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Development of Anti-collision Security and Surveillance Drone

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ABSTRACT - Drone collisions with various objects during flight are a key problem in drone technology and lead to job failure. In the field of unmanned aerial vehicles, anti-collision systems are effective in order to avoid such a situation. The goal of the current study is to construct a drone that employs an ultrasonic sonar-based sensor to avoid collisions. The current paper's goal is to create an anti-collision drone for surveillance. The whole system, including the flight controller and the main sensor for avoidance, is used for this. Finally, the built drone exhibits adequate reactions to detect the existence of various obstacles in the route and also prevent colliding under various circumstances.

Key words: Drone, Collision Avoidance, Quadcopter, Sonar Sensor

I. INTRODUCTION

With the primary benefit of being able to function without a human life, the development of any unmanned vehicle offers several important advantages [1]. Due to their distinctive characteristics and wide range of applicable uses, fully autonomous unmanned aerial vehicles (UAV), also known as drones, are of particular interest to the research community [2,3].There is a lot of research being done in the field of drones, and in recent years, both manned and unmanned ground vehicles have become more and more common, largely being used for surveillance, mapping, and inspection [4,5].

The UAVs' anti-collision systems are crucial for maintaining their survivability. Obstacle sensing, collision prediction, and collision avoidance are the three techniques that make up most UAV anti-collision technology. By detecting its environment, a UAV can identify and locate impediments, providing information that can be utilized to anticipate collisions. The sensors in the UAV gather environmental data during obstacles sensing, such as the position and speed of obstacles. The UAV will determine if it will collide with obstacles during the collision prediction process [6]. If a UAV anticipates a collision, it will plan its flight path to quickly avoid it during the collision avoidance operation. There will be many difficulties for UAVs' anti-collision systems.

One such intriguing area in which quadcopters are used is obstacle recognition and collision avoidance. In order to accomplish this goal, a variety of methods are available and have been tried and true. To achieve the goal of this paper, the strategy that was chosen was made with time and financial considerations in mind. In this research, we suggest using an Arduino nano microcontroller board in conjunction with ultrasonic sensors to achieve the collision avoidance objective.

The ultrasonic sensors, which are installed in all four directions on the quadcopter frame, are triggered by programming on the Arduino board. The ultrasonic sensors then detect an obstacle in the quadcopter's path and, in accordance with the code uploaded on the Arduino, cause a change in the quadcopter's roll/pitch motion to prevent collision. The ellipsoid limited zone shown in Figure 1 will be utilized to provide a contact point for the guiding. It uses the heading angle, flying speed, ellipsoid shape, and clearance in an optimum way [7]. The approach is often applied to fixed-wing aircraft. Due to the usage of quadcopters in this study, various flying adjustments and a less complex contact point algorithm are made.

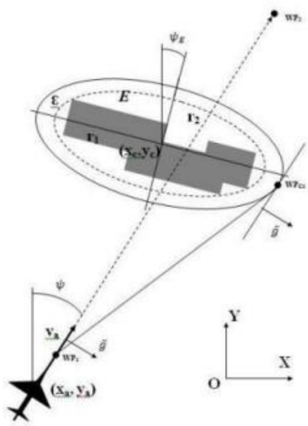

Figure1. Ellipsoid restricted zone

II. DEVELOPMENT OF DRONE

For development of proposed drone, following items are required as discussed below.

2.1 Arduino Nano

The Arduino Nano is a microcontroller ATmega328 based device with 16 digital pins that can be used for various purposes. It can be used for almost every task, from minor to massive industrial scale projects. It can be also used for prototyping and developing new applications.

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2.2 APM 2.8

Ardupilot APM 2.8 flight controller with built in compass is an amazing flight controller that allows the user to turn any fixed-wing, rotary-wing, or multi- rotor vehicle into fully autonomous vehicle, capable of performing a wide range of tasks, even programmed GPS missions with waypoints

2.3 Ultrasonic Sensor

The sensor capable of 1 mm resolution with maximum range of 5000 mm. Another specification is the output signal comes in various form such as analog voltage, RS232 or TTL serial, and pulse-width. The sensor operates from 2.5V to 5.5V. With all the specification and its small and light weight criteria, the sensor is suitable for research application.

