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Drone Technology for Real-Time Social Distance Tracking

[1]Thejaswini S, [2]Rashmi N, [3]Mamatha K R, [4]Dr. Girish H

[1]Dept. of ETE, B M S Institute of Technology and Management Bengaluru, Karnataka, India
[2]Dept. of ECE, B M S Institute of Technology and Management Bengaluru, Karnataka, India
[3]Dept. of ECE, B M S Institute of Technology and Management Bengaluru, Karnataka, India
[4]Professor, Department of ECE, Cambridge Institute of Technology, Bangalore, Karnataka, India

ABSTRACT

Drones have revolutionized human exploration, making it significantly easier to access and observe the most remote and challenging areas. They allow us to closely inspect locations that would otherwise be difficult or dangerous to reach. Equipped with cameras, drones can gather visual data from these inaccessible places, providing crucial insights before humans venture there. Amid the global disruption caused by the COVID-19 pandemic—impacting billions and leading to economic slowdowns, industry closures, and job losses—countries have prioritized health as a key concern. Our project focuses on developing a quadcopter for pandemic monitoring and enforcing social distancing. The simulation features a drone movement model with a single-layer path and a fixed distance, based on real-world drone mobility and area coverage for social distancing monitoring.

KEYWORDS:

INTRODUCTION

The COVID-19 outbreak shows no signs of ending, with the virus affecting 216 countries globally, over 7 million confirmed cases, and 400,000 deaths. Despite this, economic pressures have led communities to gradually resume activities, with some regions lifting lockdowns while maintaining strict health protocols. Local governments are now implementing new regulations to enforce social distancing, aimed at reducing virus transmission and minimizing casualties. Monitoring systems are essential to mitigate transmission risks, as traditional methods like police patrols at crowded areas expose personnel to potential infection and are inefficient, risky, and expensive due to limited manpower and coverage. Our project aims to develop a social distancing monitoring system using a quadcopter. We utilize a Raspberry Pi 3 development board with a Broadcom BCM2711 microprocessor, chosen for its higher clock speed and memory, ideal for image processing. OpenCV and deep learning models in Python, with a Haar Cascade classifier, are employed to detect human faces. A vector distancing algorithm calculates the distance between individuals. If the attached camera detects people standing less than 6 feet apart, those maintaining social distancing will be marked with a green rectangle on the screen, while those who are not will be highlighted in red.

METHODOLOGY

The key aspect of this project is detecting unidentified human appearances. A database of images will be stored in the system. Small, low-noise drones equipped with Raspberry Pi, utilizing OpenCV and Haar features, are used for detection. The proposed face detection system follows several steps: (1) Face detection, (2) Feature extraction, and (3) Vector Distancing Algorithm.

(1) We are using a Raspberry Pi 3 development board with a Broadcom BCM2711 microprocessor, chosen for its higher clock speed and memory, ideal for image processing.

(2) To monitor individuals and enforce social distancing, we are using OpenCV and deep learning models in Python, with a Haar cascade classifier to detect human faces. The vector distancing algorithm will measure the distance between individuals.

(3) If the camera detects that the distance between two or more people is less than 6 feet, those maintaining social distancing will be highlighted with a green rectangular box on the screen, while those who aren't will be marked with a red box.

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A. RASPBERRY PI

Fig. 1: Pi 4

The Raspberry Pi is a series of single-board computers developed by the Raspberry Pi Foundation, a UK charity focused on making computing education more accessible. First launched in 2012, the Raspberry Pi has since seen multiple versions. The original model featured a single-core 700MHz CPU with 256MB of RAM, while the latest versions now boast a quad-core 1.4GHz CPU and 1GB of RAM. This affordable, credit-card-sized computer connects to a monitor or TV and works with standard keyboards and mice. It allows people of all ages to explore computing and learn programming languages like Scratch and Python. Despite its small size and low cost, the Raspberry Pi is capable of performing many tasks typical of a desktop computer, such as browsing the web, playing HD videos, creating spreadsheets, word processing, and gaming. Over time, three generations have been released—Pi 1, Pi 2, and Pi 3—typically with two models per generation: Model A, a more affordable version with less RAM and fewer ports, and Model B. Additionally, the Pi Zero, a smaller and cheaper variant, was introduced as part of the original Pi 1 lineup.

