Detection of an Explosive Material In Landmine, Aqueous And Air Medium Through Sensor Operated Unmanned Guided Vehicle

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Abstract: Various explosives and harmful materials are most dangerous for human beings; detection of such materials is growing concern with curiosity as well. This paper identifies the broad array of possible mediums of explosions. As it is very difficult to find explosive material which is hidden, saving the life of an individual or whole from chemical explosion is need for the safety of our nation. The study focuses on detection of explosives which works on landmine, water and air. Searching for an explosive material manually is difficult task for any person; hence an attempt has been made to fulfil the necessity of need to design such equipment which will help researcher and engineers to find the explosive material to save lives. This work intends to design the unmanned vehicle i.e. drone which will work under ground, water and in an air with remote control. The sensors are used to find the hidden explosion in various medium. To detect non-contact type metal object, proximity sensor is used. A clarification of the crucial investigation for each approach is joined by its overall appropriateness to the pertinent the relevant scientific findings.

1. Introduction

Terrorism is of the major concern in the world, because of the terrorist one cannot live their life with full of freedom and also in the communal zones or places there is fear to have any explosive in that areas and the bomb squad cannot reach to the explosive on time [2]. Inductive proximity sensors issued to find out metallic objects which are not contacted physically. Active principle is based on a coil and oscillator that generates an electromagnetic field in the nearby areas of the detecting surface. The existence of a metallic thing (actuator) in the functioning area causes a stifling of fluctuation generosity. The increase or tumble of such oscillation is predictable by a threshold circuit which vagaries the output of the sensor. The modules are selected from the variety of brushless motors, battery technologies and cell arrangements, and static area propellers appropriate to use in a four rotor suspended vehicle.

A quad copter is a floating vehicle where four rotors are used for lift, steering, and steadiness. Like other in-flight vehicles, a quad copter can attain upright flight in more steady form. There is no effect
by the torque concerns that a plane practices on focal rotor. Likewise because of quad copter’s persistent design, it is calmer to build and sustain.

In many areas like army, military engineers, scientists, used emerging Quad copters to apprehend various practical areas. They are used for scouting and gathering information [6]. It is having kind of finding for persistence fatalities in a catastrophe zone to check the condition of power lines. Quad copters in making today can hold light cargoes, such as foodstuff and medicinal supplies, and deliver where ordinary planes cannot reach easily.

2. Engineering Findings

2.1 Failure in handling Handheld Metal Detector:
There is a failure of handheld detector as it is having insufficient power supply, loose of connection of complicated circuit may happen and dicey mission to detect bomb by disposal person.

Scope of the Finding
- Modifications in design can be done so as to eradicate the intricate nature of the system.
- Use of higher range sensor and component for the sake of having inclusive range of detection capacity.
- Use of Camera and GPS module to find the location of bomb decorously.

2.2 Detection of Hidden explosive material

![Image of Land Mines detection](image)

**Figure 1** Land Mines detection

Finding of explosive material under land mine is possible due to AR drone [6]. Unknowingly human lose their life. AR drone is useful to capture the images from particular height and detect availability of explosive material.
3. Objectives of UAV:

i) The most important objective is to detect explosives with the help of explosive detect sensors and to achieve versatility of drone to work in different mediums such as air, under water and on land.

ii) It will be helpful to the police force, Navy and Defence and to raise the power of the nation to avoid terrorist presence thereby giving full liberty to people to live their life without fear.

iii) Cease to human corporeal from terrorist attacks.

iv) Find the exact location of explosive which are unseen and not detected certainly

4. Literature Review

To detect hidden explosive nanosensors are used with nanochemical sensors for achieving sensitivity and selectivity. These sensors are versatile in nature and they are based on receptor [2].

Finding of explosive expedients (IEDs) on the side of road is skirmish against terrorism. Localization and magnetic moment valuation of a static ferromagnetic IED by a PMAS. The PMPS combines more than 21 arrays of 3 axis fluxgate array. Nonlinear equation set is employed for framing the difficult by assuming magnetic dipole model of IED. The data is detected by sensor and these data that is localization and detection of IED is calculated by appropriate process magnetic dipole model and nonlinear optimization algorithm. The result obtained by numerical simulation displays the long baseline is useful to enlarge recognition area and the more revealing range is of 12m for group of 6 fluxgate sensors [3].

Applied analysis is done by AR drone which is used as an integrated tool. This tool is placid by AR drone quad rotor and base station for spotting the operation. After collection of data from onboard camera, algorithm is done for landmine detection. The system is collected the data averagely from landmine for outdoor state in three different constraints: flight speed, visibility of the object and flight altitude. Base on result it is decided that whether the explosive material are present or not on land [6].

