Collision Avoidance System Of An UAV

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ABSTRACT

The main objective of this project is to develop a collision avoidance system in an UAV. Safe navigation through corridors plays a major role in the autonomous use of unmanned aerial vehicle (UAV) in indoor and outdoor environment. Nowadays the use of aerial vehicles in the indoor environment is getting popularized. The use of aerial vehicles in indoors has a disadvantage of getting collided with objects. To avoid collision with objects these aerial vehicles are to be installed with a collision avoidance system. In this project I present an approach for wall collision avoidance using ultrasonic sensors on a quad rotor. An IMU data is needed for maintaining the stability of the aerial vehicle. The presented approach is designed for safety maneuvering a UAV through indoor and outdoor corridor.

Keywords: Dynamic Environment, Moving Target, Robot Motion Planning, Obstacles avoidance, Anti-collision. Collision detection, Collision avoidance by ultrasound sensor

ACKNOWLEDGEMENTS

1. INTRODUCTION

An unmanned aerial vehicle (UAV), commonly known as a drone and referred to as a Remotely Piloted Vehicle (RPV) by the International Civil Aviation Organization (ICAO), is an aircraft without a human pilot onboard. Its flight is controlled either autonomously by onboard computers or by the remote control of a pilot on the ground or in another vehicle. The typical launch and recovery method of an unmanned aircraft is by the function of an automatic system or an external operator on the ground.

Historically, UAVs were simple remotely piloted aircraft, but autonomous control is increasingly being employed. They are usually deployed for military and special operation applications, but also used in a small but growing number of civil applications, such as policing and firefighting, and nonmilitary security work, such as inspection of power or pipelines. UAVs are often preferred for missions that are too "dull, dirty or dangerous" operations instead of manned aircraft.

Fig 1.1 UAV

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The main aim of our project is to develop an anti-collision system for an aerial vehicle which can be used for real time application. A simple approach for obstacle detection and collision avoidance of a quad rotor both autonomous and remote control using a low cost ultrasonic sensors and micro controller.

1.2 COLLISION AVOIDANCE SYSTEM

A collision avoidance system is an system designed to reduce the severity of an accident. Also known as precrash system, collision warning system or collision mitigating system, it uses radar and sometimes laser and camera sensors to detect an imminent crash. Once the detection is done, these systems either provide a warning to the pilot when there is an imminent collision or take action autonomously.

Fig1.2 sensing the obstacle.

1.3 ULTRASONIC SENSORS

Ultrasonic sensors also known as transceivers as they both send and receive, but more generally called transducers. Its work on the principle similar to radar or sonar, which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively.

1.3.1 MAXSONAR LV EZ0 MB1010

The LV-MaxSonar-EZ0 is a great choice for use where sensitivity is needed along with side object rejection. The original LV-MaxSonar-EZ0 products were the first low cost, high quality ultrasonic distance sensors to offer easy to use outputs, no sensor dead zone, calibrated beam patterns, stable range readings, low power demands, and a host of other features. The LV-MaxSonar-EZ0 is our most popular indoor ultrasonic sensor and is a good, low-cost starting place for a customer not sure of which LV-MaxSonar-EZ0 sensor to use.

Fig 1.3 LV-MaxSonar-EZ0

1.3.1.1 FEATURES

- Continuously variable gain for beam control and side lobe suppression.
- Object detection includes zero range objects.
- 2.5V to 5.5V supply with 2mA typical current draw.
- Readings can occur up to every 50mS, (20-Hz rate).
- Free run operation can continually measure and output range information.
- Triggered operation provides the range reading as desired.
- All interfaces are active simultaneously.

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- Serial, 0 to Vcc, 9600Baud, 81N.
- Analog, (Vcc/512) / inch.
- Pulse width, (147µS/inch).
- Learns ring down pattern when commanded to start ranging.
- Designed for protected indoor environments.
- Sensor operates at 42 KHz.
- High output square wave sensor drive (double Vcc).

