ORIGINAL RESEARCH

SAMRIDDHI Volume 12, Special Issue 2, 2020 Print ISSN: 2229-7111 Online ISSN: 2454–5767

Collision Avoidance System for Drones

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Abstract

"Collision avoidance system for drones," protects the drone from collision from any obstacle, such as, a wall. Nowadays, in our day-to-day life, we have heard drone crashes which do not only cause machine loss, as well as, a great threat to people around. Whereas, drones are widely used in civilian and military fields in recent years. As drones are becoming common, it increases the threat of drone failures. A collision avoidance system is designed to protect people, as well as, machine loss. Each collision avoidance system contains two main parts: sensing and detection, and collision avoidance. Based on their characteristics, each part is explained in different categories. The idea behind the project is to protect drones from a collision. Whenever any obstacle is detected from the left side the drone must drift towards the right and same in all four directions. To detect the obstacle, the sensor used is "Infrared (IR) sensors". Many IR sensors are used in all directions of drones for obstacle detection. To avoid collision with objects, these aerial vehicles are to be installed with a collision-avoidance system. In this project, we do present an approach for wall collision avoidance using IR sensors on a quadrotor. The presented approach is designed for the safety of drones indoor and outdoor.

Keywords: Unmanned Aerial vehicles (Drones), Collision avoidance system, Sensing technology (Infrared sensor), Obstacle detection.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology (2020); DOI: 10.18090/samriddhi.v12iS2.14

Introduction

A drone collision avoidance system is no doubt one of the greatest innovations to have ever been incorporated into autonomous vehicles. Collision avoidance is the ability of a drone to navigate safely through corridors and indoors without colliding with obstacles. The use of drones for indoor activities has in the recent past, gained wide popularity. Drones perform a lot of tasks that sometimes are considered dangerous for humans. Firefighters are now days using drones to enter buildings that are inaccessible and perform rescue missions without any human losses. However, the success of such missions greatly depends on the navigation system of the drone.[1] Without the collision avoidance systems, drones will collide with walls, flying objects, flying animals, or even humans, and thus, a mission failure, damages, and injuries to the collided or even the destruction of the drone itself. A collision avoidance system is a system designed to reduce or prevent collision accidents. Also known as a collision warning system, collision mitigation system, or pre-crash system, the system uses sensors or radars to detect any potential obstacle and send warnings to the pilot of a likely collision. Pilots can choose to ignore or take action.[2] However, some drones have been designed to detect and avoid obstacles by themselves without the pilot's decision. Such drones operate more like a robot.[3-5]

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How to cite his article: Katware, S.S., Bandgar, S., & Puranik, V.G. (2020). Collision Avoidance System for Drones. *SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology,* 12(SI-2), 69-74.

Source of support: Nil

Conflict of interest: None

Need of Project

- Nearly all drones have a first-person view that transmits the video from the drone camera to the remote controller, smartphone, or tablet. However, it is possible to lose this video transmission because of collision with any obstacle.
- If you have flown a good bit out of the direct line of sight, without obstacle avoidance it is going to be impossible to fly back home safely without video transmission, if you do not have obstacle avoidance it could very well crash.
- Drones are being used in many public areas and at events as they capture stunning films from unique angles. Unfortunately, there have been a few accidents which are not good. People should be safe at concerts or sporting events, so collision avoidance drones at these events is a must.

Problem Statement

The problem of mid-air collision avoidance is a challenging one. It is a prerequisite to the timely and gradual integration of unmanned aviation into the National Airspace System (NAS). The challenge becomes even greater given that no "standard technology" or "standards" have been developed. Mid-air obstacle detection and mid-air collision avoidance methodologies, techniques, tools, and support technologies are classified into two main, broad categories:

Senses detect and avoid systems, SDAA (non-visual based). SDAA systems are mostly based on radar or lidar technologies.

