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Detection and Surveillance of UAVs Based on RF and Radar Technology

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Abstract - *Unmanned Ariel Vehicles (UAVs) popular among them are drones. Drones are used widely in many areas such as imaging, payload delivery, and recently amidst COVID-19 pandemic, for contactless delivery of medicines. Every technology has its pros and cons, while drones are being used for many useful purposes; they also pose a threat to personal privacy and national security. Therefore, it is of a great significance to deploy anti-drone system in a security sensitive area. So, we have developed a system using RF and Radar technology which aims in detecting the entry of an unauthorized UAV into the restricted area. The system has been designed in such a way that there are multiple checks to detect the presence of a drone. The drone detection unit makes use of a Radar sensor, RF Analyzer and an optical camera. Positive response is mandatory from all the three sensors in order to confirm that an unauthorized UAV has entered the restricted area.*

Key Words: Unmanned Ariel Vehicles (UAVs), Anti-Drone System, Radar Sensor, RF Analyzer, Optical Camera, etc.

1. INTRODUCTION

Drones, usually known as small Unmanned Ariel Vehicles (UAVs), are experiencing explosive growth nowadays, and they have been widely used in many areas such as aerial photography, traffic monitoring, disaster monitoring etc. In the past several years, India has been seeing more use of drones or UAVs for various civilian and military purposes.

As a result of continuous cost reduction and device miniaturization, small UAVs are now more easily accessible to the public, and thus has increased the use of UAVs, better known as drones by civilians. Its use has grown exponentially and its autonomous flight control systems have improved significantly, which has resulted in a greater number of accidents and dangerous situations. Consequently, numerous new applications in the civilian and commercial domains have emerged. However, despite regulations, non-cooperative UAVs have started to abuse low- altitude airspace with potential security and safety problems and poses threats to personal privacy and public security. Therefore, it is of a great significance to bring regulation for the drone flight and to deploy anti-drone system in a security sensitive area. Such an anti-drone system is able to detect when an UAV flies into the sensitive area.

The main motive of this project is the detection of the UAVs in the security sensitive areas. To realize the detection, we use RADAR Technology which detects the entry of an unwanted UAV into the area. RF surveillance is used to detect the presence of RF signals in the area which confirms the communication between the UAV and its controller. Video surveillance which detects the motion of any object is also used as to fully confirm the presence of the unauthorized UAV. The combination of all these surveillance systems together forms the drone detection system.

2. SURVEILLANCE TECHNOLOGIES

RADAR: Radar is a useful tool for detection and tracking of large aircraft, but it faces severe challenges in detecting and tracking drones, since drones have a low radar cross-section and usually fly at low speed and low altitude. Even so, radar surveillance is promising in detecting and tracking drones. Radar is one kind of active sensor that operates all day and night with high electromagnetic energy. It has been verified that by analyzing the micro-Doppler signatures obtained by multi-static radar, clutter/target discrimination can be improved, which enables drone detection and tracking with high accuracy. In this work we have used RCWL0516 Radar sensor for obstacle detection, it is a microwave distance sensor which uses microwave frequencies of a doppler radar. The RCWL0516 chip processes the signal and outputs an analog voltage which is proportional to distance between the object and sensor. It is an alternative of PIR sensor, which also detects the movement within its detection range. The Radar sensor RCWL0516 has a range of up-to 7meters, supply voltage of 4-28V and operating frequency of 3.2GHz.

RF Analyzer: Here we have used NRF24L01 which is a wireless transceiver module meaning each module can both send as well as receive data. In addition, it has PA (Power Amplifier) /LNA (Low Noise Amplifier) where PA boosts power of signal being transmitted and LNA takes extremely weak and uncertain signals from antenna and amplify it. They are designed and operated in the frequency of 2.4GHz, which falls under the ISM band and hence it is legal to use in almost all countries for engineering applications. It uses GFSK (Gaussian frequency-shift keying) Modulation for data transmission. The modules when operated efficiently can cover a distance of 100 meters (200 feet) which makes it a great choice for all wireless remote-controlled projects.

The module operates at 3.3V hence can be easily used with 3.2V systems or 5V systems. They transfer and receive data on certain frequency called channel and each channel occupies a Bandwidth of less than 1Mhz Each module has an address range of 125, that is from 2.4GHz to 2.525GHz (2400MHz to 2525MHz) and each module can communicate with 6 other modules hence it is possible to have multiple wireless units communicating with each other in a particular area.