1.3.1.2.BENEFITS

- Very low cost.
- Reliable and stable range data.
- Lowest power ranger.
- Quality beam characteristics.
- Mounting holes provided on the circuit board.
- Very low power ranger, excellent for multiple sensor based systems.
- Can be triggered externally or internally.
- Fast measurement cycle.
- User can choose any of the three sensor outputs.

1.4. MICRO CONTROLLER

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems.

1.4.1 ATMEGA 328 PROCESSOR

The ATmega328 is a single chip micro-controller created by Atmel and belongs to the mega AVR series.it contains an on-board voltage regulator that accepts 7 – 18V and outputs 5V @ 1A. Optionally, power can be provided by the USB port when the FTDI adapter is plugged into the board. Be advised, you can damage the USB port if more than 500mA is drawn from it.
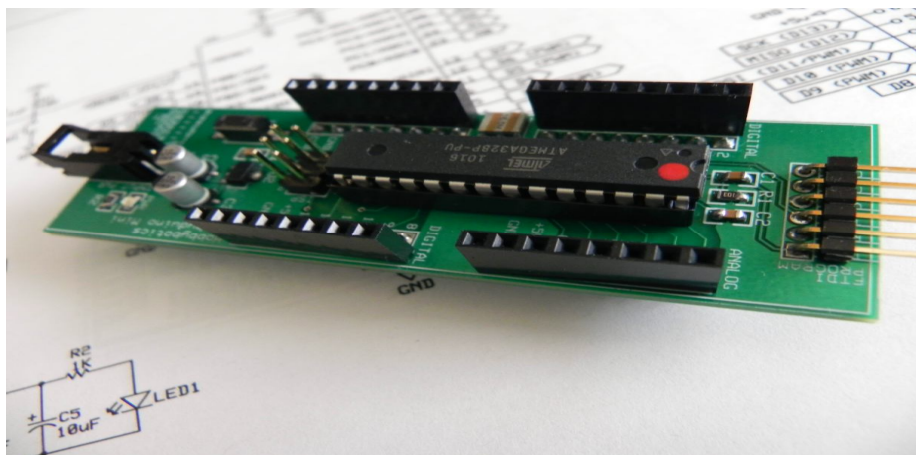

Fig1.4   AT mega 328 micro controller

1.4.2SPECIFICATION

- ATMega328 processor running at 5V.
- 16 MHz resonator.
- Input voltage 7-18V.
- Output voltage 5V @ 1A.
- USB or external power (requires FTDI adapter for USB power).
- Size: 1.1875W" x 3.5L".
- Designed to plug into a breadboard for easy prototyping.
- Configured for auto-reset after programming.
- Manual reset button.
- 6-pin ISP connector.

1.5.MOTIVATION FOR THE WORK

The motivation for doing this project was primarily an interest in undertaking a challenging project in an interesting area of research. The opportunity to learn about a new area of computing not covered in lectures was appealing. This area is possibly an area that I might study at postgraduate level.

The development of unmanned aerial systems (UAVs) is becoming a hot item in various industries due to their potential versatility and compactness in a variety of scenarios. UAVs can be utilized to gather intelligence, perform border patrol or even survey disaster areas. Most military 18 industries need UAVs for reconnaissance missions and require portable and dependable aircrafts with accurate target detection and tracking capabilities. Unfortunately, UAVs that accomplish such tasks tend to be mission specific and costly. Thus, one of the focuses in the UAV design for this project will be to design a high performance UAV at feasibly low cost when compared to current UAVs in the industry.

1.6.PROBLEM STATEMENT
Demonstrate an unmanned aerial vehicle flying autonomously without any collisions.

1.7.OBJECTIVE OF THE WORK
The main objective of my project is to develop a collision avoidance system for an unmanned aerial vehicle (UAV) using ultrasonic sensors.

