Design Of Surveillance Drone With X-ray Camera, IR Camera And Metal Detector

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***Abstract*—** Today the crucial need of the world is to counter terrorism through different ways. This paper presents a design of a special drone that has been infused with features like detecting metal, tracing its location through global positioning system (GPS) and making video of its target through two dimensional rotational cameras. It has special cameras like Infrared (IR) and X-ray cameras. It also has an additional feature of controlled shooting once the target is identified. The proposed solution achieves promising results especially in mass gatherings e.g. concerts, games, religious gatherings, etc. and is also cost effective as compared to existing solutions presented in the literature.

Keywords— Drone; Infrared Camera; X-ray Camera; GPS; Raspberry pi 3; Metal detector.

I. INTRODUCTION

We are living in an era in which terrorism is most horrifying aspect of the modern world. The whole world is suffering from large number of causalities due to terrorism. The reported number of causalities has been increased from under 10,000 to over 30,000 all over the world in 2016 as compared to 2015 [1,2]. In Pakistan, which is considered to be dangerously affected by terrorism from 2003 to 2017, the number of causalities is over 61,847 [3]. Furthermore, terrorism has jolted the economy of the world. The cost of terrorism the world has paid is $52.9 billion in 2014, the highest since 2001 [4].

The main target of the terrorist is public. Their common ways of attacking (in the recent years) are through suicide attacks, bombs placed in bags and some armed persons in public gatherings. Landmines, suicide bombers, suspicious bags, cars and armed persons are difficult to detect especially in crowded areas. In addition, once the suicide bomber is identified, it is difficult to catch him without blast which cost human lives. Although, the technology has contributed a lot in reducing the chances of terrorism but still there are the dark areas where either man power or special robotic car [5] is required to sort out the issue of surveillance. This costs human life or loss of big money (Robot loss) in case of blast during surveillance. Secondly, these methods [5-12] are not trustable as they do not have all modern aspects of surveillance.

Previously mainly work has been done on developing robotic vehicles which determined the presence of bomb or the explosive materials but they have some limitations with maximum chances of robot loss. In [8-11], work has also been done in the field of Ariel vehicle such as a quadcopter with metal detector or with Geiger counter but none of them supports real time processing and many of them did not include all aspects of modern surveillance. Technology needs to be revolutionized at that point. Therefore, a practical solution is proposed which is not only cost effective but is safe and precise and it includes all modern aspect of surveillance at your hand. This particular solution includes a metal detector mounted on an Ariel vehicle to check for any heavy metal in its proximity range. On the receiving end, an android mobile phone is used which is connected to the device through Bluetooth or Wireless Fidelity (Wi-Fi). An android application is installed on the phone with multiple features such as to control the drone in air and to display the results on the screen. It also displays the video of the target with the options of X-ray imaging and the location of drone through Global Positioning System (GPS). Upon detecting metal, a red spot is shown and a it gives a specific tone to inform the user about the presence of metal. An appropriate action can be performed by the user after that series of options available to the user which are displayed on the phone screen. To the best of our knowledge, no work has been done to identify suicide bomber, any suspicious bag and armed persons through Ariel vehicle especially in mast gatherings and to target the suspect. The contribution of this paper are summarized as follows:

- We propose metal detection through Ariel vehicle (Quad-copter) which has features of (i) wireless connectivity via Bluetooth or Wi-Fi, (ii) live video streaming through 2D rotational camera (vertically and horizontally) which can do the X-ray imaging and X-ray mode enables better view of solid object

and explosive material and guns can be easily detected.

- The most unique thing of this system is basically the real time processing which is mandatory in extreme situation. The system also enables us to use the device without need of any expertise.

- It has additional feature of controlled shooting once the suspect has been identified which has not been reported in the existing literature.

The organization of the remainder of the paper is as follows. In Section II, we present system model, transmitter and receiver components are discussed in Sections III & IV, respectively. Results are illustrated in Section V, and, finally conclusions are drawn in Section VI.

