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Development of Collision Avoidance System for Unmanned Aerial Vehicles

Nidhi Raj R[1], Saravanan E[2] and G. Anitha[3]

[1]Student, Anna University, MIT Campus
[2]Teaching Fellow, Anna University, MIT Campus
[3](Sr. Gd), Anna University, MIT Campus
E-mail: [1]nidhirajr@gmail.com, [2]elan_saravanan@yahoo.com

Abstract—*An unmanned aerial vehicle (UAV) is an aircraft without a human pilot aboard. The flight of UAVs may be controlled with either a direct remote controller or autonomously by an onboard computer and a GPS module.*
Collision avoidance is maintaining a system or any craft designed to prevent it from colliding with other vehicles or any obstacle. During autonomous flight an UAV requires the collision avoidance capability to automatically sense and avoid obstacles along the flight path during both indoor and outdoor navigation. Outdoor navigation with this facility requires measuring the instantaneous range to obstacle with using one or more sensors. Range sensors such as ultrasonic and infrared sensors are integrated in craft for the same purpose. For outdoor navigation, localization of craft is done with GPS module onboard. Decision making is done with a secondary onboard controller to maintain the craft at a safer distance from obstacle. Otherwise control signals are generated by onboard flight controllers. The specialized algorithm along with customized the flight controller firmware which upon detection of obstacle reacts to these control signals, in a predefined manner. This algorithm makes the onboard controller to change the flight mode onto a customized mode, through which it overrides the normal control signal given by the pilot which may result in collision.

1. INTRODUCTION

An unmanned aerial vehicle (UAV), commonly known as a drone and also referred by several other names is an aircraft without a human pilot aboard. The flight of UAVs may be controlled either autonomously by onboard computers or by the remote control of a pilot on the ground or in another vehicle.

As of now, Unmanned aerial vehicle (UAV) cannot autonomously detect or avoid buildings, trees or any obstacle on its flight path therefore the chances are present for inflight collision. As a result it cannot be it cannot be flown out of sight or to a more cluttered environment. The aim of detection and avoid technology is to detect obstacle within the vicinity of the UAV and to execute maneuvers to maintain the craft at a safer distance to it. Megan[2] explains, sense and avoid is a sequence of functions which, using a combination of airborne and ground-based sensors, are able to perform maneuvers to avoid collisions and serve as a replacement for the tradition "see and avoid" capability for manned aircraft.

The obstacle detection and avoid technology can be implemented using different combination of sensors. Visible light and infrared cameras, light detection and ranging LiDAR, Ultrasonic sensors are some of the options currently being implemented. Different algorithm work on data gathered by these sensors and decision is taken accordingly in real time to avoid the obstacle. Systems such as these enable the craft to divert from the planned course of UAV.

2. DEVELOPMENT OF UCAS

UCAS stands for unmanned aerial collision avoidance system which consists of normal quadcopter structure mounted with a secondary controller board along with a ultrasonic sensor. The Frame should be rigid, and be able to minimize the vibrations coming from the motors. The ultrasonic sensor chosen for this project is the SR-04 which has a range of 2 meters. The onboard processor is Arduino UNO which is a pocket sized microcomputer. UNO processes the distance information from the SR 04 and determines the relative position of obstacle. Based on this information, UNO generates digital control signals given to flight controller. The flight controller is programmed to control the custom built Quadcopter UAV, based on these control signals for collision avoidance. A Quadcopter with capabilities to carry the sensor and the secondary controller is custom built and is used for testing this system.

Fig. 1 shows the system developed for this purpose.

The sensor is placed at the front side of craft to minimize the interference caused from the propellers. Secondary controller also is placed along with the flight controller which gets signal from this mounted sensor.

Fig. 1: Basic frame with sensor mounted

3. OBSTACLE DETECTION ALGORITHM

The process of obstacle detection is done with a micro controller (Arduino UNO). The idea of obstacle detection is based on making a decision about the distance to the object detected ahead. The approach used is to generate and send a square wave which is supposed to be transmitted out from any one of the out pins. This signal is feed into an ultrasonic sensor pair which can transmit and receive the reflected signal. The generation of square pulse train is done by specifies program stored in arduino only.