1.8. ORGANIZATION OF THE THESIS
The rest of this document is organized as follows. Chapter 2 highlights significant related work, particularly in the areas of Collision Avoidance. In Chapter 3, about methodology process of sense and avoid and system. Chapter 4 describes the overview of AVR STUDIO software. In chapter 5, covers the modeling of SQADRON 2 by using design software. Finally in chapter 6 we discuss future directions of work and finally we conclude.

1.9.SUMMARY
The project is to develop an unmanned aerial vehicle to fly autonomously in indoor or cluttered environments like houses or urban canyons. The collision with obstacles is a major problem while flying under these environments and hence a collision avoidance system has to be installed. In this project obstacles are avoided using ultrasonic sensors. This method is a low cost, but efficient and simple when compared to other obstacle avoidance systems.

2. LITERATURE SURVEY

2.1 INTRODUCTION

A major challenge in designing intelligent vehicles capable of autonomous motion whether in air, water or land is a reliable collision avoidance system. Any mobile robot or vehicle needs an ability to perform reliable obstacle detection as well as have efficient and effective collision avoidance actuation ability when performing in an unknown or dynamic environment. Mobile robots and intelligent vehicles have recently been of great interest to commercial industries such as automotive and aircrafts industries as well as to the military. There has been a great amount of research devoted to the development of a reliable collision avoidance system.

2.2 PRIOR WORKS

In Laser Intensity-Based Obstacle Detection and Tracking by John A. Hancock, at 1999 works on Laser Intensity-Based Obstacle Detection and Tracking, John A. Hancock used a laser scanner for obstacle detection and tracking for vehicles traveling on highways. Pixels were classified as obstacle or non-obstacle in each line of data collected at each step by analyzing the returned intensity of the laser. Kalman filtering was used to estimate the position and variance of each obstacle's position. The focus of the paper was only on static obstacles detection and tracking. Collision avoidance algorithm is not attempted.

Kato, K., Ishiguro, H. and Barth, M. used Omni-directional vision cameras in their work involving multiple robots. These cameras enable the robots to localize and visualize one another. The robots have to detect and move in relation to other units in a cooperative system. Although both detection aspect and avoidance algorithm aspect are involved in this project, the system may need more alteration and adaptation to work in a dynamic and unknown environment where there may be many non-cooperative obstacles.

Lynne E. Parker, Kingsley Fregene, Yi Guo and Raj Madhavan used a pan-tilt-zoom (PTZ) camera for visual perception and a SICK scanning laser rangefinder for their outdoors autonomous mobile robots to operate in unfamiliar outdoors environments. For nearly all applications, the robots succeeded in avoiding navigation hazards. The work was thus focused on the development of the most efficient navigation path with collision avoidance in mind. Paths are preplanned and collision checks are then executed. If the scenario involves a time-space collision where the robots reach the same point at the same time, a dimensional coordination diagram (CD) is constructed and a free trajectory is searched and interpreted into a velocity profile for each robot. This velocity profile is actually the collision avoidance actions to be executed.

EllipsMasehian and yaldakatebi presents a new sensor-based online method for generating collision-free near-optimal paths for mobile robots pursuing a moving target amidst dynamic and static obstacles. At each iteration, first the set of all collision-free directions are calculated using velocity vectors of the robot relative to each obstacle and target, forming the Directive Circle (DC),In dynamic environments, for example in air, sea and land traffic, vehicular units

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need to avoid one another as well as static non-vehicular obstacles while moving towards their destination. EllipsMasehian and YaldaKatebi addressed the problem of motion planning in dynamic environments by presenting a method for computing the motions of a robot in dynamic environments, subjected to the robot dynamics and its actuator constraints. The main focus has been on two aspects:

(a) Time-optimal interception with a moving target

(b) Obstacle avoidance.

Key features of this approach are:

(1) It finds a safe path

(2) It incorporates simple geometric estimations on possible dead locks and local minima.