II. System Model

The system model is basically divided into two parts, the transmitter part and the receiver part. The proposed system has all modern features for surveillance. In the case of mines and buried metallic objects metal detector is used with Infrared camera. Upon finding a metal, a signal from the metal detector circuit is generated and sent to the raspberry pi 3 module. The module in turn sends the signal to the mobile. It is basically the receiver's part and connected to the raspberry pi 3 through Bluetooth. The application which is designed to locate the drone and display the live video streaming through the normal camera is available on the module. The application recognizes the signal. It displays red spot about the location of the drone on map and generates specific tone. While in case of surveillance of a public crowd or any specified area drones uses infrared camera and metal detector to locate bomb. If a suspicious object or person is found, it repeats the above mentioned process and switches X-ray camera to investigate the target. Figure 1 illustrate the system with mobile on the left side and transmitter mounted on the drone on right side.

The transmitter is mounted on the quad-copter. It has two basic parts, metal detector [13-15] and raspberry-pi 3 modules.

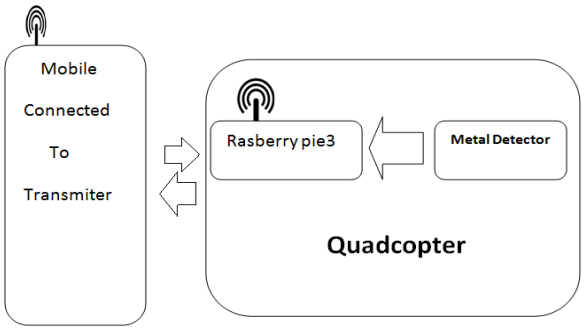

Figure 1. Proposed System Architecture.

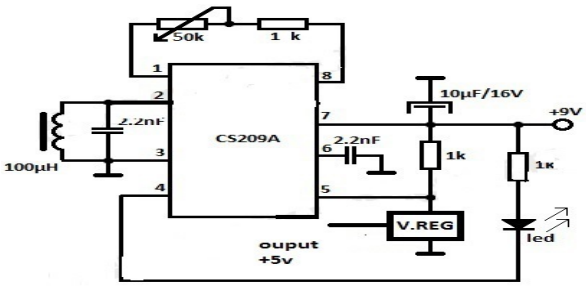

Figure 2. Metal Detector Circuitry.

III. Transmitter Components

A. Metal Detector

The circuitry of metal detector includes proximity sensor IC CS-209A.The coil used in this case is 100 Micro-Henry (uH) and it weighs 60 grams (g). The wire used is 0.4 millimeter (mm) in diameter and number of turns are 50. The coil works on the principal of electromagnetism. A little disturbance in the magnetism of coil due metal triggers the proximity sensor. The overall weight of circuit is around 100 g. The coil is joined to light aluminum rod which is further connected to motor through gears to drop or pick the coil up and down respectively. Which is used to detect mines and buried metals. The circuit is capable of detecting the metals weigh more than 500 g from 0.4 meter (m) distance (height). But it has adjustable sensitivity and range(height). Heavy metal can be easily detected from larger distance. Their value depends upon the value of pull up resistor and variable resister as well. The inside of the coil and drone motors are completely insulated to avoid any changes in the flux. This is done because aluminum rod or any other metal used inside the quadcopter can change the flux. The initial output of the circuit is 9 volts (v) from the pin 5 of CS-209A but we need 5v output to trigger the raspberry pi 3 module at the General Input Output Pin. To do so, we use a voltage regulator IC LM-7805. The basic circuit of metal detector is shown in figure 2.

B. Raspberry Pie-3 Module

The output from the metal detector is connected to a raspberry-pie 3 module which triggers raspberry-pie 3 module. The other modules like IR camera and X-ray camera are also connected to raspberry pi 3. The raspberry-pie 3 module gives direct connectivity with mobile through Bluetooth 4.0. The processing speed of a raspberry-pie 3 module is 1.2 Giga-Hertz (GHz) which is much effective compared to other devices used in previous works and is very good for real time processing. The device also can be used for image processing for additional feature of controlled shooting once the suspect has been identified which has not been reported in the existing literature**.** The weight of this raspberry pi 3 is around 42 g. Moreover, this module has also the feature of Wi-Fi connectivity which is important if range is required to increase. Module can be seen in figure 3.

C. Infra-Red and Digital X-ray Cameras

Overall the drone is equipped with two type of cameras, infrared and X-ray cameras.