See and avoid systems, SAA (vision-based). SAA systems are derived and implemented following either monocular or stereo vision methodologies.[6-7]

Literature Survey

We decided to do a project on a collision-avoidance system for drones in the seventh semester. The idea came to us while searching for topics on which to do project work. We always wanted to put the theory that we studied into practice. In the first couple of months, we spent searching topics for project work, we came across numerous instances of the rapid advancements made in the field of collision avoidance system, as described in various journals and magazines, as well as, over the internet.

Collision avoidance is key for the integration of manned and unmanned missions in civil and military operation theaters. Large efforts have been done to address the collision avoidance problem to both manned and unmanned aircraft. In this paper, we present a survey of the collision avoidance approaches deployed for aircraft, especially for unmanned aerial vehicles.

System Design

Controller[6,7]

- 32-bit STM32F427 Cortex M4 core with FPU 168 MHz/256 KB Random access memory (RAM)/2 MB Flash
- ST Micro L3GD20 3-axis 16-bit gyroscope
- ST Micro LSM303D 3-axis 14-bit accelerometer/ magnetometer Invernesses MPU 6000 3-axis accelerometer/ gyroscope.
- MEAS MS5611 barometer (Figure 1)

Battery Eliminator Circuit (BEC)

- A BEC is an electronic circuit designed to deliver electrical power to other circuitry without the need for multiple batteries.
- Historically the expression was sometimes used to describe devices used to power battery-driven equipment from mains electricity. This is still the case in many products offered in retail electronic supply stores (Figures 2 and 3).

Power Supply

- A power supply is an electronic device that supplies electric energy to a load. The primary function of

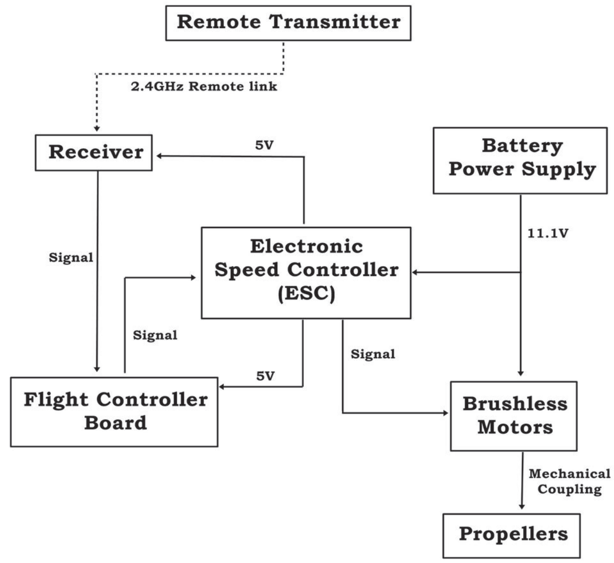

Figure 1: Block diagram

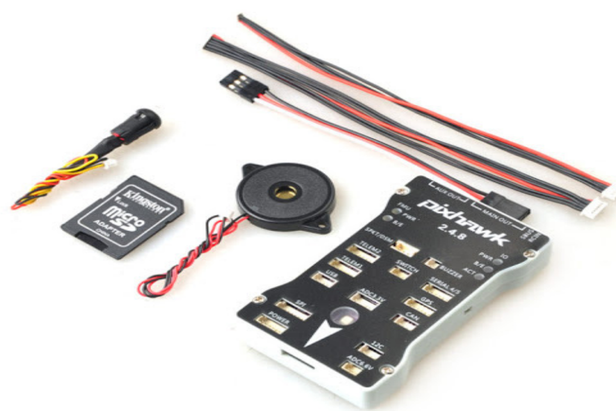

Figure 2: Controller

Figure 3: Battery eliminator circuit (BEC)

a power supply is to convert one form of electrical energy into another, for example, lithium polymer or LiPo batteries are most commonly used in all sizes of quadcopters.

- Some power supplies are discrete, stand-alone devices, whereas others are built into larger devices along with their loads. The types of power supplies can be used in drones, such as, solar cells, hydro fuel cells, combustion engines, lipos, and tethered.