(3) It is practical in a real-time environment with various obstacles.   Another property of this method is the smoothness of the resulting trajectory. This method can be extended to multi-robot applications. Their concept is based on the Velocity Obstacle concept where a set off easible robot velocities that would result in a collision between the robot and obstacle is defined. This set of velocity is crucial because it will be from this set where the avoidance maneuver at a specific time is computed.

LINDSAY KLEEMAN and ROMAN KUC did a research investigating the optimal deployment of ultrasonic transducers and associated signal processing for indoor robotics applications, with environments composed of surfaces that can reflect acoustic energy similar to a mirror reflecting light. Their research established that two transmitters and receivers are necessary and sufficient to distinguish planes, corners and edges of obstacles. They provided an optimal sensor array with the minimum number of transmitter and receivers, with the receivers closely spaced to minimize the corresponding problem of associating different receiver echoes from multiple targets. The array harnessed the ultrasonic sensors to be applied in a robust and accurate manner for obstacle detection. However, their investigation involved a static sensor array, not implemented unto a mobile platform. Also, the performance is limited by physical properties of air, reflectors and noise .For the application of ultrasonic sensors, Borenstein and Korenvi developed a vector field

Histogram (VFH) to enable the detection of unknown obstacles and avoid collision while still enabling the robot to steer towards its destination. This VFH method uses a two-dimensional Cartesian histogram grid as a 'world model'. Range data sampled by on-board range sensors continually updates the 'world model'. The idea is to construct a polar histogram around the robot's momentary location and select the region of lowest polar obstacle density direction to steer the robot towards.

Albaker and Rahim (2011) introduced a new collision avoidance algorithm based on geometrical intersection method for the estimation of collision risk. When a potential conflict along the trajectory exists, the collision avoidance is activated to take the action of filtering the possible trajectories to avoid the conflict and the best option to consider based on optimization problem.

Van Dam et al defined the workspace key functions required by the airborne separation assistance tool. A geometrical approach, supporting free flight concept, is proposed for conflict avoidance without the need to communicate among the conflicting aircraft. The authors based on implicit coordination among aircraft in a shared airspace. Speed and heading travel functions is utilized as resolution maneuvers to clear incoming threats.

Hojjat Emami and Farnaz Derakhshan described a multiagent solution to aircraft conflict resolution based on satisficing game theory. This paper investigates a simple, conceptual and abstract conflict detection and resolution model based on the multi-agent system and PSO algorithm. This system uses two types of agents namely flight path controller agent (FPCA) and aircraft agent (AA), providing a proper balance between distributed and centralized authority in order to resolve aircraft conflicts. The proposed system can be used beside current air traffic management systems a key feature of the theory is that satisficing decision makers form their preferences by taking into consideration the preferences of others. The results in behavior is attractive both in terms of safety and performance. Mixed Integer Nonlinear Programming is also used as an optimization problem to solve traffic conflicts. However, this algorithm is hard to be extended to consider many maneuvering commands.

Bayen et al. presented an optimization approach using game theortical technique for controller design that covers moving obstacles. In this technique, a pursuer's trajectories are examined based on all possible plans and the evader seek for collision free paths those are not intersecting with pursuer's trajectories. Although it is interesting, it does not appear practical at present

Holdsworth deals the other optimized conflict resolution algorithms utilize techniques such as genetic algorithms, expert systems, or fuzzy control to the problem . These techniques may be complex and therefore would require a large number of rules to completely cover all possible encounter scenarios. This leads to demanding high computational processing power. Resulting in difficult to certify that the system will always operate as intended.

2.3 SUMMARY

From the above survey Pre-mission path planning is often formulated as an optimization problem and many different optimization problems can be applied. Path planning for UAVs is difficult problem because it requires the ability to create paths in environments containing obstacles or noflying zones. Additionally, UAVs are constrained by minimum turning radius, minimum speed, and maximum climb rate constraints. Generally, CAS algorithms are used to sparsely search the space for solutions and then the best solution is chosen.