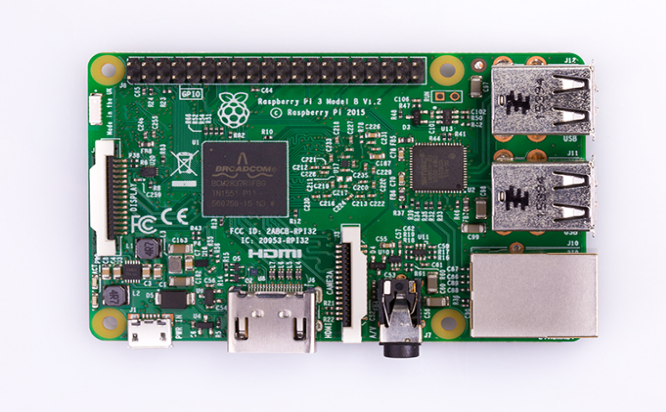

Figure 3. Raspberry Pi 3 Module.

Infrared improves the working of drone as it has modes like night-vision and thermal imaging. To detect the hidden explosive material or gun, x-ray camera is used which is directly connected to raspberry pi 3 module through the Ethernet port available on it. The camera used is iRayA6(ADX6000) [16] .It weighs 3.6 Kilo-grams (kg) and has following features like rechargeable Li-polymer battery pack, variable power settings from 1 mili-amperes (mA) to 5 mA and from 50 kilo-volts (kV) to 80 kV, attachable 8" x 10" flat panel detector, digital sensor, intraoral camera which works with any other radiographic medium; film, digital sensors, color touch screen display with built in image processing that allows live viewing and handling, internal memory storage for over 1000 X-ray images.

D. GPS Module

The GPS module (u-Blox NEO-6M) is also attached with the same circuitry. The figure of the circuitry of GPS and raspberry-pi 3 is shown in figure 6. Raspberry-pi 3 uses serial communication universal asynchronous receiver/transmitter(UART), and the GPS module itself acts like a system-on-a-chip. So it is a separate system by itself, automatically boot and perform its function upon powering it. Thus, no specific driver required to use the module. Operating system will automatically recognize the GPS module as a serial device after connection.

Figure 4. X-ray Camera Module.

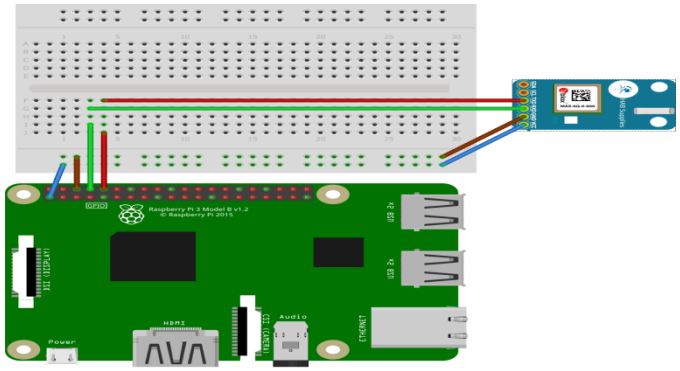

Figure 5. GPS Module Circuitry.

IV. DRONE

The drone used id basically a DJI-S1000+ hexacopter [17]. It has capacity to lift 6-11 kg. It is basically a digital single-lens reflex camera(DSLR) camera lifter drone. In our case the total weight is around 4kg without drone weight. The other specifications are it is weighing approximately 4.4kg with a maximum takeoff weight of about 11kg, the S1000+ can easily carry equipment such as the Zenmuse gimbal systems and a set of shooting equipment. Used with a 6S 15000mili ampere hour (mAh) with battery timing of 15 minutes. The gimbal is placed low on the frame on a specifically designed bracket. When it is merged with retractable landing gear, one will have very wide range of possible shooting angles. The gimbal and battery are framed to the same bracket, with dampers placed between the bracket and the frame. This appreciably reduces high-frequency vibrations and makes shots clearer and sharper. The battery tray's position also makes it more stable and appropriate for mounting and dismounting. The drone is shown in figure 6.

Figure 6. DJI S1000+

V. Receiver Module

The receiver module is any android mobile phone with reasonable processing speed and a pre-developed application for the proposed system. The application includes all aspects of GPS, video/snapshots options and controlling of quad-copter and the mode of camera, i.e., rotation and zooming options. The application displays the GPS position of a device on the map in small window and video streaming in large window. Upon finding the heavy metal, a red spot is displayed on the map with a tone and appropriate options are available to the user. The user can use the available options in his own way to examine the area. The device is connected to mobile through Bluetooth 4.0. The raspberry pie 3 module provides very good range of connectivity with better results. The connectivity and quality of video depends upon the user mobile specifications as well.

