Real Time Video Surveillance and Obstacle Avoidance using Quadcopter

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Abstract— A Quadrotor, is a unique kind of UAV's that uses four-fixed rotors, with two rotors per axis (each axis is orthogonally aligned with the other) powered by four motors to lift and propel the aircraft. The scheme of controlling a Quadrotor is done by varying the speed of the motors relative to each other, also the dynamics of the Quadrotor demand constant adjustment of the motors simultaneously. To allow a balanced flight, an advanced control system must be integrated, and so an on-board controller (brain) is required to implement the control algorithm and to be able to receive (for example from the pilot) and send (for example command the motors) instructions. With use of on board camera and suitable modulation scheme, real time video surveillance is possible. An obstacle avoidance system is implemented for fully autonomous functioning.

Key words: Unmanned Aerial Vehicles, Quadrotor, LIDAR sensor

I. INTRODUCTION

A quadrotor, or quadrotor helicopter, is an aircraft that becomes airborne due to the lift force provided by four rotors usually mounted in cross configuration, hence its name. It is an entirely different vehicle when compared with a helicopter, mainly due to the way both are controlled. Helicopters are able to change the angle of attack of its blades, quadrotors cannot.

At present, there are three main areas of quadrotor development: military, transportation (of goods and people) and Unmanned Aerial Vehicles (UAVs). UAVs can be classified into two major groups: heavier-than-air and lighter-than-air. These two groups self-divide in many other that classify aircrafts according to motorization, type of liftoff and many other parameters. Vertical Take-Off and Landing (VTOL) UAVs like quadrotors have several advantages over fixed-wing airplanes. They can move in any direction and are capable of hovering and fly at low speeds. In addition, the VTOL capability allows deployment in almost any terrain while fixed-wing aircraft require a prepared airstrip for take-off and landing. Given these characteristics, quadrotors can be used in search and rescue missions, meteorology, penetration of hazardous environments (e.g. exploration of other planets) and other applications suited for such an aircraft. Also, they are playing an important role in research areas like control engineering, where they serve as prototypes for real life applications.

Video surveillance has been evolving significantly over the years and is becoming a vital tool for many organizations for safety and security applications. Initially, it was dominated by analog cameras connected using coax cables. For cost and performance reasons, there was a switch to digital switching systems.

Autonomous navigation of quadcopter in outdoors is easy by using GPS. But for indoor navigation a quadcopter needs to have Obstacle detection and avoidance system in order for smooth operation without crashing.

II. RELATED WORK

There is a fair amount of published research with regards to quad-rotor aircraft.The research related to Quadcopter covers the areas of design, control, stability, communication systems and collision avoidance. Park et.al. (2001) [Ref. 1]studied on the 3-DOF attitude control free-flying vehicle. The characteristic to be heavily coupled with inputs and outputs, and the serious nonlinearity appear in the flying vehicle and due to this non-linear control, multi variable control or optimal control for the attitude control of flying Quadcopter. Ashfaq Ahmad Milan et.al. (2007) [Ref. 2] developed of nonlinear model and nonlinear control strategy for a 6-DOF Quadcopter aerial robot. The nonlinear model of Quadcopter aerial robot is based on Newton-Euler formalism. Model derivation comprises determining equations of motion of the Quadcopter in three dimensions and seeking to approximate actuation forces through modelling of the aerodynamic coefficients and electric motor dynamics. Achteliket.al. (2009) [Ref. 3] done research on control of Quadcopter by visual tracking using stereo camera. The motion of a Quadcopter is control based on visual feedback and measurement of inertial sensor. In this research, active markers were finely designed to improve visibility under various perspectives. Jun Li et.al. (2011) [Ref. 4] is done research to analyse the dynamic characteristics and PID controller performance of a Quadcopter. This paper is describe the architecture of Quadcopter and analyses the dynamic model on it. Besides that, this paper also designs a controller which aim to regulate the posture (position and orientation) of the 6-DOF Quadcopter. An J. Michels et.al (2012) [Ref. 5] collects sensor data from both a Hokuyo URG laser rangefinder and a stereo camera, and transmits the data to a computer cluster which runs a localization algorithm. Celik et al. [Ref. 6] first demonstrated on-board indoor SLAM on a MAV using a monocular camera; however theMAV did not perform obstacle mapping and path planning.

III. QUADCOPTER

A. Quadcopter Frame:

High Payload capacity of Quadcopter is possible due to use of light weight, glass and fiber composite frame. Weight of the Quadcopter is proportional with it hover ability. Less weight will increase hover ability of it with minimum power consumption. This Quadcopter frame consist of a minimum area that just enough to place all the parts such as motor, controller board and batteries.