B. PI CAMERA v2

Fig. 2: Pi cam v2

The Raspberry Pi Camera Modules are official products developed by the Raspberry Pi Foundation. The first 5-megapixel camera was introduced in 2013, followed by the 5-megapixel Camera Module v1.3 in 2016, both available in visible light and infrared versions. In 2020, a 12-megapixel High-Quality (HQ) Camera was launched, though it lacks an infrared version, the IR filter can be removed if necessary. The Raspberry Pi Camera v2 features an 8-megapixel Sony IMX219 image sensor with a fixed-focus lens, capable of capturing 3280 x 2464-pixel static images and supporting 1080p30, 720p60, and 640x480p60/90 video. It allows users to record high-definition video and take still photos, making it user-friendly for beginners but also robust enough for more advanced users interested in tasks like time-lapse, slow-motion, and video effects. The camera is compatible with all models of Raspberry Pi 1, 2, 3, and 4 and can be controlled via the MMAL and V4L APIs. Additionally, various third-party libraries, including the Pi camera Python library, are available for extended functionality.

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C. A.P.M Flight Controller

Copter is a sophisticated open-source autopilot system designed for multicopters, helicopters, and other rotorcraft. It supports a range of flight modes, from fully manual control to fully autonomous operation. As part of the broader ArduPilot software ecosystem, it integrates seamlessly with various Ground Control Station (GCS) programs, allowing users to configure the vehicle, monitor real-time flight data, and perform advanced mission planning. It also leverages additional ArduPilot tools, such as simulators, log analysis utilities, and high-level APIs for vehicle control. ArduPilot is widely used in many commercial autopilot systems, but it’s also an excellent option for enhancing the capabilities of DIY multirotor projects.

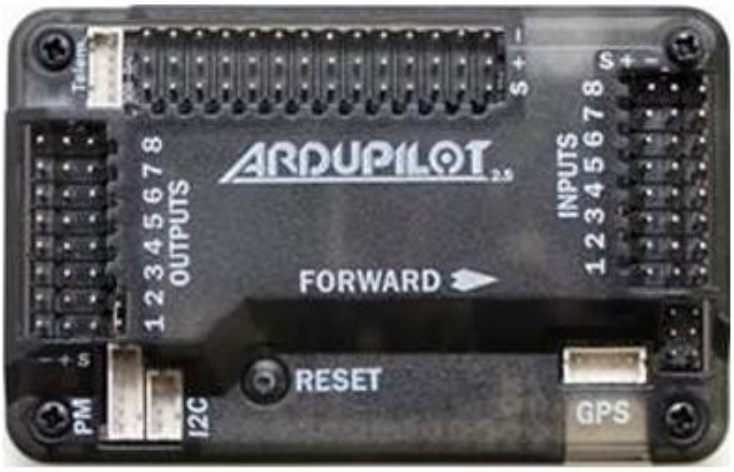

Fig. 3: Flight Controller

D. BRUSHLESS MOTORS

As the name suggests, a brushless FPV drone motor operates without brushes. It consists of two main components: the rotor and the stator. The stator is the stationary part of the motor, housing a series of radial electromagnets. When current flows through the windings, these electromagnets are alternately powered on and off, creating a temporary magnetic field. The rotor, which is mounted within the stator, contains permanent magnets placed near the stator's electromagnets. The interaction between the magnetic fields of the rotor and stator—both attractive and repulsive—generates rotational movement.

