S E S 2 0 2 0
Sixteenth International Scientific Conference
SPACE, ECOLOGY, SAFETY
4 – 6 November 2020, Sofia, Bulgaria

AN ACOUSTIC DRONE RECONNAISSANCE SYSTEM

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Keywords: *BAT Vision system (Beamforming Acoustic Tracker Vision system), acoustic drone detection.*

Abstract: *BAT Vision (Beamforming Acoustic Tracker Vision system) is an acoustic drone detection, identification and tracking system that uses passive acoustic technology to maintain security over an area vulnerable to malicious drone attacks or forbidden for drone trespassing.*

The BAT Vision system was conceived in 2017 by the author and since then has been in constant research and development phase. The current stage of the project is aiming at the completion of several prototype modules with the expectation of a forthcoming test phase.

The acoustic reconnaissance system is passive (does not emit any signals) and employs an array of microphones organized in a hierarchical two level structure. The signals from the microphones are amplified, digitized and processed digitally in software. By means of digital beamforming a 3D video stream of the observed volume is generated with cadence of a few milliseconds. The system is foreseen to employ deep learning techniques for drone acoustic identification, determination of physical and technical properties and consequent classification.

АКУСТИЧНА СИСТЕМА ЗА СЛЕДЕНЕ НА ДРОНОВЕ

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Ключови думи: *Система BAT Vision (Beamforming Acoustic Tracker Vision system), акустично откриване на дронове.*

Резюме: *Настоящият доклад разглежда акустична система за контрол на дронове – BAT Vision (Beamforming Acoustic Tracker Vision). Системата служи за откриване, идентификация и следене на дронове, използвайки пасивен звуков метод. Целта е гарантиране на сигурността в определен обект/територии, която е застрашена от нападения с дронове или е забранена за прелитане.*

Системата BAT Vision е замислена през 2017 г. от автора на тази публикация и е в процес на изследване и разработка. Тя е пасивна акустична система и не излъчва сигнали. Състои се от масив от микрофони, организирани в йерархична структура на две нива. Сигналите от микрофоните се усилват, дигитализират и обработват цифрово в софтуер. С помощта на цифрово лъчеформиране се генерира 3D видео изображение на наблюдавания обем. Очаква се системата да прилага дълбоко обучение с цел акустична идентификация на дроновете, определяне на техните физически и технически характеристики и последваща класификация.

Introduction

The fast advent of unmanned aerial vehicles (UAVs) technologies in the past few years imposes a risk of their malicious use. Such use may involve attacks on targets with drones carrying bombs and guns or other weapons, intelligence by means of drones observation and reconnaissance, transport of illegal goods, trespassing over forbidden territories or borders, etc. Such attacks might be counteracted if the attacker drone is detected and identified as a culprit. The development of drone detection systems in the recent years followed due to the strong demand for anti-drone systems. A new major technological approach has been established – the acoustic method. A few companies are offering detection, identification and tracking systems involving the acoustic approach. Such a system is SafeSky Drone Detection and Neutralization System (http://www.detectdrones.com/#system) by Advanced Protection Systems. Their acoustic array detects drones at up to several hundred meters. Furthermore, this system is a combination of proprietary X-band radar, acoustic array, camera for visual detection, and RF sensors.

The most contemporary technological method for acoustic drone control is a further development of the acoustic array detection system leading to the acoustic camera drone detection method. Companies that have large experience in acoustic cameras intended for other applications are trying to adapt their products and knowledge and create drone control acoustic cameras. Testing is carried out by the Swiss company Distran (https://www.distran.ch). The company has been developing ultrasonic acoustic cameras like Ultra M used for ultrasonic examination and detection of mechanical faults in industrial equipment. Distran was able to detect drones with a modified version of their camera from 300 meters distance.

Other manufacturers of acoustic cameras, though not yet specialized in drone detection, are Acoustic Camera (https://www.acoustic-camera.com/en.html), Cae-Systems in Germany (https://www.cae-systems.de/en/products.html), Microflown (http://www.microflown.com/), NLA Acoustics (http://www.nlacoustics.com/), Norsonic (https://web2.norsonic.com/product/324/), etc.

