

# Review Paper on Real-Time Collision Avoidance System Using Quadcopter

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**ABSTRACT:** Real-time collision avoidance of a quadcopter using Arduino programming and SONAR sensors is proposed in this paper. The basic idea is to change roll and pitch values with the help of Arduino and sonar sensor. The flight controller runs on six channel PWM signals coming from receiver, four of which (throttle, yaw, arming, angle mode) are directly connected to the flight controller and the other two (pitch and roll) are first connected to the Arduino board and then from Arduino to flight controller. The Arduino microcontroller board is used to program a code for obstacle avoidance with the help of SONAR sensors which manipulates roll and pitch signals coming from receiver and then feed them into the flight controller for avoiding collision with any obstacle in the path. These sensors will be installed on quadcopter which will help to detect an obstacle within a specified range (30 cm). Hence, Arduino acts as an interface between the SONAR sensors and flight controller by measuring the distance from the object lying in the path of the quadcopter which induces a change in the path as per the input code.

**KEYWORDS:** Collision Avoidance, Quadcopter, Sonar, Arduino, PID tuning, PWM

## I. INTRODUCTION

Quadcopters are omnipresent in today's world. Their compact size, robust performance and ease of assembly make them the most widely-used rotorcraft. Thus, there is scope for a lot of research in this field as quadcopters have wide-ranging applications which are difficult to replicate in other aerial vehicles like helicopter and fixed-wing aircraft.

A multirotor helicopter, lifted and propelled by four rotors, is known as a quadcopter. Two pairs of identical fixed pitched propellers; two clockwise (CW) and two counter-clockwise (CCW) are used in quadcopters. These use independent variation of the speed of each propeller to achieve control. The total thrust is generated by changing the speed of each propeller. Each propeller produces both thrust and torque about its centre of rotation, as well as a drag force opposite to the vehicle's direction of flight. Altitude is controlled by applying equal thrust to all propellers. Yaw is adjusted by applying more thrust to propellers spinning in a specific direction. Roll/Pitch is adjusted by applying more thrust to one propeller and less thrust to its diametrically opposite propeller.

Obstacle detection and collision avoidance is one such exciting field where quadcopters find application. There are a number of techniques that are available and have been tested successfully in order to achieve this aim. The approach that has been selected was done so keeping in mind the time and budgetary constraints in order to fulfil the aim of this paper. In this paper, we have proposed the use of Arduino UNO microcontroller board along with HC-SR04 ultrasonic sensors for realising the goal of collision avoidance.

Programming on Arduino board is used to trigger the ultrasonic sensors installed in all four directions on the quadcopter frame, which in turn detect an obstacle lying in the path of the quadcopter and as per the code uploaded on the Arduino induce a change in the roll/pitch motion of the quadcopter to prevent collision.

After assembly of all the components and integration of the Arduino with the ultrasonic sensors, rigorous testing is done in order to ensure efficient and desirable operation of the quadcopter system as a whole such that it can be deployed for a variety of applications as discussed later.

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### II. LITERATURE REVIEW

[<sup>1</sup>] **Prathamesh Salaskar, Sae Paranjpe, Jagdish Reddy, Arish Shah:** In this paper, obstacle detection and collision avoidance has been achieved in an autonomous quadcopter using low-cost ultrasonic sensors and simple data fusion. Arduino programming is used to make the quadcopter autonomous and PID algorithm is applied to calculate output values of motor commands on basis of input received from transmitter and sensors. An Inertial Measurement Unit (IMU) sensor is used to calculate angles and angular velocities of the quadcopter. The data received from the IMU is instrumental in detecting rotations and dismissing incorrect measurements of the ultrasonic sensors.

[<sup>2</sup>] **Muhammad Fazlur Rahman, Rianto Adhy Sasongko:** In this paper, obstacle avoidance in a quadcopter has been proposed by integrating the quadcopter with a pre-defined system which consists of several modes in order to carry out avoidance. The hardware setup includes Arduino microcontroller, Pixhawk flight controller and the ultrasonic sensor. The algorithm used by the microcontroller has two parts.

The first is Obstacle Avoiding algorithm in which 4 modes have been defined for autonomous flying and obstacle avoidance by the quadcopter. These modes are- *Position Hold* which is used to maintain constant location, *Altitude Hold* which is used to maintain constant altitude, *Autonomous* which is used to carry out a pre-programmed mission stored in the flight controller, and *Keep Distance* which is used to prevent the quadcopter from hitting the obstacle.

The second is Signal Processing algorithm wherein the ultrasonic sensors are triggered to measure the distance from obstacle and then avoidance mode is initiated. This algorithm also makes use of a filter as noise is experienced during measurement of distance. A *moving median* type of filter is used to interpret noise as an outlier in the given dataset.

