CRASH AVOIDANCE SYSTEM FOR DRONES

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Abstract - *Several factors must be considered to ensure a safe flight while a drone is in the air, there are times when one of the drone's motor does not respond or does not work at all. In this instance, the drone loses its stability and crashes into the ground at a high velocity, potentially causing harm to both the drone and its surroundings. Drones are high-priced pieces of equipment used in a variety of sectors for a variety of purposes, and losing drones on a frequent basis can be expensive. The presented methodology tackles this issue by focusing on both software and hardware perspective, in contrast to the existing strategy, which is primarily focused on software. We're aiming to convert a quadcopter to a tri-copter by developing a system that responds to this situation by altering the drone's configuration via manual signal sent by the pilot and backed by an externally linked circuit to the flight controller. This technique provides the pilot control over the drone during the fail safe mechanism which switches the configuration to tri-copter, unlike the conventional fail safe systems, which ceases the control from pilots in many occasions. This solution ensures that the drone will do no harm to the surroundings or to itself by landing on the desired coordinates.*

Key Words: Robotics, UAV, Pixhawk

1. INTRODUCTION

A multi-rotor is a system that controls its aerial mobility by using thrust force produced by many fixed pitch propellers. Because the thrusters on the multirotor are all oriented vertically, the horizontal steering system of the platform requires fuselage attitude management, which would be the process of supplying a fraction of the thrust horizontally. The common hardware configurations, a quadrotor arrangement with four propellers is the minimum standards for a steady flight, and sustaining a smooth ride is exceedingly difficult if one or even more quadcopter thrusters fail. The ability to control the speed and rotation of the motor is critical in the construction of a drone. An electronic speed control (ESC) manages these tasks, which includes a power distribution stage, a current-sensing circuitry, a microprocessor, and a communication link with the flight control system. The crash avoidance system for drones is implemented where additional logic is combined externally with Pixhawk and the configuration is being made to change from quadcopter to tricopter when the motor breaks down. The dedicated switch in the transmitter is signaled for changing the configuration. Once the Pixhawk gets this signal, the drone seamlessly transitions to tri-mode. At this stage, the drone is working on a tricopter configuration state where it will consider only 3 inputs for the motors. Once the drone is in this state the only goal is to land the drone in a secure and sound manner, the pilot will have control over the drone and the drone will respond in a very subtle manner which will help the drone to be stable and take the inputs from the pilot at the same time. Lately, we can see the applications of drones in many fields, varying from medical, agriculture to the military and losing one would be the greater loss.

2. LITERATURE SURVEY

Lee, Seung Jae et.al [1] explains a quadcopter failsafe flying system that can fly with the four controlled DOF as a typical quadcopter even if a failure occurs in one of the arms. The new method makes use of the T 3 -Multirotor, a novel multirotor platform that applies a unique strategy of actively manipulating the center of gravity to recover controlled degrees of freedom. A specific control structure is introduced, as well as a thorough examination of the platform properties as they alter during emergency flights. The practicality of the suggested method is validated using experimental data.

B. Wang et.al [2] presents addressing simultaneous actuator defects, a unique adaptive sliding-mode based control allocation system. The suggested control method consists of two independent control modules, one for virtual control and the other for control allocation. The control allotment system is being used as a basic control module in fault-free as well as defective situations to allocate virtual command signal among the available motors. When several actuators fail at the same time, the control allocation and reallocation module may not be able to meet the needed virtual control signal, compromising overall system stability. To reduce the influence of the virtual control error and preserve the closed-loop system's stability, the suggested online adaptive technique may smoothly modify the control gains for the high-level sliding mode control module and reorganize the distribution of control signals. Furthermore, using the boundary layer to build the adaptation law prevents overestimation of control benefits, and adaptation stops once the sliding variable is within the boundary layer. The stability of the closed-loop system is assured in the presence of simultaneous motor defects, which is an important element of this research. Experimental findings using a modified unmanned multirotor helicopter under single and simultaneous actuator failures are compared to a standard sliding mode controller and a linear quadratic regulator system to illustrate the efficacy of the suggested control strategy.

Wang, Rijun et.al [3] states Identifying and rebuilding actuator failures in an aircraft flight system is critical for minimizing negative effects on the drone, as well as its surroundings. And a fault classification-based motor defect detection and reconstruction technique for the hex-rotor drone is proposed. The error of the actuator is first examined and categorized, and then a motor failure model based on multiple failure classification is created.

Second, for the hex-rotor unmanned aerial vehicle, a flaw detection and reconstruction technique is provided. Extended Kalman filter is used for fault identification and separation in the proposed approach, and the multi-sensor navigation unit provides the flight state input required. The output is then used to suggest an actuator fault reconstruction algorithm. For testing, the planned system is fitted to a hex-rotor drone. The simulation results demonstrate that the suggested design is capable of fault detection and actuator fault reconstruction, and the actual flight confirms the efficacy of the proposed approaches.