Electronic Speed Controller (ESC)

- An ESC is an electronic circuit that controls and regulates the speed of an electric motor. It may also provide reversing of the motor and dynamic braking.
- The ESC connects the flight controller and motor. Drones required four ESCs for each brushless motor.
- Therefore, the ESC takes the signal from the flight controller and power from the battery and makes the brushless motor spin.
- Full-size electric vehicles also have systems to control the speed of their drive motors (Figure 4).

Figure 4: Electronic speed controller (ESC)

Figure 5: BLDC motor

Brushless Direct Current (BLDC) Motor

- BLDC motors have been a much focused are for numerous motor manufacturers as these motors are increasingly the preferred choice in many applications, especially in the field of motor control technology.
- BLDC motors are superior to brushed DC motors in many ways, such as, ability to operate at high speeds, high efficiency, and better heat dissipation (Figure 5).

Light Emitting Diode (LED) Driver

- LED driver is an electrical device that delivers power to a string of LEDs in a regulated manner.
- The driver also prevents the LEDs from having a premature failure by controlling thermal runaway, which is a phenomenon wherein with an increase in the temperature of an operating LED, the forward voltage VF (i.e., the voltage the LED requires to conduct electricity and light up) decreases thereby increasing the current.
- Simply put, with time an LED gets hotter and hotter, and keeps drawing more and more current, thus, eventually burning out early due to premature failure.
- The constant current driver prevents the LEDs from such premature failure. Its efficacy is at its best when its output impedance matches the input impedance of the LEDs (Figure 6).

Figure 6: LED driver

Figure 7: Propellers

Propellers

- A propeller is a device with a rotating hub and radiating blades that are set at a pitch to form a helical spiral, that when rotated performs an action that is similar to Archimedes' screw (Figure 7).

Sensor

- The light sensor module has strong adaptable to the environment, having a pair of infrared transmitter and receiver, transmitter launch a certain frequency infrared when meeting an obstacle in the detection direction, the infrared receiver is reflected by the receiver tube, after processing through the comparator circuit, the green indicator light will illuminate while the signal output interface output digital signal (a low-level signal) can be adjusted via potentiometer knob detection distance, the effective distance range approximately 2–30 cm, working voltage is 3.3 to 5V.
- The detection range of the sensor can be adjusted by the potentiometer, with little interference, easy to assemble, easy to use features, can be widely used robot obstacle avoidance (Figure 8).

Parameters

- When the module detects an obstacle in front of the signal, the circuit board green indicator lights up while output low signal on the out port, the module detects the distance approximately 2 to 30 cm, detection angle 35°.
- The detection distance can be adjusted using the potentiometer adjust potentiometer clockwise, the detection distance increases; counter-clockwise adjustment potentiometer, detection distance decrease.
- The sensor module output portable directly connected with the microcontroller input/output (IO) port can also be driven directly to a 5V relay; Connection: VCC-VCC; GND-GND; OUT-IO.
- The comparator using LM393, 3 to 5V DC power supply can be used for the module when the power is turned on.
- The red power indicator light, with 3 mm screw holes for easy mounting, installation.
- The circuit board size: 3.1 × 1.4 cm, each module in the delivery has a threshold comparator voltage adjustable via potentiometer.