[<sup>3</sup>] **J. Dani Reagan Vivek, Mariappan M., Micheal Jesus Rickson:** This paper proposes the use of an autonomous quadcopter for video surveillance and monitoring. In order to make the quadcopter autonomous, an Arducopter platform is used and the respective mission planner software generates a flight path for the quadcopter on the basis of data received from sensors. An Inertial Measurement Unit (IMU) sensor is used to calculate angles and angular velocities of the quadcopter. APM 2.8 is used as the flight controller board which senses data from the onboard gyroscope, accelerometer etc. and makes the necessary calculations to change outputs going into ESCs which changes the speed of the motors to keep the quadcopter stabilised. The Mission Planner Software is used as the ground station for carrying out autonomous operation. The implementation of video surveillance by a mobile camera which has been interfaced with the PC using an app.

[<sup>4</sup>] **Sevkuthan Kurak, Migdat Hodzic:** In this paper, LQ and LQG servo controller methodologies have been used for quadcopter control system. This control system is based on the 6DOF mathematical model, hence the model has 3 linear and 3 angular motions. Initially, a nonlinear mathematical model is used for the 6DOF approach. Then this nonlinear model is linearized in hovering mode and finally the resultant linear model is reduced to be used as starting model for the controller design. In the mathematical model, the quadcopter dynamics are summarised using Newton's and Euler's Laws. The work done involves the use of regulation and trajectory tracking controller design techniques based on an LQ servo controller as well as LQG servo controller with Kalman Filter state observer in both the continuous and discrete time domains. The use of Kalman filter makes the system more robust as it can account for environmental disturbance, model errors and measurement errors.

[<sup>5</sup>] **Hanafi Anis, Ahmad Haris Indra Fadhilah, Surya Darma and Santoso Soekirno:** This paper proposes the use of image processing to identify the position of an object and ultrasonic sensor is used to measure obstacle distance. The Lucas-Kanade-Tomasi Tracker method was used for image processing as it offers high accuracy. For controlling drone movements, visual feedback control based PID controllers have been used. The image processing method produces the output of a path planning for quadcopter movement. It consists of two stages- *feature detection* and *optical flow*. Feature Detection method defines and tracks the important points in an image. Optical Flow method is used for comparison of features between two frames. A decision making algorithm is used for processing information from the

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camera and ultrasonic sensors in order to accurately determine the position and distance of the obstacle. The authors were able to achieve a success rate of 85% in image processing for detecting obstacles lying at a distance of 50-200 cm.

[6] **Pedro Castillo, Alejandro Dzul, Rogelio Lozano:** This paper proposes a controller design for a mini rotorcraft having four rotors. The four rotor rotorcraft is unique in the sense that it does not need any blade pitch control. The controller proposed herein is based on Lyapunov analysis which makes use of a nested saturation algorithm. After carrying out real-time testing the controller is able to perform the tasks of taking off, hovering and landing autonomously. The four-rotor rotorcraft has been approximated as the interconnection of two PVTOL (planar vertical take-off and landing) aircraft. Although the dynamical model of the four rotor rotorcraft is obtained via a Lagrange approach, the pitch and roll movement of the rotorcraft is based on the PVTOL. The three angular velocity feedbacks provided by the onboard gyros are considered as an inbuilt control loop. A control strategy for stabilising the hovering capability of the rotorcraft prove the global stability of the closed-loop system.

[7] **Zoran Benić, Petar Piljek, Denis Kotarski:** This paper discusses the mathematical modelling of unmanned aerial vehicles with four rotors. It is an indispensable aspect in quadcopter simulation and modelling of the control algorithm. Coordinate systems are defined and explained at the beginning of mathematical model derivation. By using these coordinate systems, relations between parameters in the Earth coordinate system and those in the body coordinate system are defined. The coordinate system in the Earth fixed frame measures the physical properties like roll, pitch and yaw angles, angular velocity and the coordinate system in the body-fixed frame measures physical properties like linear accelerations. Essentially, mathematical modelling a function that maps inputs on outputs. The purpose of this mathematical model is to predict the position and attitude of a quadcopter by knowing the four angular velocities of the propellers. For the purpose of demonstration, only the quadcopter frame with propellers is considered.

[8] **Swee King Phang, Jun Jie Ong, Ronald T. C. Yeo, Ben M. Chen, and Tong H. Lee:** In this paper, a vision processing system has been developed for indoor navigation of an unmanned aerial vehicle. Linux computer systems are used as onboard processors. A camera module is used for image processing which enable the UAV to perform simple indoor navigation by tracking the coloured paths on the ground. The main processing unit for the embedded vision platform is the Gumstix Overo Fire. The image processing algorithm used here is based on the fast path detection method which this allows the use of single dimension algorithms that are relatively cheaper than conventional two-dimensional image processing algorithms and it offers resizing which has the effect of averaging. Some noise is eliminated in this process. Ultrasonic sensors are used for the purpose of height measurement. The overall flight control algorithm has three parts: inner loop control (reliant on data input from IMU sensors), outer loop control (reliant on vision based measurements) and the path planning algorithm generate position set point to drive the UAV.

