MALICIOUS DRONES INTERCEPTION AND NEUTRALIZATION – LATEST TECHNOLOGIES OVERVIEW

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Abstract: *The unmanned aerial vehicles innovations bring those high technological devices to the access of almost every individual around the world. Drones provide many benefits and capabilities, but these features may be utilized for illegal and ill-natured purposes. Such scenarios include flying over non-trespassing zones, smuggling of materials over borders, spying, carrying out weaponized attacks by drones carrying munitions and explosives and many others.*

Because of that the advance of drone technologies requires a similar catch up advance of the anti-drone systems and measures.

The current article is a concise overview of the latest technologies and approaches employed to counteract malicious drones.

ПРИХВАЩАНЕ И НЕУТРАЛИЗАЦИЯ НА ЗЛОНАМЕРЕНИ ДРОНОВЕ – ПРЕГЛЕД НА НАЙ-НОВИТЕ ТЕХНОЛОГИИ

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Резюме: *Иновациите при безпилотните летателни апарати дават възможност на почти всеки човек по света да има достъп до тази технология. Дроновете предлагат много предимства и възможности, но тези характеристики могат да бъдат използвани за незаконни и злонамерени цели. Такива сценарии включват прелитане на забранени за полети зони, контрабанда, шпиониране, осъществяване на въоръжени атаки от дронове, пренасящи муниции и експлозиви и много други.*

Поради това напредъкът на технологиите, свързани с дроновете изисква подобен догонващ напредък на анти-дрон системите.

Текущата публикация е кратък преглед на най-новите технологии подходи за противодействие срещу злонамерени използване на дронове.

Introduction

The fast advance of drone technologies imposes a risk of their ill-natured implementation in different attacks by growing number of potential user parties. Major threat from malicious use of drones is towards facilities engaged in air transport such as airports. Unmanned aerial vehicles (UAVs) when flown in the vicinity of airports may endanger the airplane flights through causing destructive failure of passenger and cargo aircraft during take-off or landing manoeuvres. Such scenarios include both deliberate and unintentional collisions of drones and aircraft. The first drone-airplane collision is considered to be a 2017 incident in Quebec, Canada. Other threats of this kind include planned utilization of UAVs as flying weapons. This is achieved by loading drones with bomb and guns or other poisonous or dangerous materials and crashing the drones into targets. Such materials could be chemicals, radioactive substances, biological hazards, etc. Still another application of drones to illegal actions is the use of drones for spying.

For these reasons, anti-drone system are being constantly developed by companies or by state government agencies to counteract such threats. Due to the lack of one single winner technology in this field, there are many technological approaches under thorough development for detecting, tracking, identifying and neutralizing drones.

This report will not delve into exhaustive enumeration of commercial entities or trademarks related to anti-drone systems.

Fig. 1. Italian Army soldiers of the 17th Anti-aircraft Artillery Regiment "Sforzesca" with a portable CPM-Drone Jammer in Rome. Attribution: www.esercito.difesa.it

Detection, identification and tracking technologies

The following approaches are used for detection, identification and tracking of drones:

1. Radar
2. Visual, ultraviolet or near infrared light cameras
3. Thermal cameras
4. Acoustic methods
5. Drone radio emission receivers

Some of the above categories are active-only technologies such as the radar, passive-only ones like the acoustic methods, thermal cameras and drone RF emission receivers, or still active or passive like the IR, UV and visible light cameras.

An interesting novel method are the active cameras that measure time-of-flight of the emitted light thus acting as lidars. These cameras offer 3D view of the observed volume and are capable of measuring target distance without stereoscopic installations.

Another technological niche having intense research and development activity are the acoustic methods. The most innovative acoustic instruments are the acoustic cameras capable of generating 3D volumetric images of the guarded region using digital solid-state beamforming techniques and passive acoustic reception of the sound signals produced by the drones. Such a system is under development at the Space Research and Technology Institute – Bulgarian Academy of Sciences and is designated BAT Vision system (Beamforming Acoustic Tracking Vision system).