Giribet, Juan et.al [4] A multirotor with six degrees of freedom (6DOF) has been the subject of several studies. However, the capacity to maintain total control in case of a complete loss of one of the rotors has yet to be investigated. In this paper, it is demonstrated that eight rotors are required to provide 6 degree of freedom control of a multirotor in the event of a total loss of one of them. Also presented and investigated through numerical simulations is an Octo-rotor configuration with 6 degrees of freedom control capabilities in a fault condition, comparing flying performance in a normal and failure mode.

Pose, Claudio et.al [5] examines fault tolerance in multirotor vehicles, with a focus on hexarotors, where fault tolerance is attained by changing the centroid in the event of a failure.It will be demonstrated that for a hexarotor vehicle, there is an ideal fixed location for the center of mass for each of the potential motor failures towards maintain independent control of four degrees of freedom and gain the greatest mobility. In the event of a motor failure, the performance of this approach will be weighed up against a proceeding design based on rotor reconfiguration.

3. METHODOLOGY

When the drone's motor fails, the operator will flip a switch to transform the drone into a tricopter. The signal for altering the configuration is first sent through the specialized switch on the transmitter. The receiver then sends the signal to the Pixhawk. Pixhawk sends the PWM signal to the Arduino UNO through aux pins which are preprogrammed in Qgroundcontrol.Fig.1 represents the schema of a proposed solution when one of the motor breaks down and the implementation flowchart is shown in Fig.2.

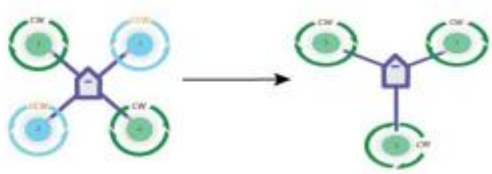

Fig -1: Schema of proposed solution

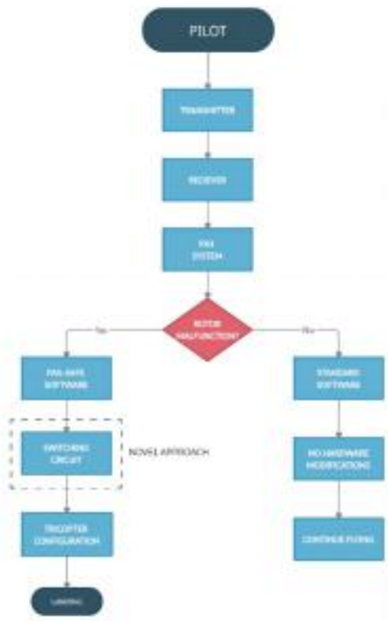

Fig -2: Flowchart for Implementation of proposed solution

3.1 DESIGN

The Arduino boards are a good alternative since they make it simple to integrate a variety of devices with a microcontroller. Relays are a type of device that may be interfaced with Arduino to operate a number of other devices that are connected to the microcontroller. We connected a four-channel relay module to an Arduino Uno.

First, we wired the common pin of each relay module to the Electronic Speed Controller (ESC). Each relay module's normally open pin has been linked to the 5, 6, 7, and 8 pins of the pixhawk which are mapped to the tricopter firmware. Each relay module's normally closed pin has been linked to the 1, 2, 3, and 4 pins of the Pixhawk, which are mapped to the quadcopter firmware. Arduino Relay circuit is depicted in Fig.3.

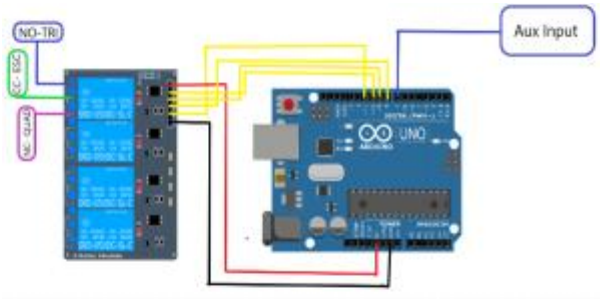

Fig - 3 : Arduino Relay circuit

3.2 Implementation

Input signal for relay is first set to high to keep the relay normally closed since the relay is an active low device, which is done through digital Write function in Arduino code, where it changes the state to high and low. Pulse In function blocks the program and waits for a signal to change it to a certain range, where it measures the duration of the pulse. While the signal falls under PWM range of 1800 to 2200, the input for relay is set to low which triggers it and ESC is then connected to tricopter pins and drone acts as a tricopter. We use the Serial. println() function to check the output through the serial monitor where it continuously checks for the PWM signal. The firmware manipulation in pixhawk is done in such a way that both quadcopter and tricopter works simultaneously and one of the aux pins is programmed to provide signal for Arduino.