[9] **Celine Teuliere, Laurent Eck, Eric Marchand, Nicolas Guenard:** This paper proposes a model-based vision system for the position control of a quadrotor. The quadrotor is equipped with a camera for visual input and an Inertial Measurement Unit (IMU) for providing stability to the quadrotor. The complete system is divided into 3 parts namely, *control scheme* in which motion equation of UAV for quasi-stationary flight conditions are used to estimate position and translational velocity of the vehicle; *visual tracking subsystems* in which multiple hypotheses are considered to evaluate the relative pose between the moving camera and the fixed environment using a 3D model of linear edges; and *velocity estimator* which uses an extended Kalman filter to estimate the translational velocity of the vehicle by fusing inertial data with the pose estimate.

[10] **Sven Lange, Niko Sunderhauf, Peter Protzel:** The work done in this paper focuses on autonomous landing and position control of a multirotor UAV. A vision based detection algorithm is used to estimate the 3D position of the UAV relative to a pre-designed landing pad. This landing pad has a specific design (several concentric white rings on a black background) according to which the vision based detection algorithm is created. This algorithm is programmed in C/C++ so as to ensure fast and efficient image processing. A total of three controller systems are developed and tested viz. *Altitude Controller* which receives its inputs from the SRF10 sonar sensor for height measurement; *Position and Velocity Controller* which relies on an optical flow sensor to determine the current velocity and position of the

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quadcopter; and lastly *Landing Controller* which receives the images from the on-board camera. The corrected position estimates so obtained are then used as inputs for a PID-controller that generates the necessary motion commands to keep the UAV steady and level over the centre of the landing pad. After trial runs, the quadcopter is able to stabilize its altitude, position and velocity and can detect and approach the landing pad marker.

[11] **Tin Thet Nwe, Than Htike, Khine Myint Mon, Dr.Zaw Min Naing and Dr.Yin Mon Myint:** This paper proposes the development of an Inertial Navigation System (INS) using low cost MEMS (micro-electro-mechanical systems) sensors for the purpose of control of a quad-rotor craft. A single-axis gyroscope and two dual-axis tilt accelerometers are interfaced with a Microchip PIC 8 bit microcontroller for designing an inexpensive navigation system. The gyroscope is mounted in the centre of the craft and measures the yaw rate during flight. The device used here is capable of measuring +/- 150 degrees per second of angular velocity. The accelerometers are mounted in the central hub of the craft and provide acceleration values in the range of  $\pm 2g$  as X- and Y- analog output signals. The microcontroller takes these analog inputs from the accelerometer and gyroscope, decodes them into acceleration and angular velocity and further sends these values to the main onboard processor. Rotational Calibration method is used which determines the offset and scale factor for each axis separately which improves the accuracy of the output obtained from the accelerometer sensors.

[12] **Umberto Papa, Giuseppe Del Core, Francesco Picariello:** In this paper, the atmospheric effects on the performance of ultrasonic sensors has been studied. Since ultrasonic sensors used in UAVs for the purpose of obstacle detection are susceptible to humidity and atmospheric variations, their measurements contain systematic errors. A comparative study is carried out between two popular ultrasonic sensor modules available in the market: HC-SR04 and Parallax PING. Arduino UNO microcontroller board is used to obtain distance values from the two sensors and LabVIEW application is used to store and process the measured distances. LabVIEW application is preferred as it allows the user to communicate with the microcontroller board and displays results using a user-friendly graphic interface. The two sensors are tested in a small KK-105 CH climactic chamber at different values of temperature and humidity. A correction equation is obtained on the basis of the experimental results and the maximum error distance and mean are determined. This correction equation can be used to compensate for the effects of temperature and relative humidity on distance measurements and improve the results in adverse weather circumstances.

[13] **Alireza Nemati, Mohammad Sarim, Mehdi Hashemi, Eric Schnipke, Steve Reidling, William Jeffers, Jesse Meiring, Padmapriya Sampathkumar, Manish Kumar:** This paper suggests and simulates an Unmanned Aerial Vehicle system equipped with inertial and ultrasonic sensors capable of autonomous flying in a GPS-denied indoor environment having obstacles. A realistic simulation environment is designed in MATLAB for testing the UAV system along with the software algorithms to be used for navigation and control. The software developed allows data communication between the various sensors for effective navigation, obstacle avoidance and path planning. Higher level Proportional Derivative (PD) control is used to provide pitch, roll and yaw commands. The navigation algorithm is a combination of path planning and decision-making approaches so that the UAV is able to maintain its orientation along pre-set waypoints and avoid collision with obstacles. A dynamic model of the quadcopter is prepared using Newton-Euler equations and to validate the designed algorithm, testing is carried out in a simulated environment using MATLAB.

