmission", frame)
    cv2.imshow("mask", mask)
    cv2.imshow("res", res)
    key=cv2.waitKey(5)
    if key==ord('q'):
        break

cv2.destroyAllWindows()
```

Figure 3.

Figure 4: Code for color detection.

3 CONCLUSIONS

This study addresses concerns related to the misuse of drones for non-ethical purposes, particularly in border surveillance. The integration of radars, counter UAV systems, and color detection using ESP32 CAM presents a promising approach to address the issue of unethical behaviors of drones. By combining radar technology with the ESP32 CAM's color detection capabilities, it becomes possible to enhance the detection and identification of drones engaged in non-ethical activities.

The utilization of radars allows for detection and tracking of drones, providing valuable information about their presence and movement. Coupled with the ESP32 CAM's color detection functionality, the system can further refine the identification process by analyzing the visual characteristics of the drones, such as their color patterns. The algorithm accurately determined the presence of colors based on predefined color ranges and provided detailed information about the position, size, shape, centroid coordinates, area, and perimeter of the detected color regions. A pictorial representation visually depicted the detected colors, enabling a clear understanding of the algorithm's performance.

However, it is important to acknowledge that the effectiveness of such a system relies on continuous research, development, and refinement. Ongoing advancements in radar technology, counter UAV systems, and color detection algorithms will be essential to stay ahead of evolving drone capabilities and potential new unethical behaviour.

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