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4pAB10. Benign exclusion of birds using acoustic parametric arrays

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Excluding birds from areas can be important in aviation safety, agriculture, and facilities maintenance. Presenting audible stimuli or predator vocalizations in the affected area often has initial success, but has a limited effect over the long-term, even if the signals are varied to reduce the chances of the birds habituating to the sounds and objects. Many birds are highly vocal and rely on auditory communication in almost every aspect of their life history. By creating noise specifically targeted to be within the vocal range of the nuisance species we hypothesize that the birds will be less able to communicate and will move to more acoustically suitable environments. To avoid introducing noise pollution to the surrounding environment we create spatially well-controlled 'sonic nets' using a mix of speakers and acoustic parametric arrays. To better understand the interaction of the sound field and the environment we combine finite difference solutions of the KZK equation with 3D acoustic finite integration simulation. These simulations allow us to propagate a nonlinear acoustic beam to a real-world target and then study the scattering from the target. We discuss initial experiments with a parametric array in an aviary on the exclusion of starlings from a food source.

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EXCLUDING BIRDS FROM CRITICAL AREAS

Excluding birds from certain areas can be important to aviation safety, agriculture, and facilities maintenance. Aircraft collisions with birds create a serious economic and safety problem, with total direct and indirect costs to the worldwide civil aviation industry exceeding $1.2 billion annually [1]. In the US alone, 9791 bird strikes were reported in 2011 [2] and even more are predicted in coming years as the number of flight hours increase and birds become more adjusted to living in urban environments. In agriculture, crop damage from birds has an economic impact of more than $800 million yearly in the United States [3]. Perhaps more serious is crop destruction by pest bird species in the developing world, where flocks of birds can cause ruinous crop losses and endanger a small-scale farmer's source of sustenance.

Current techniques of bird removal, including targeted bird kills, visual and auditory scare devices, netting of crops, and large scale application of environmentally harmful avicide chemicals often don't effectively reduce the number of birds in a targeted area. Presenting audible stimuli or predator vocalizations in the affected area can have initial success, but has a limited effect over the long-term, even if the signals are varied to reduce the chances of the birds habituating to the sounds and objects.

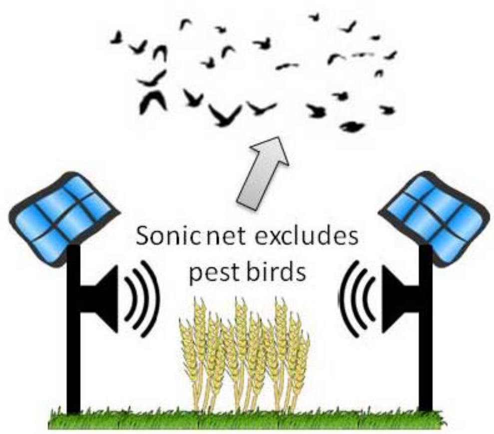

FIGURE 1: The sonic net excludes pest birds from a targeted area by using a tightly-controlled beam of sound to mask bird communication

Our approach (Figure 1) uses engineered 'sonic nets' to block communication channels between birds. Many birds are highly vocal and rely on auditory communication in almost every aspect of their life history [4]. By creating noise specifically targeted to be within the vocal range of the nuisance species, the birds are less able to communicate and move to more acoustically suitable environments. We use a mix of speakers and acoustic parametric arrays to create spatially well-controlled areas of sound and to avoid introducing noise pollution to the surrounding environment.

AVIARY TESTS

Aviary-based experiments using a common pest bird, the European Starling, are currently underway. European starlings were introduced to the United States in 1890 and have since spread throughout North America [5]. These birds often feed and roost in large aggregations near airports and rank second to gulls in the number of reported strikes on aircraft [6]. Our study focuses on the foraging activity of these birds in an outdoor aviary as a controlled test of the application of the 'sonic nets'.