[14] **Umberto Papa, Giuseppe Del Core:** This paper deals with the design and assembly of a low-cost small UAV. The design is modelled on the Quadcopter ARF 450 which is classified as a mini UAV. An avionic system has been designed using Arduino Mega 2560 as a microcontroller, an IMU (Inertial Measurement Unit) which is composed of a series of sensors namely 3-axis accelerometer, 3-axis gyroscope and 3-axis compass and GS-405 GPS sensor. A Meteo system is also used to provide temperature, humidity and pressure measurement using two sensors. The power supply is provided by a 4.8V 1800mAh LiPo battery and a DC-DC convertor has been used to accommodate for different input voltage levels of each hardware component. During the assembly process, it was important that the weight of the avionic system acts around the centre of mass of the quadcopter frame so as to ensure stable flight. The assembled

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weight of the UAV turns out to be less than 7 kg. The UAV is then subjected to a series of ground and flight tests to verify the accuracy of data acquired.

[15] **A. Imam and R. Bicker:** In this paper, a small scale rotorcraft UAV system has been designed. The objective has been realised in the following five steps- (i) Virtual design environment selection, (ii) Hardware components selection, (iii) Avionic system design and integration, (iv) Vehicle design and construction and (v) Performance and reliability evaluation. Proper market research and comparison of available options is carried out to determine the *propulsion system* consisting of motors, battery, ESC (electronic speed controller) and propellers; *flight control system*; *microcontroller board selection* and *navigation sensors* termed as NAVSENSOR Module. The NAVSENSOR Module consists of MEMS-based IMU, MEMS-based three-axis magnetometer, and miniature-size GPS receiver, barometric pressure sensor and airspeed sensor. For the avionic system design and integration, it was important that vehicle C.G. (centre of gravity) was balanced at all times. Excess vibration has been kept in check by using damping materials such as Sorbothane and Silicone pads. Proper shielding of the components is done to minimise the harmful effects of radio frequency interference and electromagnetic interference.

[16] **Jörg Müller, Wolfram Burgard:** This paper focuses on the use of miniature airships as indoor navigation systems. Localisation is carried out using small on-board sensors like miniature sonars, microelectromechanical systems (MEMS) based IMUs or thermal airflow sensors. A particle filter is used to carry out probabilistic state estimation. The miniature airship used here is equipped with five ultrasonic sensors, three thermal airflow sensors and an IMU for navigation. The IMU sensor data is fused in an extended Kalman filter on the processor integrated into the IMU and provides accurate attitude and heading estimates. An odometry motion model was also developed using the data from the air flow sensors and IMU. The model proposed herein is able to outperform the particle filter localisation which is based on the standard control motion model.

[17] **Jean-Baptiste Devaud, Stéphane Najko, Pierre Le Nahédic, Cédric Maussire, Etienne Zante, Julien Marzat:** This paper proposes the design of a quadrotor UAV under the constraints of a low budget. The intent is to design a UAV which can move inside a building, pass through doors, to remain stable and take off and land automatically. A Human Machine Interface (HMI) visualises the motion of the UAV and allows the user to switch between automatic and manual flight modes. The hardware structure of the UAV consists of the following components- Mbed card with ARM Cortex-M3 microcontroller, 9DOF Inertial Measurement Unit (IMU), AtXmega controller, Bluetooth module and an ultrasonic rangefinder. The entire system is powered by a 4500mAh LiPo battery. Classical P&D control is used to stabilize the UAV in roll, pitch and yaw and to reach a reference altitude. The quadrotor is closed-loop controlled to ensure its stabilization and so that it can follow a given trajectory autonomously.

[18] **Umit Soyly:** This paper proposes a model for generating a common operational picture (COP) for unmanned systems particularly a swarm versus swarm unmanned systems scenario in which opposing teams of UAVs approach each other. COP basically an object's understanding of other objects located in its surroundings. A COP is generated for each member of the swarm and then a simulation is generated for testing realistic scenarios and providing statistical analysis of COP accuracy. This simulation is coded in MATLAB using object-oriented design. The multi-target tracking (MTT) framework presented includes the following key algorithmic components, including: (1) track generation using K-means clustering of detection measurements of targets; (2) track association over time using probabilistic data association (PDA) approaches with the Munkres method; (3) state improvement of tracks with Kalman filtering (KF).

[19] **Jack Langelaan, Steve Rock:** In this paper a method for passive GPS-free navigation of a small UAV has been developed. The navigation problem has been addressed by SLAM (Simultaneous Localisation and Mapping) approach, which is also called Concurrent Localisation and Mapping. An Unscented Kalman Filter (UKF) is used to provide a solution to the navigation problem. Simulations are carried out for low altitude (5 metre) flight in an unknown environment in which the UAV follows a circular trajectory of radius 20 metres at a velocity of 20 m/s. The simulation

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results are then compared with hardware test results which are obtained from an IMU and a monocular camera are used for showing mapping and navigation in a laboratory environment.

