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Research paper

Aerial Landmine Detection

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Abstract

This paper aims at designing a quad copter which not only capable of detecting landmines but simultaneously has innumerable other applications, putting the feudal way of losing life at rest. The quad copter uses four brushless motors connected to the flight control microcontroller board through electronic speed control (ESC) module, which will provide the necessary thrust and greater maneuverability. The whole set up is remotely controlled by the help of NRF module and powered by 2200mAh 3s lipo battery. The quad copter consists of a mine detector sensor, wireless camera and detonation system all of which will in turn be connected to the Raspberry-pi for wireless control and processing. The camera provides the real time image to the raspberry pi which will do digital image processing on it and give out digitally enhanced images for edge detection making it easier for the user to detect the mines. Further it will also help in detecting surface mines present in water thus imparting twin benefit. In the detonation system, servo motors are used to open the gate of the box containing detonation material which fall on the mine to neutralize them.

Keywords: *quadcopter, image processing, sensors, remotely, landmine*

1. Introduction

There are around 100 million mines buried all over the world. Although these Mines are meant for wars however they eventually remain active even after warfare ends. Innocent civilians step on these landmines accidently, ravaging the land and killing or maiming them. Thereby to circumvent the damage to the environment and life, there is need to develop cost effective demining techniques. The goal of military demining is to clear a path for troop movement, in contrast the goal of humanitarian mining is to clear enough mines to permit unhindered civilian use of land.

The most common demining technique now days for mine detection are manual by using proders. The common approach to mine detection is prodding, rigid sticks of metal about 25 cm long, the de-miner scans the soil at a shallow angle of typically 30 degrees. Every time an object is hit using prodders, the contour is assessed indicating if the object is mine or not. There is always risk of stepping on the mine itself by the deminer.

2. Related Work

Nowadays, studies on mine detectors have attracted researchers and academia due to its sense of urgent requirement. One such application is provided in this research paper. This research covers different areas of design, control, detection and detonation Said Alvarado [2] have studied the design of a low cost quadcopter prototype intended as a research platform that allows the study of control algorithms for autonomous flight. The dynamics of this quadcopter were described with a mathematical model,and controlling of the Quadcopter. The prototype uses arduino uno microcontroller board to control quadcopter and all its sensors. Yuvaraj Ganesh have [3] described Mine detection using a surveillance drone is a modern conceptual prototype, which has been designed to detect landmines. The prototype developed helps us to detect a landmine using a flying drone. The prototype has a quad copter which has a mine detector mounted on it. These are extensively used in aiding this whole operation. C.L.Brown [1] has said about failure to keep pace with developments that made land mines more difficult to find .Here, techniques for the detection of buried objects using a metal detector are presented, evaluated and compared. C.L.Brown [1] has also suggested on the findings highlight a number of deficiencies.

3. System Architecture

The figure 1 shows the block diagram of proposed system which comprises of Raspberry Pi 3 (operating on Ubuntu), camera(for live feed) , metal detector Sensor ,ultrasonic Sensor , ball dropping mechanism . The proposed system will not only detect mines but also help in their detonation and all of the above systems is incorporated onto a quadcopter. The quadcopter will be controlled remotely.

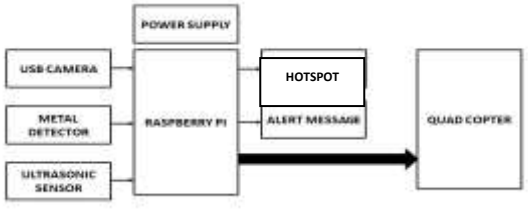

Fig. 1: Flow Chart of aerial landmine detection

The quadcopter is incorporated with a landmine detection sensors, a camera and a detonation mechanism. Quadcopter uses four BLDC (Brushless DC Electric) motors which will be connected to their own ESC (Electronic Speed Control). All the ESCs will be intern connected to a single KK board which consist of built-in gyroscope sensor and accelerometer. Hence, it will help in balancing the quadcopter. The payload capacity of quadcopter will be 600 grams approximately. The camera will provide the real time video output. The real time feed of this is digitally processed which is visible to the user will aid in detection of not only landmines but also surface mines in water terrain. As the Landmine Detector passes on the mine field, the ultra-sonic sensor will keep on measuring the variation in the terrain. It will send the data to raspberry pi3 which can be viewed in the real time. Landmine detection sensor will work on the principle of colpitts oscillator. It consists of a LC resonance tank circuit made of 2 series capacitors connected parallel to an inductor. The change in the resonance frequency because of mine leads to ramification of current which in turn is detected by the circuit. The detonation box will contain the detonation material, for example RDX. As and when the mine is detected, on command, the gate of the detonation box will open, thereby dropping the detonation material on the mine.