Fig. 1: Quadcopter Frame

B. Flight Controller:

This is the heart of the Quadcopter. Its function is to direct the RPM of each motor in response to input. A command from the pilot for the multi-rotor to move forward is fed into the flight controller, which determines how to manipulate the motors accordingly. Flight controllers employ sensors such as Gyroscope, Magnetometer, Barometer, etc. GPS can be used along with Flight Controller for Autonomous operations.Flight controllers are configurable & programmable, allowing for adjustments based on varying multi-rotor configurations. Gains or PIDs are used to tune the controller, yielding snappy, locked-in response.

C. Motors, Propellers & ESC:

Brushless motors are chosen over DC motors as they offer many advantages including more torque per weight, efficiency, reliability, reduced noise, longer lifetime (no brush and commutator erosion), and elimination of ionizing sparks from the commutator, more power, and overall reduction of electromagnetic interference. Propellers convert rotary motion into aerodynamic lift force. Two pairs of counter rotating propellers are needed in a quad rotor so that the net aerodynamic torque is zero.Brushless Electronic Speed Controllers (ESC) are used to control the brushless motors. An ESC controls the brushless motor by converting the supplied DC from the battery into three phased AC. It does this by varying the switching rate of a network of field effect transistors.

D. Camera:

Various options are available for Camera. This include CCD, CMOS, Action Sports Camera, etc. We plan to explore the option of Smartphone cameras. As they provide high resolution option. Smartphone camera will be configured as IP Camera on WLAN for video transmission. Latency of smartphone camera is high which only drawback of using Smartphone.

IV. OBSTACLE DETECTION AND AVOIDANCE

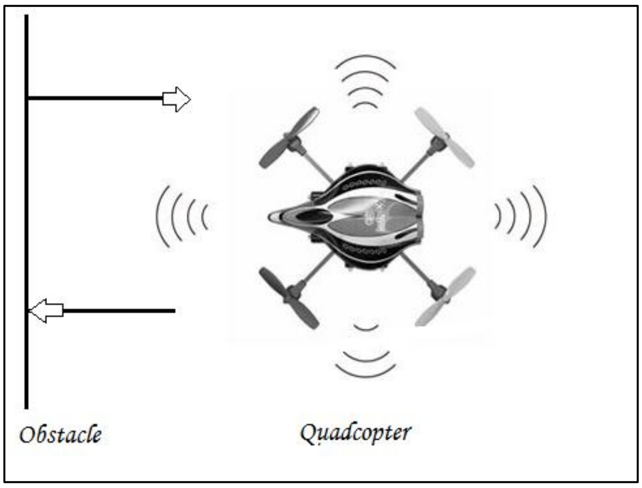

Fig. 2: Obstacle Avoidance System

Lots of research has went into obstacle detection and avoidance system. This includes use of simple Ultrasonic sensors to Lidar sensors. Algorithm also vary from Simple sense and fly to complex running random tree algorithm.

Use of obstacle avoidance system leads to a robust navigational system which will effectively navigate in any envoirment, indoor or outdoor. The system aquires immunity from crashes and accidents. Such system can be used for co-ordinated flights and swarm robotics. With certain modification such system can be used for rough indoor mapping.

Use of LIDAR sensor for sensing is the best possible solution possible. It provides 36000 samples per seconds which enables us to use it in pair with Servo motor for a circular scan at very faster rate. With use of suitable algorithm this system will provide a faster and reliable solution.

Fig. 3: LIDAR

But drawback of this system is the cost of sensor. The cheapest LIDAR retails at $300 making it a costly alternative and unusable for cheap object avoidance system.

The last of the solution includes the use of Cameras. The images from the camera are captured and are processed on an on board computer to generate edges and by using complex algorithm such as SLAM algorithm one can detect the object and also map the environment. 3D Mapping and object avoidance both are possible using this system. As this system use fuzzy logic and complex algorithm a separate on board processing unit is required. This will result into increased cost and payload. Although it's the most ideal candidate it's not chosen due to its complexity.

The proposed system uses four IR sensors The IR sensor measures the distance between the sensor itself and the object and sends it to the arduino in the form of analog signal (value range: 0 to 1023). We should make a set point say 40cm from the IR sensor so if the set point reaches below 40cm the PID algorithm in the arduino will start its work by sending out the correction value to the stabilization board.

The normal range is 1000us to 2000us and 1500 us is the center or neutral value for roll pitch and yaw. We are going to use only range from 1200us to 1800us since we don't want to flip the quad if the quad is a bit closer to the wall. We will be having the having the full control of the throttle stick and the rudder stick.We are going to manipulate the inputs of stabilization board using arduino.