[20] **Ahmad Drak, Hassan Noura, Mohammad Hejase, Younes AL Younes:** In this paper, a fault diagnostic and fault tolerant control algorithm is designed for the altitude sensor of a quadrotor UAV. This fault tolerant control is based on hardware redundancy of three altitude sensors. Residuals are generated based on the three altitude measurements, which are then used to compute indicators about fault occurrences. The fault isolation algorithm uses these indicators to determine the faulty sensor, and in return allows for automatic switching between the sensors in case the faulty sensor is used in the closed-loop system. QUANSER's Qball-X4 is used in this test. A dynamical model of the quadrotor vehicle is derived based on the force/moment dynamics and kinematics. For the testing platform, altitude measurements are also provided by Optitrack localisation cameras (for ground station) and two sonar sensors (mounted at the bottom of the quadrotor).

[21] **Young-Rae Kim:** This paper discusses the design of a Small Unmanned Aerial Vehicle (S-UAV) to be marketed as a product. Focus was laid on designing the UAV for civilian applications so payload was kept detachable so that the UAV can be used for a various types of mission with an appropriate payload. Market assessment was performed initially to figure out the needs and requirements of the user. Six different mission profiles were studied namely Military, Search and Rescue, Inspection, Law Enforcement, News Coverage and Environmental Studies. A basic autopilot system having attitude and heading-hold was also designed and three modes of operation were generated to suit the different mission profiles. A collision avoidance system was designed using two sonar sensors and an algorithm so that the UAV was able to detect a point where no obstacle lies and fly uptill that point. Simulations were carried out using straight-edge walls as obstacles.

[22] **Chen Friedman, Inderjit Chopra, Svetlana Potyagaylo, Omri Rand:** In this paper, a mapping methodology has been proposed for the autonomous navigation of Micro Aerial Vehicles (MAVs). Navigation and path planning is supported by a laser scan matching algorithm and virtual occupancy grid method. The laser range finder is used for both position estimation and map generation. The occupancy grid represents the surroundings of the vehicle. The major assumption made here is that the vehicle only has two-dimensional motion and small pitch and roll attitudes. A simulated laser scan of the MAV's environment is also performed which serves as a reference for the map which matches the position of the MAV with that obtained by the actual laser scan. An adaptive direct algorithm was constructed to compare the two maps. Path planning for the MAV is performed using a potential field approach. SLAM (Simultaneous Localisation and Mapping) algorithms can also be used for solving problems of this type but there is difficulty in coupling between maps and position estimation. The methodology adopted herein produces results that are comparable with probability based SLAM methods.

[23] **Karin Sigurd, Jonathan How:** This paper studies the feasibility of a total field sensing approach as a means of collision avoidance in a swarm system of UAVs. In this total field sensing approach, each vehicle is modelled as a magnetic dipole and provided with sensors to sense the total field. The field sensing approach is of magnetic nature and each vehicle in the swarm generates a magnetic field around itself and is provided with a set of magnetic sensors that sense the total field generated by the whole network of vehicles. The algorithm proposed is based on Magnetic Field Theory and simulation is carried out to test the algorithm in a highly cluttered and constrained space. Experiments were also performed in real time using one sensor and two identical light-weight magnets to simulate the scenario of two vehicles moving relative to each other.

[24] **Ben Ludington, Eric Johnson, George Vachtsevanos:** This paper presents results on three systems modelled on vision-based navigation and target tracking for UAVs. The components required for assembly of the UAV are packaged into exchangeable modules: two computer modules, the global positioning system (GPS) module, the data link module (wireless Ethernet, wireless serial, Ethernet switch), and the inertial measurement unit (IMU) module. An extended Kalman filter (EKF) uses the vision measurements along with inertial (accelerometers and gyros) measurements to estimate the vehicle state. Through the use of an EKF, vision sensors become a viable alternative to

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GPS in inertial navigation. The ground target tracking system has three components- (i) a particle filter, which estimates the position of the target within the incoming video frames; (ii) a camera controller, which is used to move the field of view (FOV) to keep the target within the video frames. (iii) a trajectory (waypoint) generator, which commands the UAV to smoothly follow the target. When the particle filter is integrated with a camera controller and waypoint generated, the resulting system is able to track a target autonomously.

[25] **Eric N. Johnson, Alison A. Proctor, Jincheol Ha, Allen R. Tannenbaum:** This paper deals with the design, development, and testing of an unmanned aerial vehicle (UAV) with automated capabilities. These allow the system to search a prescribed area, identify a specific building within that search area based on a small identifying sign located on one wall, and identify an opening into that specified building. The GTMax research UAV, which is based on the Yamaha R-Max Industrial Helicopter airframe, was utilized for this work. A new, automated visual subsystem is developed to augment the automated guidance and navigation of the UAV. Fast image processing and tracking algorithms were used to ensure a rapid search of the area in which the UAV is flying. Simulations were carried out to test the algorithms for symbol tracking and window tracking.

[26] **Mohamad Farid bin Misnan, Norhashim Mohd Arshad, Noorfadzli Abd Razak:** In this paper, the appropriate position and angle of orientation of ultrasonic sensors was determined for two-dimensional mapping application on UAVs. A structure of the sonar sensors has been prepared using four sonar sensors. The sensors output was connected to a 16-bit microcontroller which then converted the analog value into digital value. The sonar sensors measure heights between the UAV and ground in the range of 0-140 cm and horizontal distance in the range of 0-160 cm. The experiments carried out are used to determine the most suitable arrangement of sonar sensors for the purpose of mapping by UAV.