4. Detection Methods

4.1. Digital Image Processing

The camera will capture the video and send it to the Raspberry module for processing using OpenCV Python. Python program will conceptualise the image for processing. The image will be converted into greyscale image for ease of processing. Then greyscale image will be used for detection of edges. Open CV libraries of python are used for the above. The displayed processed image is that of laplacian and sobel processed image. The Laplacian operator is used to calculate the derivative of a matrix. In order to calculate a Laplacian, derivatives of Sobel needed to be calculated first, each of which takes into account the
gradient variations in a certain direction: one horizontal (sobelx), the other vertical (sobely).

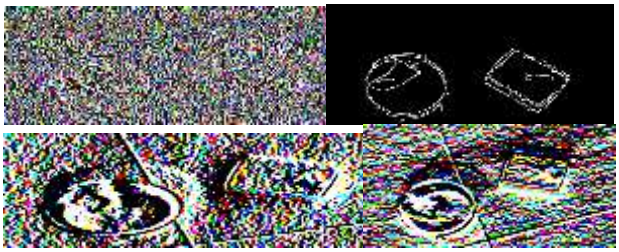

Fig 2: Object detection on water bowl and sand box i) Edges ii) Laplacian iii) Soby iv) Sobex

4.2. Sensors

There are two types of sensors one is Colpitts oscillator sensor and Ultra-sonic sensor.
Colpitts Oscillator: Mine detection using a colpitts oscillator. It uses two capacitors (C1 and C2 of values 220pF and 270 pF respectively) in series and an inductor connected in parallel. The resonance frequency of oscillation is determined by using the value of the capacitance and inductance. Whenever the power is given the two capacitors charges, and after the charge is full , discharging begins through inductor, thereby producing dammed harmonic oscillations. Because of this, AC voltage is produced across the capacitor. When the capacitor gets fully discharged, the energy gets transferred through the inductor in the form of magnetic flux. Whenever a metal is brought close to the inductor, electromotive force are induced in the coil due to Faraday's law (due to change in magnetic flux) With the help of resistors, capacitors, transistors, diodes etc. closed to design the circuit for colpitts oscillator metal detector.
Ultra-sonic sensor: It works on the principle of sound waves. Ultra-sonic sensor consists of a transmitter and a receiver. The transmitter transmits the ultrasonic sound. The sound wave move in straight line and gets reflected back by an object in its path. These reflected waves are received by the receiver and distance is calculated on the basis of the time taken for the wave to propagate and return.

5. Methodology

The quad-copter will be embedded with sensors, camera and detonation mechanism. The whole detection process is divided into two parts.
The first is image processing. When the quad copter passes over a field of mine the camera is used to detect land and surface mines. The camera captures the real time video, this video is processed in the raspberry pi which conceptualise the stream. The video captured is converted in the grey scale format. The grey scale image is digitally processed by with various image filters. As a result, different image outputs such as, Laplacian, Sobelx, Sobely and Edge detection Hue saturation are obtained. The representation of digital image is done using matrix that stores RGB/BGR/HSV (whichever colour space the image belongs to) value of each pixel in rows and columns. Hence, together these processed images will not only aid in the detection of the landmines but also in the detection of surface mines or the mines that get dropped into small water patches on the land.
The second part is confirmation of the mine. Now, the metal detection sensor and Ultra sonic sensor are used to confirm whether the object is a mine or not. While using the sensor at an angle on sand surface, it gives some absurd value (very high), as the sound waves from the sensor gets scattered. But while using it on a metal surface, it gives a finite value.
Metal Detector Sensor-The following figures are of the sensor design for metal detector. The sensor works on the principle of the Colpitt's oscillator, it consists of two capacitors and an inductor, connected parallel to each other. This causes the generation of magnetic flux in the inductor coil. Whenever a mine comes close to the coil, there is a change in the resonant frequency. This change in frequency is detected in form of current by the voltage. It uses combination of transistors diodes resistors for detection stage. The signal generated by the oscillator is rectified and fed to the transistor. Another Transistor is used is used to drive the Buzzer and LED. Therefore when a metallic object is brought close to the coil the LED glows and buzzer produces sound. The confirmation message can be seen in the Raspberry pi viewer.

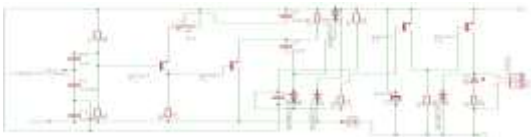

Fig. 3: Schematic of sensor

Fig. 4: PCB board design of sensor

After the detection of the mine, the command is given to the detonation box to drop the detonation object on the mine. The gate of the detonation box is controlled by a servo-motor. Once the command is given, the servo motors will open the gate of the box, allowing the content of the box to fall on the mine. There by, detonating the mine. Quadcopter-The detection of mines is always a risky task for anyone. To circumvent this, we employ a surveillance drone, which can be facilitated from safe distance. A quadcopter is used for the purpose of surveillance drone. The landmine detectors and camera with raspberry pi were mounted on the quadcopter, which is built using four brushless DC motor, ESC, KK controller and T6 configure transmitter and receiver. The chassis design used here puts a constraint on the quadcopter which could be carried weight up to around 1 kilograms.