Web Camera: A webcam is a video camera that feeds or streams an image or video in real time. In this project we have used a 720p resolution camera. Therefore, a 720p HD camera resolution provides images that are 1280 x 720p pixels that adds up to 921,600 pixels where 1280 represents the number of horizontal pixels and 720 represents the number of vertical pixels.

WORKING

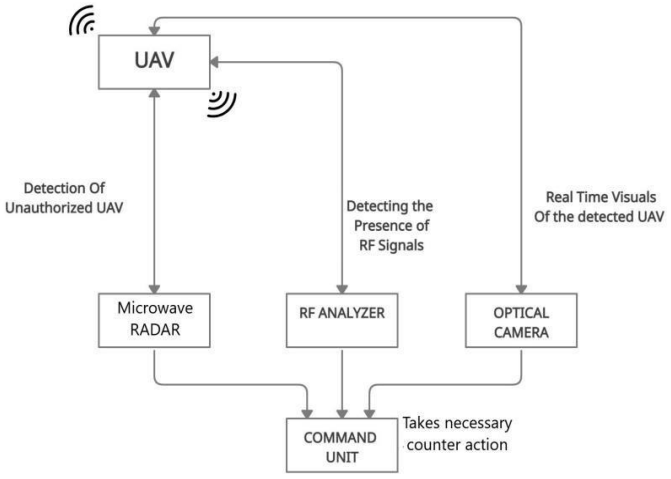

Figure 2.1: Block Diagram

The drone detection unit consists of RADAR sensor, a RF Analyzer, a Web Camera and a microcontroller board (Arduino UNO) to interface all these components. RADAR is used to detect the entry of a UAV into the sensitive area. The Radar sensor transmits high frequency waves which get reflected on hitting an object and the Radar sensor alerts RF Analyzer. The RF Analyzer detects the presence of RF Signals, since drones use RF signals for the communication with its remote the RF Analyzer detects those signals and this confirms that the detected object is a drone. The detected object may be a bird also thus for further clarification an Optical Camera is rotated in the direction of the detected object and the visuals are shown to the controller in the command unit, which also automatically alerts if there is any entry of unmanned aerial vehicles in the sensitive area.

METHODOLOGY

The Arduino is a small computer that can be programmed to read information from the world around and send commands to the outside world. Basically, it is a small development board with a brain (also known as a microcontroller) that is connected to electrical circuits. This makes it easy to read inputs – read data from the outside – and control outputs - send a command to the outside. The brain of this board (Arduino Uno) is an ATmega328p chip where you can store your programs that will tell your Arduino what to do. The Arduino IDE (Integrated Development Environment) is where you develop your programs that will tell the Arduino what to do. In this project an Arduino Uno was used to get readings from the sensor and take necessary actions. The Radar sensor is a microwave sensor that emits microwave frequency signals and receives the echoed signals, a transmitting and receiving antenna is used for transmitting and receiving. Upon receiving the signal, the property of obstacle is calculated using a processor present in Radar sensor

We have built a 2.4GHz WLan scanner using the nRF24L01 radio board. The transceiver output delivers all the interference and information in the scanned area in the form of ASCII codes. We have used Arduino Uno as a processor. The activity of the nRF24 RF radio board is transmitted to the Arduino board via the serial interface and displays any type of activity in ASCII code. Domains are displayed in different channels with the help of a simple mapping·

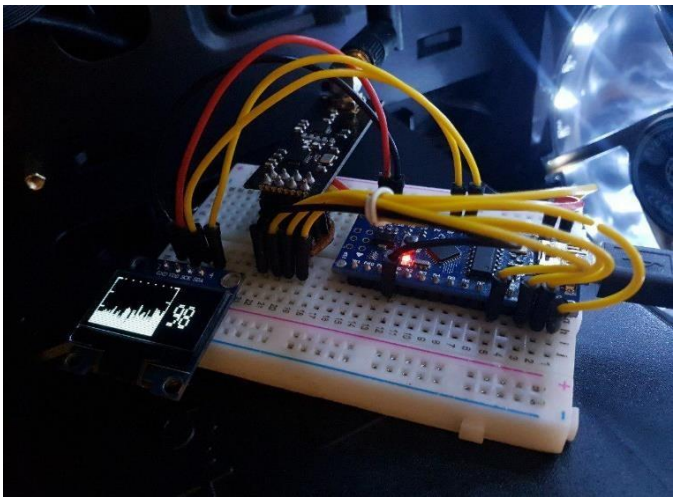

Figure 2.2: nRF24L01 transceiver designed as a RF scanner

Further, we have added an OLED display to display the scanned values in graphs as shown in Fig.2.2. With the nRF24 module, we can scan and view the entire 2.4GHz network. The graph values are based on the nRF power consumption at the moment of scanning using the OLED display. The difference between this scanner and packet monitors is that in the monitor pack, it only monitors the 14 channels available for Wi-Fi networks, but in this project, we can detect and actually see any frequency in the 2.4 range.