E. ELECTRONIC SPEED CONTROLLER

An Electronic Speed Controller (ESC) is a device that manages the power supply to an electric motor, enabling it to throttle from 0 to 100%. There are two types of ESCs: brushed and brushless, both operating on similar principles. An ESC is composed of three primary components: a BEC (Battery Elimination Circuit)/voltage regulator, a processor, and a switching system that uses FETs (Field Effect Transistors). To delve a bit deeper, the BEC/voltage regulator is the part of the ESC that the BEC (Battery Eliminator Circuit) sends a regulated amount of power, typically 5V at 1A, back to your receiver to power the servos. Additionally, it serves as a safeguard by cutting power to the motor when the battery reaches its minimum voltage, ensuring the battery is not over-discharged. The kit includes the FS-iA6B receiver, a compact 6-channel unit with a range of over 500 meters. It features a dual antenna for strong reception and interference rejection. Each transmitter has a unique ID, and once bound, the receiver only accepts data from that specific transmitter, preventing interference from other signals and enhancing safety.

F. Li-Po BATTERY

A LiPo cell typically has a nominal voltage of 3.7V. In the case of the 7.4V battery mentioned, it consists of two cells connected in series, which adds their voltages together. This is why you might hear people refer to it as a "2S" battery pack—indicating 2 cells in Series. Therefore, a two-cell (2S) pack provides 7.4V, a three-cell (3S) pack gives 11.1V, and so on.

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SOFTWARE

The software used in this project were all open sourced as well as the best in line for top optimization and performance. The software used are namely 1. Raspbian Buster (Operating System) 2. Python 3. OpenCV

A. RASPBIAN OS

Following the unexpected release of the Raspberry Pi 4, the Raspberry Pi Foundation introduced a new version of its default operating system, Raspbian Buster. Buster maintains backward compatibility with older hardware and will serve as the default OS for all Raspberry Pi models. It succeeds Raspbian Stretch, which had been the default for nearly two years, and is compatible with every Raspberry Pi model. Built on Debian Linux 10 (Buster) with the 4.19 Linux kernel and GCC 8.3 compiler, it continues to offer the PIXEL desktop environment (based on LXDE). Interestingly, Raspbian Buster was released ahead of the official Debian Buster release due to the new open-source OpenGL video drivers, developed using the latest Debian version. While there are no significant visual differences from Raspbian Stretch, Buster brings enhanced security features to make the Raspberry Pi more resistant to hacking. If you've downloaded "Raspbian Buster with desktop and recommended software," most preinstalled applications remain the same, with a few additions. Notably, the 'Eject' icon for USB devices only appears when there's a device to remove. You can download Raspbian Buster from the official Raspberry Pi website.

B. PYTHON

Python is a high-level, interpreted, and general-purpose programming language. Developed by Guido van Rossum and first introduced in 1991, its design philosophy emphasizes readability, particularly through the use of significant whitespace. Python's constructs and object-oriented design aim to make it easier for programmers to write clean and logical code, whether for small or large projects. It features dynamic typing and automatic garbage collection, and supports multiple programming paradigms, including procedural, object-oriented, and functional programming. Known as a "batteries-included" language, Python offers a rich standard library. Python interpreters are widely available across many operating systems. The language is open-source, with a global community of developers contributing to its maintenance. The Python Software Foundation, a non-profit organization, oversees the management and development of Python and its reference implementation, CPython.

C. OPEN CV

OpenCV [3] is a BSD-licensed, open-source library that provides hundreds of computer vision algorithms. This document covers the OpenCV 2.x API, which is primarily a C++ API, in contrast to the older C-based OpenCV 1.x API (the C API has been deprecated and has not been tested with a "C" compiler since OpenCV 2.4). OpenCV is organized into a modular structure, meaning it includes multiple shared or static libraries. Key modules include:

- Core functionality (core): Provides essential data structures like the multi-dimensional array Mat and basic functions used by other modules.
- Video Analysis (video): Offers video analysis tools, including motion estimation, background subtraction, and object tracking.
- Camera Calibration and 3D Reconstruction (calib3d): Covers algorithms for multiple-view geometry, single and stereo camera calibration, object pose estimation, stereo correspondence, and 3D reconstruction.
- 2D Features Framework (features2d): Includes feature detectors, descriptors, and matching algorithms.
- Object Detection (objdetect): Detects objects and instances of predefined classes, such as faces, eyes, cars, and more.
- High-level GUI (highgui): Provides a simple interface for UI functionalities.
- Video I/O (videoio): Offers an interface for video capture and working with video codecs.