The drawback of this system is that if the passage for passing is narrow even then the quadcopter attempts to pass. This can cause an accident. In order to avoid this use of more than four ultrasonic sensors is required.

V. LIMITATIONS OF SYSTEM

Ultrasonic range measurements suffer from some fundamental drawbacks which limit the usefulness of these devices in mapping or in any other task requiring high accuracy in a domestic environment. These drawbacks are not related to the product of a specific manufacturer, but are inherent to the principle of ultrasonic range finders and their commonly used wavelengths.

Even though ultrasonic ranging devices play a substantial role in many robotics applications only a few researchers seem to pay attention to (or care to mention) their limitations. In our experiments, one well established device the MaxSonar ultrasonic ranging kit, was used and extensively tested. This unit performed up to our expectations, but, of course, is also subjected to the limitations which are described next.

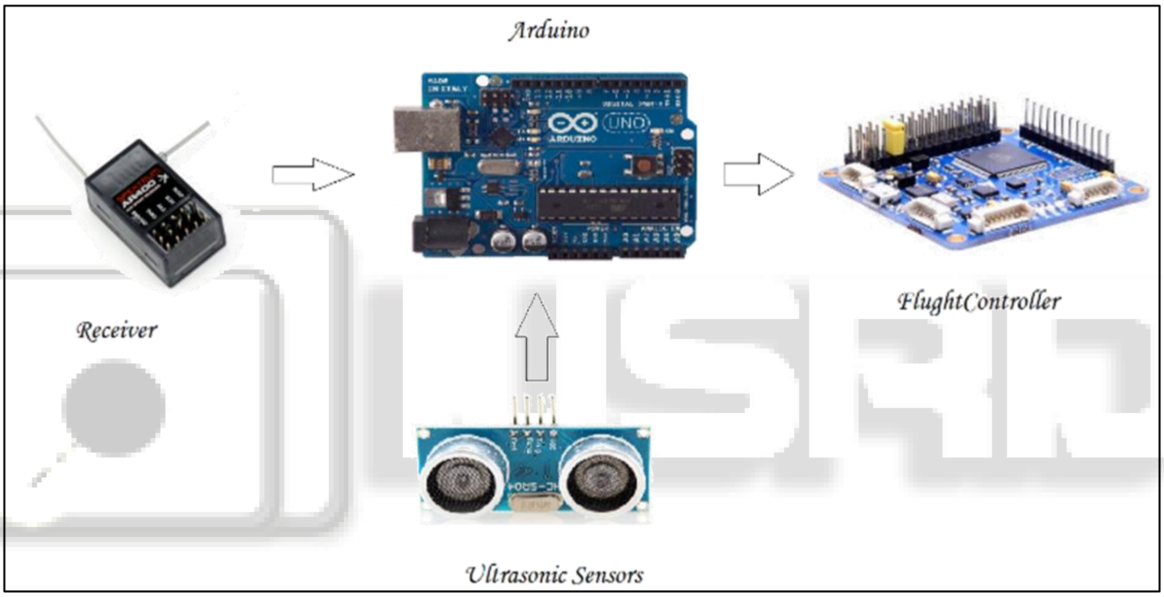

Fig. 4: Working Principle of Obstacle Avoidance System

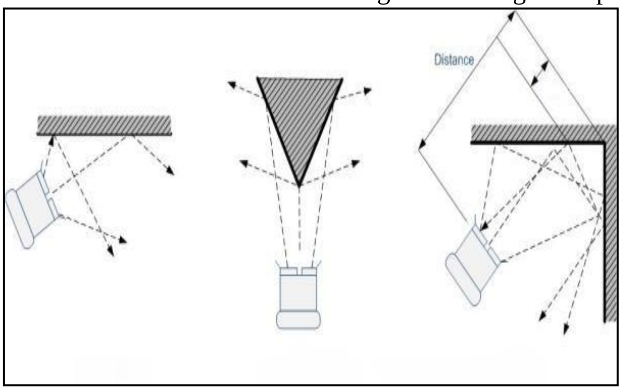

Fig. 5: Reflection of Sound through Various Surfaces

Fig. 5 shows (schematically) one part of the wavefront, emitted by the ultrasonic transceiver S toward a parallel surface of an obstacle. Most of the sound energy is reflected perpendicular to the surface and will be detected by S, while only a small percentage of the energy is scattered in other directions. However, if the surface of the obstacle is tilted relative to the acoustic axis of S, then only an undetectably small amount of energy will be reflected towards. For a mobile robot application this means that the obstacle has not been detected.

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