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Development of Novel Embedded Controller for Safe Landing of UAV

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ABSTRACT: This paper demonstrates that development of novel embedded controller for safe landing of UAV. UAV (Unmanned Aerial Vehicle) commonly known as drone MAV (Micro aerial Vehicle) is a class of miniature UAVs having size restriction. Used in many applications for defense purpose, crowd areas etc. The work is caused by using five ultrasonic sensors placed in all direction right, left, front, back and towards ground. As the detection range is 400 cm. Four sensors are used for landing purpose and covered an area at an angle of 30° . These sensors are connected to Arduino uno microcontroller board. Pixhawk is a flight controller board used in this experiment this can be interfaced with Arduino microcontroller board through UART. The command is requested from RC transmitter to auto land safely using microcontroller board attached to the MAV vehicle. The ultrasonic sensor shows different value that can be corrected by tuning PID values which are adjusted by physically RC transmitter. After recheck the ultrasonic sensor shows the same value from all the sensor then the vehicle is said to be stable condition then its stop the motor and landing. This algorithm has successfully implemented. Results are seen in Arduino IDE.

KEYWORDS: Ultrasonic Sensor, Arduino uno Microcontroller board, Pixhawk autopilot board, servo motor, ESC, Arduino IDE, Mission planner, transceiver.

I. INTRODUCTION

UAV (Unmanned Aerial Vehicle) commonly called as drone come in different shapes and sizes. Each of these has their own distinct pros and cons. UAV is an aircraft usually flied without human pilot. These are large in size MAV (Micro aerial Vehicle) is a class of miniature UAVs having size restriction The MAV classified into three types namely fixed wing, rotary wing, flapping wing. Rotary wing quadcopter is used for safe landing application by avoiding strike landing. Because vertical take off and take land (VTOL) is the main advantage of rotary wing. The Aim of project is to develop an embedded controlled autopilot system for MAV application using Pixhawk board for safe landing.

II HARDWARE AND SOFTWARE

2.1 Ultrasonic sensor (HC-SRO4)

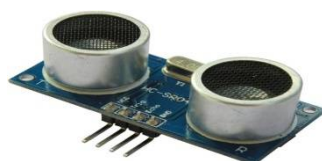


FIGURE 1: Ultrasonic sensor module (HCSR04)

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Figure 1 shows ultrasonic sensor module HCSR04 used in safe landing purpose. This sensor having unique feature hit and bounce property. The ultrasonic sensor can helps to identify the obstacles presents and also measuring distance. This sensor can be calculate the distance by using distance formula $\text{distance} = \text{time} * \text{speed}$.

Specifications of HCSR04

Working voltage	DC 5 V
Working current	15 ma
Working frequency	40 kHz
Max range	4 m
Min range	2 cm
Measuring angle	15 degree
Trigger input signal	10 us TTL pulse
Echo output signal	Input TTL level signal and range in proportion

2.1 Arduino Uno microcontroller

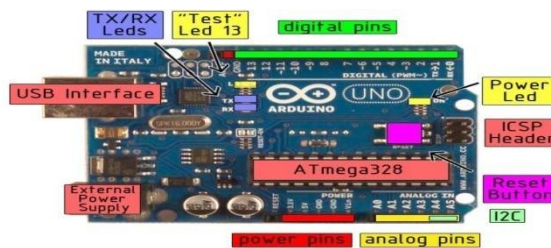


Figure 2: The arduino uno board

The figure 2 shows Arduino Uno microcontroller board based on ATmega 328 processor. Having 14 digital input/output pins and 6 analog input pins. It can be connected by using USB cable through laptop or power battery. The recommended voltage is 7 to 12 V. The ATmega 328 processor is a low power CMOS 8 bit microcontroller and having RISC architecture. Easily we can dump the code in a microcontroller board. The Arduino board having separate power pins, analog pins, digital pins, and LED pin.