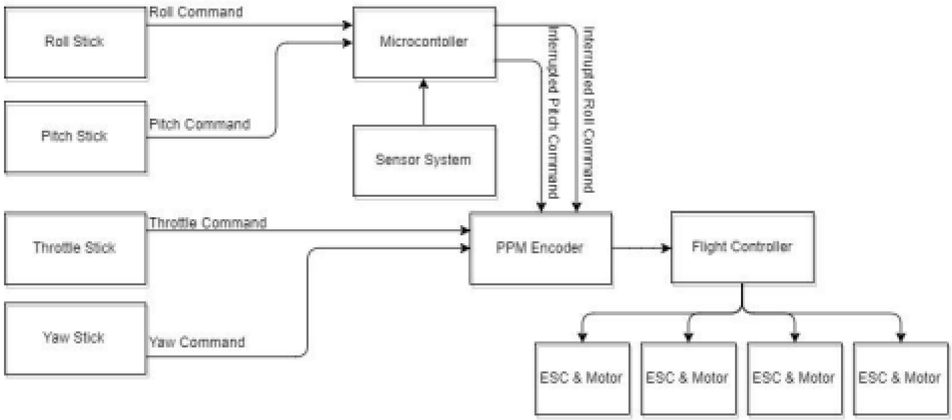

Figure 2. System Architecture

III. MICROCONTROLLER ALGORITHM

Obstacle Avoiding Algorithm

This algorithm's primary goal is to let the quadcopter to go between preset waypoints while avoiding obstacles along the route, if any. The quadcopter has five modes for the algorithm, including manual takeoff, autonomous flight, and obstacle avoidance.

The switching between modes is done with a number of settings. The first factor is clear distance, which is the shortest distance a quadcopter can fly on its own. The safe distance, which is the shortest distance at which the quadcopter can begin scanning, is another. The distance to the obstacle should have reduced in the avoidance mode, as the quadcopter tried to fly both forward and sideways at once. As a result, another parameter is established that clearly delineates the avoidance distance, beyond which the quadcopter should not move in order to avoid the obstacle. Figure 3 illustrates an illustration of the parameters.

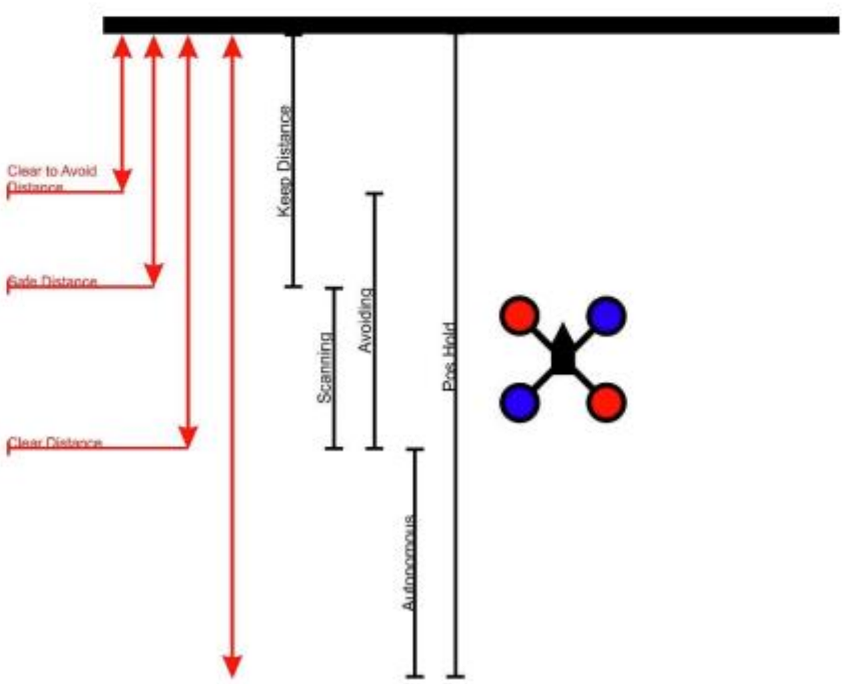

Figure 3. Avoiding Scenario

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Position Hold, often known as PosHold, is a flying mode that uses information from the inertial measurement unit (IMU), GPS module, and compass to maintain a consistent location, direction, and altitude. This flying mode is preferred over others because it gives the pilot a more intuitive sensation of control by directly controlling the vehicle's lean angle in response to stick inputs [8].