The research is done on design of Quad copter. The modification is done on simple Quad copter. The frame is essential part because all other parts are mounted on that. To check whether the frame can sustain the load of vehicle or not, static analysis is done on that. A small deformation was occurred on plate but that is up to tolerable limit and design is safe for use. [7]
The rotor is used in searching hidden explosive and rescue operation. The rotor is used in unmanned aerial vehicle (UAV). Here Aerodynamic analysis is done on rotor. In rotor vehicle, fixed pitch propeller is used and to model the aerodynamics blade element and vortex theory was investigated combined. It is clear that the propeller can be suitably utilized for quad rotor UAV[11]

Study is focuses on robot working under water for explosion detection. Here mainly three types of superior wireless control systems are used for robot to operate under water. ZigBee communication is the first system, second system is light approach system and last one is magnetic field. ZigBee communication system is used to transmit and received the data. Data is provided to the ARM controller and depending upon nature of command the robot get operated [10].

This paper discusses experimental and numerical vibration analysis of a multirotor frame and application of the modal analysis technique on a multicopter chassis. Analysis of vibration is done on six arm multirotor. It focuses on experimental model analysis of structural components of hex copter frame. For analysis hit impact and shaker excitation is used. Very accurate and reliable result shows the balance between experimental and numerical work [19].

5. Architecture of the proposed work

The research is based on drone, working in three medium in air, under water and on land. The drones are available which are working in all three medium separately but combination is not available. The intention of work is to design single drone which can work in three medium. For this work initially literature review is done and what methodology they have adopted is understood. From study it is decided to work on finding hidden explosive from single drone in all medium. Experimentation is done by using different components and sensors like PID controller, wireless communication, Single controller etc. As a result of this the components are properly mounted on frame and after analysis it is found that the design of drone is safe and it successfully worked in all three medium to find explosive material.

6. Blades:

6.1 Directions of Rotation:

![Figure 3 Counter Clock Wise and Clock Wise Propellers.](image)

Number of Blades:
- As mention in figure 3, for mini quad copter, 3-blade (or tri-blade) propellers are normally used in racing as well as for free-style flying. The tri blades have more grips in the air.
- If more blades are used, the surface area added more and hence it creates larger thrust in expense of and more drag better current draw.
### Table 1 Selection of components

| Frame Size  | Prop Size | Motor Size                  | KV                |
|------------|-----------|-----------------------------|-------------------|
| 150mm or smaller | 3” or smaller | 1105 -1306 or smaller          | 3000KV or higher |
| 180mm      | 4”        | 1806                        | 2600KV - 3000KV  |
| 210mm      | 5”        | 2204-2208, 2306              | 2300KV-2600KV    |
| 250mm      | 6”        | 2204-2208, 2306              | 2000KV-2300KV    |
| 350mm      | 7”        | 2208                        | 1600KV           |
| 450mm      | 8”, 9”, 10” or larger | 2212 or larger              | 1000KV or lower  |

6.2 H–Type Frame:

For durability the aluminum frame is used with carbon fiber plate. To support motors, the frame is designed with many different configurations so that components can be mounted on that. The arms are prepared of consistent 5/8 inch aluminum bars which are hallow and square in size and customs mutual nuts and bolts to clamp the frame together.

- Length of Rod – 18cm
- Frame Type – H-Type Quadcopter
- Weight – 10 gm

6.3 Metal Touch Sensor:

There are three important components on circuit board of sensor. One module deals with the surrounding area and analog signals are sending to the second unit and amplifier. The amplifier magnifies the signals as per resistant value of potentiometer; signals are sending to analog output of component. Third module of sensor which acts as a comparator is used to switch on the digital output and LED.

7. Experimental Validation

7.1 UAV Quad copter

UAV Quad copter is having four rotating rotors which are used for movement and lift purpose. For stabilization it uses electronic control system and electronic sensors. [11]

7.1.1 Flight Control

Quad copter contains of four motors uniformly dispersed on frame of quad copter as shown in figure 4. The circular shape signifies the spinning rotors of quad copter and the arrows denote the direction of rotation [19]. First and third number motor rotates in a clockwise route by consuming pusher rotors. Second and fourth rotor rotates in an anti-clockwise direction with the help of puller rotors. All motor generates a thrust and torque around the centre of quad copter. Because of the reverse spinning orders of the motors, the clear torque about the centre of quad copter is preferably nil, creating nil angular acceleration. It removes the need of yaw stabilization.
An upright force is formed by growing the speed of all motors by a similar quantity of throttle. As the upright forces overwhelmed the gravitational forces of earth, the quad copter creates an upsurge in altitude. Figure 4 shows the vertical movement of the quad copter. As above, the rounds epitomize the spinning rotors, loftier arrows symbolize the path the rotors are spinning, and the black arrows epitomize the forces caused by the spinning rotors.

![Figure 4 Quad copter: Vertical thrust movement.](image)

The front or rear motor speed is increased or decreased which is given by pitch, result of this the Quad copter is turned along x-axis. Due to left and right motors the overall thrust is same as hovering, so only pitch angle acceleration is changed. In Figure 4 example of pitch movement of quad copter is given. If the speed of front motor goes down the forces produced by respective rotor are minimum than the forces produced by back rotor. These forces are indicated by blue arrows. The forces indicated by blue arrows are responsible to tip quad copter in forward direction and this movement indicated by red arrow.

