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24 GHz Millimeter Wave Radar Based Obstacle Detection and Collision Avoidance System

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***Abstract*: Efficient Obstacle detection and avoidance system for man-made flying objects has been a topic of great interest over the years due to the increasing number of air accidents/ incidents reported all over the globe. A flying object during its flight must evade encountering obstacles like towers, walls, wires, trees, high tension grid wires, hills etc. for the safety of the precious aircrew lives and the costly flying object. Most of the advanced obstacle detection and avoidance systems uses stereoscopic imaging, embedded stereo vision and laser based technologies. The Obstacle detection and avoidance system can be used for military drones and unmanned aerial vehicles, which executes the vital task of information gathering pertaining to terrorists and to carry out area surveillance in low intensity conflict areas. The system will also have a diversified use in search and rescue of casualties during disaster management. In this paper we propose a reliable and robust design of obstacle detection and collision avoidance with features such as high frequency 24 GHz mm wave RADAR evading obstacles during the flight. In our proposed system, the obstacle will be first sensed and then according to the programmed pattern the flying object will find a new path and execute its mission and in case of the path is not determined, the flying object will return to its launching station.**

***Keywords*: 24 GHz mm wave RADAR, Telemetry device, GPS, DSP circuit (FFT).**

1. Introduction

An efficient obstacle detection and avoidance system is implemented for artificial flying objects such as Helicopters, Unmanned Aerial Vehicles, Drones etc. using a 24 GHz mm wave RADAR integrated along with GPS, receiver and transmitter assembly, signal processor, DSP circuit(FFT) and detection circuit. This proposed work is an attempt to design and develop a quad copter based smart obstacle detection and avoidance system, which employs 24 GHz mm wave RADAR to detect the obstacle in the flight path by the principle of "Doppler Effect". The system will judge the exact distance of the obstacle meanwhile calculating its own flying speed and will efficiently avoid the obstacle. The efficacy of the system will depend upon the frequency of the 24 GHz mm wave RADAR, the speed of the flying object and the shape of the obstacle. The system is fabricated as a quad copter model having four propellers driven by four brushless DC Motors and the system is embedded with the GPS antenna with built in compass to ascertain the way points and to maintain the stability of the quad copter which in turn will be fed to the microcontroller to take necessary decisions to avoid the obstacle in the flight regime. The language used to develop the model is C++ (high level language) and the microcontroller is Pixhawk. The system will work in two modes i.e. the Manual mode and the Autonomous mode. The is embedded with speed controllers, which will change the RPM of the motors as per the requirement of the flight maneuvers. Once all the components are mounted on the quad copter, the dynamic balancing is done by carrying out calibration in the mission planner ground station, which is compatible with Windows.

2. Hardware Layout and Description

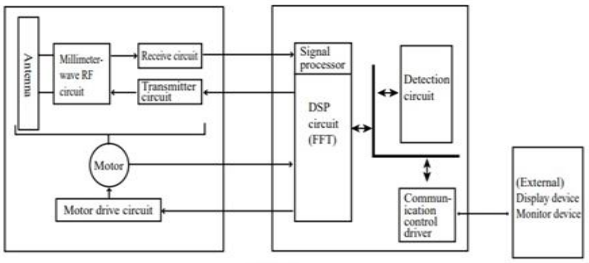

Fig. 1. Hardware layout of the system

A. Pixhawk

Specifications:

(i) RAM: 256 Kb
(ii) Dimension: 1.7x0.5x 1.5 inches
(iii) Weight: 140 grams
(iv) Operating voltage: 7 Volts
(v) Programming: Linux
(vi) GPS Module: Integrate

Pixhawk is an open source hardware project that aims to provide on hand, hiqh-quality and low-cost autopilot hardware designs for the ab initio developer communities for multiple flight stacks. Pixhawk is a PPM-input autopilot, which gets Resistor Capacitor input from a single cable to the receiver, either via the PPM port, or the special satellite receiver port.

Features:

i. Advanced 32-bit ARM Cortex® M4 Processor running NuttX RTOS14 PWM/servo outputs with fail safe and manual override features.

ii. Abundant connectivity options for additional peripherals (UART, I2C, CAN) and Integrated backup system for in-flight recovery and stand-alone power supply.
iii. Backup system integrates mixing, providing consistent autopilot and manual override mixing modes.
iv. External safety button for easy motor activation.
v. High-power, multi-tone Piezo audio indicator micro-SD card for long-duration high-rate data logging.