Roll and pitch control stitch is used to regulate horizontal position on the ground, with a default maximum lean angle of 45 degrees. It indicates that the order will be treated as an attitude reference to maintain the lean angle at that location when the stick on the remote control reaches its maximum position. Using ground station control and the ANGLE_MAX option, this maximum lean angle may be modified [9].

A feature of avoidance mode called "keep distance" stops the quadcopter from colliding with an obstruction. When the quadcopter's distance from an obstacle is too close, this mode is activated. Depending on the detected distance to the obstacle, the autonomous mode will switch to position hold mode and the microcontroller will send a signal to the flight controller to fly rearward. As the distance to the barrier grows, the quadcopter's pace of backward flight diminishes.

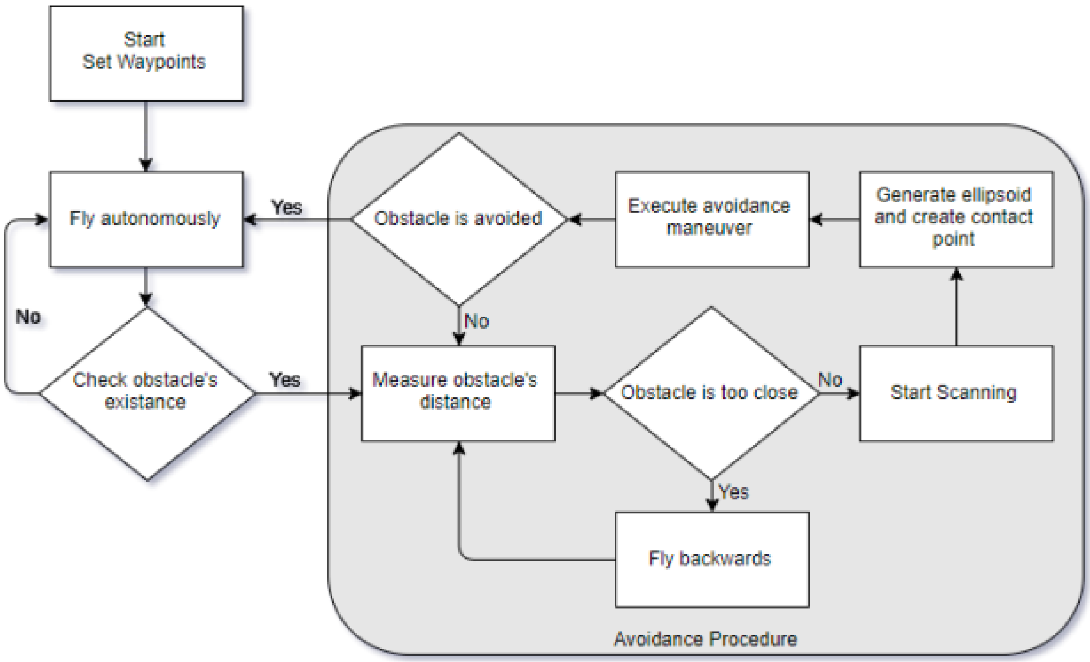

Figure 4. Avoiding Procedure Flowchart

During scanning mode, the avoidance procedure will begin by scanning the obstacle first. The ultrasonic sensor will be rotated using a servo because it can only measure distance for a single spot. Since reflection angles more than 25 degrees cannot be detected, rotating ultrasonic is only possible at certain angles [10]. These information will eventually be quantified into a barrier with an elliptical shape, and the path planning algorithm will provide a contact point as a consequence. The relationship between autonomous flying and the avoidance process is depicted in Figure 5. Fly rearward block, start scanning, and execute avoidance, respectively, stand in for the keep distance, scanning, and avoidance modes. These modes are all dependent on sensor measurements. The quadcopter switches to avoidance mode after locating the contact site. In this mode, the microcontroller sends PWM signals to the pitch and roll channels in accordance with the intended course. Once the barrier has been overcome, the quadcopter will switch to waypoint following mode. When the measured distance exceeds the clear distance, it occurs. Since the quadcopter must first approach the barrier, there is a chance that it will go too near to it. As a result, the flight mode will change to maintain distance.