2.2 Pixhawk autopilot board



Figure 3: Pixhawk module

Pixhawk is a updated version of flight control board of 3DR. It contains two advanced processor STM32F103 back up failsafe 32 bit ARM cortex processor. The Pixhawk board having four internal sensors namely gyroscope, accelerometer, barometer, magnetometer. It provide multicolor LED indicator. It is easily connect to any hardware and flexible for redevelopment. Gyroscope is used to know the exact position of MAV like it acts as a GPS. Accelerometer



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is used for measure the speed of the vehicle. Barometer is used for measure the pressure of vehicle and magnetometer helps to find the height of the vehicle from ground station is as shown in figure 3

2.3 Servo motor

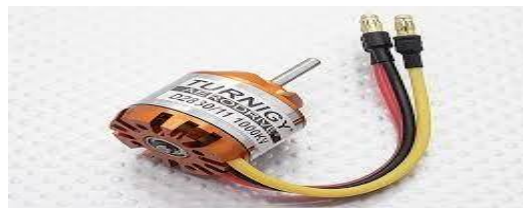


Figure 4: Brushless DC motor

Figure 4 shows brushless DC motor The brushless DC motor is commonly known as electrical commutated motors. Brushed less DC motor has well known function of brushed motor. It has high power high speed and highly controlled device. The brushless DC motor having stator and rotor its working is same as a brushed DC motor. And having internal shaft feedback. It have permanent magnets rotate around fixed armature.

2.5 Electronic Speed Controller (ESC)

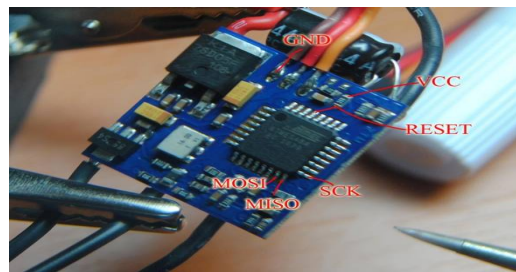


Figure 5: Electronic speed controller

Figure 5 shows electronic speed controller. The electronic speed controller is configured with flight controller board with normal PWM inputs so that it matches the expected working. Input voltage to be given 2-4 cells Lithium Polymer/ Lithium Ion battery. It supplies 5 V, 3 A for external receiver and servos. The ESC is connected to servo motor in order to increase the speed of the motor the motor connected roll and pitch movement for vehicle in clock wise and anti-clockwise direction respectively.

2.4 Arduino IDE software

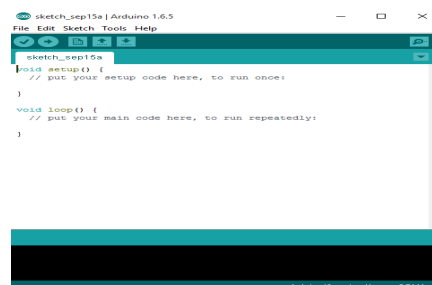


Figure 6:Arduino sketch window version 1.8.5



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Arduino IDE is an open source project to which ATmega chips connect it. In the software the code is written and uploaded to any ATmega chip and then the code is executed on the chip. Many 3D printer electronics and Arduino compatible use ATmega chip. Sketch is the window in which the program is to be written which is shown in figure 6 Arduino programs can be divided into three main parts namely structure, values, functions.

2.6 Mission planner

Mission planner is software present in the ground station. It is connected to the RC transmitter by set the baud rate and is connected to the MAV auto pilot board the mission planner having different section during flight. The Autopilot board can monitor the vehicle and can be seen in ground station. depending the MAV can be select the frame types. Calibration of sensors is required before any mission is started and the RC transmitter is also calibrated for pitch, roll and yaw movements. The mission planner consists of three windows: head-up display, control area, map area. The mission planner software is as shown in figure 7.

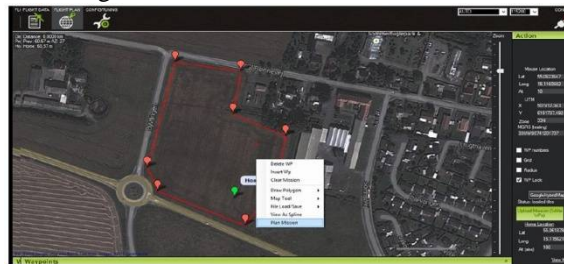


Figure 7: Window showing mission planner.

