ACOUSTIC DETECTION AND TRACKING OF SMALL, LOW-FLYING THREAT AIRCRAFT

Tien Pham* and Leng Sim

US Army Research Laboratory
Attn: AMSRL-SE-SA
2800 Powder Mill Road
Adelphi, MD, 20873-1197
Email: tpham@arl.army.mil
Tel: 301-394-4282

ASTRACT

Acoustic sensor arrays can be used effectively to provide situational awareness and perimeter defense against small low-flying threat aircraft. Being small and flying low, these aircraft can elude radar detection. However, similar to heavy ground vehicles, these small aircraft emit strong harmonic lines that can be detected and tracked (bearing) at long range. Experimental results from a 16-element cross array are presented for several types of a small aircraft.

1. INTRODUCTION

Small low-flying aircraft can pose a significant threat to soldiers in the battlefield as well as to homeland security. These small aircraft include fixed-wing and unmanned aerial vehicles (UAVs) tend to fly low to avoid radar detection. However, they emit broadband noise that can be detected at significant ranges by acoustic sensors. Acoustic sensors are non-line-of-sight sensors that can create a first line of defense or a perimeter defense around a strategic site or building by alerting the soldiers of oncoming low-flying aircraft. The US Army Research Laboratory (ARL) has been developing acoustic, seismic and other low-cost passive sensor systems for Unattended Ground Sensor (UGS) applications. In general, acoustic sensor arrays can be used effectively to detect, track (bearing), and classify multiple targets in the battlefield in real-time. Localization and tracking can be achieved using several sensor arrays networked together. These low-cost acoustic sensor systems are portable and can be deployed in remote tactical areas or along borders to provide situational awareness. They can also be deployed at airports or landing sites to monitor air traffic activity.

2. RESULTS AND DISCUSSION

In this paper, we discuss the use of a single acoustic sensor array for detection and tracking (bearing only) of small low-flying aircraft for surveillance. Like tanks and other ground vehicles [1-3], these aircraft emit very strong harmonic lines as well as broadband energy as shown in Figure 1. In contrast to the ground vehicles, the harmonic lines generated by small aircraft tend to be more stationary; therefore, consistent direction of arrival (DOA) estimates can be obtained. However, these lines can become nonstationary during maneuvers as shown in Figure 1 during the 60-100 second time period. From the spectral content, classification (e.g., gasoline engine vs. electric engine) can be accomplished while identification of a specific type of aircraft is more difficult but still possible [4].

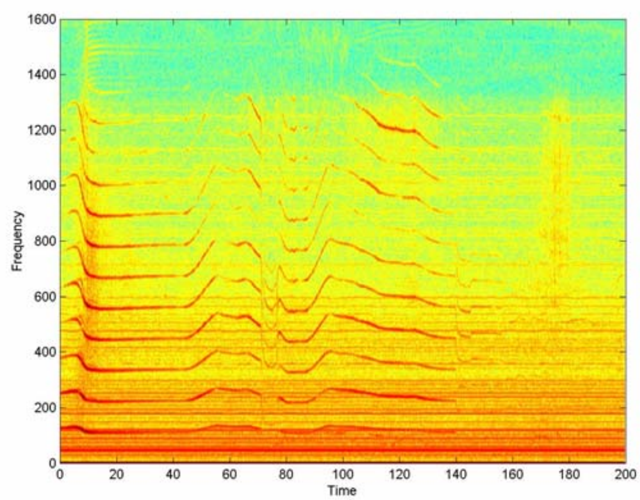

Figure 1: *Spectrogram of a small aircraft as detected by a fixed acoustic array on the ground.*

Due to the strong harmonic structure, the Incoherent Wideband MUSIC (IWM) algorithm is ideal and efficient to use for high-resolution DOA estimation [1-3]. We applied the IWM algorithm to experimental data collected from a small baseline acoustic array and estimated the DOAs. Figure 2 shows the 16-element cross array on the ground with 1 ft spacing. The elevated microphones belong to a large baseline orthogonal array used for wideband processing [5]. Further details of the small aircraft data and field experiment can be found in [6]. Figure 3 shows a beampattern vs. time plot for data of a diesel engine aircraft with the spectrogram shown in figure 1. The beampattern spectrum is generated by utilization of the IWM algorithm with 10-20 harmonic peaks (depending on the SNR) in the frequency range 100-200 Hz [1-3]. Accurate detection and DOA estimation can be obtained at ranges up to 2 km (equivalent to 180 s in figure 3).

Figure 2: *16-element cross sensor array with 1 foot spacing located on the ground.*

3. CONCLUSION

Small aircraft can be effectively detected and tracked by ground based acoustic sensor systems at significant ranges. Further experimental analysis for several different types of small aircraft will be presented in the poster sessions. The DOA results from the IWM algorithm are compared with GPS ground truth data to estimate the detection range and bearing accuracy of the DOA estimation at those ranges. Issues such as latency, wind noise and elevation calculation near the closest point of approach will be discussed also.

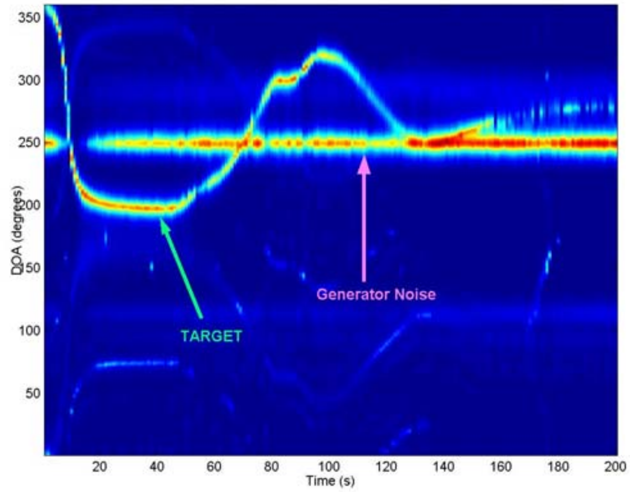

Figure 3: *Beampattern vs. time results for a low-flying aircraft.*

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