IV. Result and Discussion

Two avoidance situations are evaluated, as a consequence of which the whole flying mode is tested. The quadcopter's waypoint navigation speed is 75 cm/s in the first instance and 60 cm/s in the second. The range of the distance parameters is fixed at 210 to 140 cm to allow for scanning. The gain for the avoidance manoeuvre, set at 40, will have an impact on the speed when avoiding.

Table 1. Test Parameters

Case Number	Waypoint Navigation Speed[cm/s]	Clear Save Distance[cm]	PWN gain for Avoidance
1	75	210-140	40
2	60	210-140	40

Figures 5 and 6 depict the control of roll and pitch during a flying test. From around 3.5 to 5 seconds, the signal

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becomes weak with a steady roll value and decreasing pitch value, indicating that the quadcopter is flying to the left and in close proximity to the object in order to avoid it. The keep distance manoeuvre, which takes place between 5 and 6 seconds, is indicated by a positive pitch, which indicates that the quadcopter is flying rearward.

The measured distance and flying mode, as shown by Arduino, are presented in Figure 7. It is demonstrated that when the measurement increases to roughly 500 cm, the quadcopter successfully avoids the barrier by gradually reducing its distance. With the exception of an issue that doesn't affect flying mode, the rest displays a consistent reading.

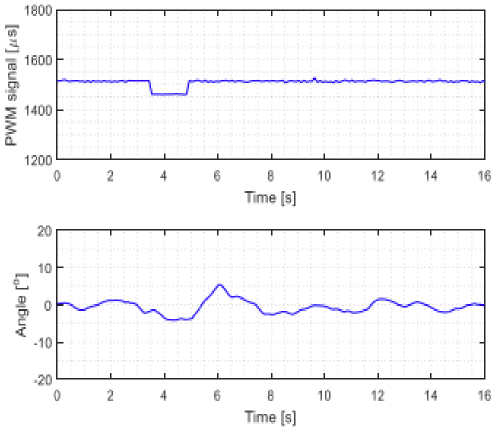

Figure 5. Roll Command

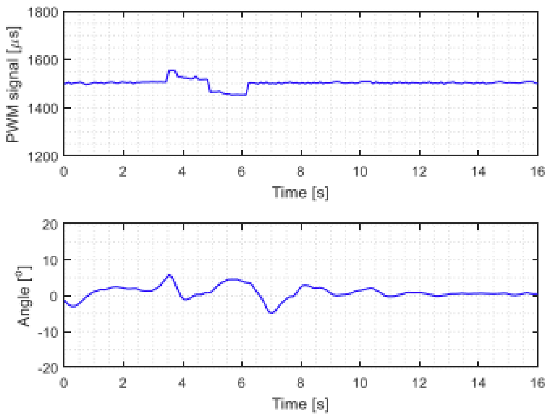

Figure 6. Pitch Command

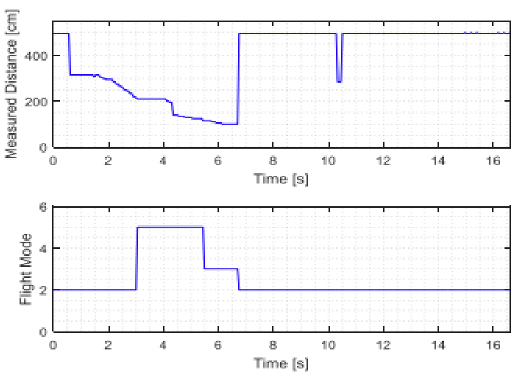

Figure 7. Measured Distance and Flight Mode Based on Arduino

Figures 8 and 9 depict roll and pitch control during this second case's flying test. The same instruction may be used to explain why the roll signal is the same from about 5 to 7.5 seconds. While the pitch signal is rather strong during the initial attempt of avoidance and gradually decreases until the barrier is successfully avoided.