BLOCK DIAGRAM

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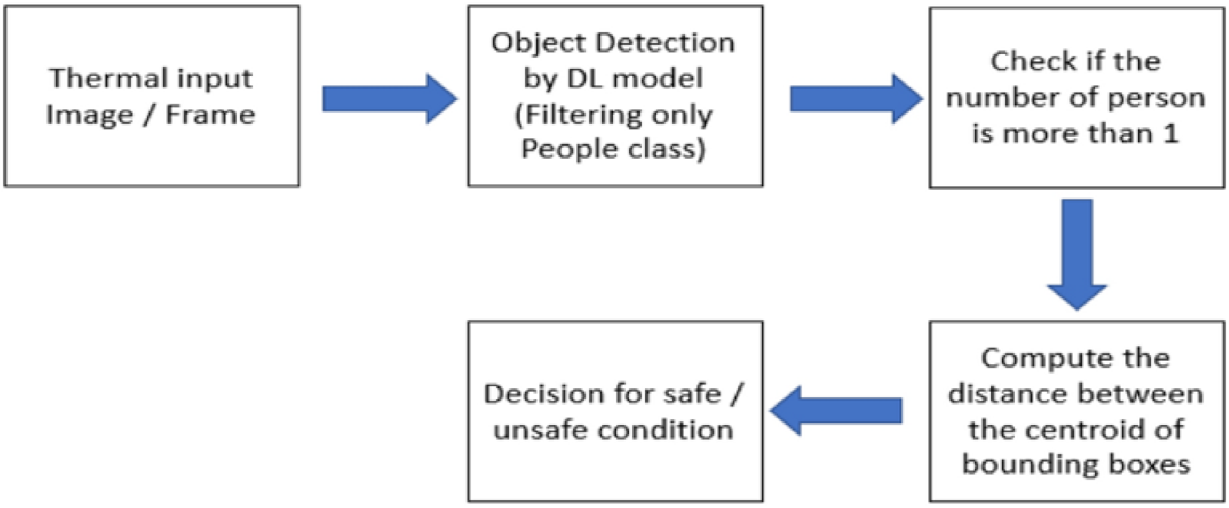

Fig. 4: Architechture

IMPLEMENTATION

The procedural steps being followed to implement this project are:-

- The drone will be powered using 11.1V 2200 mAh 3S LiPo(lithium polymer) Battery using a 3DR voltage regulator.
- 5V-3A DC to DC buck converter will be connected to LiPo battery to supply power to Raspberry-pi 4.
- NEO 7M GPS module will be installed with APM 2.4.8 flight Controller.
- 5MP camera will be installed on Raspberry-pi 4 to run live Human detection Algorithm.
- A 5.8 GHz video transmitter with 1000 TVL CMOS camera is installed on drone for the live footage from drone as First Person View.

ALGORITHM

- The Python script for human detection utilizes the OpenCV and Numpy libraries to implement the algorithm.
- The live video feed's frames per second are captured using the videocapture() function built into OpenCV.
- Human detection is performed using the HOG (Histogram of Oriented Gradients) feature descriptor, along with an object detector. This structure is pre-integrated into OpenCV and helps with object detection via its member functions.
- The video frames are first cropped and resized to 640x360 pixels for faster human detection, followed by normalization.
- To identify humans in the live video frames, green rectangular boxes are drawn around them for visual indication.

CONCLUSION

This paper can used in the Covid-19 crisis to monitor communities for compliance to public safety orders.Each drone is fitted with a camera and an AI that can detect humans within a range of 100 meters to 150 metres. Social distancing violation warning is active based on distance between detected people. The green bounding box indicates that the distance between objects meets the social distancing requirements while red bounding box for social distancing violation. Then, the drone tell the global position of the violator to the supervisor.

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