While light cameras and acoustic systems show good results, thermal cameras are often incapable of detecting drones as the latter, if designed properly, will emit almost none thermal radiation.

Radars are effective, but being active systems and requiring extreme power to detect small targets at reasonable distances tend to be bulky, hard to disguise, power hungry, dangerous for people and animals in their vicinity and easily spotted by their RF signatures. Further, electronic counter measures might be used by more sophisticated drones to lower the detection range or completely disable the detection capability of the radar system.

The drone RF emissions are a potential technology for passively detecting drones, but still it is not universal as complex and advanced drones would seize RF emissions when approaching target or would resort to light-based data links.

Most modern systems tent to fuse some or all of the above technologies in a single system to increase the probability and quality of detection.

Drone neutralization technologies

Once a malicious drone has been identified and located a system for its neutralization should be employed. The following technologies are used:

1. Conventional weapons such as missiles, machine guns and mines.
2. Directed electromagnetic energy weapons such as lasers and RF guns.
3. Particle beams.
4. Plasma weapons.
5. Web throwing weapons.
6. Electric discharge weapons.
7. Jamming or hijacking of the hostile drone through interfering with its communication data link.
8. Employment of a specialized drone that hunts and destroys enemy drones.
9. Use of animals to counteract drones such as eagles.

Conventional weapons show effectiveness against small sized enemy drones. As the Moscow TASS agency reported, a small-sized anti-drone missile has been developed in Russia designated Tor-M2. The commander-in-chief of Russia's ground forces, General of the Army Oleg Salyukov, stated in an interview published in Rossiyskaya Gazeta:

> *"Currently the air defense system Tor-M2 is the most effective means against tactical drones. The cost of one guided air defense missile is way above the cost of a small-size drone. For this reason a relatively inexpensive small missile is being developed for this system."*

Directed electromagnetic energy weapons are effective. Lasers (Fig. 2) are capable of knocking down a small UAV in seconds. They are bulky though and require enormous amounts of power to be run. RF guns are also bulky and power hungry and in many cases of engaging off-the-shelf drones they burn certain electronics in the drone avionic thus disabling the attacker.

Particle beams haven't been developed yet, but work is in progress. Plasma weapons and electric discharge weapons are in their infantry.

Web throwing weapons are effective against small sized and slow flying drones, still short range should be maintained and the web is generally aimed manually towards the hostile drone.

Jamming and hijacking RF emitters are also useful (see Fig. 1). These are light weight and in most cases handheld. They jam drone communication systems and make it uncontrollable by an operator. Another approach is to hijack the drone by overpowering the operator's radio remote control. Thus such an approach is ineffective with sophisticated drones.

Employment of a specialized drone that hunts and destroys enemy drones is a complex task, nevertheless competition for proposals of such systems was issued by the USA government recently.

Use of animals to counteract drones is feasible approach, but at the harm caused by the drones to the animal. We find this method unacceptable.

Fig. 2. AN/SEQ-3 Laser Weapon System (LaWS) aboard USS Ponce

Conclusions

The anti-drone systems are a fast developing branch of drone related technologies. The authors find that acoustic methods are of top importance in the detection and tracking procedures and a sophisticated and novel high-tech approach to acoustic cameras is a promising future solution for realizing successful anti-drone systems. Hence, attention has been allocated towards the development of the BAT Vision system. The project research and development continues.

References:

1. Dent, Steve (2017). Drone hits a commercial plane for the first time in Canada. *Engadget*.
2. https://www.parliament.bg/pub/PK/172275%D0%BE%D1%82%D0%B3%D0%BE%D0%B2%D0%BE%D1%80554-05-27.pdf
3. Kloet, N., Watkins S. and Clothier R. (2017). Acoustic signature measurement of small multi-rotor unmanned aircraft systems, International Journal of Micro Air Vehicles, 2017, Vol. 9(1) 3–14 DOI: 10.1177/1756829316681868.
4. Zabunov, S., Mardirossian G., Getsov P. (2018). Acoustic Anti-Drone Reconnaissance System Based on Tethered Aerostat, Bulgarian Patent Office, Utility model #2872/15.02.2018.