Fig. 2. Pixhawk controller

B. EMAX MT2213 brushless DC Motor

Specification:

1) Operating Voltage: 10 V
2) Thrust : 0.84 N
3) Propellers : 8 – 10 inch
4) Dimension: 40 x 28 x 53 mm
5) Weight : 53 grams

High torque is required for quad copters, since we have to balance by changing the revolutions of the motor for dynamic balancing. The higher the torque the faster we can change the speed of our propellers and also higher torque means there is no need of a gearbox, which save a lot of load.

C. 24GHz millimeter-wave RADAR

Specification:

1) Working frequency: 24 Ghz.
2) Transmitting power: 23 dBm
3) Modulation mode: FMCW
4) Detection angle: horizontal(-6dB):28 deg, pitch(-6dB):18deg
5) Detection Precision: +/-0.02 m
6) Detection Range: @0dBsm wall 0.5-100m, @0dBsm 0.5-30m
7) Tracking object: 1pcs
8) Range resolution:0.75m
9) Target update range:50Hz
10) Working voltage:5-12v
11) Power consumption:< 2w
12) Working temperature: -25 o 60 deg C
13) Output port:115200bps@UART
14) Weight:120 g

ABSJ008 is a 24GHz millimeter-wave obstacle avoidance radar which provides high-reliability and high-stability environmental sensing capability to the drone by integrating multi-angle millimeter-wave radar to actively detect target obstacles on the flight path by adopting highly integrated MMIC radar solution, advanced target detection algorithm, with low power consumption, high stability and low latency, target refresh rate of 50Hz.

Based on the millimeter wave radar sensor to build an obstacle avoidance sensing system, the millimeter wave radar can fully utilize the advantages of strong anti-interference ability, and provide a low-cost and high-reliability solution for the obstacle avoidance of the drone, and outputs the target information through the standard UART/CAN interface. The millimeter-wave radar can be easily integrated with PIXHAWK, and it is especially suitable for industrial drones and robots.

3. Working/Utility of the Project

The proposed system is having a built-in micro-controller, which is programmed for detection and avoidance of obstacles dynamically and a pattern of new path is been fed that will be followed in case of detection of obstacle. The system is also incorporated with return to launch facility in case of undetermined obstacle. The system starts working automatically as soon as the mission starts thus eliminates the need of any trained initiator. The system works in two clear and distinct modes: Automatic mode and Manual mode. Choice to use the requisite modes rests with the authorized user(s). The choice the user(s) can make when he accesses the system is based on the type of the mission and the type of obstacle envisaged.

Mode 1- Manual Mode: In the Manual Mode the activation of the system is carried out by the user and throughout the flight regime of the flying object, human intervention is necessary for controlling the bird. The autonomous flight mode and its associated programs like GPS systems are all over-ridden during the manual mode. Thus the user can manually operate the system in case of emergency or autonomous system failure. The use of this mode is generally feasible for flight regimes in visual distance of the operator and thus is limited to smaller distances and subjected to weather and visual conditions.

Mode 2- Autonomous Mode: In autonomous mode, the way points are fed to the controller and thus the human intervention is not necessary. In this mode, the GPS is activated to make the bird fly within the given coordinates with 5 meters accuracy along the pre-designated path. In case of detection of an obstacle, the processor will take decision according to the programmed pattern and will also execute return to launch operation in case of battery discharge, undetermined object or after completion of mission. This mode can be used for relatively larger ranges subjected to specification of battery and can perform its task in bad weather conditions without involvement of user.

Future Enhancements

a) Use of LIDAR sensor will be cost effective as the costs involved in Millimeter-wave RADAR is very high.
b) The system may be embedded with 360º rotating high resolution portable camera for real time image analysis.
c) The system may be integrated with load carrying and release mechanism for delivering essential survivability items for persons struck during disasters.

d) The system could have built-in swarm technology with programmed formations to have a master drone controlling the slave drones for better and wide area mapping to obtain real time information and execute covert operations.

4. Conclusion

Efficient obstacle detection and avoidance system is getting to be progressively vital with increasing usage of air space for military and civil flying operations and the system needs to be more reliable and secured and should be incorporated with redundancies to avoid catastrophic conclusion in case of main system failure. The system has continuous ability to rise with a specific end goal to fortify the safety of flying object by assembling present day data advances or technologies. Updating this setup is simple which makes it open to future a prerequisite which likewise makes it more efficient. The proposed work is cost-effective, reliable and has the function of preventing accidents due to obstacles emerging during flight. A smart obstacle detection and avoidance system is one of the essential systems that comprises of 24 GHz mm wave RADAR due to its reliability and higher accuracy. Along with providing operation oriented features of selecting new path in case of obstacle detection and return to launch facility makes the system more mission reliable. This framework with necessary up gradation is intended for use in all military and civil flying objects and the system is simple to use and is extremely user friendly and the reliability factor is relatively high due to provisioning of redundancies in the system.

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