III IMPLEMENTATION

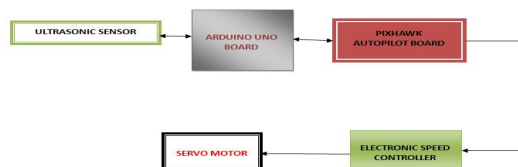


Figure 8 Block diagram of safe landing

The figure 8 shows the block diagram of safe landing by using ultrasonic sensor, Arduino board, Pixhawk autopilot board, ESC, servo motor. The ultrasonic sensor can be attached to the Arduino microcontroller board. The sensor helps to find the distance obtain from the ground and also obstacle can detect. The result can obtain and seen in Arduino IDE software. The microcontroller board can interface to the flight control board by using UART communications. The flight control board is advanced version of autopilot board name as Pixhawk autopilot board. The quadcopter can considered is X configuration. For pitch moment the rotors can be fixed in anti clock wise direction and roll moment the rotor can placed in clock wise direction. The source code is dumped on microcontroller board using Arduino Integrated Development Environment. The flight controller board having some internal sensor helps to calculate the distance, height obtains from the ground. Electronic speed controller is connected to autopilot board to control the servo motor.

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FLOW DIAGRAM for SAFE LANDING

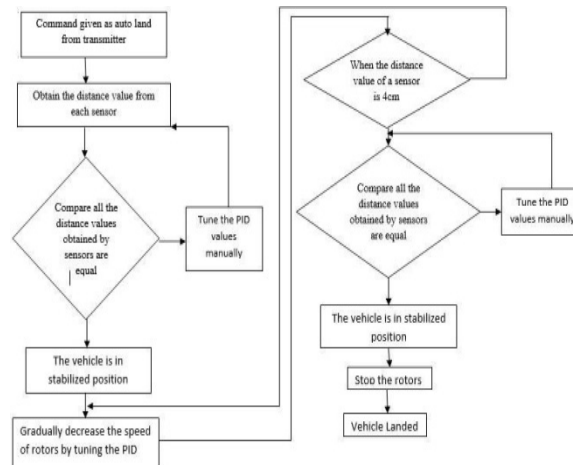


Figure 9: Algorithm for safe landing

The figure 9 shows an algorithm for safe landing for UAV. The flow diagram explains the path followed to execute safe landing by avoiding crash land. In first step the initial values is obtained from ultrasonic sensor placed in all direction. The signal can transmit from transmitter module of ultrasonic sensor and reflects back from ultrasonic receiver. The altitude height of the land is obtained from barometric sensor and altimeter. The RC transmitter is helps to control the MAV during the mission. The command can be requested from RC transmitter is given to auto land safely to the microcontroller board attached to the MAV vehicle. If the sensors shows unequal distances then it can be corrected by tuning PID values after recheck the value then vehicle gets stabilized position and stop the motor then its landing on the ground.

IV. RESULTS AND DISCUSSION

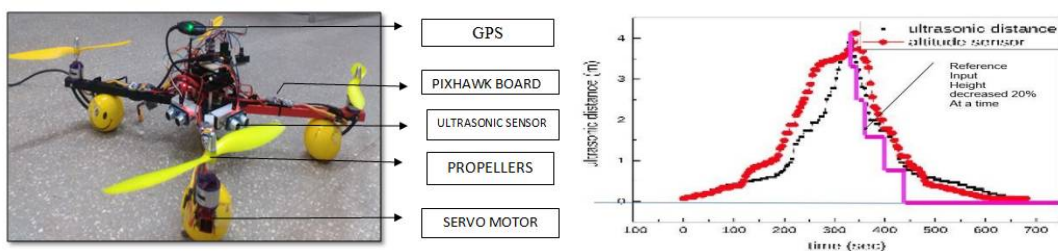


Figure 10: Experimental setup of hardware

Figure 10 shows that experimental setup for hardware is as shown in figure. Satisfactory results were obtained by the algorithm developed. Ultrasonic sensor was initially connected to flight control board. Before connecting to mission planner software first settings were done to obtain the result from ultrasonic sensor. The initial voltage was set 0.03V and maximum range upto which the ultrasonic sensor can detect was also mentioned in mission planner software. The results were taken by telemetry of 915MHz. MAV was connected to mission planner a flight test was conducted for 5 minutes. The algorithm has been implemented for safe landing while safe landing it should be gradually decrease the speed of the motors.



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V. CONCLUSION

The algorithm has been developed and suitable for autopilot system in order to avoid crash landing and safely, smoothly landing on the earth. By using ultrasonic sensors on the controller for safe landing was checked. This experiment was successfully done and performed.

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