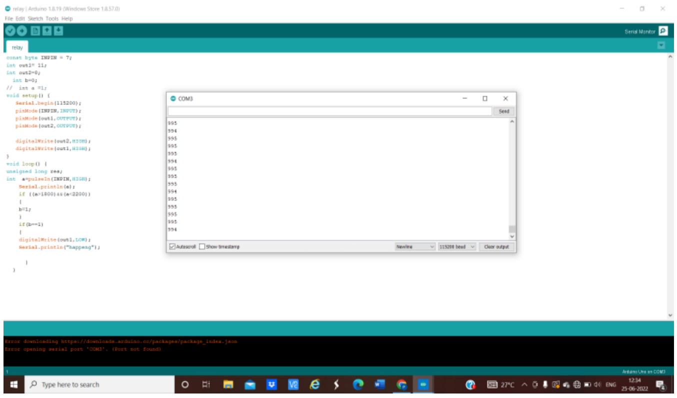

Fig - 4 : Serial monitor before receiving signal from transmitter

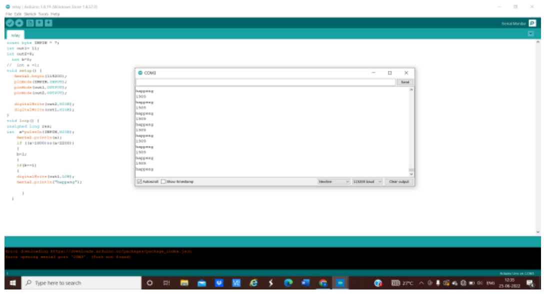

Fig - 5 : Serial monitor after receiving signal from transmitter

By downloading the source code from Github and changing INSTALL_SIM as false to exclude the simulation software as shown in fig.6. For building the source code CMake plays an important role. After building a custom firmware with a .px4 extension, which is finally uploaded to pixhawk through Qgroundcontrol. The custom firmware runs both the firmware side by side computing data for quad configuration and tri configuration as shown in fig.7.

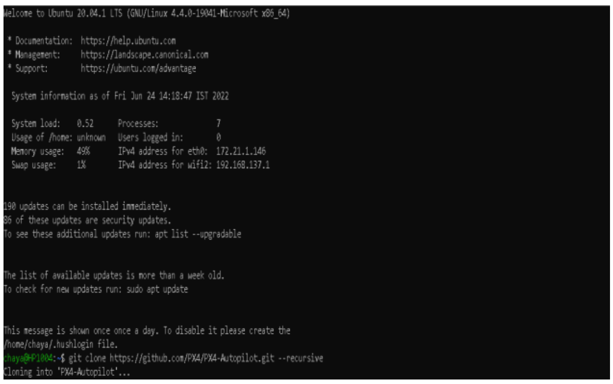

Fig - 6 : Cloning of source code with Github

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R: 4x
R: 3y

# Yaw servo
M: 1
S: 0 2 10000 10000 0 -10000 10000
```

Fig-7 : Custom Firmware

After relay switches from normally closed to normally open ESC starts getting a PWM signal for tricopter configuration, which means it will only examine three motor inputs. Once the drone is in this state, the only purpose is to land it safely and securely. The pilot will have very little control over the drone, and the drone will respond in a subtle manner, allowing the drone to remain steady.

Because of the servo system employed in the tail motor, tricopters are more maneuverable than conventional rotary wing aircraft. Tricopter's fixed body which include, ease of control, endurance, ease of to-downstream maintains the air vibrations constant and, like many other features, steady flight.

4. RESULTS

The implementation is successfully carried out by firmware modification along with the supporting system which is designed to change configuration. Pixhawk open source code is modified to custom firmware so that the processor runs both the firmware side by side computing data for quad configuration and tri configuration. The system was designed in order to support the firmware modifications so that it could seamlessly transit from quadcopter to tricopter as a fail-safe.

Fig.8 shows the proposed system with additional logic changing configuration from quad to tri when one of the motors breaks down.

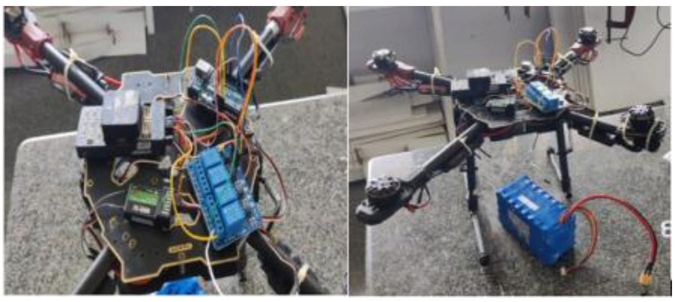

Fig-8: Drone with the switching circuit

5. CONCLUSION

Drones are an emerging field with niche applications, the use of this in developing projects is growing exponentially. As the use of UAV technology is expanding to a wide range of sectors, it has to adapt to new operational challenges and risks. Here, together with the effective circuitry to support it and with custom firmware, switching from a quad configuration to a tri configuration when one of the motors fails is successfully implemented.

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