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Performace Bounds for a Multi-Array Network Approach to Gunfire Detection and Localization

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Acoustics-based gunfire detection and sniper localization have become important in both military and civilian sectors. For the case of rifle fire, most current localization algorithms rely on estimating parameters using the projectile's cone-shaped shockwave and the muzzle blast. Previous studies have attempted to quantify shockwave detection performance as a function of range for various approaches such as wavelet matched filtering for the "N" shaped shockwave. Accurately detecting the shockwave is important because the shockwave shape can be used to determine bullet trajectory if the bullet velocity is known. A second layer of direction of arrival (DOA) estimation can be added by using the time difference of arrival between the shockwave and the muzzle blast. These DOA methods require a two step process of detection and estimation. In this work, a signal model is developed for a network of microphone arrays that receives the acoustic waveform generated by supersonic projectiles. The best-case localization performance of the multi-array network is quantified via the Cramer-Rao lower bound on the error in estimating shooter position. Results are illustrated using simulated data to generate CRLB ellipses on shooter position estimation error and via live fire experiments using several calibers and a multi-array network of microphones.