[27] **Guowei Cai, Ben M. Chen, Kemao Peng, Miaobo Dong, and Tong H. Lee:** This paper presents the modelling and flight control-system design for the yaw channel of an unmanned aerial vehicle (UAV) helicopter. A composite nonlinear feedback (CNF)-control technique is used as it has been proven to be capable of yielding a fast transient response with no or very minimal overshoot in tracking a specific target. The yaw channel of the UAV is modelled on the basis of following two assumptions: (1) The simplified bare yaw dynamics is a first-order system, and (2) the embedded controller is characterized by a first-order low-pass filter. A high-performance controller is designed using the CNF-control technique. Stabilisation and agility tests are then carried out after implementing the controller into the yaw channel of the UAV.

[28] **Mario J. Valenti:** In this paper, the development and implementation of approximate dynamic programming methods used to manage multi-agent systems is discussed. The problem is considered to be a Markov Decision Process (MDP) and a system architecture is designed to improve mission-level functional reliability through system self-awareness and adaptive mission planning. Focus has been laid on UAVs (Unmanned Aerial Vehicles) that perform autonomous surveillance operations. An indoor multi-vehicle testbed called RAVEN (Real-time indoor Autonomous Vehicle test Environment) was developed to study long-duration missions in a controlled environment. RAVEN is capable of autonomously managing the platform's realistic air and ground vehicles during multi-vehicle operations.

[29] **Courtney S. Sharp, Omid Shakernia, S. Shankar Sastry:** This paper proposes the design and implementation of a computer vision system for a rotor-craft unmanned aerial vehicle to land onto a known landing target. The algorithm designed for the vision system software consists of two stages of execution: *image processing* and *state estimation*. The landing target is designed in such a way that it is easy to identify and has distinctive feature points, thus simplifying the image processing algorithm. For state estimation, both linear and non-linear optimisation algorithms are used. The linear optimization algorithm is globally robust but sensitive to noise. The nonlinear optimization algorithm requires adequate initialization but is more robust to noise. This is then applied to the camera control which increases the range of motion of the UAV.

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[30] **Pierre-Jean Bristeau, François Callou, David Vissière, Nicolas Petit:** In this paper, the navigation and control technology of a commercialized micro Unmanned Aerial Vehicle (UAV) is studied. The AR.Drone system includes an MEMS inertial measurement unit (IMU), two cameras, a sonar and a two processors board. The first processor which constitutes the navigation board is used to gather the input and output from the various sensors. The second one (Parrot P6 ARM based) constitutes the mother board and is in charge of running the algorithms. The sensors used are calibrated and data from the inertial sensors is used for attitude estimation and video processing. The control architecture of the UAV is realized by two nested loops, the Attitude Control Loop and the Angular Rate Control Loop.

[31] **Umberto Papa, Giuseppe Del Core:** This paper proposes the design of a sonar sensor model for the safe landing of a UAV. A three-dimensional (3D) map is created for a horizontal plane by analysing data from the ultrasonic sensors. The system is designed using four ultrasonic sensors mounted on the roll and pitch axes. These sensors have been linked to an Arduino microcontroller board that manages them and sends data distances via serial port. Data distance is given by ultrasonic sensor through two or more measurements of the same point and averaging the two or more measures from sensors to get the value of final distance. The system designed essentially works like a radar as it scans an area, detects obstacles and maps it. It is fully automatic and runs on a 9V battery.

[32] **Abdelhamid Tayebi, Stephen McGilvray:** In this paper, a new quaternion-based feedback control scheme is developed for exponential attitude stabilization of a quadrotor aircraft. A  $PD^2$  feedback structure is used in the controller, where the proportional action is in terms of the vector quaternion and the two derivative actions are in terms of the airframe angular velocity and the vector quaternion velocity. The mathematical model of the quadrotor is prepared and the feedback control scheme used for attitude estimation consists of two steps- *airframe torque design* and *motor torque design*. The attitude controller is then tested experimentally on a small-scale quadrotor aircraft equipped with low-cost sensors. The quadrotor aircraft is mounted on a stationary ball joint base. This base gives the aircraft unrestricted yaw movement and around  $\pm 30^\circ$  of pitch and roll, while restricting the aircraft to a fixed point in the three-dimensional space.

[33] **Kourosh Parsa, Jorge Angeles, Arun K. Misra:** This paper proposes an attitude-calibration method by using an accelerometer array, which is applied to determine and account for the accelerometer installation errors with a high degree of accuracy. In this array, a set of triaxial accelerometers are used to measure the acceleration of multiple points on a rigid body. An iterative procedure that processes the acceleration readouts recorded for arbitrary motion of the body is used for attitude calibration. Two schemes are studied- Gravitational Attitude Calibration and Kinematic Attitude Calibration and the implemented in MATLAB for simulation using 2<sup>nd</sup> order Runge-Kutta method. The sample rigid-body motion to be observed is a fixed point harmonic rotation about a vertical axis with an amplitude of 1.5 rad and a circular frequency of 1.0 rad/s.