VI. Results

The proposed system is tested under different scenarios with different explosive materials. At first, the proposed system is successfully tested on a mass gathering. For testing purpose a man with explosive material is sent in the crowded area, i.e., football match. The drone is taken to a reasonable height. The drone is flown through this area and the suspected man is successfully detected by the metal detector. Accordingly, a signal is initiated. When the mobile application reads the specific signal sent by the transmitter module, it displays a red spot on map showing the position of device through GPS. It also produces a specific sound. The application also displays the available options to the user so that the user can use appropriate action like taking snapshot of the suspect and sent the details to the remote control room. Once suspect is identified, soft X-ray camera is used for final confirmation. The results clearly show the presence of explosive. In addition, a suspected man can be shooted if necessary. Here the important point to note is that metal detector is set to detect metals weighs more than 500 g and at a height of 0.4m. Moreover, the range(height) and sensitivity is adjustable. Secondly it looks like a DSLR camera holder drone so it does its work secretly. The result obtained from the X-ray camera is shown in figure 7.

In the second scenario, the proposed system is tested to detect the buried mines. The drone again taken to reasonable height but here coil is dropped using aluminium rods. When drone is flown over the target area, the metal detector successfully detected the buried mines at a reasonable height. Here one can also adjust the sensitivity as per use.

In the third scenario, a C4 explosives are placed in a car. When drone passed over the target car, the X-ray camera detected the explosive material as shown in figure 8. Here initially infrared is used and after suspicious object detection X-ray camera is used and important point to note that is metal detector is not deployed in this case because cars are made up of heavy metals and it effects the surveillance process through metal detector. So, the it depends upon application to which feature for surveillance.

Figure 7. Man wearing explosive jacket.

For safety purpose, the X-rays are not directly used. X-ray camera is only used for confirmation after the detection of suspicious object through metal detector otherwise a live IR video camera is used available on the drone. Comparison of normal and X-ray imagining is shown in figure 9.

It is worth highlighting that, the same cost effective proposed system can also be used to detect natural solid resources like gold, aluminum, copper, etc. We strongly believe that the desired results can be obtained by using the proposed system

VII. Conclusion

Today the basic demand of the world is to reduce terrorism by different ways. Every country is trying to keep its citizens safe. A number of revolutionary measures are already done for surveillance by the authorities. Firstly, general metal detectors are used to detect explosive materials. After that, the technology is shifted to the robotic cars which not only detect but also defuse the bomb and lastly, the Ariel vehicles (drones) are used. The previous work on this type of Ariel vehicle had many problems. None of them had all modern aspects of surveillance.

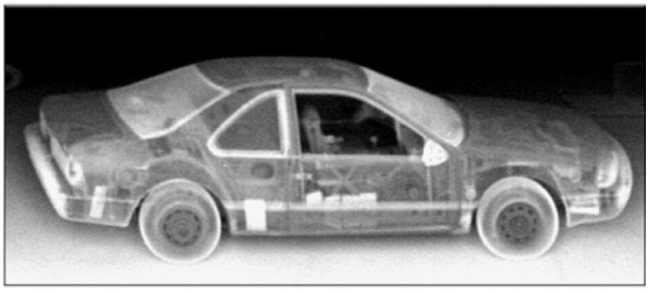

Figure 8. Explosive planted in car.

Figure 9. Comparison between normal and X-ray imaging.

Some of them have technology that will cause failure in extreme conditions like in case where Geiger counter is used, the chances of finding bomb is least and it is not a practical solution.

The practical solution to find a bomb or explosive material is through the metal detector because landmines, guns and explosive jackets posses heavy metals in large amount as compared to gunpowder to create large impact. Secondly, it is the cheapest and effective method all over the world. Therefore, we proposed practical system (use of metal detector via Ariel vehicle) to detect bomb, explosive materials and armed persons and get desired results in various scenarios. Secondly it looks like DSLR camera drone so, secrecy remains there. The use of raspberry-pi 3 provides more speed and gives direct connectivity with mobile and with multiple options like through Wi-Fi direct and internet through Wi-Fi. It is providing real time processing which is also ignored in the previous works. Moreover, the development of smart mobile application makes it easy to handle with no expertise needed. It basically provides surveillance at your hand and in no time. Lastly, once the target is identified, the controlled shooting option is also available in proposed system. The same option is also not available in the previous works.

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