![Figure 5 Gyroscopic motions in quad copter](image)

Due to high or low speed of left rotor and right motor roll is provided, this cause the quad copter turns along y axis. The back and front motors balanced the overall upright thrust as a result of this only roll angle get changed. In Figure 5 it is seen that if the speed of right motor decreases, the corresponding rotor creates less force as compared to left rotor. The blue arrows denoted the force created by right rotor. Because of this force, the tip of quad copter moves in right side which is denoted by red colour.
8. Design

- Length of rod = 18cm,
- Length of landing gears = 5.4cm

8.1 Frame

- Specifications:
  - Control board Size = 3.4*3.4cm
  - Thickness = 0.5cm
  - Arm:
    - Size = 8.4*0.5cm
    - Weight = 0.25 gm each
    - Thickness = 0.2
    - Outside corner hole = 1.5cm
    - Inside hole = 0.4cm

8.2 Electronic Speed Controller

According to battery Specification = 2200 mAh
The C rating is 30C
30C = 30 * 4 = 120 A
Safe current flow is 120 A.

8.3 frame size

Propeller size = n×m
Where, n = Diameter of propeller
m = Pitch of propeller
Propeller size = 9×4.5
Radius (R) = 4.5
X = 2.R
X = 2×4.5 = 9 cm

9. EXPERIMENTATION

9.1 Fundamentals of Aerodynamics:

![Fixed pitch propeller geometry](image)

If there are variation of β and c throughout the length of the radius, the angle of attack α is also varied. [11]
- Pitch angle β=blade angle
- Fixed pitch
- Propeller as ‘air screw
- P = 2πr tanβ
8

- \( P/D = \pi x \tan \beta \)
- \( X = r/R \)

9.2 Efficiency of the propeller and an Advance Ratio

The efficiency is represented as,

\[
\eta = \frac{V C_T}{nD C_P}
\]

Where, \( V = \) free stream fluid velocity = 8 m/s,
\( n = \) rotation per seconds = 150 rpm,
\( D = \) Diameter of Propeller = 0.09 m,
\( C_T = \) Coefficient of thrust = 0.06,
\( C_P = \) Coefficient of power = 0.05.

\( \eta = 71.11\% \)

The velocity ratio is also known as the advance ratio, \( J \)

\[
J = \frac{V}{n \ast D} = 0.59
\]

9.3 Results and Discussion

| Parameter               | Frame         | Propeller    |
|-------------------------|---------------|--------------|
| Analysis                | Structural    | Structural   |
| Load / Speed Applied    | 10 N          | 1480 rpm     |
| \( S_u \) for ABS       | 44 MPa        | 44 MPa       |
| Max equivalent stress   | 1.85 MPa      | 1.375 MPa    |

From above result, as the load increases the Stress is also increases on both frame and propeller.

10. Analysis of Frame:

10.1 Loading Condition FBD:

![Figure 7 Free Body Diagram of Frame.](image)

10.2 Total Deformation:

Maximum Deformation = 0.26753 mm
10.3 Maximum Combined Stress:
Maximum Combined Stress = 1.8505 MPa

10.4 Minimum Combined Stress:
Minimum Combined Stress = 1.8505 MPa

10.5 Total Bending Moment:
Maximum Bending Moment = 950N-mm
Minimum bending Moment = 0 N-mm
10.6 Modal Analysis:

Frequency due to inertia forces

\[ \omega = 2 \sqrt{\frac{K}{M}} \]

**Table 3 Modal Analysis.**

| Sr No. | MODE | FREQUENCY [Hz] |
|-------|------|----------------|
| 1     | 1    | 360.52         |
| 2     | 2    | 360.53         |
| 3     | 3    | 445.07         |
| 4     | 4    | 445.07         |
| 5     | 5    | 510.29         |
| 6     | 6    | 510.36         |

Excitation Frequencies Due to propeller

\[ \omega = \frac{2 \pi N}{60} \]
\[ \omega = \frac{2 \pi \times 1480}{60} \]
\[ \omega = 154.98 \text{ rad/sec} \]

\[ f_n = \frac{\omega}{2\pi} \]
\[ f_n = \frac{154.98}{2\pi} \]
\[ f_n = 24.66 \text{ Hz} \]

Since excitation frequency is less than frequency so resonance will not occur hence the system is safe.
10.7 Stress Analysis of Propeller:
Maximum Equivalent Stress: 1.375 N/mm²

![Stress Analysis of Propeller](image)

**Figure 13** Stress Analysis of Propeller.

11. Conclusion

In the conclusion, the present study demonstrates the design and analysis of the single unmanned vehicle i.e. drone which can work in water, underground and in air with remote control system. Various components are selected in such a way so that it can work in all three medium. All the components are tested, interface and verified. The sensors are used to find non-contact hidden explosion in various medium. Pitch, roll and yaw are carefully tuned with PID controller for proper stabilization. Wireless communication system is used to receive and transfer the data. Single controller is used to fly in air and drive on land in the drone so as to achieve the compactness of system. The frame is made with light material and analysis of frame is done for checking deformation, combined stress and bending. After experimentation it is observed that the system is safely design. The device showcases the potentialities of the drone to detect an explosive material in aqueous, air and water medium.

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