[34] **Erdinç Altug, James P. Ostrowski, Camillo J. Taylor:** This paper proposes a vision-based stabilization and output tracking control method for a model helicopter. A comparative study is carried out between two methods of control- (i) feedback linearization and (ii) backstepping controller. These two methods are used to perform output tracking control. Pose estimation technique is used to obtain the relative position and orientation of the helicopter with respect to a ground frame using vision. In the two-camera pose estimation method, two cameras that are set to see each other are used. One of the cameras is located on the ground and the other is an on-board camera looking downwards. Simulations which are performed on MATLAB Simulink show the ability of the controller to perform output tracking control even when there are errors on state estimates.

### III. CONCLUSION

Different approaches to the problem of collision avoidance and obstacle tracking in a quadrotor aircraft has been presented here. Various techniques have been used and their experimental results have been analysed to determine the accuracy in each case. The most common approach involves the use of ultrasonic sensors for the purpose of distance measurement and an Arduino microcontroller for processing the data received from the sensors. Ultrasonic sensors like



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HC-SR04 are preferred for their ease-of-availability, inexpensiveness and easy integration with other hardware components. Programming on Arduino IDE is simple and easy-to-understand as it based on C/C++ syntax. There are a plethora of applications for UAV in the field of collision avoidance. The frame size of the quadrotor aircraft also plays an important role in determining the approach used for this purpose.

## REFERENCES

- [1] Prathamesh Salaskar, Saeed Paranjpe, Jagdish Reddy, Arish Shah, "Quadcopter – Obstacle Detection and Collision Avoidance", *International Journal of Engineering Trends and Technology (IJETT)* – Volume 17, Number 2, November 2014
- [2] Muhammad Fazlur Rahman, Rianto Adhy Sasongko, "Obstacle Avoidance for Quadcopter using Ultrasonic sensor", *J. Phys.: Conf. Ser.* 1005 012037, 2018
- [3] J. Dani Reagan Vivek, Mariappan M., Micheal Jesus Rickson M., "Autonomous Quadcopter for Surveillance and Monitoring", *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, Volume 7, Issue 4, April 2018
- [4] Sevkuthan Kurak, Migdat Hodzic, "Control and Estimation of a Quadcopter Dynamical Model", *Periodicals of Engineering and Natural Sciences*, Volume 6, Number 1, March 2018
- [5] Hanafi Anis, Ahmad Haris Indra Fadhillah, Surya Darma and Santoso Soekirno, "Automatic Quadcopter Control Avoiding Obstacle Using Camera with Integrated Ultrasonic Sensor", *IOP Conf. Series: Journal of Physics: Conf. Series 1011*, 2018
- [6] Pedro Castillo, Alejandro Dzul, Rogelio Lozano, "Real-Time Stabilization and Tracking of a Four-Rotor Mini Rotorcraft", *IEEE Transactions on Control Systems Technology*, Volume 12, Number 4, July 2004
- [7] Zoran Benić, Petar Piljek, Denis Kotarski, "Mathematical Modelling of Unmanned Aerial Vehicles with Four Rotors", *Interdisciplinary Description of Complex Systems*, January 2016
- [8] Swee King Phang, Jun Jie Ong, Ronald T. C. Yeo, Ben M. Chen, and Tong H. Lee, "Autonomous Mini-UAV for Indoor Flight with Embedded On-board Vision Processing as Navigation System", *IEEE Region 8 SIBIRCON, Irkutsk Listvyanka, Russia*, July 2010
- [9] Celine Teuliere, Laurent Eck, Eric Marchand, Nicolas Guenard, "3D model-based tracking for UAV position control", *French ANR National Project SCUAV*
- [10] Sven Lange, Niko Sunderhauf, Peter Protzel, "A Vision Based Onboard Approach for Landing and Position Control of an Autonomous Multicopter UAV in GPS-Denied Environments", *InnoProfile project GPSV supported by the chair for Circuit and System Design and the Chemnitz University Communication Testbed (TUC-CTB)*
- [11] Tin Thet Nwe, Than Htike, Khine Myint Mon, Dr.Zaw Min Naing and Dr.Yin Mon Myint, "Application of an Inertial Navigation System to the Quad-rotor UAV using MEMS Sensors", *World Academy of Science, Engineering and Technology* 18, 2018
- [12] Umberto Papa, Giuseppe Del Core, Francesco Picariello, "Atmosphere Effects on Sonar Sensor Model for UAS Applications", *IEEE A&E Systems Magazine*, June 2016
- [13] Alireza Nemati, Mohammad Sarim, Mehdi Hashemi, Eric Schnipke, Steve Reidling, William Jeffers, Jesse Meiring, Padmapriya Sampathkumar, Manish Kumar, "Autonomous Navigation of UAV through GPS-Denied Indoor Environment with Obstacles", *American Institute of Aeronautics and Astronautics Conference*, January 2015
- [14] Umberto Papa, Giuseppe Del Core, "Design and Assembling of a low-cost Mini UAV Quadcopter System", *Department of Science and Technology, University of Naples "Parthenope"*, December 2014
- [15] A. Imam, R. Bicker, "Design and Construction of a small-scale Rotorcraft UAV System", *International Journal of Engineering Science and Innovative Technology (IJESIT)*, Volume 3, Issue 1, January 2014
- [16] Jörg Müller Wolfram Burgard, "Efficient Probabilistic Localization for Autonomous Indoor Airships using Sonar, Air Flow, and IMU Sensors", *Department of Computer Science, University of Freiburg, Germany*
- [17] Jean-Baptiste Devaud, Stéphane Najko, Pierre Le Nahédic, Cédric Maussire, Etienne Zante, "Full Design of a low-cost quadrotor UAV by student team", *International Conference on System Engineering and Technology, ICSET 2012, Bandung, Indonesia*, September 2012
- [18] Umit Soylu, "Multi-Target Tracking for Swarm vs. Swarm UAV Systems", *Postgraduate Thesis, Naval Postgraduate School, Monterey, California*, September 2012
- [19] Jack Langelaan, Steve Rock, "Passive GPS-Free Navigation for Small UAVs", *Department of Aeronautics and Astronautics, Stanford University*, 2005
- [20] Ahmad Drak, Hassan Noura, Mohammad Hejase, Younes AL Younes, "Sensor Fault Diagnostic and Fault-Tolerant Control for The Altitude Control of a Quadrotor UAV", *8th IEEE GCC Conference and Exhibition, Muscat, Oman*, February 2015
- [21] Young-Rae Kim, "Small Unmanned Aerial Vehicle (S-UAV) Study for Civilian Applications", *Postgraduate Thesis, Massachusetts Institute of Technology*, February 1998
- [22] Chen Friedman, Inderjit Chopra, Svetlana Potyagaylo, Omri Rand, "Towards Obstacle Avoidance and Autonomous UAV Operation", *Specialists' Meeting on Unmanned Rotorcraft and Network Centric Operations, Tempe, Arizona*, January 2011