Our aviary is constructed of two rectangular 2.3 x 6.2 m legs connected by a 9.8 m long tunnel. Exterior walls are constructed of a double layer of 1/2-inch galvanized steel mesh and ceiling height is at 2.3 m throughout. The aviary structure was modified to minimize possible scattering effects of the acoustic beam, and acoustic flanking paths between the legs of the aviary were reduced with acoustic curtains. Measurements confirm that the sound level in the non-active end is within the ambient background.

During a test, starling food sources are placed in both legs of the aviary and the acoustic masking signal fills one of the legs to determine whether birds are excluded from that area. No sound is ever presented in the middle neutral zone, which is where the starlings roost at night. The number of birds present in each leg of the aviary (measured from video footage) and the total weight of consumed food in each leg are some of the metrics used to track bird behavior.

This stage of the project allows us to demonstrate our approach in a carefully controlled environment. Among other variables, the required sound level and frequency content of the masking signal can be optimized to most effectively block communication between birds. Follow-on work will include deploying the sonic nets at farms and airports while monitoring the resulting bird exclusion.

Numerical simulations of nonlinear acoustic beams

To better understand the interaction of the sound field and the environment we combine finite difference solutions of the KZK equation [7] with 3D acoustic finite integration simulation. These simulations allow us to propagate a nonlinear acoustic beam to a real-world target and then study the scattering from that target [8]. Since we use the specific physical properties of our parametric array and experimental setup, direct comparisons can be made to acoustic measurements (Figure 2).

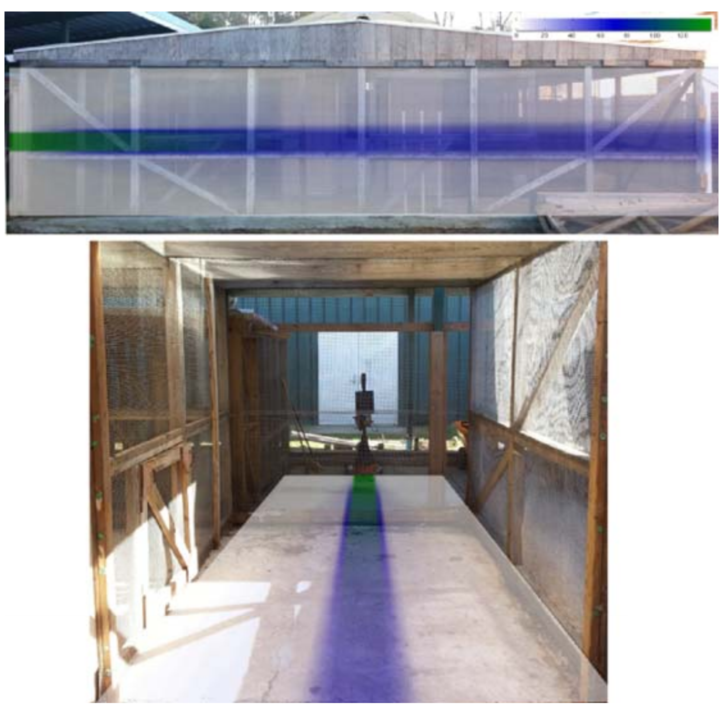

Figure 2: Numerical simulations of the nonlinear beam propagation overlaid on the aviary show sound coverage at the legs of the aviary. The combination of the overlay transparecy and simulation color scale highlights the directionality of the beam more than normal.

Another advantage to our simulations is the ability to easily model many different parametric array configurations. Figure 3 shows what happens when the geometrical focal length of the parametric array is varied. This has the effect of changing the coefficients of the simulation in a physically meaningful manner.