According to Figure 10, the distance starts to shrink from 5 to 2.5 seconds. It is a measurement made when the quadcopter is flying close to an obstruction. The quick rise that follows indicates that the barrier was avoided, and the flying mode has now switched to autonomous mode until the entire mission has been completed.

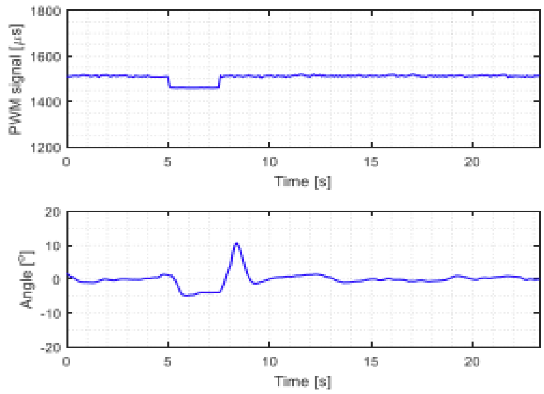

Figure 8. Roll Command

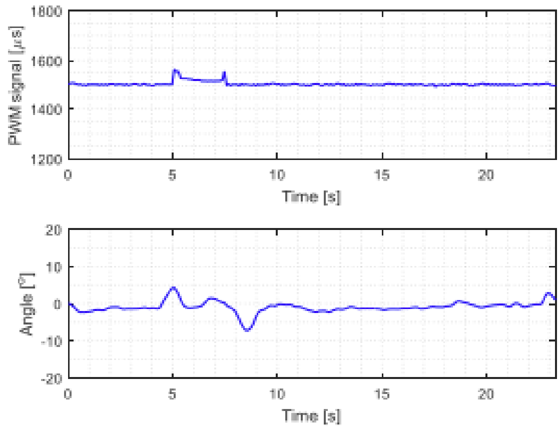

Figure 9. Pitch Command

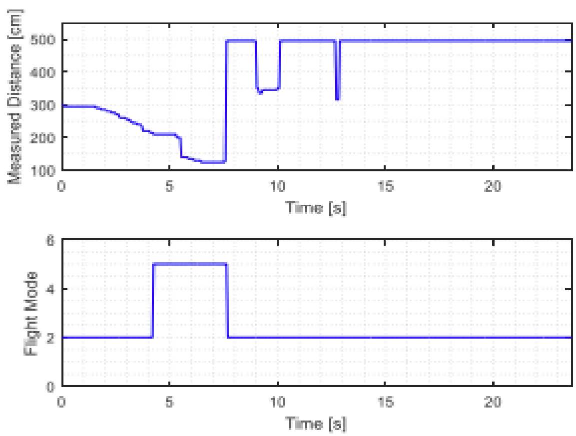

Figure 10. Measured Distance and Flight Mode Based on Arduino

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V. Conclusion

Ultrasonic sensors have been used to accomplish quadcopter obstacle avoidance. The outcome demonstrates that when the obstacle's distance is less than the specified distance parameter, the quadcopter correctly changes modes to avoidance mode or maintain distance mode. A set of distances are then obtained via rotating ultrasonic rotation once the quadcopter switches to scanning mode.The quadcopter will enter autonomous mode and continue waypoint following if no impediment is identified. It has been demonstrated by every flying command, attitude, and trajectory that the quadcopter can avoid the obstruction. With its flying mode, more proof of the measured distance has been provided. However, a wider range of flying and avoidance speeds should be used.

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