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Vol. 8, Issue 7, July 2019

- [23] Karin Sigurd, Jonathan How, "UAV Trajectory Design using Total Field Collision Avoidance", *American Institute of Aeronautics and Astronautics Conference*
- [24] Ben Ludington, Eric Johnson, George Vachtsevanos, "Augmenting UAV Autonomy", *IEEE Robotics & Automation Magazine*, September 2006
- [25] Eric N. Johnson, Alison A. Proctor, Jincheol Ha, Allen R. Tannenbaum, "Visual Search Automation for Unmanned Aerial Vehicles", *IEEE Transactions on Aerospace and Electronic Systems*, Volume 41, Number 1, January 2005
- [26] Mohamad Farid bin Misnan, Norhashim Mohd Arshad, Noorfadzli Abd Razak, "Construction Sonar Sensor Model of Low Altitude Field Mapping Sensors for Application on a UAV", *IEEE 8th International Colloquium on Signal Processing and its Applications*, 2012
- [27] Guowei Cai, Ben M. Chen, Kema Peng, Miaobo Dong, and Tong H. Lee, "Modeling and Control of the Yaw Channel of a UAV Helicopter", *IEEE Transactions on Industrial Electronics*, Volume 55, Number 9, September 2008
- [28] Mario J. Valenti, "Approximate Dynamic Programming with Applications in Multi-Agent Systems", *Postgraduate Thesis, Massachusetts Institute of Technology*, May 2007
- [29] Courtney S. Sharp, Omid Shakernia, S. Shankar Sastry, "A Vision System for Landing an Unmanned Aerial Vehicle", *IEEE International Conference on Robotics & Automation, Seoul, Korea*, May 2001
- [30] Pierre-Jean Bristeau, François Callou, David Vissière, Nicolas Petit, "The Navigation and Control technology inside the AR.Drone micro UAV", *18th IFAC World Congress, Milan, Italy*, August 2011
- [31] Umberto Papa, Giuseppe Del Core, "Design of Sonar Sensor Model for Safe Landing of a UAV", *Department of Science and Technology, University of Naples "Parthenope"*, 2015
- [32] Abdelhamid Tayebi, Stephen McGilvray, "Attitude Stabilization of a VTOL Quadrotor Aircraft", *IEEE Transactions on Control Systems Technology*, Volume 14, Number 3, May 2006
- [33] Kouros Parsa, Jorge Angeles, Arun K. Misra, "Attitude Calibration of an Accelerometer Array", *IEEE International Conference on Robotics & Automation, Washington DC*, May 2002
- [34] Erdinç Altug, James P. Ostrowski, Camillo J. Taylor, "Control of a Quadrotor Helicopter Using Dual Camera Visual Feedback", *The International Journal of Robotics Research*, Volume 24, Number 5, May 2005