Geolocating Active Shooters Using Proximity and Cloud-Based Multilateration Algorithms

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The objective of this investigation was to to design and test an economical, audio-based gunshot detection method which can be used in two different use cases to increase situational awareness. The sensor unit is composed of a Raspberry Pi computer and microphone to detect unusually high sound amplitudes, and costs $10.00 each. In the proximity use case, the sensor can be deployed in large numbers in schools, restaurants, and offices, similar to smoke detectors being mandatory in every room of a building. For instance, with this system, an average high school with about 100 rooms can be equipped with a sensor per room for $1,000 with no recurring fees. Tested with a 9mm Glock 19 gun, all of the gunshots triggered the alert, which was sent in the form of an email and text with an attached map of the location of detection. Tests also showed that no false alarms occurred with varying levels of ambient noise (70, 80, and 90 dB). The second use case has applications outdoors in city-center monitoring, for example, and uses multilateration to geolocate the gunfire. The computerized tests showed that with randomized gunfire locations, the central server was able to use data from individual sensors to estimate the GPS coordinates. With realistically implemented discrepancies between the clocks of the sensors, the server estimated the location of the gunfire, on average, within 2.52 meters of its actual location and sent an immediate alert. With a sensor clock discrepancy of less than one millisecond, the sensor located the gunfire to within 0.16 meters on average. The low cost of this sensor compared to the $250,000 annual per square mile system by ShotSpotter makes gunshot identification more accessible and an effective solution in increasing situational awareness.