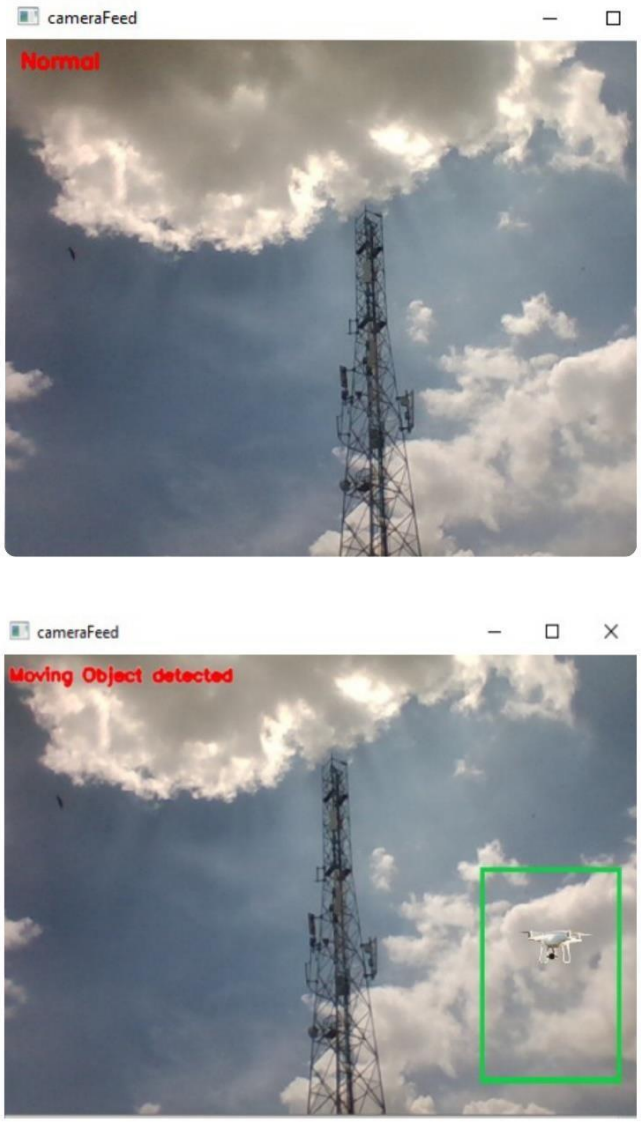

Figure 2.3: Left side of image shows the normal case Right side of image shows object detected case

The Web Camera continuously monitors the entry of any object in the fixed frame and displays it on the screen. With the help of Computer Vision (CV) we have written a python code for the detection of motion of any object within the fixed frame, that is we have fixed a frame as default and any change in it is detected as motion and a text is displayed on the screen along with the image as shown in Fig 2.3. It displays as "Moving Object Detected" when there are any changes in the frame and displays as "Normal" if there is no change in the frame. Thus, Web Camera continuously monitors the motion that is entry of any object within the fixed frame. Computer Vision is the ability of a computer to see as humans here as the captured video is displayed on the screen there is no need to look into it every time as Computer Vision has the ability to see it and identify it as an intruder or not and alerts upon entry of any obstacle in the sensitive area.

Thus, upon confirmation from all these sources that is, radar, RF and Web Camera an ALERT is created and the required actions can be taken.

3. CONCLUSIONS

Considering the numerous positive aspects of Drone system. The use of drones, however, poses threats to personal privacy and public security. It is of a great significance to deploy anti-drone system in a security sensitive area. The current anti-drone systems use either Radar or RF analyser which creates blind spot hence there is a need to include these both in a single system. An anti-drone system is very helpful to reduce its downsides to the community. In this paper, We have tried to develop a prototype of an Anti-drone system which detects entry of any unmanned aerial vehicles (UAVs) in sensitive areas using three major technologies. The experimental results shows that our prototype was successful in detecting and localizing the drone using RADAR, RF and CAMERA.

Further, the jammer or spoofing techniques can be implemented to take control over such UAVs and cut their connection with the controller as a counter action

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