Fig5: Quadcopter design with hardware installed a) Top view b) Side view

Coding and Controlling- All the coding related to detection and detonation of the mine is done on Raspberry Pi 3. The proper codes are written for video processing on Python using OpenCV libraries as well as for the operation and output of Ultrasonic sensor and metal detector sensor. The servo motor for the detonation box is also operated through code of python on Raspberry pi.

6. Results

Fig.5: Land Terrain with different filters of image processing

Canny ii) Sobely iii) Hue Saturation iv) Laplacian v) Sobelx vi) Hue Saturation with different mask.

6.1. Land Terrain

For identifying one of the best image processing filters for a specific terrain , various form of filters are used as shown in fig. 5. In land terrain, sand particles, granules etc. are present so the surrounding factors for image processing get changed for each filter.

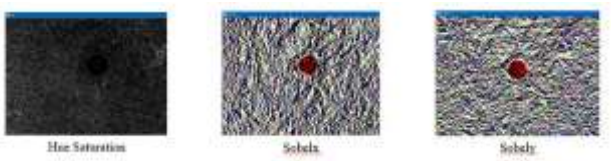

Fig.6: Best Results for Land Terrain i) Hue Saturation with different mask ii) Sobelx iii) Sobely

- Sobelx and sobely filters are best for detection in desert soil as it can be seen aesthetically.
- However, the do not work in gravel sand terrain. For that hue saturation is the best.

Fig.7: Water Terrain with different filtersrmat of image processing i) Canny ii) Sobely iii) Hue Saturation iv) Laplacian v) Sobelx vi) Hue Saturation.

6.2. Water Terrain

Unlike land terrain, the parameters are totally different and so is the output of various filters.

Fig.8: Best Results for Water Terrain Canny filter

- Canny edge detection is the best for detection of surface mines in water terrain as it forms the edges of the mine. In other filters, it is difficult to detect dark coloured mines.

6.3. Ultrasonic Sensor

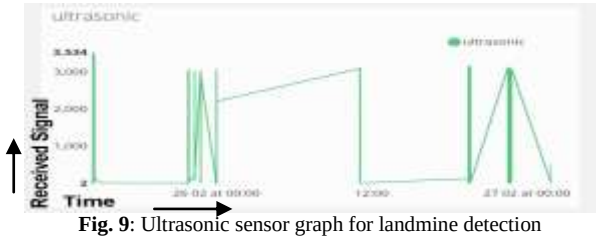

Fig. 9: Ultrasonic sensor graph for landmine detection

As shown in figure. 9, graph is between received signal delay and time. In the graph, there is absurdly high values of more than 2000cm which depicts the scattering of wave by sand. It also, at certain time, gives a finite value of 2 cm which depicts that a metal surface is found. Transition from finite to high value is also shown which explains the change of surface texture.

Fig.10: Ultrasonic sensor reading on mobile for landmine

6.4. Detonation Mechanism

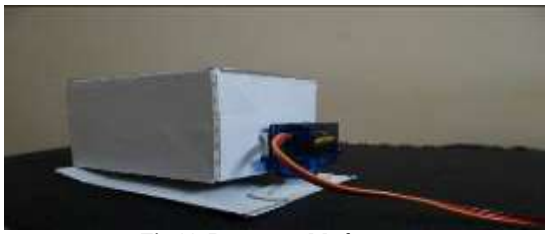

Fig.11: Detonation Mechanism

In the above figure.11. The above detonation mechanism was constructed using servo motor. When operated, the servo motor opens the gate of the box and let the detonation material fall on the mine.

7. Future Work

The Colpitts Oscillator Circuit can be made more sensitive to the changing Magnetic Flux. It can be compared to a Reference Voltage and any miniscule change in the current can be detected using IOT. Hybrid Blimp can be used instead of quadcopter as it will provide more stability. We can implement Artificial Intelligence which will even further reduce the effort as AI is based on self-learning process and ultimately make it fully autonomous.

8. Conclusion

The objective is to identify the land mines using sensor and digital image processing integrated in a quadcopter and simultaneously neutralise them was successfully achieved and hence in future if this technology is provided to army soldiers then it will surely ensure their safety . This will also escalate in the advancement of defence system and will strengthen the defence of the country.

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