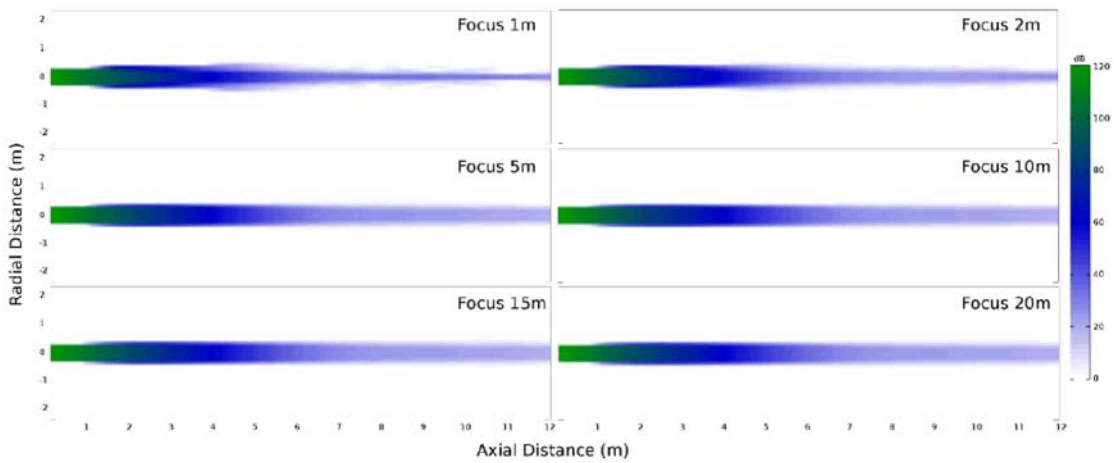

FIGURE 3: An 120 dB pressure field consisting of two sines at 35 and 45 kHz is produced at the face of the parametric array. As the nonlinear beam propagates through air, self-demodulation creates an audible signal at the difference frequency (10kHz). Here we see the acoustic beam become more uniform as the parametric array is unfocused.

We can also adjust parameters of the simulation to more clearly understand the physical effects of nonlinear beam propagation. For example, when the nonlinearity is turned off in the simulation (Figure 4), no low-frequency difference frequencies are created and the ultrasonic carrier signal quickly attenuates.

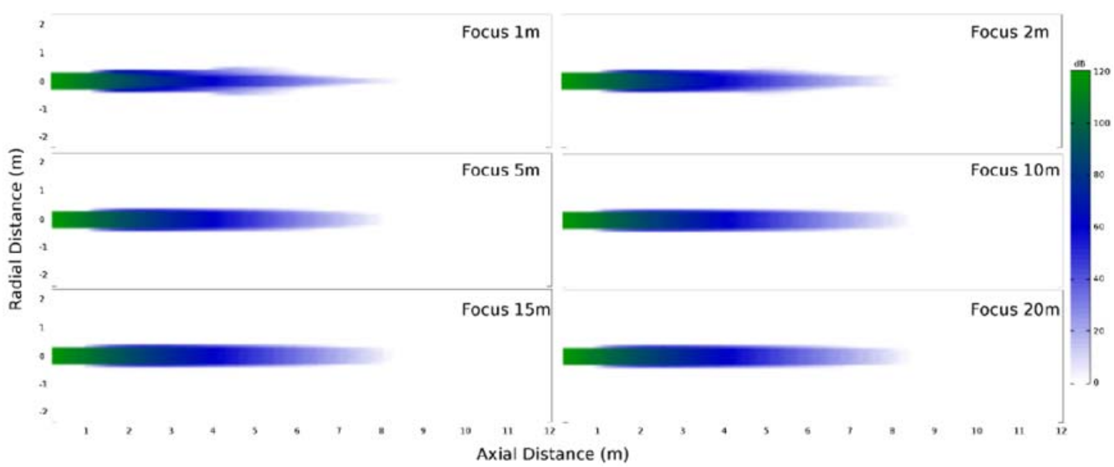

FIGURE 4: When nonlinearity is turned off, the main effect is a shortening of the beam propagation, since no audible frequencies are created

Using such simulations allow us to create accurate models of the area covered by the sonic nets that can be compared to aviary measurements. They can also be used to design sonic nets that reversibly exclude pest species from target areas without increasing the overall sound level in the larger area.

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