3.METHODOLOGY

3.1. INTRODUCTION

An unmanned aerial vehicle (UAV), commonly known as a drone and also referred to as an unpiloted aerial vehicle and a remotely piloted aircraft (RPA).There are many different names for these aircraft. They are called as UAS (unpiloted air system), UAV (unpiloted aerial vehicle), RPAS (remote piloted aircraft systems) and model aircraft. It has also become popular to refer to them as drones. Their flight is controlled either autonomously by onboard computers or by the remote control of a pilot on the ground.

Ultrasonic sensors are also known as transceivers as they both send and receive, but more generally called transducers. They work on a principle similar to radar or sonar, which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Active ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object. Passive ultrasonic sensors are basically microphones that detect ultrasonic noise that is present under certain conditions.

3.2. SENSE AND WORK

The sensing function refers to the ability of the system to monitor the environment and collect appropriate current state information for encounters, e.g. aircraft position, velocity and heading, about the environment surrounding UAV. This is done through the utilization of active and passive sensors.

The main role of avoidance function is to evade from a possible collision. This function will be invoked after detection of a near future collision. It determines how and what action should be performed.

The detection function is the ability of the system to acquire the sensed data, process it to extract useful information and discover collision risks to the UAV. Whereas, awareness function is used to dynamically projects the states into the future to check whether a potential conflict will occur in the near future or not. It also extracts the collision parameters in case of a potential conflict detected. In addition, it handles the process, when action should be taken.
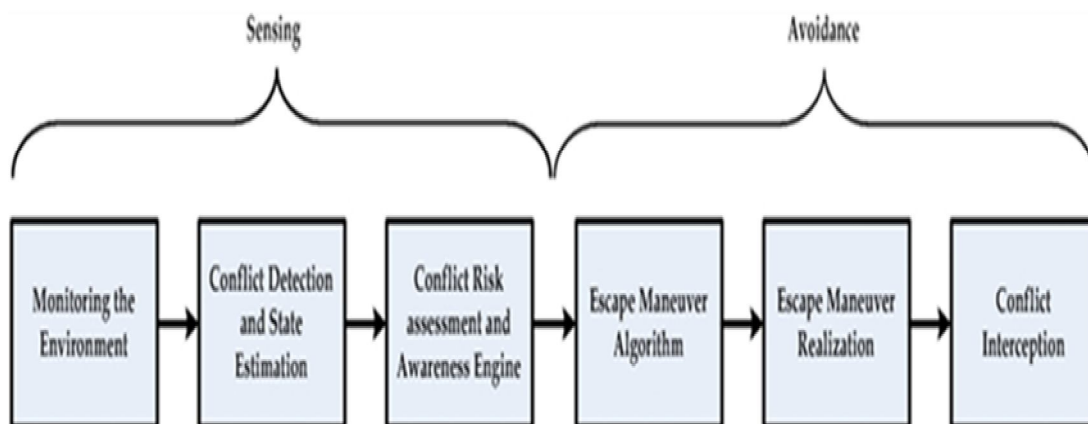

Fig [3.1] Process of Collision Avoidance System

We connect the max sonars with the microcontroller unit. The MCU is a pre-programmed one using AVR studio. After receiving the sound waves by the sensor, the distance of the obstacle will be measured. The measured values are then fed as input to the micro controller which will calculate the errors occurred during transmission and reception of sound waves. The microcontroller compensates the errors and feeds the data to the FCS.

3.3. SUMMARY

The use of navigation keeps the UAV to move from one point to another. It works efficiently when equipped with obstacle avoidance system. Moreover this navigation technique consumes very less power and uses very less equipment. Thus the use of this navigation reduces the overall system weight and enables it to be used in ultra-light aircrafts.

4. SOFTWARE AN OVERVIEW

4.1 INTRODUCTION

Computer software or simply software is any set of machine-readable instructions that directs a computer's processor to perform specific operations. Computer software contrasts with computer hardware, which is the physical component of computers. Computer hardware and software require each other and neither can be realistically used without the other. Computer software includes computer programs, libraries and their associated documentation. The word software is also sometimes used in a more narrow sense, meaning application software only.