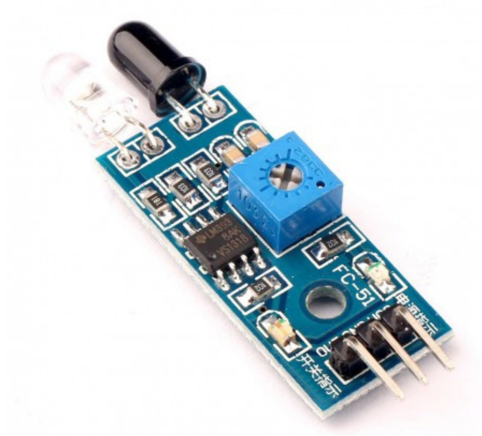

Figure 8: IR sensor

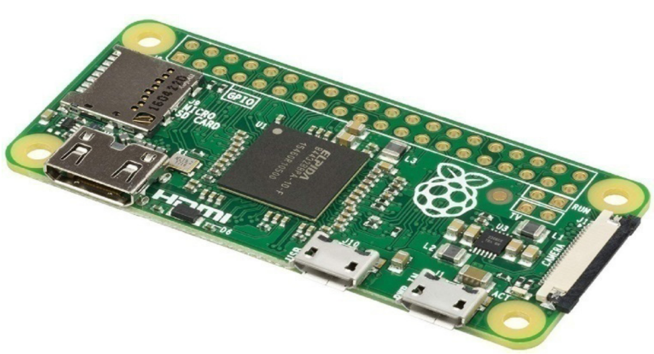

Figure 9: Raspberry Pi Zero W

Raspberry Pi Zero W

- The credit-card-sized computer has become even smaller. The Raspberry Pi Zero W is still the Pi, but at a largely reduced size of only 65 mm long by 30 mm wide and at a very economical price. With the addition of wireless Local area network (LAN) and Bluetooth, the Raspberry Pi Zero W is ideal for making embedded Internet of Things (IoT) projects.
- The Pi Zero W has been designed to be as flexible and compact as possible with mini connectors and an unpopulated 40-pin GPIO.
- In the middle of the Raspberry Pi Zero W, is a 1 GHz BCM2835 single-core processor with 512 MB RAM. Frankly, this Raspberry Pi is about four times faster than the original Raspberry Pi and is only a fraction of the cost of the current RPi3.
- The setup for the Raspberry Pi Zero W is a little more complicated than on other Pi. Because of the small size, many of the connectors on the Raspberry Pi Zero are not standard. For starters, you will want a mini HDMI to HDMI cable or adapter to connect to your monitor. We will also need a USB On-To-Go (OTG) cable to connect a USB device, as well as, a unique Camera serial interface (CSI) camera cable. No matter how we want to use your Raspberry Pi Zero W, we will need a micro SD card with an operating system and a high-quality 5V power supply to power your board (Figure 9).

Features

- 802.11 b/g/n wireless LAN
- Bluetooth 4.1
- Bluetooth Low Energy (BLE)
- 1 GHz, single-core CPU
- 512 MB RAM
- Mini HDMI and USB On-The-Go ports
- Micro USB power
- HAT-compatible 40-pin header pins

Figure 10(a-f): Experimental Setup

- Composite video and reset headers
- CSI camera connector

Experimental Setup

Refer to Figure 10 (a-f).

Results

- We presented a comprehensive literature review on collision avoidance systems and strategies used for unmanned vehicles (Drones).
- As any collision avoidance system needs a means to be able to sense or perceive its surroundings.
- The considered collision avoidance approaches were divided into four main categories: geometric methods, force-field methods, optimization based methods, and sense and avoid methods.
- We also analyzed the different types of sensors relevant to unmanned vehicles, classifying them into active and passive devices in a traditional manner.
- An active sensor has its own transmitter, a source of energy, for emitting a wave, with a given range of

wavelengths, and a receiver for reading incoming waves reflected back from objects in the environment.

- A passive sensor, in contrast, only detects the light or energy discharged or reflected by objects, relying on an external source of energy to be present.
- Discussed collision avoidance approaches can be compared from different perspectives and by defining different evaluation metrics.

Conclusion

We have presented a survey of major collision avoidance systems from various papers from the past to the recent. We have discussed aspects of different components , as well as the advantages and applications of the approaches to different problems in collision avoidance. As future work, we plan to improve the priority strategy considering that different applications may need different priority levels, and so different alternatives for handling priority assignment will be studied. We would like to use these drones to perform life saving action in mountains with human help to get proper direction and to avoidance if any obstacle present. It also can be used to detect animals or even to catch criminals in a big mass of people. The drones navigate automatically with GPS.

As new mission-based applications for multicopter emerge, the number of Drones flying simultaneously also increases, and the risk of collision between them becomes higher. In addition, there are currently no collision avoidance protocols developed for Drones from different owners when performing planned missions.

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