The normal flow of operation for quadcopter is altered when it observes an obstacle. Otherwise it will operate like an RC flying model quadcopter. The following flow chart shows the sequence of procedure happening.

The quadcopter will be always flying in the normal operating mode which is manual mode. While it is flying in manual mode it will be constantly searching for obstacle ahead of it. Just when it observes an obstacle ahead of it in its path, the mode of flying will be changed from manual to some predefined mode which can be even a GPS assisted.

The PWM signal generated, an is exact replica of normal PWM signal generated by the transmitter. So the initial step is to identify the PWM signal generated by the transmitter for any mode. For this an arduino has to be programmed in such way to identify the characteristics of PWM wave which is been transmitted by the radio transmitter.

RC radio has several outputs, one for each channel/stick /switch/knob. Each radio channel transmits a pulse at 50Hz with the width of PWM signal depends on the position of stick at each instant. Typically pulse is between 1000uS to 2000uS with 1800uS to 1900uS pause before next pulse. But in order to change the mode of flight for a quadcopter, the PWM signal on channel 5 has to be varied accordingly. This is because, by default the channel 5 represents the mode changing switch of transmitter. So the aim is to vary the width of signal in channel 5 when it detects an obstacle on its path which results in changing the mode of flight.

The mode is changed on to a customized one in which the quadcopter will hover at the place overriding the command coming from the transmitter.

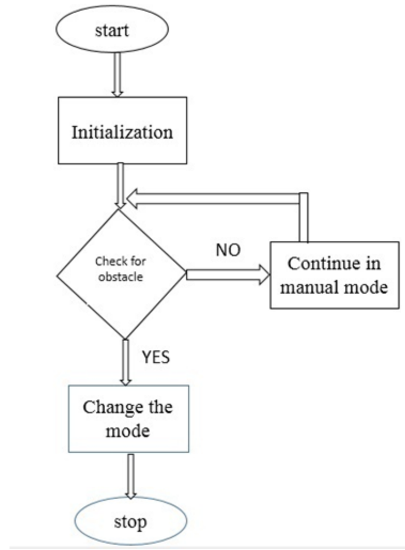

Fig. 2: flow chart

4. IMPLEMENTATION AND TESTING

Once the basic frame is integrated with the electronic components it is been tested. The testing process includes process from finding out the COG of craft to checking each individual electronic component.

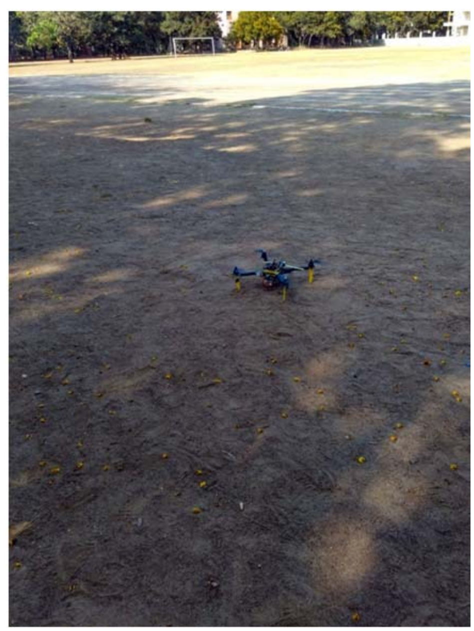

Fig. 3: Testing of craft with sensor mounted.

Make sure that the place is available with GPS signal since the mode to which it is changing is a customized one. If any alterations are done with the main code makes sure that the craft is flying in safe zone and is flying in proper control. Hand held launching was done due to the back scattering of signal coming from the propellers and ground. Back scattering may result in unwanted mode toggling during flight and even during takeoff. This might result in instability and hence may result in crash.

5. FUTURE SCOPE

The collision detection and avoidance system implemented here is for frontal obstacle only. To detect the objects in the sides and rear of UAV, thus enabling complete autonomous operation, a multisensory craft has to be designed and some data fusion algorithm has to be implemented. A separate path planning algorithm also needed is situations like continuous obstacle. Using of long range sensors from same category will allow decreasing the response time of system. Along with these the system should be capable of working under GPS denied environments. For this purpose IMU sensors and separate processing units needs to be implemented. Thus rather than providing the commands from ground, the UAV can navigate itself with such a system integrated onboard

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