The advantage of acoustic cameras over other acoustic methods for detection is the generation in real-time of acoustic pseudo-colour visualization of the observed volume and visual signalling of the operator about the position and other characteristics of the detected and tracked drones.

Fig. 1. BAT Vision uses microphones for its two-level hierarchical acoustic array

BAT Vision system

The current report elaborates on the BAT Vision project (BAT Vision stands for Beamforming Acoustic Tracker Vision). BAT Vision is a system under development that is used for acoustic drone detection, identification and tracking through passive means of acquisition of air transmitted sound waves. This technology is implemented in the maintenance of security over areas vulnerable to malicious drone attacks or forbidden for drone trespassing.

The BAT Vision system was conceived in 2017 by the author of this article and since then has been in constant research and development phase. The current stage of the project is aiming at the completion of several prototype modules that are to be employed in a forthcoming test phase.

The acoustic reconnaissance system is passive (does not emit any signals) and is based on an array of microphones organized in a hierarchical two level structure. The microphone signals are amplified, digitized and processed in software. By use of digital beamforming a 3D image of the observed volume is generated with cadence of a few milliseconds. A 3D video stream is output based on pseudo-colours available for observation. Further features of the BAT Vision system include a deep learning technique for drone acoustic identification, determination of major physical and technical UAV properties and consequent classification. BAT Vision is foreseen to be able to track hundreds of targets simultaneously while the data stream would be available remotely through the Internet.

The system design

The BAT Vision system, as earlier mentioned, is based on microphones to receive sound signals coming from drones through air. The hierarchical structure of each BAT Vision unit establishes two levels of sensors employing 1024 microphones in total (Fig. 1). These are structured in 16 modules (Fig. 2) organized in a 4x4 planar array (Fig. 3). Each module uses 64 microphones and has four channels of acoustic information by grouping the 64 microphones into 4 sub-squares, 16 microphones each. Due to the used upper limit of acquired sound frequencies of approximately 4 kHz, the size of one square of 16 microphones has smaller dimensions than the wavelength at those frequencies thus not impeding the beamforming efficiency and beam maximum declination angle of the whole module. Each of the four channels of a module employs a low noise audio preamplifier and preconditioner that feeds the signal to a four channel analogue to digital converter with 24 bits of resolution and 390 kHz sample rate. The module also includes auxiliary electronics for filtering the power supply and regulating its voltage.