At the lowest level, executable code consists of machine language instructions specific to an individual processor typically a CPU. A machine language consists of groups of binary values signifying processor instructions that change the state of the computer from its preceding state.

Software written in a machine language is known as "machine code". However, in practice, software is usually written in high-level programming languages that are easier and more efficient for humans to use than machine language.

High-level languages are translated, using compilation or interpretation or a combination of the two, into machine language. Software may also be written in a low-level assembly language, essentially, a vaguely mnemonic representation of a machine language using a natural language alphabet. Assembly language is translated into machine code using an assembler.

4.2 AVR STUDIO

AVR Studio was created by Atmel in order to help developers to create applications for AVR microcontrollers using C/C++ programming languages. This piece of software which allow the users to get familiar with the application. It provides the users with access to the tools for writing, building and debugging their codes.

AVR Studio is a Development Tool for the AT90S Series of AVR microcontrollers. AVR Studio enables the user to fully control execution of programs on the AT90S In-Circuit Emulator or built-in AVR Instruction Set Simulator. AVR Studio supports source level execution of Assembly programs assembled with the Atmel Corporation's AVR Assembler and C programs compiled with IAR Systems' ICCA90 C Compiler for the AVR microcontrollers. AVR Studio runs under Microsoft Windows95 and Microsoft Windows.

This application is easy-to-use and offers access to powerful tools for both beginners and experienced developers, making it easy for the users to find their way through C/C++ programming. Some of the key features are: "cycle correct" simulator with advanced debugging functionality, rich SDK that enables tight integration of customer plug-ins and compatibility with many Microsoft Visual Studio plug-in. Also the tool provides a "split window" button that allows the users to work on more than one project at a time.

4.3 Summary

The general purpose programming language is a programming language designee to be used for writing software in a wide variety of application domains. High level programming language is a programming language with strong abstraction from the details of the computer. In comparison with low level languages, it may use natural language elements which are easier to use,AVR Studio programming language is used in this project. It is a widely used general purpose high level programming language.

5. MODELLING

5.1 INTRODUCTION

In 3D computer graphics, 3D modeling is the process of developing a mathematical representation of any three-dimensional surface of an object (either inanimate or living) via specialized software. The product is called a 3D model. It can be displayed as a two-dimensional image through a process called 3D rendering or used in a computer simulation of physical phenomena.

The Squadron 2 structural design was drawn using CATIA. This software offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether

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started from scratch or from 2D sketches. CATIA is able to read and produce STEP format files for reverse engineering and surface reuse.

5.2 3D MODELING OF SQUADRON 2

3D models represent a 3D object using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc. Being a collection of data (points and other information), 3D models can be created by hand, algorithmically (procedural modeling), or scanned.

3D models are widely used anywhere in 3D graphics. Actually, their use predates the widespread use of 3D graphics on personal computers. Many computer games used pre-rendered images of 3D models as sprites before computers could render them in real-time.