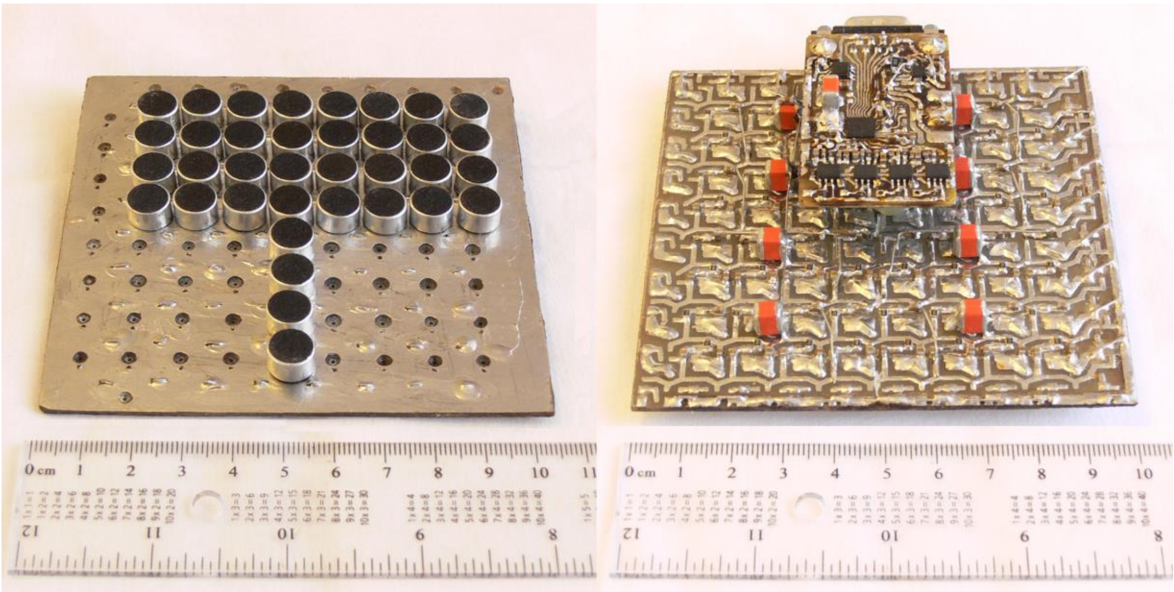

Fig. 2. A BAT Vision module (work in progress): microphones side (left) and components side (right)

All 16 modules in one unit send their digital signals over a serial bus to a computer dedicated to the BAT Vision unit. All the processing of digitized information is carried out by the dedicated computer. There is a large computational demand by the implemented algorithms, such as beamforming computation, clutter removal, drone identification and its properties evaluation, etc. While this computer may employ high performance processors in order to cope with the high computationally intensive algorithms, it is expected that a parallel processing unit would provide significant parallel processing power with lower electrical power requirements than central processing units (CPUs). The implementation of modern graphical processing units (GPUs) for this purpose is a preferred option.

The dedicated computer to each BAT Vision unit maintains real-time network communication with a central computer, the latter acting as a server. The server may be connected to several BAT Vision units located at different sites or observing the same site but from different positions and angles. Network communication is applicable through wired LAN or Wi-Fi networks. This approach permits the server to be connected to the units over the Internet.

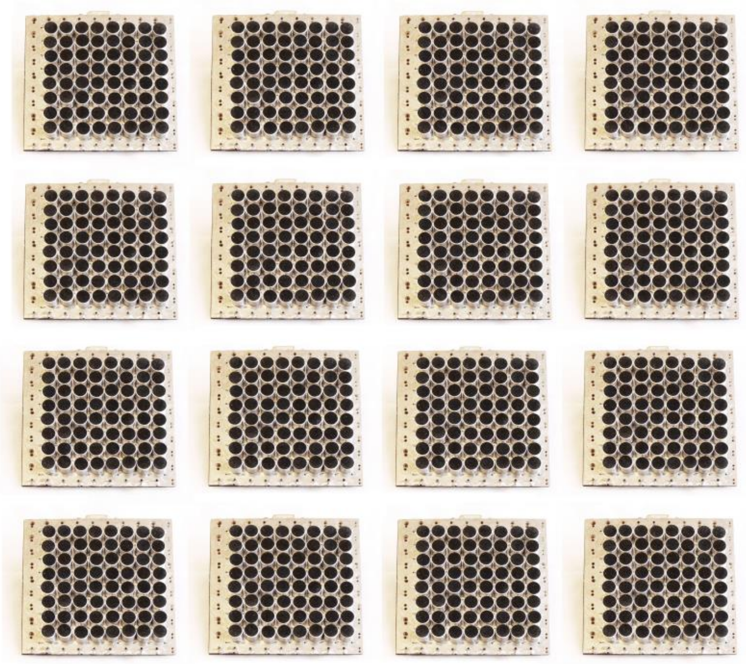

Fig. 3. One BAT Vision unit consists of 16 modules, 64 microphones each

Conclusions

There is a strong demand in the recent years for protection of people and facilities against drone attacks. In order to guard from malicious drone usage the UAVs must first be detected and identified. Further countermeasures require tracking of the targets. All these tasks are well solved by acoustic anti-drone systems and their further innovative development is justified. Hence the author is continuing his work on the subject towards the testing phase of the BAT Vision prototype modules.

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