Today, 3D models are used in a wide variety of fields. The engineering community uses them as designs of new devices, vehicles and structures as well as a host of other uses. We used 3D models as the basis for physical devices that are built with 3D printers and CNC machines.
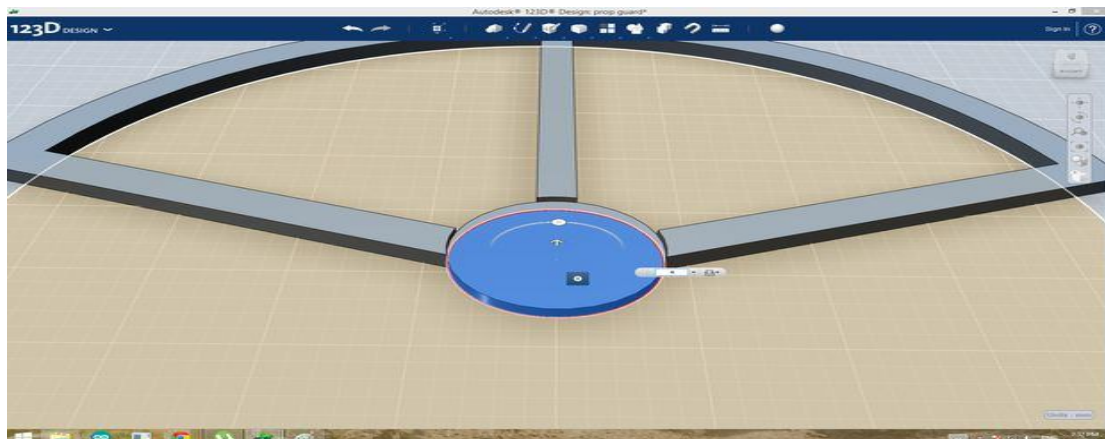

Fig 5.1 Over all structural design of SQUADRON 2
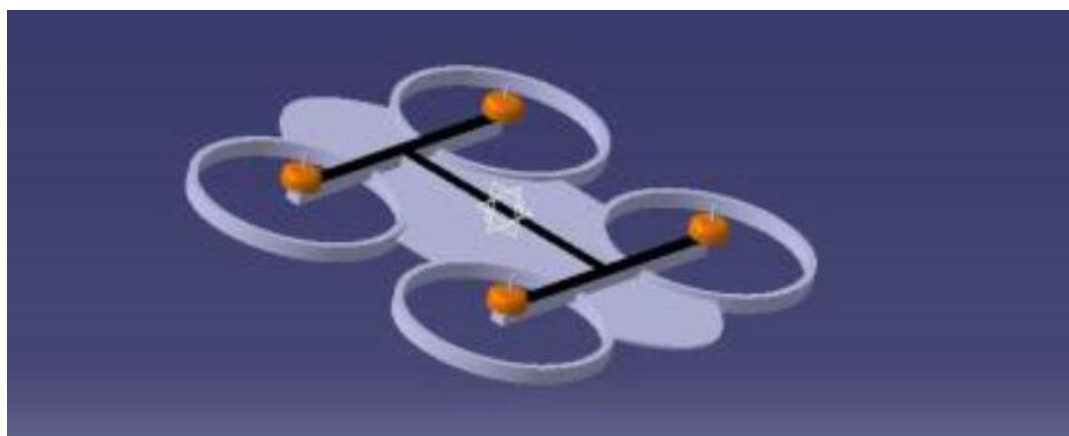

Fig 5.2 Design of Propeller Shield

Fig 5.3 SQUADRON 2 design with Propeller Shield

5.3 SUMMARY

The 3D modeling software enabled the creation of 3D parts, from 3D sketches, composites up to the definition of mechanical assemblies. The software provides advanced technologies for mechanical surfacing. It provides tools to complete product definition, including functional tolerances as well as kinematics definition.

The software provides a wide range of applications for tooling design, for both generic tooling and mold & die.

6.FUTURE ENHANCEMENT

6.1 INTRODUCTION

Future enhancement is that the work to be continued in the forthcoming phase in order to complete the project which is to be completed.

6.2 FUTURE WORKS

Phase one avoidance system was successful, however longer sensors range are necessary for faster flight as the obstacles would need to be detected sooner. Additionally flight testing of phase 1,collision avoidance showed that the sensors would either need to be gimbaled to determine distance to objects as the quad rotor titled. Lag in sensor data output through serial showed that the system would need more processing power. The future work includes completion of phase two avoidance bench and flight testing and makes the system as reliable as possible.

7.CONCLUSION

A quad rotor UAV is used as the research platform. Ultrasonic sensors are used for obstacle avoidance. The paper shows the use of cheaper commercial off-the-shelf sensors processor board in the design and implementation of obstacle avoidance algorithm.

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